



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

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A Cebr report for the Institute of Physics

November 2021

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London, November 2021

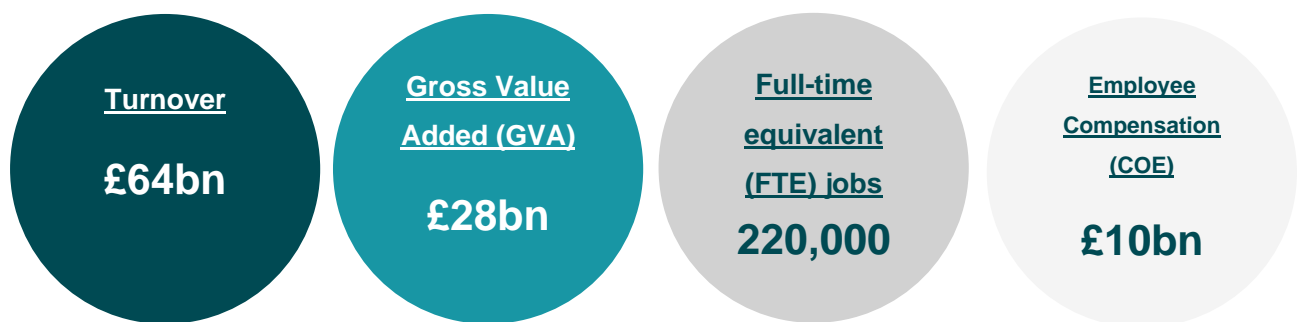
## Contents

<b>Headline Findings .....</b>	<b>5</b>
<b>1. Introduction .....</b>	<b>7</b>
<b>1.1 Background and purpose of the study</b>	<b>7</b>
Mapping Scottish PBIs .....	8
<b>1.2 Earlier research</b>	<b>9</b>
<b>2. Enterprises in the Scottish PBIs.....</b>	<b>10</b>
<b>2.1 Turnover</b>	<b>10</b>
Industry comparison.....	12
<b>2.2 Business demography</b>	<b>13</b>
Business count .....	13
Size of enterprises.....	16
<b>3. Economic Contribution of the PBIs to the Scottish economy .....</b>	<b>18</b>
<b>3.1 Gross value added (GVA)</b>	<b>18</b>
Industry comparison.....	21
<b>3.2 Employment</b>	<b>22</b>
Labour productivity .....	25
Industry comparison.....	27
<b>3.3 Compensation of employees (COE)</b>	<b>28</b>
Industry comparison.....	30
<b>4. National comparisons.....</b>	<b>32</b>
<b>4.1 Turnover</b>	<b>32</b>
<b>4.2 GVA</b>	<b>32</b>
<b>4.3 Employment</b>	<b>33</b>
<b>4.4 COE</b>	<b>33</b>
<b>4.5 Business demography</b>	<b>33</b>
<b>Appendix I: SIC-based definition of PBIs and sectoral alignment.....</b>	<b>35</b>
<b>Appendix II: Full tables .....</b>	<b>38</b>
<b>Appendix III: Methodology .....</b>	<b>41</b>
<b>Economic impact of the PBIs in the UK as a whole</b>	<b>41</b>

**Economic impact of the PBIs in Scotland**

## Headline Findings

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



- Overall, nominal GVA in the PBIs in Scotland grew by 4.3% over the ten-year period, which was much less than the overall growth of the nation (32.4%). The sub-sector that saw the largest growth was the Telecoms sub-sector, which grew by nearly two and a half times (from £1 billion to £2.5 billion).
- The biggest PBI sub-sector in terms of GVA was Oil & Gas Extraction, which contributed £11.46 billion, followed by Physics Science & Technology (£5.53 billion) and Physics Manufacturing (£4.11 billion).
- The aggregated £28.4 billion GVA contribution in 2019 was equivalent to 17% of Scottish GDP; a very strong share relative to the 11% for the PBIs across the UK. This is because the Oil & Gas sector is disproportionately (relative to levels of wider economic activity in Scotland compared to the UK) located in Scotland.
- There were 27,235 PBI enterprises operating in Scotland in 2019. This compares to 177,075 enterprises for the whole of Scotland, meaning 15.4% of all Scottish enterprises were PBI related.
- In 2019 Physics Science & Technology was the PBI sub-sector with the greatest number of enterprises, with 20,850 enterprises in Scotland (76.2% of all PBI enterprises).
- 93.2% of PBI enterprises were considered micro enterprises. Of the remainder, 5.5% of enterprises were small (10-49 employees), with the remaining 1.2% medium (50-249 employees) or large (250+). In Scotland as a whole, 88% of all enterprises were micro, 10% were small, and 2% were medium or large.
- Throughout the decade, the turnover of the PBIs decreased by 3.7%, from £66 billion to £64 billion. This is due to the fall in output in the Oil & Gas Extraction sub-sector, which saw a drop from £24 billion to £18 billion (26.7%). The highest absolute growth was

experienced by the Physics Science & Technology sub-sector, which increased from £7.5 billion to £11.6 billion (54.5%), while the Space Transport & Air Transport Services sub-sector nearly doubled its initial value (from £491 million to £956 million, 94.6%).

- Besides Oil & Gas Extraction, turnover decreased in three industries: Defence (from £433 million to £316 million, 27.1%), Telecoms (£7.3 billion to £5.2 billion, 29.7%) and Physics Machine Sales (£229 million to £ 106 million, 53.6%).
- Employment in the PBIs topped more than 220,000 in 2019. Employment growth averaged 0.9% annually over the decade.
- Within the PBI sector in Scotland, the Physics Science & Technology sub-sector employed the largest proportion of people, 42.6% of the total Scottish PBI employment in 2019. The Physics Manufacturing sub-sector reported the second largest share, with 26.3%. At the start of the decade, the two sub-sectors had very similar levels of employment, but the growth rate of employment in the Physics Science & Technology sub-sector was much stronger over the period.
- PBIs experienced a growth of 1.9% on a yearly average employee compensation, from £8.8 billion to £10.4 billion over the period. This is a much higher growth rate compared to employment, meaning that average employee compensation increased throughout the period.
- Employee compensation per FTE worker increased overall across PBIs. The Physics Manufacturing sub-sector particularly had significant growth, of 40.7% over the period.

# 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 Scottish 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 to the Irish economy.

## 1.1 Background and 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 (and the R&D activity can be expected to significantly 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:

- GVA<sup>1</sup> contributions to Scotland and constituent regional GDP generated by the PBIs
- Full-time equivalent (FTE) jobs supported by the sector<sup>2</sup>
- The value of the turnover of the PBIs

<sup>1</sup> 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  $GVA + Taxes\ on\ products - Subsidies\ on\ products = GDP$ .

<sup>2</sup> 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 employee compensation<sup>3</sup> generated by PBIs, representing the total remuneration of employees operating in the sector
- The productivity of the PBIs (value added per worker)
- The number of PBI enterprises operating in Scotland

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 Scottish economy

### Mapping Scottish 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 sectors.<sup>4</sup> 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

<sup>3</sup> Compensation of employees is the total remuneration, in cash or in kind, payable by an employer to an employee in return for work done by the latter, mainly consisting of wages paid to employees, employers' actual social contributions (excluding apprentices), employers' imputed social contributions (excluding apprentices) and employers' social contributions for apprentices.

<sup>4</sup> 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 vary 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 Scotland specifically.

## 2. Enterprises in the Scottish PBIs

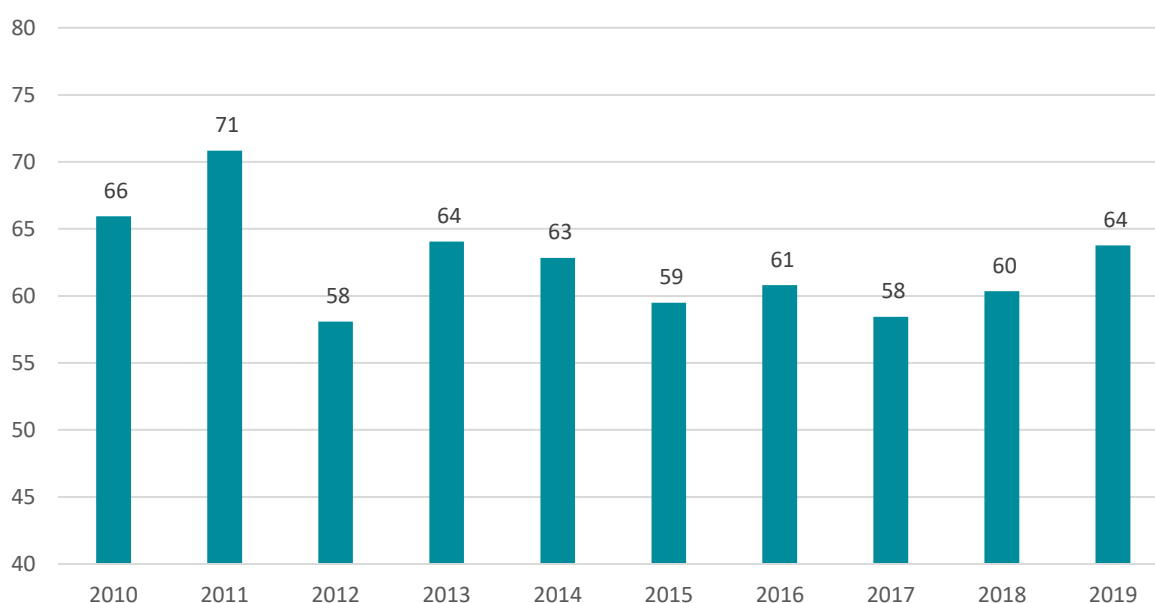
This section provides an assessment of the importance of PBIs to Scotland in terms of turnover and business demographics over the period 2010-2019.

### 2.1 Turnover

We firstly present the contribution of the PBIs to the Scottish economy in terms of the turnover generated by those industries. Throughout the period, the turnover in Scotland decreased by 3.3%, from £66 billion to £64 billion. Figure 1 shows that after a strong start to the decade in 2011 (a peak of £71 billion), total turnover generated by the PBIs declined in 2012, then fluctuated around an average of approximately £60 billion over the rest of decade. Scotland's contribution to the UK turnover declined slightly over the period, from 12.9% to 10.1%, but it was still the second largest contributor to total UK PBI turnover.

On an average annual basis, the physics sector in Scotland decreased by 0.4%, compared to the average UK-wide PBI sector yearly turnover rise of 2.4%. This decline is largely driven by the falling turnover in the important Oil & Gas Extraction sub-sector, which played a significant part in Scotland, but was less impactful in the rest of the UK.

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



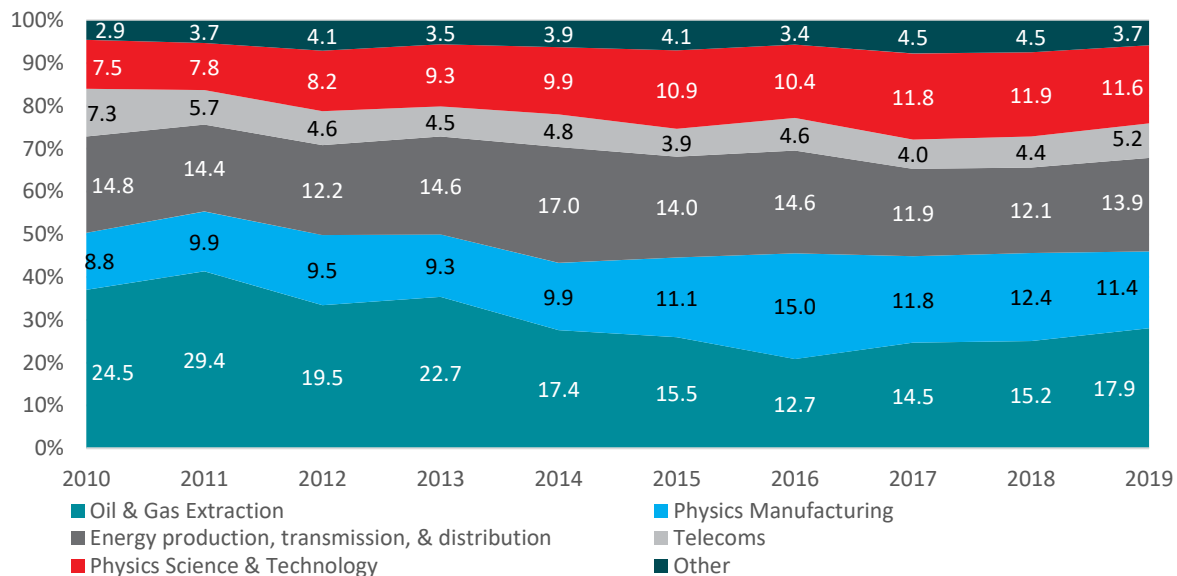
Source: ABS, Cebr analysis

Figure 2: Turnover in the different sub-sectors of PBIs in Scotland, presents a comparison of the different sub-sectors comprising the PBIs. Their composition has shifted throughout the 2010-2019 period, with reducing dependence on the Oil & Gas Extraction sub-sector. This contributed nine percentage points less to the overall value in 2019 than 2010 (28.1% compared to 37.1%).

