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FIRM INVESTMENTS IN SKILLS AND CAPITAL IN THE UK SERVICES SECTOR

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Abstract/Résumé

Firm investments in skills and capital in the UK services sector

Investments in both human and physical capital are key drivers of economic growth and productivity gains. The United Kingdom has had a turbulent recent history, being strongly affected by the Global Financial Crisis of 2008 and more recently voting to leave the European Union, its largest trading partner. We use firm-level survey data for the UK services sector to show that firms were less likely to increase expenditure on worker training in the periods following each event. In the period following the EU Referendum, firms were 9% less likely to increase expenditure on worker training relative to the period before the referendum. The effects were most severe for larger firms and for those located in London and the South East. The impacts also varied across industries, with firms in real estate, professional, scientific and technical activities among those most negatively affected, while administrative activities and accommodation services were least negatively affected. We see similar changes in expenditure on all forms of physical capital available in the data: IT; vehicles, plants and machinery; and land and buildings. Following the EU Referendum, firms were also more likely to reduce training expenditure, although the magnitudes of the changes were smaller than those following the Financial Crisis of 2008.

Keywords: Human capital; physical capital; training; EU exit; Financial Crisis.

JEL Classification: E22, F66, M53

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Investissements d'entreprises dans les compétences des travailleurs et le capital dans le secteur des services au Royaume-Uni

Les investissements en capital humain et physique sont les principaux moteurs de la croissance économique et des gains de productivité. Le Royaume-Uni a connu une histoire récente mouvementée, fortement affectée par la crise financière mondiale de 2008 et par la décision de quitter l'Union européenne - son principal partenaire commercial. Nous utilisons les données d'enquêtes au niveau des entreprises pour montrer que les dépenses des entreprises dans la formation professionnelle ont diminué au cours des périodes suivant chaque événement. Au cours de la période qui a suivi le référendum sur l'UE, les entreprises étaient 7,5% moins susceptibles d'augmenter leur formation qu'au cours de la période précédente et 9,0% au regard des données au sein de l'industrie. Les effets ont été les plus marqués pour les grandes entreprises et pour celles situées à Londres et dans le sud-est. Les impacts varient également selon les industries, les entreprises des secteurs de l'immobilier, des activités professionnelles, scientifiques et techniques étant parmi celles qui ont enregistré les baisses les plus importantes, tandis que les activités administratives et les services d'hébergement ont été les moins affectés. Nous constatons des baisses similaires des dépenses pour toutes les formes de capital physique: TI; véhicules, installations et machines; et terrains et bâtiments. La baisse des dépenses de formation après le référendum a été similaire à celle qui a suivi la crise financière, même si les ampleurs ont été plus marquées après la crise.

Mots Clefs: capital humain, capital physique, formation, sortie de l'UE, crise financière.

Classification JEL : E22, F66, M53

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Firm investments in skills and capital in the UK services sector

By Josh De Lyon, University of Oxford & CEP and Swati Dhingra, LSE, CEP & CEPR[1]

Introduction

Investment is a key driver of economic growth and productivity gains. It is widely recognised that human capital accumulation and research and development (R&D) are important factors in increasing output per worker (Acemoglu, 2008; Romer, 1996).[2] Since the Great Recession of 2008, real wage and productivity growth have slowed substantially in many developed countries including the United Kingdom. One likely contributor to this "productivity puzzle" is a slowdown of investment in both tangibles and intangibles (Bank of England, 2014). The effects of underinvestment are long-lasting and this paper examines the trends in key tangible and intangible investments in the United Kingdom in the last fifteen years.