Those PBIs that were engaged in Oil & Gas Extraction still occupied the largest share by 2019, around 30% on average, followed by those engaged in energy activities, approximately 22%. The Physics Science & Technology sub-sector on the other hand grew steadily, and while in

2010 it contributed only 11.4% of all PBI turnover, by 2019 this share rose to 18.3%. The figure below presents the turnover for selected categories of Scotland PBIs for the entire period.<sup>5</sup>

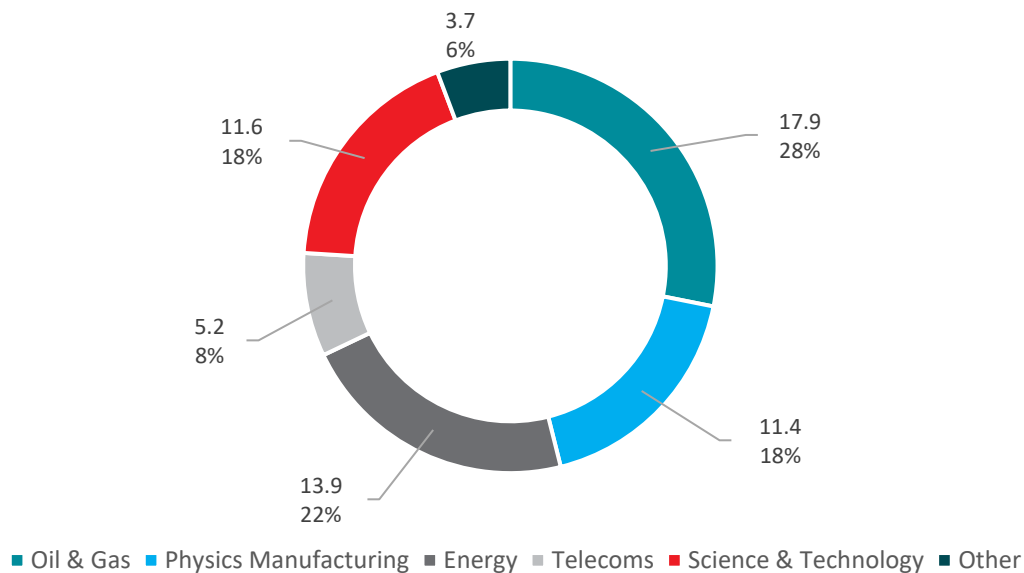
Figure 2: Turnover in the different sub-sectors of PBIs in Scotland, % of PBI total (LHS axis) and monetary value (£ billions, label), 2010-2019



Source: ABS, Cebr analysis

Figure 3 below visualises the breakdown of turnover in 2019.

Figure 3: Turnover in the different categories of PBIs in Scotland, £ billions, 2019

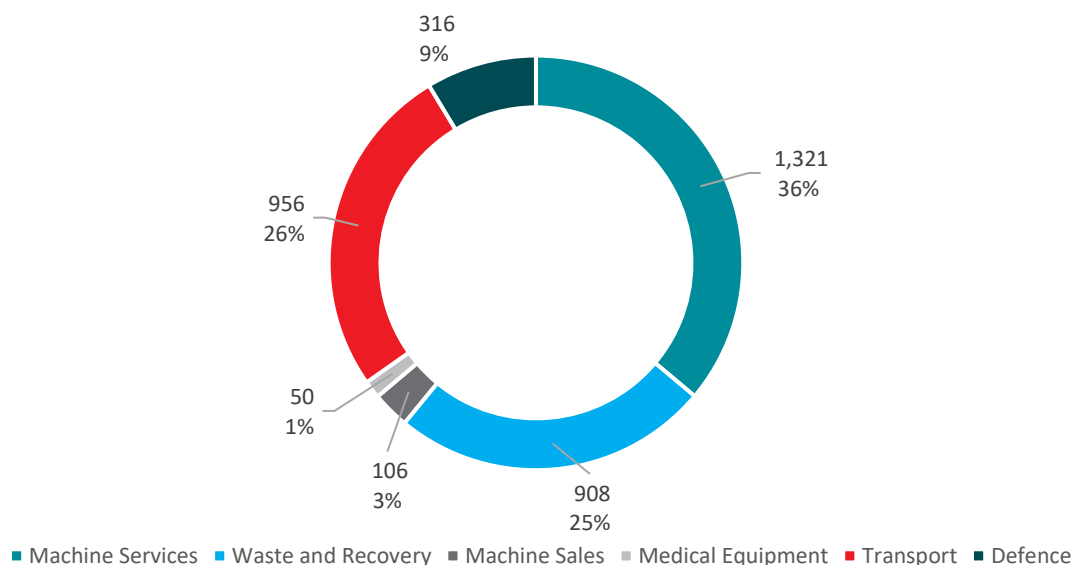


Source: ABS, Cebr analysis

<sup>5</sup> See Table 9 in Appendix II: Full tables for a full breakdown of the contribution to total turnover by Scottish PBIs, disaggregated by all industries.

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', £ millions, 2019



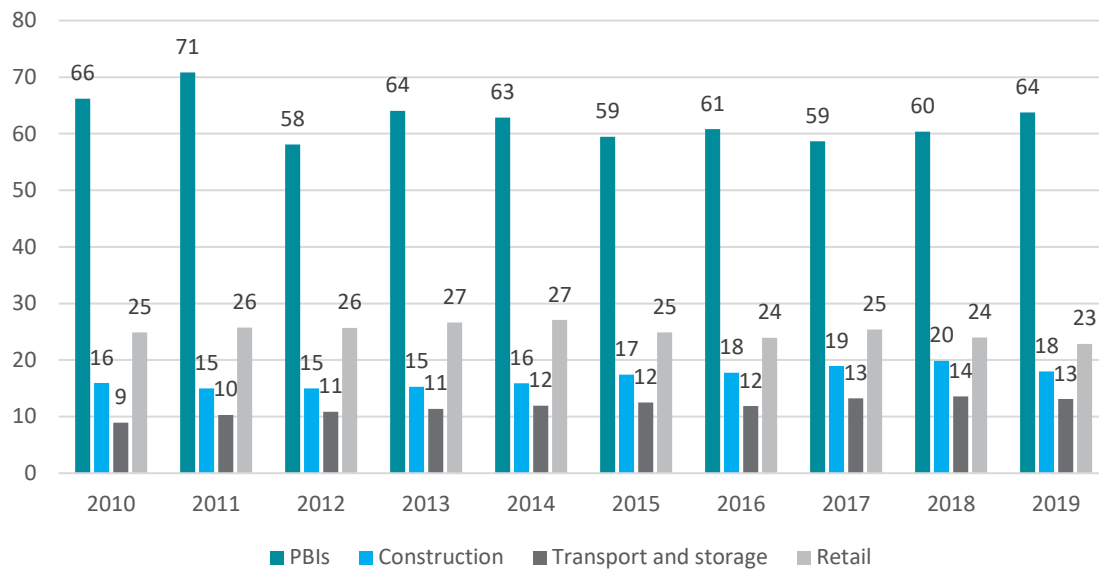
Source: ABS, Cebr analysis

### Industry comparison

In 2019, the Scottish PBI sector generated £64 billion in turnover, compared to \$54 billion in Construction, Transport & Storage, and Retail combined. Figure 5 compares the turnover generated by the Scottish PBI sector with a selection of sectors across 2010 to 2019.<sup>6</sup> This data highlights the importance of PBIs to the Scottish economy, with PBI-generated turnover outstripping the sum of turnover in Construction, Transport & Storage, plus Retail in every year of the sample. The turnover of the PBI sector is much larger than any of the other three sectors shown below: more than triple that of Transport & Storage and Construction in 2019, and double of Retail. However, both the Construction and the Transport sectors had positive growth rates over the decade: 29.1% and 46.4%, respectively. The Retail sector had a loss of 8.1% during this period. In 2019, the Scottish PBI sector generated £64 billion in turnover, compared to £54 billion in Construction, Transport & Storage, and Retail combined.

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

Figure 5: Turnover comparison for selected sectors of the Scottish economy, £ billions, 2010-19



Source: ABS, Cebr analysis

When compared to the UK as a whole, the Scottish PBI sector is a bigger contributor in relative terms to the Scottish economy than these three other sectors, and this is constant during the 2010-2019 period. The ratio of turnover generated in Scotland by PBIs to the sum of the turnover of the three other sectors is 1.17 on average during the period, compared to 0.76 for the UK as a whole. This means that for every £1 these three sectors produce combined, PBIs produce £1.17 in Scotland, compared to £0.76 across the UK.

## 2.2 Business demography

### Business count<sup>7</sup>

In 2019, there were 27,235 PBI enterprises in Scotland, which made up 7.8% of all PBI enterprises in the UK. The share of all PBI business turnover in the UK that was generated in Scotland was 10.1%. This means that on a per PBI enterprise basis, PBI enterprises in Scotland had a disproportionately large impact compared to other UK nations. The PBIs experienced a steady upward trend in terms of the number of enterprises operating between the period of 2010-2017. In 2010, there had been close to 17,000 enterprises counted, which increased to more than 27,000 by 2017. The greatest change was seen in 2015, when the number jumped from around 22,820 to over 26,095 (a 14.4% increase).

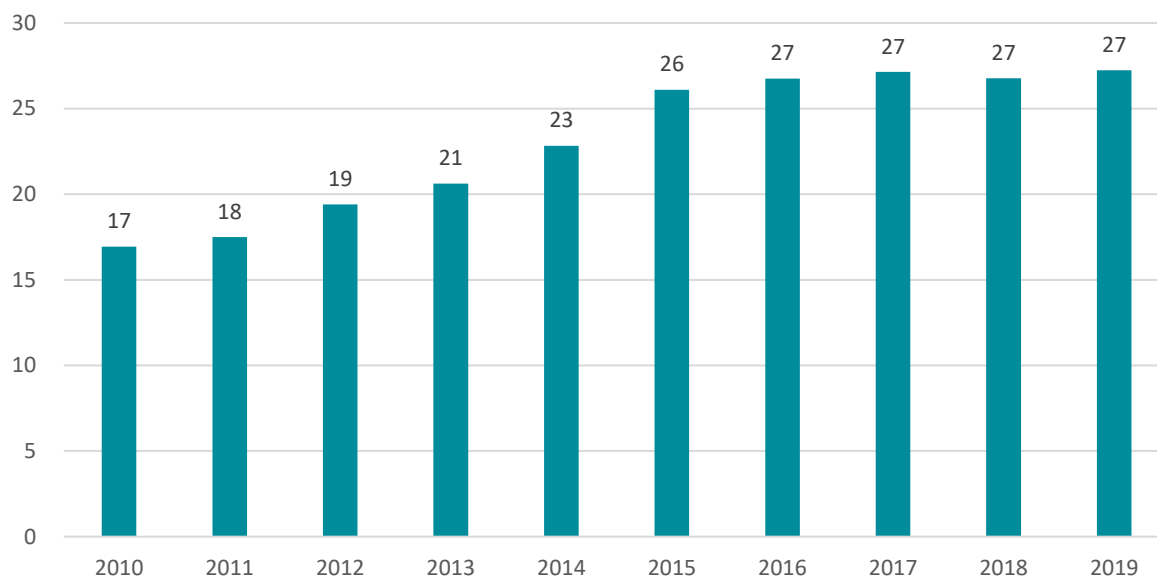
After this steady growth however, the sum of enterprises dropped to 26,770 in 2018 and only increased marginally in 2019, as shown in Figure 6 below. Nonetheless, the overall result of the decade is one of strong growth; the number of enterprises in the PBIs rose by 60.7% over the period, which compares to 22.5% for Scotland as a whole.

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

This growth in business numbers is notable given the lack of growth in business turnover, however this can be explained by the distribution of businesses within the PBIs and their average size.

The share of UK PBI enterprises operating in Scotland was only 7.8% (27,235 out of 350,135) in 2019. Across the other economic impact metrics, Scotland accounted for closer to and above 10%. Therefore, for a smaller number of enterprises in PBIs, Scotland has a disproportionately large impact on a per-firm basis compared to the UK average.

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



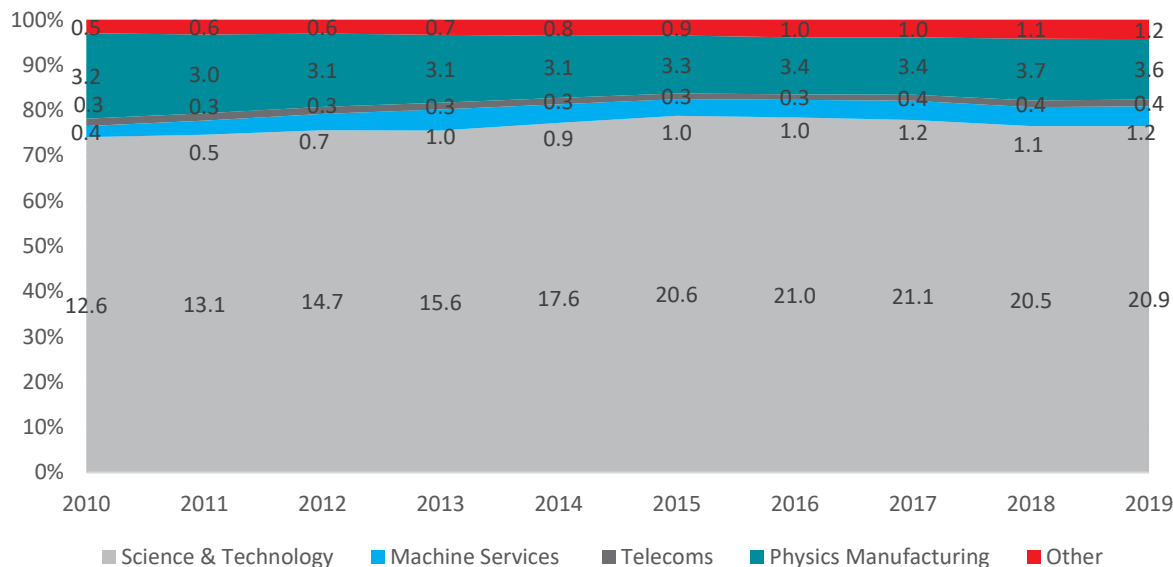
Source: Nomis, Cebr analysis

Figure 7 shows the composition of the number of Scottish PBI enterprises by PBI 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, due to the sub-sector being very micro-oriented compared to the rest of the sub-sectors. On average, this sub-sector contributed 75.8% of all physics-related enterprises (compared to 73.7% for the UK), and this ratio peaked in 2015 with 79.4%. The biggest sub-sector in terms of turnover and GVA, the physics manufacturing sub-sector, had a share of 14.5% in all PBI enterprises.

Notably, despite the high level of turnover generated, the Oil & Gas Extraction sub-sector had very few companies relative to the other sub-sectors; for example, in 2019, there were only 45 companies in Scotland<sup>8</sup>. Thus, declining turnover in the Oil & Gas Extraction sub-sector did not significantly impact the number of PBI enterprises in Scotland. Growth across the other sub-sectors was associated with an increase in enterprise numbers, but as the number of Oil and Gas extraction firms was low across the period, the decline in this sub-sector did not come close to offsetting.

<sup>8</sup> For reference, this is approximately a third of all enterprises in this sub-sector in the UK; England has most of the remaining, with 100. However, these English businesses generate only a third of the total turnover of their Scottish counterparts in the same sub-sector.

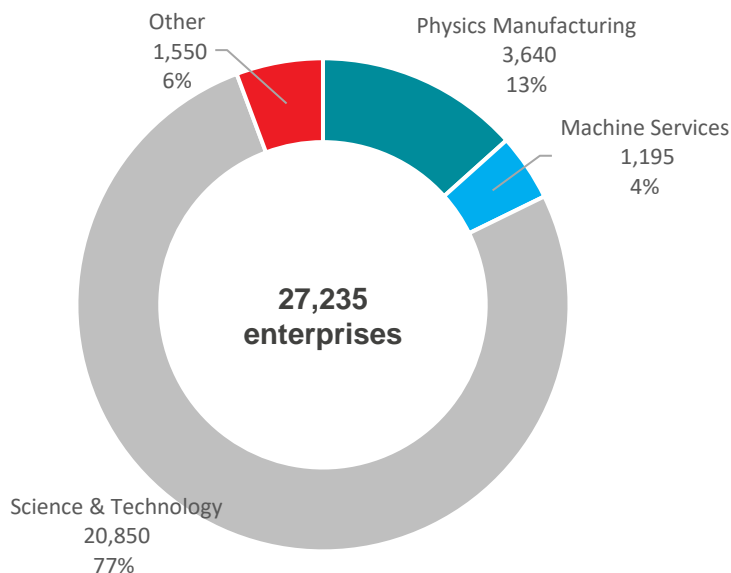
Figure 7: Number of enterprises in the PBIs in Scotland, % of PBI total (LHS axis) and value (thousands), 2010-2019



Source: Nomis, Cebr analysis

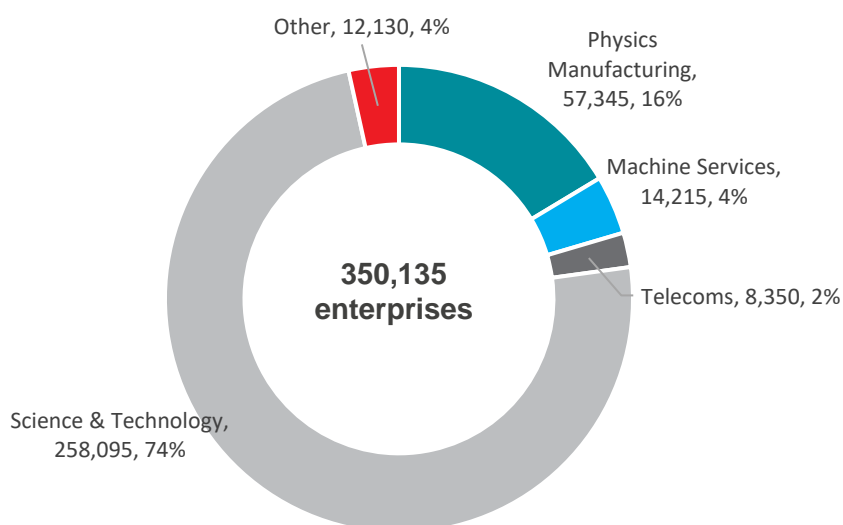
Figure 8 visualises the distribution of enterprises within the PBI by sub-sectors for 2019 in Scotland, while Figure 9 illustrates the division of the sub-sectors for 2019 across the whole of the UK. For both, Physics Science & Technology is the sub-sector with the largest share of enterprises across the decade. In 2019 specifically, this particular industry was slightly more dominant in Scotland compared to the rest of the UK (77% compared to 74%), while the share of Physics Manufacturing enterprises out of all PBI firms in Scotland was lower than in the UK (13% compared to 16%).

Figure 8: Division of enterprises in PBIs in Scotland, 2019



Source: Nomis, Cebr analysis

Figure 9: Division of enterprises across all UK PBIs, 2019



Source: Nomis, Cebr analysis

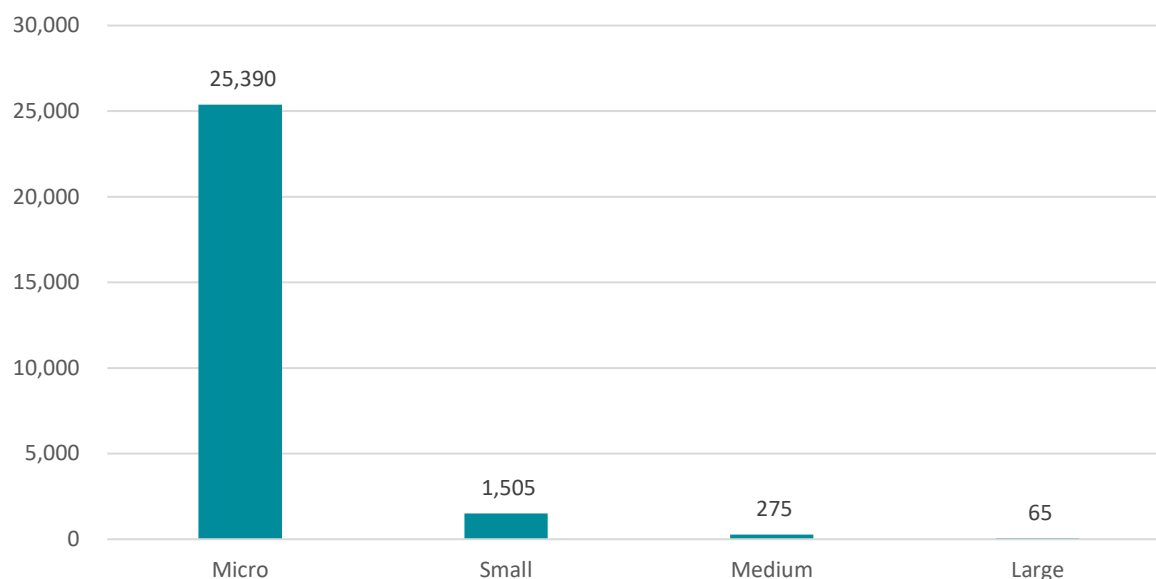
### Size of enterprises

Micro enterprises are considered as enterprises which employ a maximum of nine people. Consistent with wider trends in the economy, the Scottish PBIs were dominated by these micro enterprises in 2019, as 93.2% of all PBIs fell into this category. Of the remainder, 5.5% of enterprises were defined as small (10-49 employees), with the remaining 1.2% medium (50-249 employees) or large (250+). This broadly 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 wider Scottish economy, 88.0% of firms were micro enterprises in 2019, 10.0% small and the remaining 2.0% medium or large.

Figure 10 shows the composition of firms by size in the PBIs in Scotland for 2019.



Figure 10: Number of enterprises in UK PBIs, distinguished between size, 2019



Source: Nomis, Cebr analysis

Table 1 presents division of enterprises in Scotland for selected PBIs, distinguished by size for 2019. The Physics Science & Technology sub-sector had the smallest enterprises proportionally, as 95.6% of all related enterprises are accounted as micro. Supporting this, while we do not have specific data for enterprise age in Scotland, across the UK, Physics Science & Technology firms also tend to be younger than the average for the PBIs. As of 2019, 24.6% of Physics Science & Technology enterprises were less than a year old (compared to 21.2% across the PBIs), while just 13.8% were more than five years old (23.7% across the PBIs). Assuming this trend holds in Scotland, the relatively young average nature of firms in this sub-sector may go some way to explaining the smaller average size.

The Waste & Recovery and Space Transport & Air Transport Services sub-sectors had the smallest number of micro firms proportionally (78%), while Oil & Gas Extraction had the biggest share of large firms (11%). The full results by sub-sector can be seen in Appendix II: [Full tables](#).

Table 1: Division of enterprises in PBIs in Scotland, distinguished between size, 2019<sup>9</sup>

Sub-sector	Micro	Small	Medium	Large
Physics Manufacturing	2,995	845	140	40
Physics Machine Services	1,075	95	15	10
Telecoms	350	35	5	-
Physics Science & Technology	19,925	805	100	20
Other	1,045	85	15	15
<b>Total</b>	<b>25,390</b>	<b>1,505</b>	<b>275</b>	<b>65</b>

Source: Nomis, Cebr analysis

<sup>9</sup> “-” means that the raw data showed zero. The raw data from Nomis used to estimate these, were rounded to the nearest five; this means it is possible that there are one or two enterprises present in the industry.

## 3. Economic Contribution of the PBIs to the Scottish economy

This section provides an assessment of the importance of physics-based industries to Scotland 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 Scottish economy in terms of their GVA contributions to GDP. We present our estimates of the Scottish PBIs' GVA contributions to GDP in Figure 11. The latest data suggests a £28.4 billion GVA contribution in 2019, equivalent to 17% of Scottish GDP - a very strong share relative to the 11% for the UK.

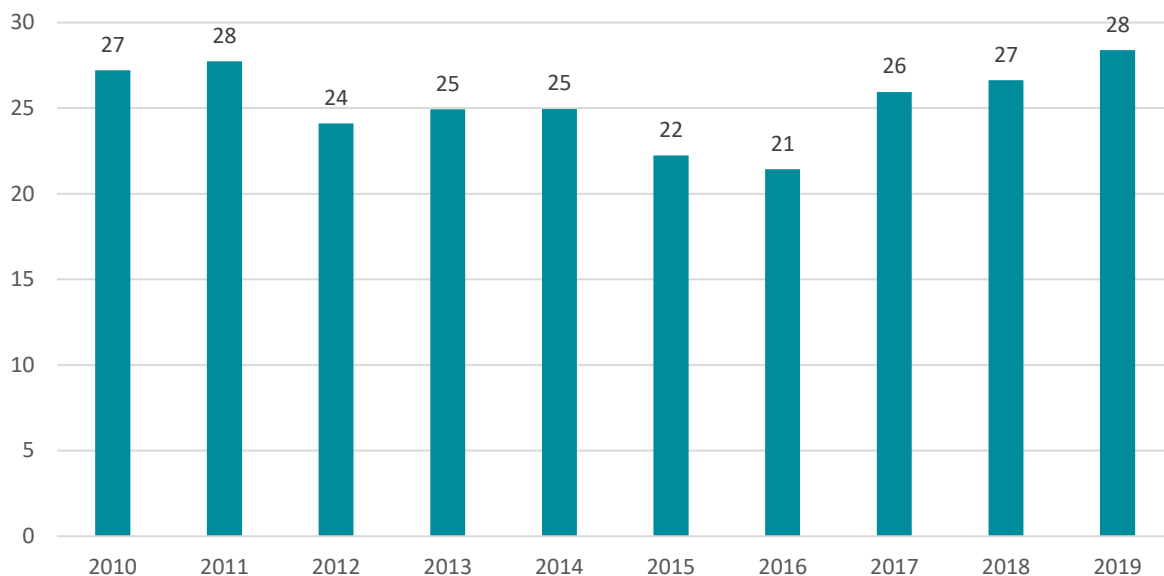
Scotland was also the second biggest contributor to UK GVA by PBIs in 2019, behind England (Scotland was at 12.4%, compared to 82.9% for England, and 3.2% and 1.5% for Wales and Northern Ireland, respectively). However, Scotland's share used to be higher, as in 2010 it was 14.3%, which slowly declined to 10.1% until 2016. Since then, the share has been on an upward trend.