Capital accumulation is a key driver of productivity growth (Romer, 1990). Investments in information technology and plant and machinery are the classic ways in which businesses invest to raise their productivity and innovative activities. In recent years as economic polarisation has increased, there are concerns however that investments in new technologies can replace certain tasks that are currently performed by workers (see for example Autor et al., 2003, and Frey and Osborne, 2017). In OECD countries, nearly one in two jobs is likely to be significantly affected by automation (Nedelkoska and Quintini, 2018). This transformation has important implications for policy, which are explored in the new OECD Going Digital initiative.[3]

Investments in skills provide productivity growth together with the potential for wage progression (see for example Lynch, 1992; Dearden et al., 2006). These investments are therefore crucial in overcoming economic stagnation and concerns regarding displacement of workers from technological changes. Intangible assets like human capital are easier to scale up and have greater spillovers than other sources of growth such as physical capital (Haskel and Westlake, 2018). They also provide support to workers in adjusting to structural economic changes such as ongoing technological change and globalisation, the gains and losses from which are often unequally distributed.

An important part of investment in skills takes place through job-related education and training of workers. These make up the largest component of investment in intangibles and the key contributor to skills development over the working life of individuals. Yet recent trends have shown a slowdown in job-related education and training of workers. The OECD estimated that only two in five adults participate in education and training in any given year, with participation as low as 20% for adults with low skills (OECD, 2019).

[1] The authors working at University of Oxford & CEP and LSE, CEP & CEPR. They are grateful to Sebastian Barnes, Oliver Denk, Shinyoung Jeon, Annabelle Mourougane, Balazs Stadler for useful comments and discussions and to Michelle Ortiz for excellent technical assistance. They are grateful to the Confederation of British Industry (CBI) for kindly allowing us access to their survey data. The views in this paper do not reflect those of the CBI. The Centre for Economic Performance (CEP) has no institutional views, only those of its individual researchers.

[2] Estimates from the US suggest that increasing levels of human capital over the second half of the last century accounted for approximately one-third of productivity growth (Griliches, 1997).

[3] See www.oecd.org/going-digital.

According to the report, in the United Kingdom 30% of adults have low skill levels in literacy and/or numeracy, putting it at the 12th highest rate out of the 29 OECD countries in the survey.

The UK economy has had a turbulent recent history. At the time of writing, the COVID-19 pandemic has sent the country into lockdown, causing a huge immediate reduction in economic activity (De Lyon and Dhingra, 2020). At this stage of the pandemic, it is too early to identify changes in factors such as worker training, but the effects of the virus will compound previous significant events that have impacted the UK economy.

The first of these was the Financial Crisis, which resulted in a sharp reduction in economic activity across the world. The UK experienced a fall in GDP and real wages in the period of the Great Recession and the recovery in the following years has been sluggish. Real wages are at approximately the same level as they were in 2006 (Office for National Statistics, 2018a) and productivity growth has been puzzlingly slow.

A second major event that has reinforced these trends is the referendum on membership of the European Union (EU) on 23 June 2016. The UK economy is highly integrated with that of the EU. In 2015, before the Referendum, 43% of UK exports were to the EU and 53% of imports were from the EU. Similarly, 45% of the stock of foreign direct investment (FDI) in the UK was from EU countries and 43% of UK investment abroad went to the EU (Office for National Statistics, 2018b). There are also approximately 3.3 million immigrants from other EU countries living in UK (Wadsworth et al., 2016).

The decision of the UK electorate to vote to leave the EU represented a largely unexpected change in the state of the economy. In the 24 hours in June 2016 during which the UK electorate unexpectedly voted to leave the European Union, the value of sterling plummeted. It caused the largest depreciation that has occurred in any of the four major currencies since the end of the Bretton Woods system in 1971. This depreciation caused real wage growth to again become negative, after having finally picked up in the year preceding the referendum (De Lyon et al., 2017, Costa et al. 2019). Also in the period following the referendum, GDP growth has slowed relative to other G7 countries (De Lyon and Dhingra, 2019), exports to the EU have fallen (Crowley et al., 2018), inward FDI has fallen and outward FDI increased (Serwicka and Tamberi 2018, Breinlich et al. 2020) and Brexit has been cited as a major cause of uncertainty (Bloom et al., 2018).