The prominence of Scotland's Oil & Gas Extraction sector within the UK's Oil & Gas Extraction sector, over a decade when annual UK crude oil production has declined by nearly 14 million metric tonnes, or 21.4%<sup>10</sup>, is significant when assessing the economic impact of the PBIs within Scotland. Firstly, the year-on-year trend analysis is often less favourable, driven by declining Oil & Gas Extraction output. However, in absolute terms, the PBIs are arguably more important within Scotland than some other UK nations, as alongside the strong contribution of the non-Oil & Gas Extraction PBI sub-sectors (as with other UK nations), the Oil and Gas Extraction sector remains significant in both size and performance in Scotland. These dual impacts can be seen throughout the report.

Annual nominal growth in Scottish GVA averaged 0.5% between 2010 and 2019 but was strongest in 2017 at 21%. The biggest annual contractions came in 2012, when industry GVA decreased by 13.1% relative to 2011, and in 2015, when GVA decreased by almost 10.9% compared to the year before. The causes of these declines were the significant drops in GVA for the Oil & Gas Extraction sub-sector (£2.5 billion overall fall during the period).

10 Statista. (2021). [Volume of crude oil produced in the United Kingdom \(UK\) from 2010 to 2020](#).

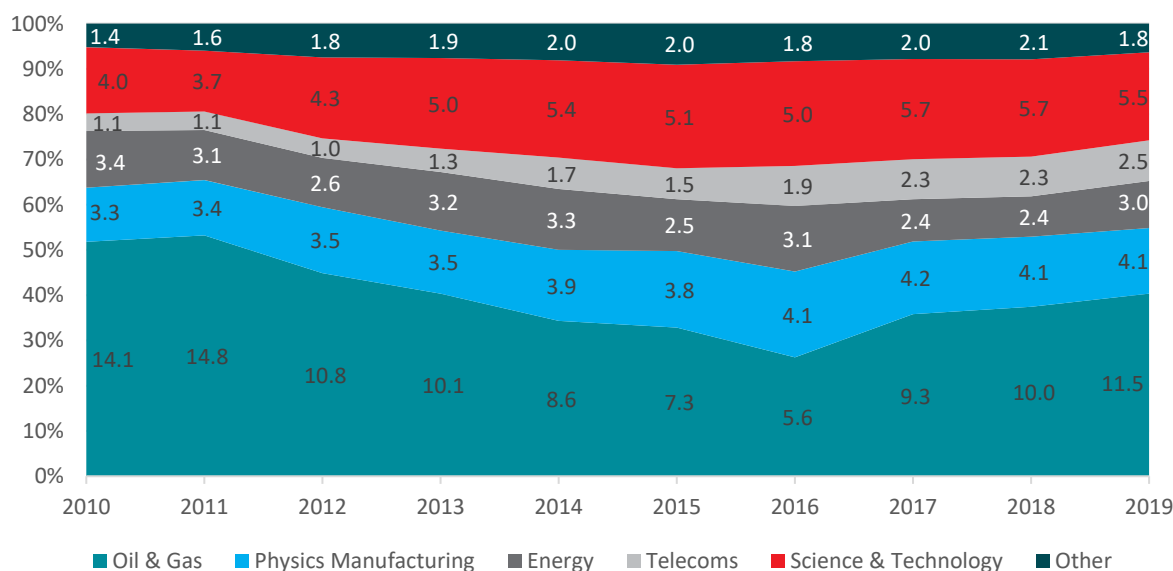
Figure 11: GVA in PBIs, £ billions, 2010-2019



Source: ABS, Cebr analysis

At its peak in 2011, the Oil & Gas Extraction sub-sector contributed over 53.2% of all physics sector GVA, and over the decade this share halved to 26.3% in 2016 before going back up to 40.4% in 2019. On average, the Oil & Gas Extraction sub-sector accounted for almost 40% of all GVA by PBIs in Scotland during this period. The decline in this sub-sector’s output around 2016 could be associated with the oil price plunge of 2014-2016, a shock which affected the global economy and was one of the largest oil price plunges since World War II. The next largest contributor was the Physics Science & Technology sub-sector, which accounted for around 19.5% on average, closely followed by the Physics Manufacturing sub-sector, at 14.9%.

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



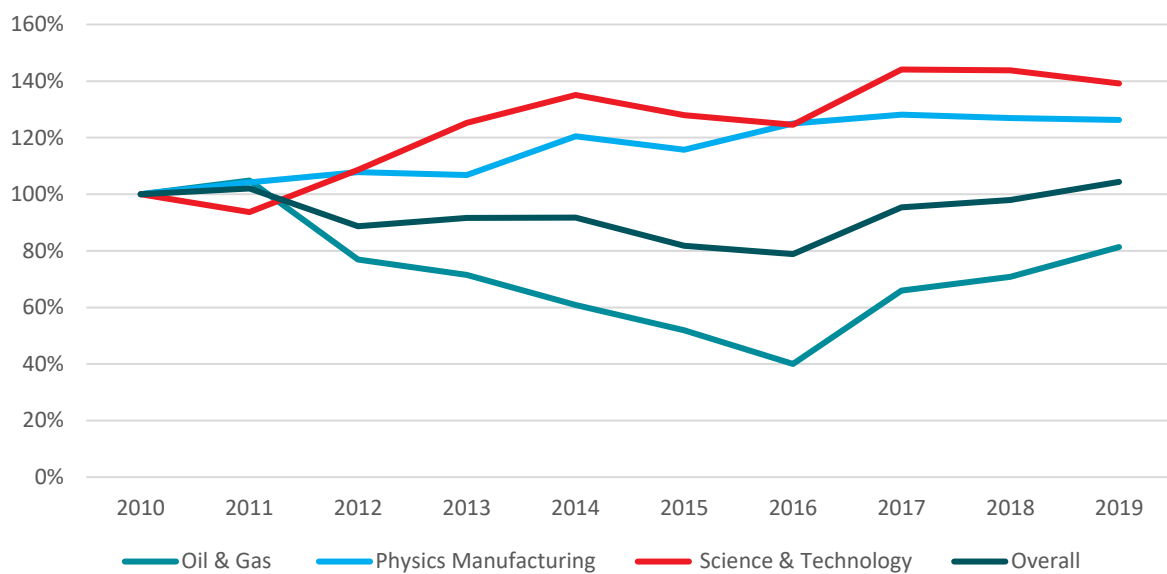
Source: ABS, Cebr analysis

Annual growth in GVA in the PBIs in Scotland was just 0.5%, significantly lower than the average of 2.1% across the UK. However as with the significantly higher share of GVA in Scotland attributable to the PBIs (compared to the UK), this can be explained by the

prominence of the Oil and Gas Extraction sector in Scotland. Figure 13 and Figure 14 below, show the relative change in GVA over the decade in the Oil & Gas Extraction sub-sector; growth in the two other largest sub-sectors (Physics Manufacturing and Science & Technology); and average growth across the PBIs, for Scotland and the UK respectively.

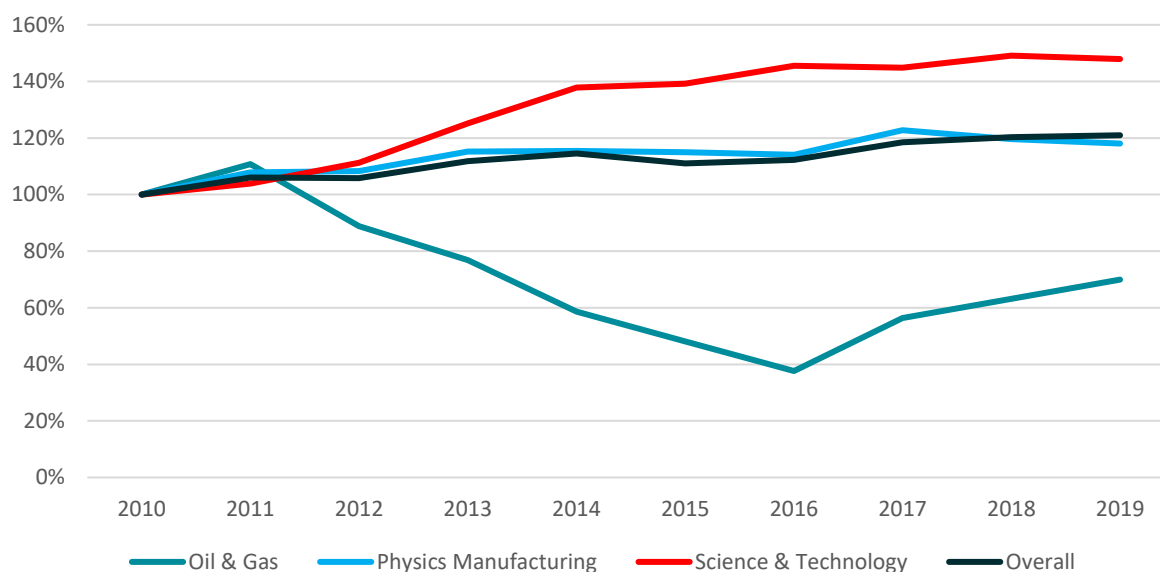
In both the UK and Scotland, GVA in the Oil & Gas Extraction sub-sector decreased (70% and 81% of the 2010 value respectively). However, in the two largest other sub-sectors, Physics Manufacturing grew by 18% and 26% in the UK and Scotland respectively, while Physics Science & Technology grew by 48% and 39%. As can be seen Figure 13 and Figure 14, the growth trends across the UK and Scotland by sub-sector over the decade are relatively similar. It is however the distribution of sub-sectors, with the decline of Oil & Gas Extraction more prominent relatively in Scotland, that drives the lower average growth across the PBIs (just 4% over the period) than in the UK as a whole (21%).

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



Source: ABS, Cebr analysis

Figure 14: GVA in selected PBIs in the UK, % of 2010 value, 2010-2019



Source: ABS, Cebr analysis

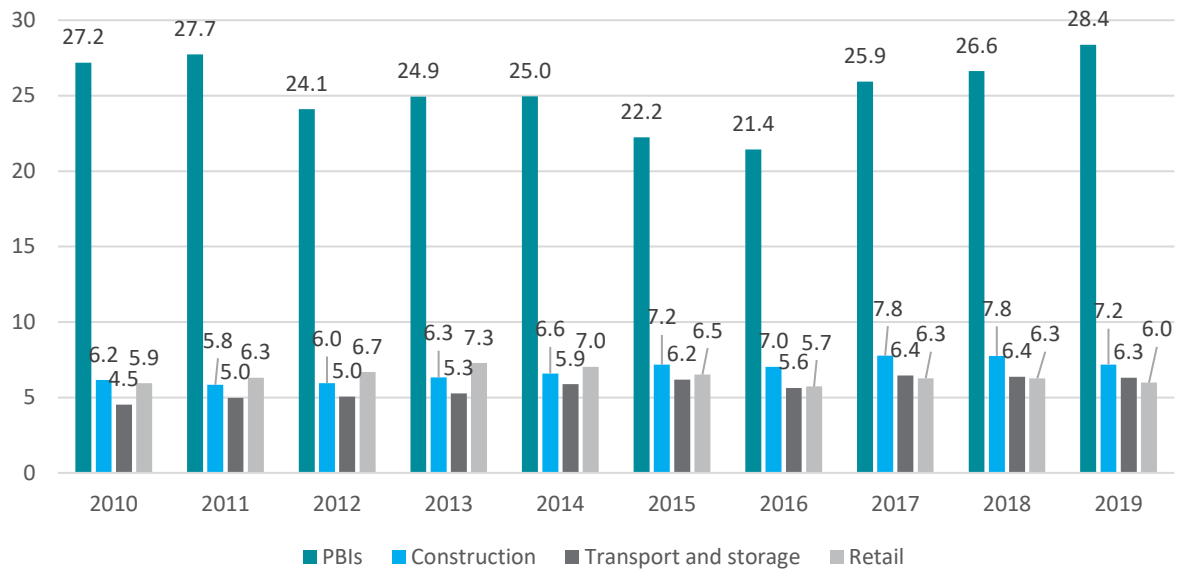
Much like the rest of the UK, comparing the Physics Manufacturing and Physics Science & Technology sub-sectors shows us that the Physics Science & Technology sub-sector, in relative terms, performs much better in terms of GVA than turnover. The Physics Science & Technology sub-sector generates more direct GVA per pound of turnover than the Physics Manufacturing sub-sector (£0.48 and £0.36 in 2019, respectively). The sub-sector with the highest GVA contribution per pound of turnover is Oil & Gas Extraction, at £0.64.

### Industry comparison

The GVA contributions of the entire physics sector is compared with the same three other sectors in Figure 15 below. On this measure, the gap is even wider between the PBI sector and the other sectors: the PBIs directly generate 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 £0.41 between 2010 and 2019 for PBIs. This was higher than in Retail (£0.25), and very slightly higher than in Construction (£0.40), but less than the Transport & Storage sector, which averaged £0.44 across the period.