The vote to leave the EU has changed the expectations of the current and future state of the UK economy. As businesses change their perceptions over economic conditions, they re-calibrate their investment opportunities (see for example Bloom, 2014; Handley and Limäo, 2015). Firm-level investments are often a flexible margin of adjustment to economic changes because they do not directly disrupt short-term production and are often not contractually bound. In particular, Costa et al. (2019) provide causal evidence that wages and training fell in sectors where intermediate import prices rose by more as a result of the sterling depreciation induced by the Referendum result. There is also existing evidence from Germany that individual training decreased as a result of the Financial Crisis (Dietz and Zwick, 2018).

In this paper, we examine recent trends in tangible and intangible investments, particularly those in employer-provided training, using firm-level survey data collected by the Confederation of British Industry (CBI) covering the period 2005Q4-2018Q3. We identify what happened to worker training and capital investments in the two-year periods after both the Financial Crisis and the EU Referendum. In the UK, 82% of training expenditure is provided by employers (Social Mobility Commission, 2019), motivating our focus on firm-level training expenditure. We focus on the services sector and our data account for 43% of the UK's economic output.[4] The key findings of the paper are as follows.

[4] We omit the financial services and distribution services sectors from our analysis as they are covered in a different set of CBI surveys.

Key Findings:

- Firms were less likely to increase expenditure on worker training in the period after the EU Referendum relative to the period before. There is also tentative evidence to suggest that firms were more likely to reduce expenditure on worker training in the period after the EU Referendum relative to the period before.
- The changes in training expenditure that have occurred since the Referendum have varied across industries. Real estate, professional, scientific and technical activities are among those most likely to reduce expenditure in training while firms in administrative activities and accommodation services were more likely to increase training expenditure.
- The changes in training expenditure that have occurred since the Referendum have varied across regions. The largest decline in the probability of increasing training expenditure has been in London and the South East.
- Larger firms were most likely to stop increasing or reduce their expenditure on worker training.
- Firms were more likely to reduce expenditure on all forms of physical capital in the period after the Referendum relative to before.
- Firms were more likely to reduce training expenditure in the period following the Financial Crisis relative to the period before.

We find that there have been two major changes in the trends of training expenditure by firms. The first, most stark change, occurred in the wake of the Financial Crisis. Looking at within-industry changes in investments, firms were 9.9% less likely to increase training expenditure during the Great Recession than in the period before. It is unsurprising that firms cut back on their provision of training after experiencing this fall in demand for their output. The effect is likely to have been compounded by increasing uncertainty and more limited access to credit.

The second major change in training expenditure occurred immediately after the UK Referendum on whether it would remain a member of the European Union in June 2016. Businesses became more likely to reduce their training investments. The combined effects of higher import costs, reduced future export demand and greater uncertainty could be likely reasons for the cut back in investments.

In the period following the Referendum, firms were 7.5% less likely to increase their training expenditure than in the period before the Referendum and 9.0% less likely when looking at within-industry changes. The effects are strongest for larger firms, as measured by employment and turnover, perhaps simply because these firms initially provide more training (Black et al., 1999) and therefore have a greater margin for adjustment. In fact, small and medium size enterprises (SMEs) have made no significant changes to their training expenditure since the Referendum. The results are consistent with the findings of Costa et al. (2019) who use worker-level data from the Labour Force Survey to show that the exogenous change in trade costs of intermediates caused by the Brexit Referendum resulted in a reduction in worker training. While our analysis focuses on key services industries, we have also investigated the equivalent trends in the manufacturing sector and similar patterns appear to have occurred.

Looking at within-industry changes in physical capital in the periods before and after the Brexit Referendum, we find that firms were 11.9% less likely to increase expected IT expenditure, 12.7% less likely to increase expenditure on vehicles, plants and machinery, and 11.4% less likely to increase expenditure on land and buildings in the period after the Referendum.

Finally, we show that the changes in training expenditure that followed the Financial Crisis were more severe than those seen after the Brexit Referendum. The effect seems to have been doubly strong in the case of the Financial Crisis because firms were also 14.9% more likely to decrease training expenditure than in the pre period.

We do not attempt to causally explain the changes in investments or explicitly attribute the productivity puzzle to these changes. Instead, we document the timing and extent of firms' changes in training expenditure and decompose the sources of these changes by industry, region and firm size.