Figure 15 : GVA in selected sectors in Scotland, £ billions, 2010-19



Source: ABS, Cebr analysis

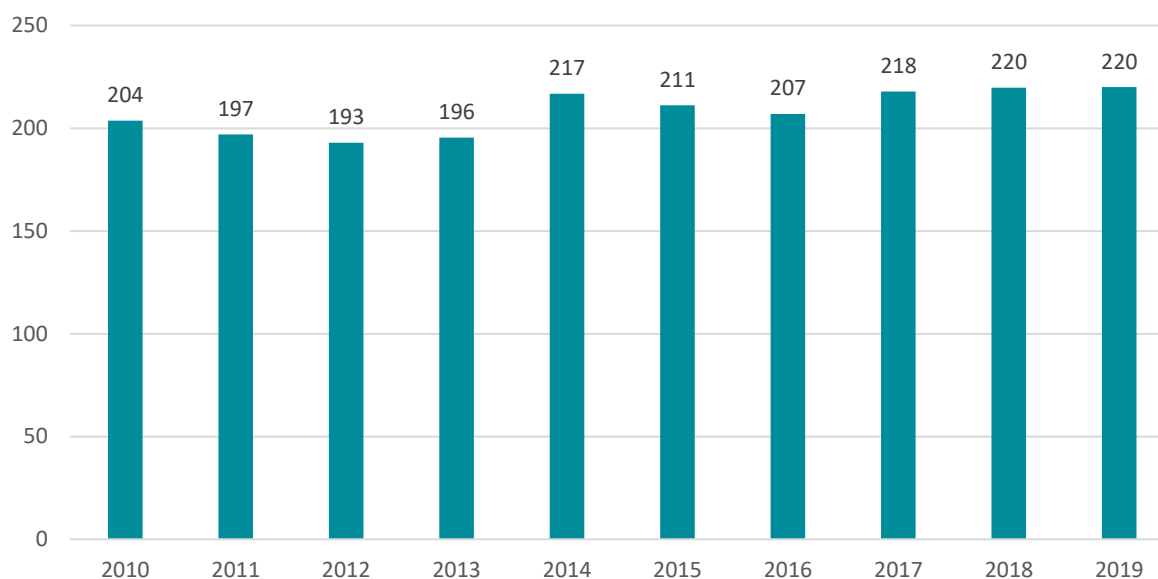
### 3.2 Employment

Employment in the PBIs in Scotland topped more than 220,000 workers in 2019, equivalent to 9.8% of all Scottish FTE employment. Employment growth averaged 1% annually between 2010 and 2019, but was strongest in 2014 at 10.9%. Broadly, the employment trends are more stable than observed for turnover or GVA.

Compared to the rest of the UK and the other home nations, the PBIs in Scotland accounted for the same share of national FTE employment (9.8%) as in Wales (9.8%), and represent a broadly equal share relative to the UK total (10.0%). However, employment in PBIs accounted for a lower share of total employment in Scotland than in England (albeit marginally, 10.1%) but a higher share than in Northern Ireland (6.8%). This is notable given the importance in GVA terms of the PBIs in Scotland, suggesting also the sector has very high productivity (driven again by the Oil & Gas Extraction sub-sector's high productivity).

Just as we have seen with turnover and GVA, Scotland's share of UK PBI employment also decreased, from 8.5% in 2010 to 8.1% in 2019. While in the UK the growth of FTE was 13.2%, Scotland falls slightly below this at 8.1%.

Figure 16: Physics-based employment in Scotland, FTEs, thousands, 2010-19



Source: BRES, Cebr analysis

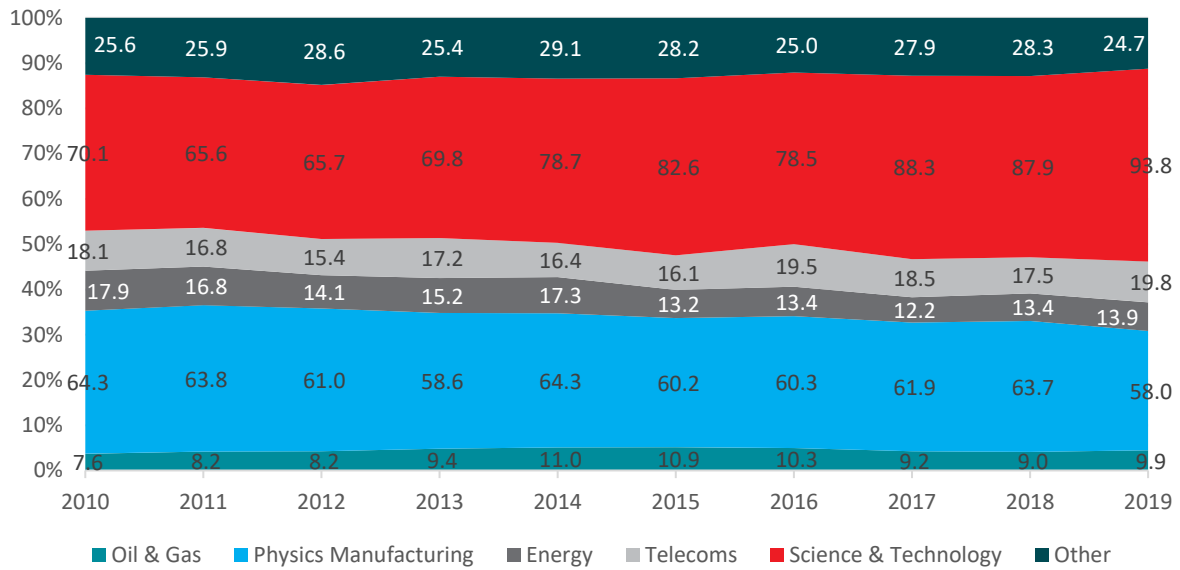
Large shares of employment in the PBIs are accounted for by the Physics Manufacturing and Physics Science & Technology sub-sectors (26.3% and 42.6% recorded in 2019, respectively). However, while the number of people employed by the Physics Science & Technology sub-sector grew substantially (by 33.8% over the ten-year period), employment in Physics Manufacturing actually decreased by almost 10% during the same period. In the former, this was caused mostly by SIC 82.99 (Other business support service activities nec.<sup>11</sup>), which almost doubled its FTE value from 8,400 to 16,600 (96.9%). In the Physics Manufacturing sub-sector, the fall was consistent across all industries, but three of the biggest industries can be highlighted especially: machining (SIC 25.62), the biggest in terms of employment, decreased from 7,800 to 6,800 (-13.0%); manufacture of metal structures and parts of structures (SIC 25.11), from 5,900 to 4,400 (-25.8%); and printing (other than printing of newspapers and printing on labels and tags) (SIC 18.129), from 5,800 to 2,800 (51.1%).

It is clear that the employment growth seen across the PBIs in Scotland is heavily dependent on the Physics Science & Technology industry, while the Oil & Gas Extraction sub-sector, the biggest in terms of turnover and GVA, provided only 4.5% of all FTE employees in 2019.

Energy Production, Transmission & Distribution (at 6.3%, on average) and Telecommunication (at 9%, on average) are the other broad sub-sectors of note contributing significant shares of employment within the PBIs in Scotland.

<sup>11</sup> 'Nec' means not elsewhere classified.

Figure 17: Employment in selected PBIs in Scotland, % of PBI total (LHS axis) and value (thousands), 2010-2019

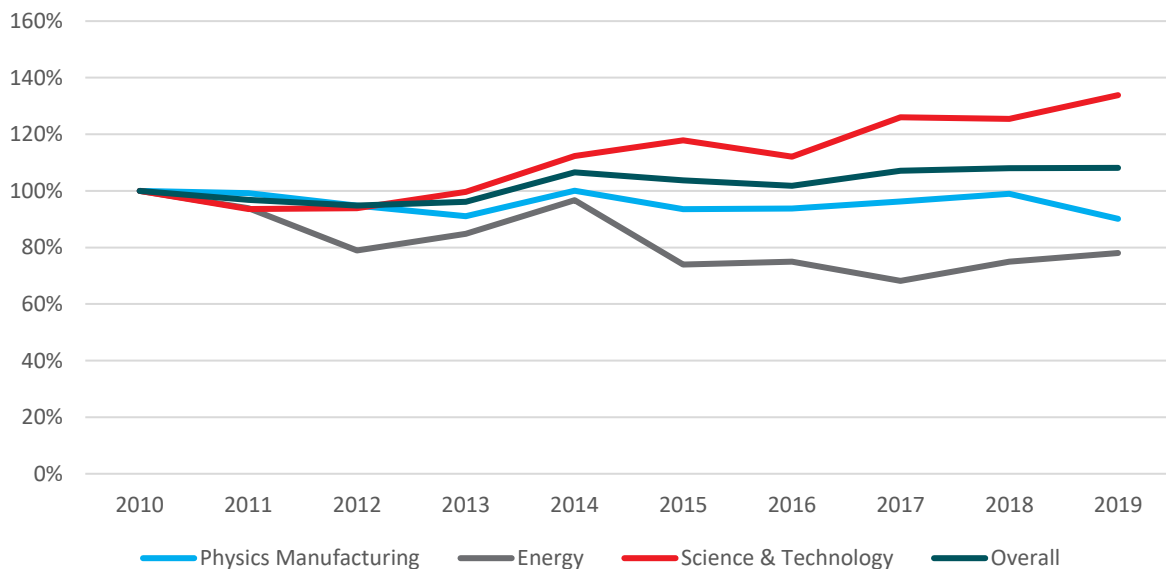


Source: BRES, Cebr analysis

It is further notable that while the Oil & Gas Extraction sub-sector’s GVA declined significantly (by £2.6 billion, or nearly 20%), the employment share within the PBIs was relatively stable and the level of employment actually increased slightly (by over 2,000 FTE workers).

Figure 18 further demonstrates the trend observed above: the growth rate in the Physics Science & Technology sub-sector significantly exceeds that of the overall PBI average and has been a key driver in the physics sector’s FTE growth over the last decade in Scotland.

Figure 18: FTEs in selected PBIs in Scotland, % of 2010 value, 2010-2019



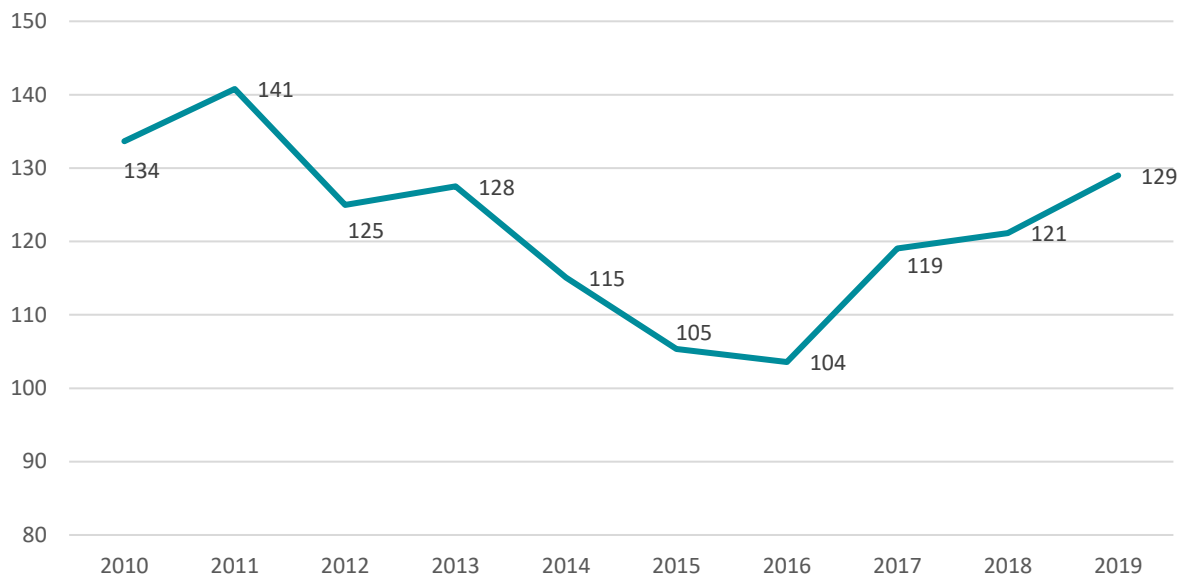
Source: ABS, Cebr analysis



## 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 Scottish PBIs, Figure 19 shows the evolution of this metric over the period. It had a steep decline until 2016, but after that it started to recover. Over the whole 2010 to 2019 period, labour productivity decreased by 3.5% from £134,000 to £129,000. There was a local peak in 2011, at £141,000 of output per worker.

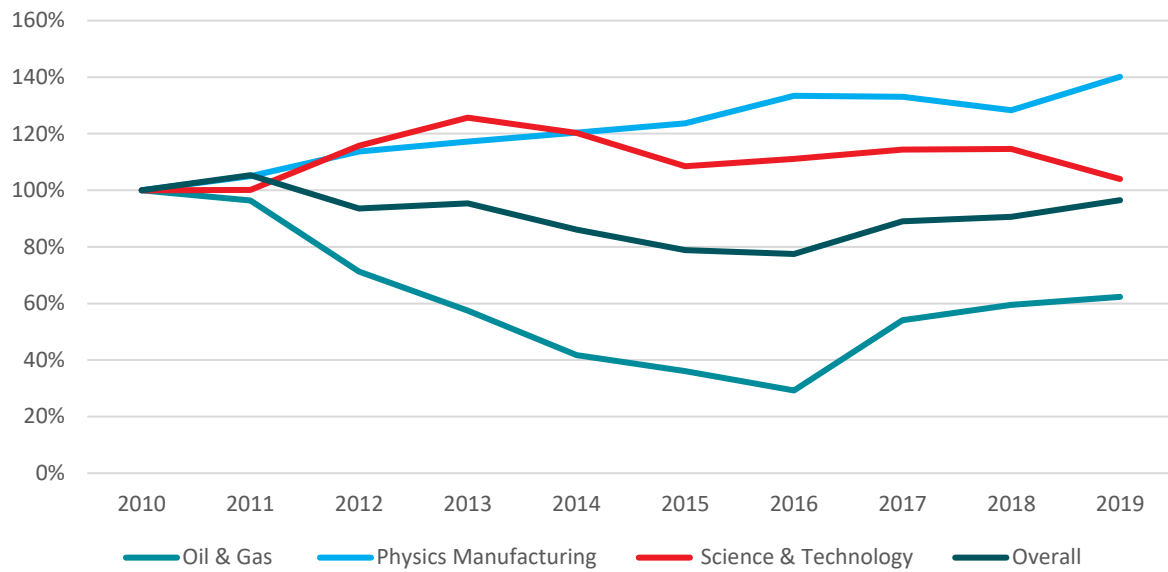
Figure 19: Overall labour productivity for PBIs in Scotland, £ thousands, 2010-2019



Source: ABS, BRES, Cebr analysis

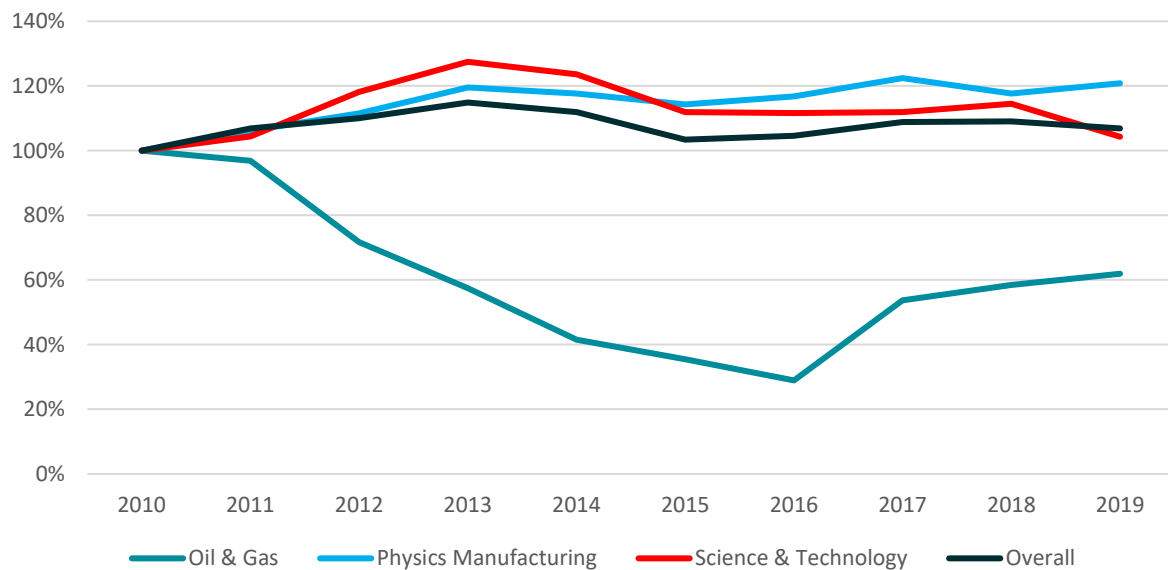
Figure 20 and Figure 21 show the growth of labour productivity in selected sub-sectors and the PBI sector overall for Scotland and the UK, respectively. This shows that the reason for the fall in Scottish productivity is due to the heavy dependency on the Oil & Gas Extraction sub-sector, which also declined in the UK, but is not relatively as influential across the nation. The Physics Science & Technology sub-sector had a similar trend when compared to the UK, whereas the labour productivity in the Physics Manufacturing sub-sector increased almost twice as much in Scotland as in the UK.

Figure 20: Labour productivity in selected PBIs in Scotland, % of 2010 value, 2010-2019



Source: ABS, BRES, Cebr analysis

Figure 21: Labour productivity in selected PBIs in the UK, % of 2010 value, 2010-2019



Source: ABS, BRES, Cebr analysis

Scotland had the highest GVA per worker (at £128,992), compared to England's £81,342, Wales's £64,828, and Northern Ireland's £72,266 – as discussed throughout this report, this is due to the relative strength of Scotland's Oil & Gas Extraction industry. If we exclude the economic activity from the Oil & Gas industry from our labour productivity calculations and simply focus on all other PBIs, labour productivity in the Scottish physics sector is £80,547 in 2019, virtually the same as seen in England. In fact, the Oil & Gas Extraction sub-sector's shares are so strong, its labour productivity was multiple that of other sub-sectors.

Table 2 presents a comparison between the share of total FTE employment in Scottish PBIs for each PBI, and the share of the total GVA that is contributed by the respective sub-sector. In 2019, we find that these shares were broadly disproportional, with the exception of some smaller sub-sectors. For the Physics Science & Technology sub-sector, its employment share

was more pronounced than its GVA contribution, while in the Oil & Gas Extraction and Energy Production, Transmission & Distribution sub-sectors, their contributions to the total GVA generated by Scottish PBLs were greater than their respective shares of FTE employment. This suggests that labour productivity is higher in these sub-sectors than in the Physics Science & Technology sub-sector. In fact, the Oil & Gas Extraction sub-sector's shares are so strong, its labour productivity was multiple that of other sub-sectors.

Table 2: Comparison between the shares of GVA and FTE employment by Scottish PBLs, 2019

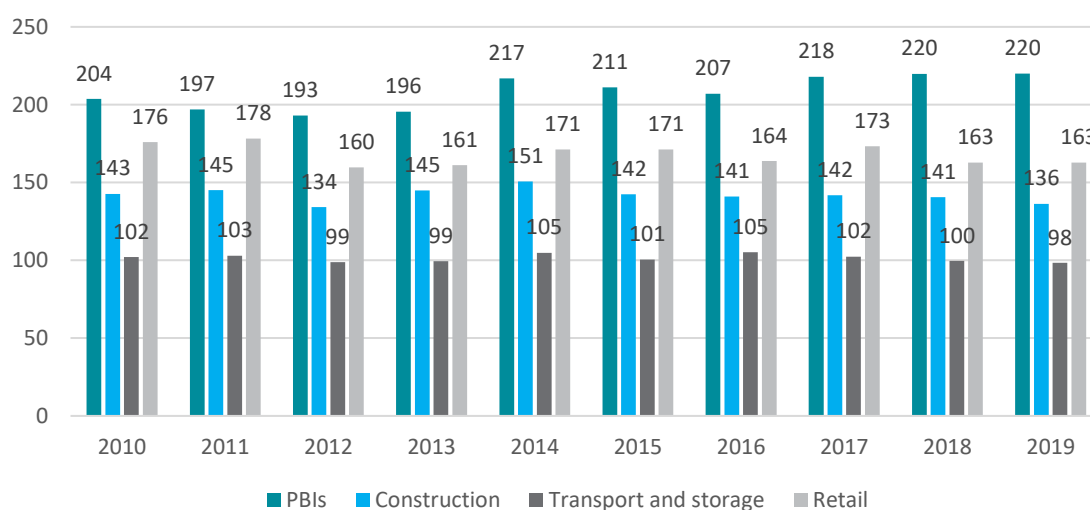
Sub-sector	Share of 2019 GVA	Share of 2019 Employment
Oil & Gas Extraction	40.4%	4.5%
Physics Manufacturing	14.5%	26.3%
Physics Machine Services	2.0%	4.5%
Energy Production, Transmission & Distribution	10.4%	6.3%
Physics Waste & Recovery	0.9%	1.9%
Physics Machine Sales	0.2%	0.3%
Medical Equipment Sales	0.1%	0.3%
Space Transport & Air Transport Services	2.4%	2.6%
Telecoms	9.0%	9.0%
Physics Science & Technology	19.5%	42.6%
Defence	0.6%	1.7%

Source: ABS, BRES, Cebr analysis

## Industry comparison

Compared to the same three sectors in Scotland, Construction, Transport & Storage, and Retail, the Scottish PBL sector contributed the greatest share of employment, as seen in Figure 22. However, this trend is not as pronounced as when considering turnover and GVA - suggesting the labour productivity advantage of the PBL sector over the comparator sectors. For a similar share of Scottish employment, the PBLs generated a greater GVA contribution.

Figure 22: Employment in selected sectors in Scotland, thousands, 2010-2019

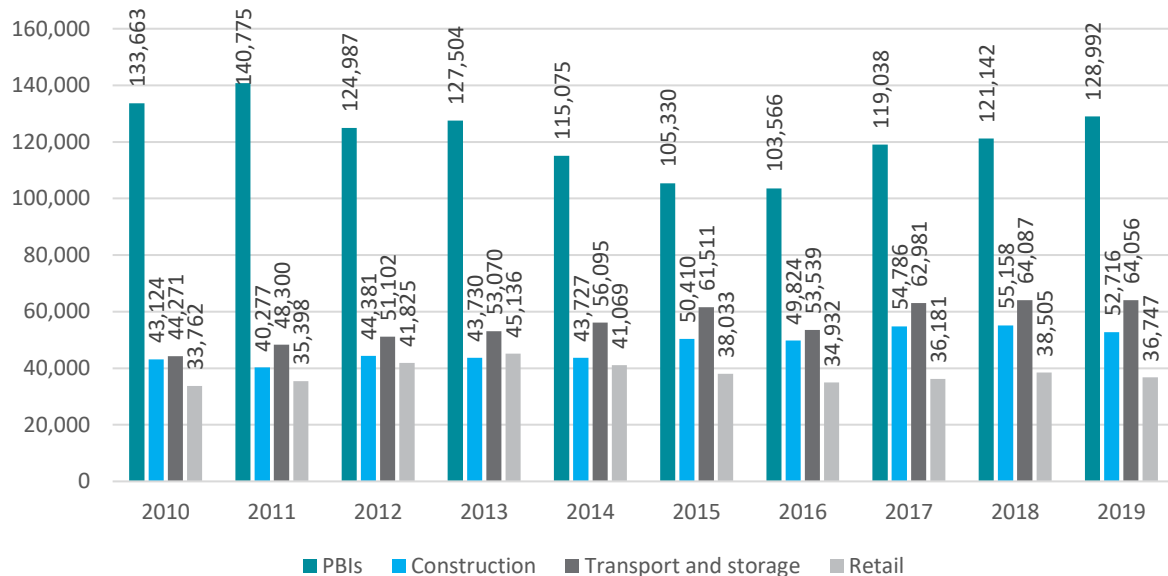


Source: BRES, Cebr analysis

Figure 23 considers this labour productivity further, comparing the GVA per worker in the selected Scottish sectors. The PBL sector in Scotland had a significant lead in this category compared to other sectors in Scotland. However, while for PBLs the GVA-FTE ratio fluctuates

– driven by the Oil & Gas Extraction sub-sector – both the Construction and the Transport & Storage sectors grew steadily over the period.

Figure 23: Labour productivity in selected sectors in Scotland, thousands, 2010-2019

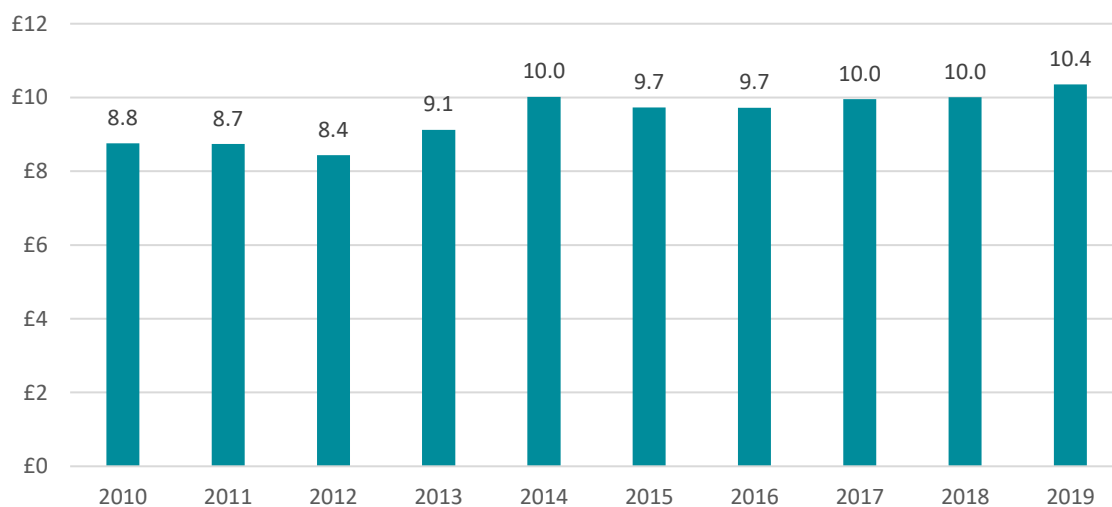


Source: ABS, BRES, Cebr analysis

### 3.3 Compensation of employees (COE)

Employee compensation in PBIs across Scotland saw an overall growth of 18.3% over the period, from £8.8 billion to £10.4 billion. This is a higher growth rate compared to the growth in employment (8%), meaning that average compensation per employee increased over the years. Specifically, the average COE/FTE increased from £43,000 to £47,000 (9.4%) in the PBIs. Both values are above the UK level which increased from £36,000 to £42,000 throughout the period, however, this is a bigger relative change (16.1%). This COE value meant a 9.1% share of the total UK COE for PBIs, which is a 1 percentage point decline compared to 2010.