The importance of these findings is amplified with the current spread of COVID-19. This paper shows that employer-provided worker training has fallen following the last two major events that impacted the UK economy. This trend will almost certainly be repeated during the economic crisis that is associated with the spread of the virus. To compound this, workers who have received less training in recent years may be less mobile across sectors which could restrict productivity and employment growth as the economy structurally adapts to the shock.

The rest of the paper is organised as follows. Section 2 describes the dataset used and documents long-term trends in business optimism, training expenditure and expenditure on IT. Section 3 presents evidence of changes in training expenditure before and after the Brexit Referendum. It also examines how this varies with firm characteristics including industry, region and firm size. Section 4 estimates how expected expenditure on other forms of capital varied before and after the Brexit Referendum. Section 5 compares changes in training around the Brexit Referendum with those that occurred around the Financial Crisis. Section 6 concludes.

Data

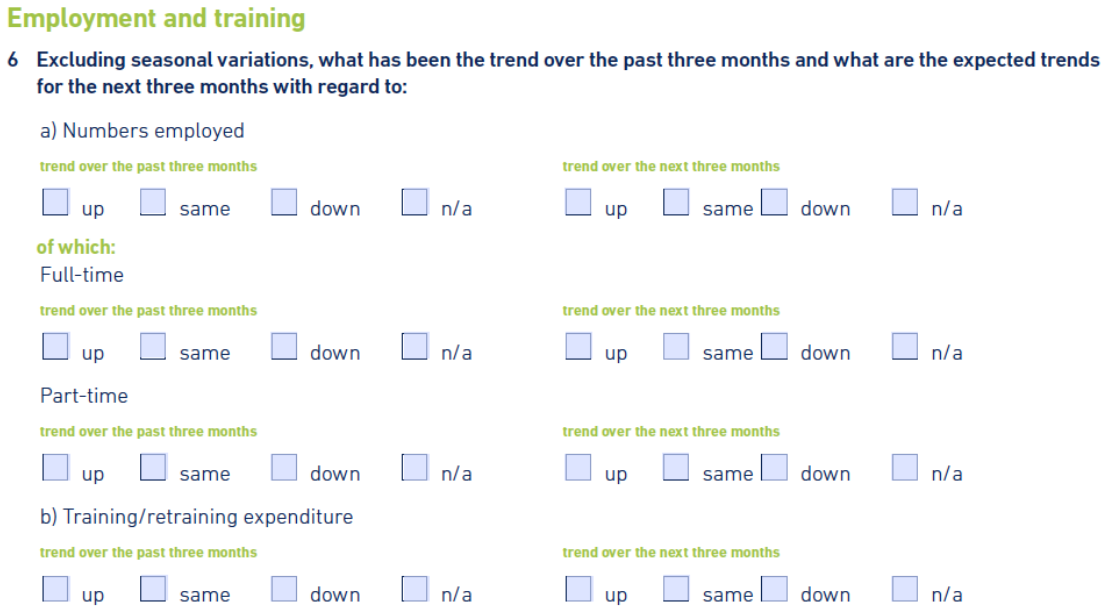
We use survey data from the Confederation of British Industry (CBI) Services Sector Survey (SSS) which they send to members and non-members on a quarterly basis. The CBI is a UK business organisation that speaks for 190 000 businesses in total and whose trade associations account for one third of private sector employment. The SSS covers the majority of services sectors, with the notable exceptions of the financial services and distribution sectors, which are covered in separate surveys conducted by the CBI. The survey is conducted with repeated sampling at the firm level on a quarterly basis with on average 170 responses per quarter. The structure of the survey questionnaire is consistent throughout our estimation period of 2005Q4-2018Q3. We estimate changes in worker training and capital investments in the two years following the Financial Crisis and the EU Referendum, so the analysis stops in the third quarter of 2018. We focus on two year periods to reduce the possibility that other events dominate the role of those studied in this analysis.