Figure 24: Physics-based COE in Scotland, £ billions, 2010-19

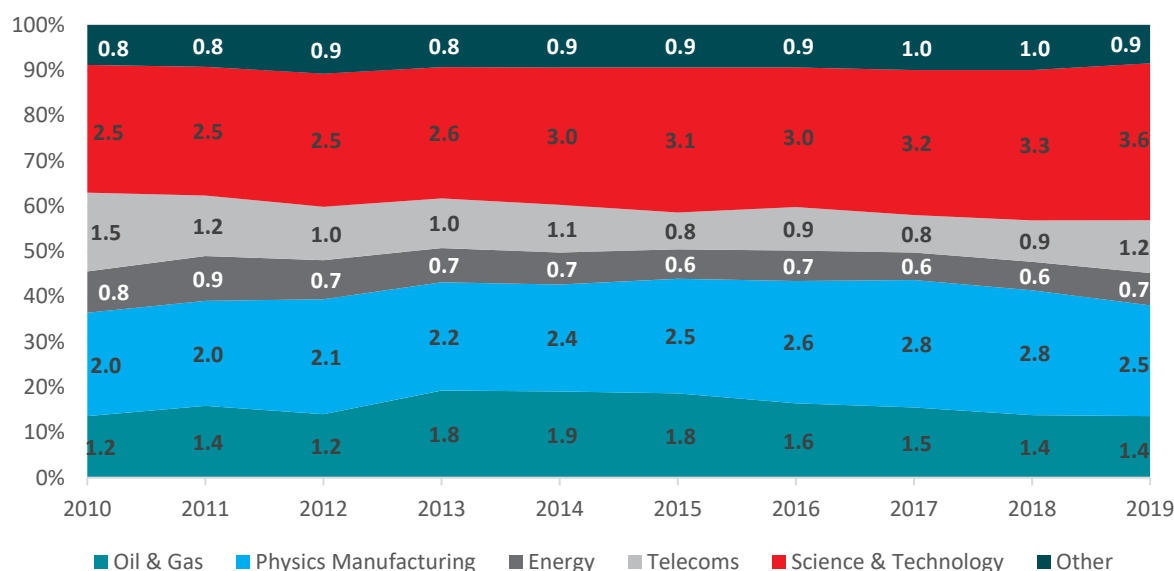


Source: ABS, Cebr analysis

The Physics Science & Technology sub-sector was the largest contributor, with 30.9% of all PBI employee compensation on average. The Physics Manufacturing sub-sector was the

second largest contributor, with an average of 25.2%. The third largest was Oil & Gas Extraction, with a 16% share of the total compensation of employees on average.

Figure 25: COE in selected PBIs in Scotland, % of PBI total (LHS axis) and monetary value (£ billions), 2010-19



Source: ABS, Cebr analysis

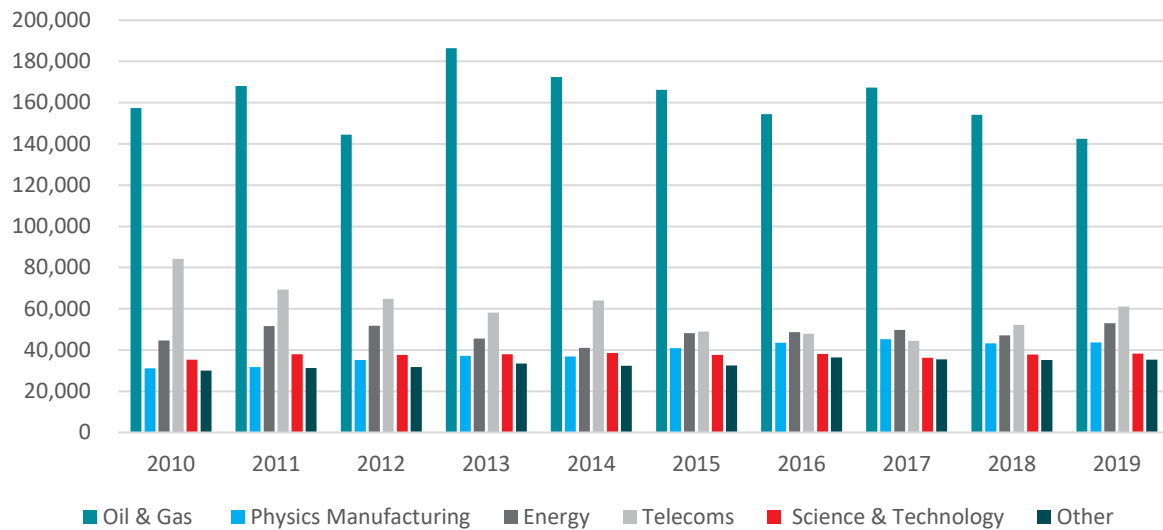
Table 3: Comparison between the shares of COE and FTE employment by Scottish PBIs, 2019

Sub-sector	Share of 2019 COE	Share of 2019 employment
Oil & Gas Extraction	13.6%	4.5%
Physics Manufacturing	24.5%	26.3%
Physics Machine Services	2.4%	4.5%
Energy production, Transmission & Distribution	7.1%	6.3%
Physics Waste & Recovery	1.6%	1.9%
Physics Machine Sales	0.2%	0.3%
Medical Equipment Sales	0.1%	0.3%
Space Transport & Air Transport Services	2.9%	2.6%
Telecoms	11.7%	9.0%
Physics Science & Technology	34.7%	42.6%
Defence	1.2%	1.7%

Source: ABS, BRES, Cebr analysis

Compensation per FTE increased overall across all PBIs in Scotland, except the Oil & Gas Extraction and Telecoms sub-sectors. Figure 26 below shows the COE across the different PBIs in Scotland, and the Oil & Gas Extraction sub-sector boasts a significantly higher COE than all the other sectors. This is followed by the Telecoms sub-sector. But, as mentioned above, both of these sub-sectors saw decreases in the average compensation per employee during the ten-year period. However, despite this, overall COE in Scottish PBIs increased by 9.4% over the period.

Figure 26: Average COE per FTE worker in selected PBI sub-sectors in Scotland, 2010-2019<sup>12</sup>

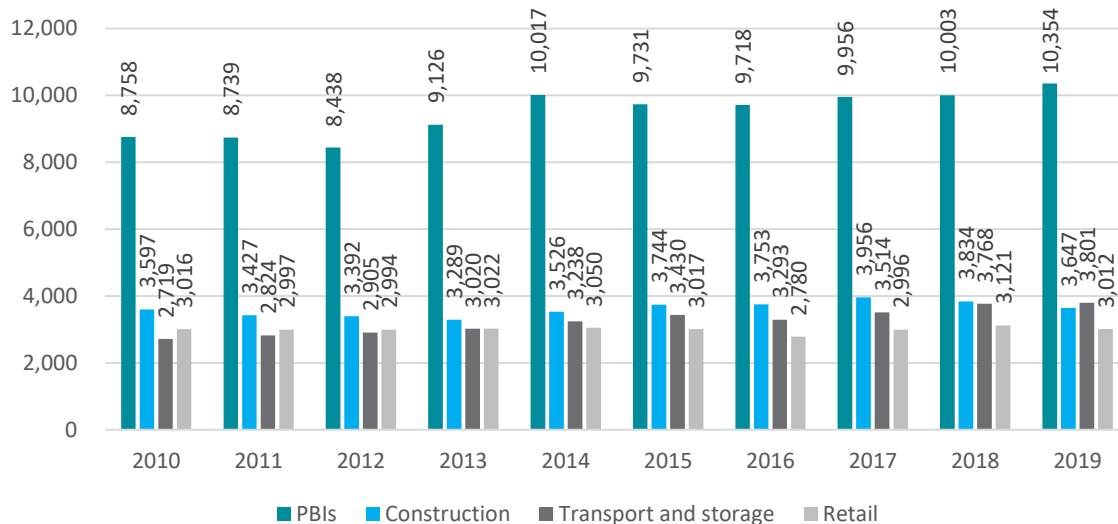


Source: ABS, BRES, Cebr analysis

### Industry comparison

Figure 27 shows the COE of the comparator sectors. Unsurprisingly, the trend is very similar to that seen for GVA. However, while GVA fluctuated greatly during this period, COE stayed relatively stable. This suggests that the volatility seen in GVA by the PBI sector in Scotland was driven by the industries' profits, rather than by COE.

Figure 27: COE in selected sectors in Scotland, 2010-19, £ millions

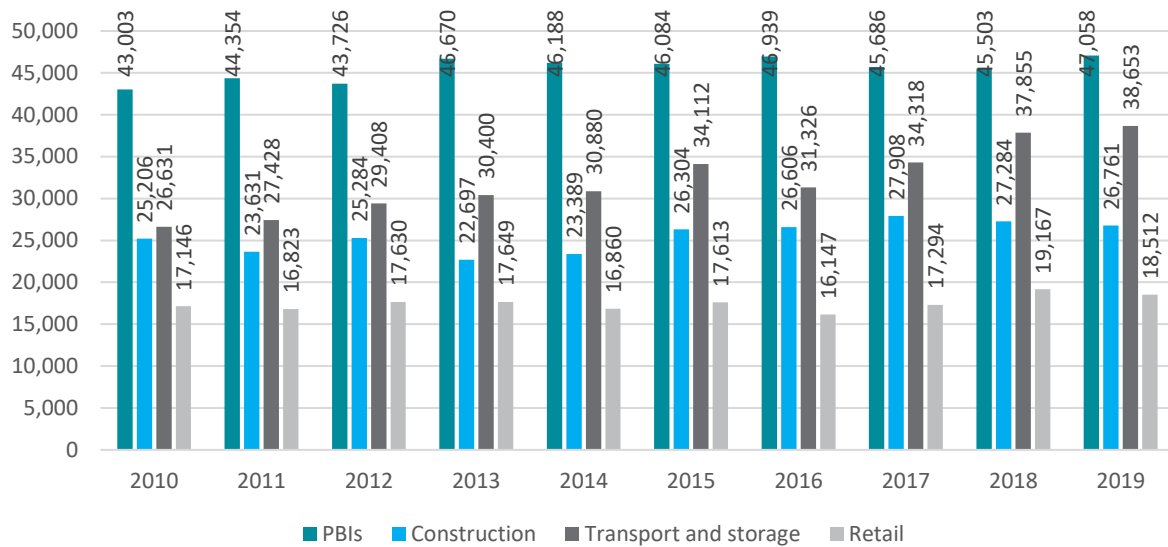


Source: ABS, Cebr analysis

<sup>12</sup> There is some variation in average COE in other labour force surveys for the Oil & Gas Extraction sector. While the trend is consistently of high employee compensation, not all report average COE as high as found here, through assessment of BRES and ABS data.

As with the labour productivity figures (measured as GVA per worker), the PBI sector topped average compensation per employee as well, with slightly more than £47,000 in 2019. However, during this period the compensation per employee in the Transport & Storage sector grew at a much higher rate than for PBIs (45.1%, compared to 9.4%), and in 2019, was much closer to reaching the same level of average compensation per employee.

Figure 28: Average COE in selected sectors in Scotland, 2010-2019



Source: ABS, BRES, Cebr analysis

## 4. National comparisons

This section provides an assessment of the importance of PBIs in Scotland compared to the other UK nations in terms of turnover, GVA, employment, COE, and business demographics over the period 2010-2019.

### 4.1 Turnover

Table 4 provides a national breakdown of the PBIs' turnover on a yearly basis. Scotland observed a slight downward trend, decreasing its contribution of UK turnover to 10.1% in 2019 (£63.8 billion out of £633.7 billion) from 12.9% in 2010 (£65.9 billion out of £510.6 billion). However, out of the four UK nations across the period, Scotland was the second largest contributor to UK PBI turnover, and in 2019, turnover per firm was the strongest in the UK, averaging £2.34 million per firm (compared to a UK average of £1.81 million).

As mentioned in Section 2.1, the Oil & Gas Extraction sub-sector played a significant part in Scotland's PBI trends, contributing an average of 30% of the total annual PBI turnover across the period. While the sector generated 3.3% less turnover in 2019 compared to 2010 levels, since 2016, Scottish PBI turnover has been increasing at an average of 1.8% year-on-year, with the 2017 dip recovering swiftly in 2018.

Table 4. 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
<b>Scotland</b>	<b>65.9</b>	<b>70.8</b>	<b>58.1</b>	<b>64.0</b>	<b>62.8</b>	<b>59.5</b>	<b>60.8</b>	<b>58.4</b>	<b>60.4</b>	<b>63.8</b>
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

We now focus on the economic contribution of the PBIs to the UK national economies, in terms of their GVA contributions to GDP. Comparing to the turnover, a similar pattern emerges, in that England contributed the majority of GVA every year, while PBIs in Scotland were the next largest contributors, averaging 12.0% of the UK total between 2010 and 2019.

Comparably to trends in turnover, GVA generated in Scottish PBIs has been on an upward trend since 2016, with a strong average annual growth rate of 6.3% from 2016 to 2019, whilst declining across the first half of the period by just over a fifth in this instance.