The survey aims to collect information on changes in business trends over time. The questions are framed relatively and therefore capture relative changes, not levels. Figure 1 shows the question on training expenditure (in part b of the question shown). This provides our primary variables of interest, which will be indicators for whether past or expected future expenditure have moved up or down.[5] The survey asks similar questions on different forms of capital expenditure except that it only asks about future expectations and the reference period for capital is the next 12 months rather than the next 3 months. This is designed to reflect the longer adjustment periods for capital relative to training. We expect that this longer period would cause changes in capital to be more likely than if they had asked about the next 3 months, everything else constant. The capital question in the survey is shown in Figure A.1 of the Data Appendix. The survey divides capital expenditures into three types of capital: Land and Buildings; Information Technology (this includes hardware/software/personnel and any other expenses related to IT); and Vehicles, Plants and Machinery.

[5] Unfortunately, we cannot see whether firms are altering the quality or quantity of training or whether the training provided is more specific or general in form. We are also unaware of papers that directly show the link between training and productivity in the UK. For publicly supported training, Patrignani and Conlon (2012) do not find any productivity benefits of the UK's *Train to Gain* programme, although they acknowledge that the data restricted them from drawing any robust conclusions. Our focus instead is on employer provided education and training.

The survey also asks basic information about the firm. This includes a detailed industry code and region of the UK, which can include the whole of the UK for firms with multiple branches. Firms also report turnover and employment in bands; there are 9 bands for employment and 11 bands for turnover. Histograms of firms by employment and turnover band are presented in Figures A.2 and A.3 in the Data Appendix. In our baseline regressions where we weight by employment, we will assume that firms have employment and turnover equal to the midpoint of the band such that we can treat the data as continuous.[6] In a robustness check, we repeat our baseline regression using the minimum of the employment band as weights and show that the results hold.

Figure 1. CBI Services Sector Survey training question



Employment and training

6 Excluding seasonal variations, what has been the trend over the past three months and what are the expected trends for the next three months with regard to:

a) Numbers employed

trend over the past three months: ☐ up ☐ same ☐ down ☐ n/a

trend over the next three months: ☐ up ☐ same ☐ down ☐ n/a

of which:

Full-time

trend over the past three months: ☐ up ☐ same ☐ down ☐ n/a

trend over the next three months: ☐ up ☐ same ☐ down ☐ n/a

Part-time

trend over the past three months: ☐ up ☐ same ☐ down ☐ n/a

trend over the next three months: ☐ up ☐ same ☐ down ☐ n/a

b) Training/retraining expenditure

trend over the past three months: ☐ up ☐ same ☐ down ☐ n/a

trend over the next three months: ☐ up ☐ same ☐ down ☐ n/a

We also have access to the sample frame used by the CBI in conducting the survey. For the most recent period available, there are 1 092 firms in the sample frame, of which 209 responded to the survey, giving a response rate of 19.1%. It is not possible to determine the exact sample frame for previous periods with the data provided so we focus here on the characteristics of respondents for the most recent quarter. Table 1 shows the percentage of employees in each band reported by firms who did not respond to the survey (Column 1) relative to those who did respond to the survey (Column 2) and the total (Column 3). The survey appears to be closely representative of the population of firms in the CBI database. If anything, larger firms appear slightly less likely to respond to the survey than small or medium sized firms. Table 2 shows the equivalent statistics for the turnover band of the firm. Again, the respondents appear very similar to the non-respondents and there is no systematic relationship between firm size and the probability of responding to the survey. We would have liked to calculate probability weights based on the observed characteristics of respondents. However, the churn in the sampling frame of firms would induce too much inaccuracy in the weights and given the similarity between the respondents and non-respondents shown in Tables 1 and 2, the survey is likely to be suitably representative along many key dimensions.

One additional note on the survey sample is that it under-represents small firms, in particular firms with only 1 employee. The conclusions of this paper are therefore most applicable to medium and larger firms.

[6] We acknowledge that firms have been shown to more closely follow a Pareto distribution and therefore some point slightly lower than the median of the band may be more accurate but the difference is likely to be small for our analysis as the range of each band is quite narrow.