Table 5: 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
<b>Scotland</b>	<b>27.2</b>	<b>27.7</b>	<b>24.1</b>	<b>24.9</b>	<b>25.0</b>	<b>22.2</b>	<b>21.4</b>	<b>25.9</b>	<b>26.6</b>	<b>28.4</b>
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

Scotland's share of UK PBI employment was 8.1% in 2019 (220,000 out of 2.7 million), which is a slight decline from its 2010 value of 8.5% (203,500 out of 2.4 million). By 2019, all four nations increased from their 2010 employment levels. Relative to the UK average increase of 13.2%, Scotland falls slightly below this at 8.1%.

With regards to the share of total Scottish FTE employment in PBIs, Scotland falls less than 0.2% below the UK average, with a 9.8% share from 2.2 million versus the UK's share of 10% from 27.2 million. Unlike Wales or Northern Ireland, Scotland peaked at the end of the period regarding the maximum number of FTE jobs in PBIs across 2010-2019.

Table 6: Employment in UK PBIs, distinguished between nations, 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
<b>Scotland</b>	<b>203</b>	<b>197</b>	<b>193</b>	<b>196</b>	<b>217</b>	<b>211</b>	<b>207</b>	<b>218</b>	<b>220</b>	<b>220</b>
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

### 4.4 COE

Scotland contributed 9.1% of the total COE for PBIs in the UK in 2019 (£10.4 billion out of £114.3 billion), 1% less than in 2010 (8.8 billion out of £87 billion). As identified in Section 3.3, total COE across Scottish PBIs was £10.4 billion in 2019, which is an 18.3% increase compared to 2010 levels. 2014 displayed the largest single year increase in Scottish PBI COE, growing by £891 million (or 9.8%) from 2013, and outperforming the 3.3% average rise across the UK in the same year.

Table 7: 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
<b>Scotland</b>	<b>8.8</b>	<b>8.7</b>	<b>8.4</b>	<b>9.1</b>	<b>10.0</b>	<b>9.7</b>	<b>9.7</b>	<b>10.0</b>	<b>10.0</b>	<b>10.4</b>
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 terms of the number of enterprises operating in Scottish PBIs, the national disaggregation can be found below. The share of UK PBI enterprises operating in Scotland was only 7.8% (27,235 out of 350,135) in 2019. Across the other economic impact metrics, Scotland accounted for closer to and above 10%. Therefore, for a smaller number of enterprises in PBIs, Scotland has a disproportionately large impact on a per-firm basis compared to the UK average.

The explanation for this is not necessarily a larger average business size: in 2019, PBIs in Scotland were dominated by micro enterprises (0–9 employees), where 93% (25,390) of all firms in Scottish PBIs fell into this category, in line with the UK average of 92% (322,255).

Table 8: Division of enterprises in UK PBIs, distinguished between nations, thousands, 2010-2019

Nation	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
England	210.1	204.6	216.2	221.5	239.8	282.7	299.4	320.1	302.9	305.4
<b>Scotland</b>	<b>16.9</b>	<b>17.5</b>	<b>19.4</b>	<b>20.6</b>	<b>22.8</b>	<b>26.1</b>	<b>26.8</b>	<b>27.1</b>	<b>26.8</b>	<b>27.2</b>
Wales	8.3	8.0	8.2	8.3	9.2	11.3	11.7	12.1	11.8	12.2
Northern Ireland	3.8	3.7	3.7	3.8	3.9	4.1	4.4	4.8	5.1	5.3

Source: Nomis, Cebr analysis

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

Code	Description	Code	Description
<b>Oil &amp; Gas Extraction</b>			
06.1	Extraction of crude petroleum	06.2	Extraction of natural gas
<b>Physics Manufacturing</b>			
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	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
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
<b>Physics Machine Services</b>			
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
<b>Energy Production, Transmission &amp; Distribution</b>			
35.11	Production of electricity	35.13	Distribution of electricity
35.12	Transmission of electricity	35.22	Distribution of gaseous fuels through mains
<b>Physics Waste &amp; Recovery</b>			
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		
<b>Physics Machine Sales</b>			
46.14	Agents involved in the sale of machinery, industrial equipment, ships and aircraft		
<b>Medical Equipment Sales</b>			
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
<b>Space Transport &amp; Air Transport Services</b>			

51.22	Space transport	52.23	Service activities incidental to air transportation
<b>Telecoms</b>			
61.1	Wired telecommunications activities	61.3	Satellite telecommunications activities
61.2	Wireless telecommunications activities	61.9	Other telecommunications activities
<b>Physics Science &amp; Technology</b>			
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		
<b>Defence</b>			
84.22	Defence activities		

## Appendix II: Full tables

Table 9: Turnover in the different categories of PBIs in Scotland, £ billions, 2010-2019

Sub-sector	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Oil & Gas Extraction	24.5	29.4	19.5	22.7	17.4	15.5	12.7	14.5	15.2	17.9
Physics Manufacturing	8.8	9.9	9.5	9.3	9.9	11.1	15.0	11.8	12.4	11.4
Physics Machine Services	1.3	1.9	2.2	1.7	2.1	2.2	1.4	2.5	1.8	1.3
Energy Production, Transmission & Distribution	15.1	14.4	12.2	14.6	17.0	14.0	14.6	12.1	12.1	13.9
Physics Waste & Recovery	0.5	0.7	0.8	0.7	0.7	0.6	0.7	0.7	1.2	0.9
Physics Machine Sales	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.2	0.1
Medical Equipment Sales	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Space Transport & Air Transport Services	0.5	0.6	0.7	0.7	0.7	1.0	0.9	0.8	1.0	1.0
Telecoms	7.3	5.7	4.6	4.5	4.8	3.9	4.6	4.0	4.4	5.2
Physics Science & Technology	7.5	7.8	8.2	9.3	9.9	10.9	10.4	11.8	11.9	11.6
Defence	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Physics Total	66.2	70.8	58.1	64.0	62.8	59.5	60.8	58.6	60.4	63.8

Source: ABS, BRES, Cebr analysis

Table 10: Number of enterprises in the different sub-sectors of PBIs in Scotland, 2010-2019

Sub-sector	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Oil & Gas Extraction	25	30	30	30	30	35	30	35	40	45
Physics Manufacturing	3,200	3,045	3,135	3,085	3,140	3,335	3,380	3,435	3,655	3,640
Physics Machine Services	415	540	690	965	935	960	1,035	1,150	1,125	1,195
Energy Production, Transmission & Distribution	80	115	145	250	355	455	555	575	635	635
Physics Waste & Recovery	145	165	155	160	170	170	185	175	175	180
Physics Machine Sales	150	150	155	140	135	135	140	130	135	150
Medical Equipment Sales	60	60	65	65	65	60	75	75	80	90
Space Transport & Air Transport Services	40	45	40	40	45	50	45	55	55	60
Telecoms	275	285	310	315	320	330	320	380	390	390
Physics Science & Technology	12,555	13,065	14,670	15,570	17,625	20,565	20,985	21,125	20,480	20,850
Overall	16,945	17,500	19,395	20,620	22,820	26,095	26,750	27,135	26,770	27,235

Source: Nomis, Cebr analysis

Table 11: Division of enterprises in PBIs in Scotland, distinguished between size, 2019

Sub-sector	Micro	Small	Medium	Large
Oil & Gas Extraction	35	-	5	5
Physics Manufacturing	2,995	485	140	20
Physics Machine Services	1,075	95	15	10
Energy Production, Transmission & Distribution	610	20	-	5
Physics Waste & Recovery	135	40	5	-
Physics Machine Sales	140	10	-	-
Medical Equipment Sales	80	10	-	-
Space Transport & Air Transport Services	45	5	5	5
Telecoms	350	35	5	-
Physics Science & Technology	19,925	805	100	20
<b>Total</b>	<b>25,390</b>	<b>1,505</b>	<b>275</b>	<b>65</b>

Source: Nomis, Cebr analysis

Table 12: GVA in the different categories of PBIs in Scotland, £ billions, 2010-2019

Sub-sector	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Oil & Gas Extraction	14.1	14.8	10.8	10.1	8.6	7.3	5.6	9.3	10.0	11.5
Physics Manufacturing	3.3	3.4	3.5	3.5	3.9	3.8	4.1	4.2	4.1	4.1
Physics Machine Services	0.6	0.8	0.9	0.9	1.0	0.9	0.6	0.9	0.7	0.6
Energy Production, Transmission & Distribution	3.4	3.1	2.6	3.2	3.3	2.5	3.1	2.4	2.4	3.0
Physics Waste & Recovery	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.3
Physics Machine Sales	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1
Medical Equipment Sales	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Space Transport & Air Transport Services	0.3	0.5	0.5	0.5	0.6	0.7	0.7	0.7	0.7	0.7
Telecoms	1.1	1.1	1.0	1.3	1.7	1.5	1.9	2.3	2.3	2.5
Physics Science & Technology	4.0	3.7	4.3	5.0	5.4	5.1	5.0	5.7	5.7	5.5
Defence	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
<b>Physics Total</b>	<b>27.2</b>	<b>27.7</b>	<b>24.1</b>	<b>24.9</b>	<b>25.0</b>	<b>22.2</b>	<b>21.4</b>	<b>25.9</b>	<b>26.6</b>	<b>28.4</b>

Source: ABS, BRES, Cebr analysis

Table 13: FTE in the different categories of PBIs in Scotland, thousands, 2010-2019

Sub-sector	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Oil & Gas Extraction	7.6	8.2	8.2	9.4	11.0	10.9	10.3	9.2	9.0	9.9
Physics Manufacturing	64.3	63.8	61.0	58.6	64.3	60.2	60.3	61.9	63.7	58.0
Physics Machine Services	11.8	13.0	15.3	13.0	16.1	14.5	11.2	14.5	12.2	10.0
Energy Production, Transmission & Distribution	18.1	16.8	14.1	15.2	17.3	13.2	13.4	12.2	13.4	13.9
Physics Waste & Recovery	2.8	3.3	3.6	3.2	3.8	4.1	4.0	3.4	4.8	4.2
Physics Machine Sales	0.9	0.3	0.3	0.8	0.4	0.3	0.2	0.2	0.8	0.6
Medical Equipment Sales	0.2	0.3	0.2	0.2	0.4	0.3	0.3	0.4	0.4	0.6
Space Transport & Air Transport Services	4.2	4.2	4.2	4.2	4.7	5.6	5.3	5.5	6.3	5.6
Telecoms	18.1	16.8	15.4	17.2	16.4	16.1	19.5	18.5	17.5	19.8
Physics Science & Technology	70.1	65.6	65.7	69.8	78.7	82.6	78.5	88.3	87.9	93.8
Defence	5.7	4.9	5.0	3.9	3.8	3.4	3.8	3.8	3.8	3.7
<b>Physics Total</b>	<b>203.7</b>	<b>197.0</b>	<b>192.9</b>	<b>195.5</b>	<b>216.9</b>	<b>211.1</b>	<b>207.0</b>	<b>217.9</b>	<b>219.8</b>	<b>220.0</b>

Source: BRES, Cebr analysis

Table 14: COE in the different categories of PBIs in Scotland, £ billions, 2010-2019

Sub-sector	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Oil & Gas Extraction	1.19	1.38	1.18	1.76	1.91	1.81	1.60	1.54	1.38	1.41
Physics Manufacturing	2.00	2.03	2.14	2.18	2.37	2.47	2.63	2.80	2.75	2.53
Physics Machine Services	0.27	0.40	0.47	0.40	0.46	0.43	0.34	0.50	0.32	0.25
Energy Production, Transmission & Distribution	0.81	0.87	0.73	0.69	0.71	0.64	0.65	0.61	0.63	0.74
Physics Waste & Recovery	0.07	0.08	0.09	0.10	0.12	0.10	0.18	0.13	0.17	0.16
Physics Machine Sales	0.08	0.02	0.02	0.03	0.01	0.01	0.01	0.01	0.04	0.02
Medical Equipment Sales	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Space Transport & Air Transport Services	0.17	0.17	0.20	0.19	0.22	0.25	0.26	0.21	0.32	0.30
Telecoms	1.52	1.17	1.00	1.00	1.05	0.79	0.93	0.82	0.92	1.21
Physics Science & Technology	2.47	2.48	2.48	2.65	3.04	3.12	3.00	3.19	3.32	3.59
Defence	0.18	0.14	0.13	0.12	0.12	0.11	0.12	0.13	0.14	0.13
<b>Physics Total</b>	<b>8.76</b>	<b>8.74</b>	<b>8.44</b>	<b>9.13</b>	<b>10.02</b>	<b>9.73</b>	<b>9.72</b>	<b>9.96</b>	<b>10.00</b>	<b>10.35</b>

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 constituent UK nations and 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 FTE employees and COE, as well as 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 (BRES) from Nomis (which also comes from ONS) and the UK business counts from Nomis.

ABS provides a very detailed database on a UK level, however, 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 figure 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: **SIC-based definition of PBIs and sectoral alignment** shows which industries belong to which sub-sector.

### Economic impact of the PBIs in Scotland

After finishing the gathering and modelling the data of the UK impacts, we were able to estimate the International Territorial Levels Level 1 (ITL1) regional values, including those for Scotland.

First, we used BRES again to estimate the share of FTEs in each of the UK nations and nine English ITL1 regions in a given industry, thus getting the implied number of full-time 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, the ABS was missing one of the regional values we needed to calculate the ratios. If there was 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.