Table 1. Employees of survey respondents and non-respondents

	Sample		
Employees	No	Yes	Total
1-9	10.0	10.5	10.1
10-19	6.8	10.5	7.5
20-49	15.2	14.8	15.1
50-99	15.2	16.3	15.4
100-199	14.9	17.7	15.5
200-499	14.5	11.5	13.9
500-4,999	19.1	15.3	18.4
5000-19,999	3.1	2.9	3.0
20,000+	1.2	0.5	1.1
Total	100.0	100.0	100.0

Table 2. Turnover of survey respondents and non-respondents

	Sample		
Turnover	No	Yes	Total
up to GBP 49k	4.0	1.4	3.5
GBP 50k-99k	0.7	1.9	0.9
GBP 100k-249k	2.6	0.5	2.2
GBP 250k-499k	3.1	4.8	3.4
GBP 500k-999k	5.5	4.8	5.4
GBP 1m-4.99m	24.0	33.5	25.8
GBP 5m-9.99m	11.0	11.5	11.1
GBP 10m-19.99m	14.9	10.0	14.0
GBP 20m-99.99m	20.0	21.1	20.2
GBP 100m-499m	9.5	7.7	9.2
GBP 500m plus	4.6	2.9	4.3
Total	100.0	100.0	100.0

We start with descriptive information on the types of firms in the UK. Table 3 shows the 1 digit industries represented in the surveys. The industries in the data cover 43% of GVA in the UK economy for 2016. The first column in the table shows the most common region for each industry. Perhaps unsurprisingly, for many of the industries reported, firms most commonly report that they cover the whole of the UK. One possible reason for this is that larger firms may be more likely to respond to the CBI survey and may be more likely to provide multiple responses over time. The second and third columns show mean employment and turnover, respectively. The fourth column shows the number of distinct firms. The final column is the percentage of firms that are Small or Medium Sized Enterprises (SMEs), where an SME is defined to have fewer than 200 employees and turnover below GBP 20 million. Overall, there is quite a lot of variation across industries.

Table 3. Summary statistics by industry

Industry (SIC07 2 digit)	Region (Most common)	Employees	Turnover (GBP millions)	Firms	SME (%)
Professional, Scientific and Technical Activities	Whole UK	817	61	214	64
Transportation and Storage	Whole UK	1513	132	124	45
Administrative and Support Service Activities	Whole UK	1741	79	124	55
Accommodation and Food Service Activities	London and South East	2742	83	73	41
Information and Communication	Whole UK	513	80	117	69
Arts, Entertainment and Recreation	South West	1168	51	53	53
Real Estate Activities	London and South East	526	48	29	78
Other Service Activities	Northern Ireland	564	23	11	59
Human Health and Social Work Activities	Midlands	1299	12	5	52

Table 4 presents the data by region of the UK. Firms are allowed to report the whole of the UK as their region, or a specific region. The first column shows the most common 1 digit industry in the region. The remaining columns present the equivalent statistics as in Table 3. These are: mean employment, mean turnover, the number of distinct firms and the proportion of SMEs. Unsurprisingly, firms that cover the whole of the UK are the biggest on average and are also by far the most common in the data.

Table 4. Summary statistics by region

Region	Industry (Most common, SIC07 1 digit)	Employees	Turnover (GBP millions)	Firms	SME (%)
Whole UK	Professional, Scientific and Technical Activities	2922	176	213	39
London and South East	Professional, Scientific and Technical Activities	701	47	180	65
North	Professional, Scientific and Technical Activities	921	66	90	55
Midlands	Professional, Scientific and Technical Activities	543	19	84	71
East	Professional, Scientific and Technical Activities	622	36	52	60
South West	Information and Communication	245	51	48	67
Scotland	Transportation and Storage	1313	59	42	46
Wales	Information and Communication	666	24	20	60
Northern Ireland	Transportation and Storage	149	12	20	89

Time trends

This section examines trends of key variables over time. Figures 2-4 plot firm responses regarding business optimism, training expenditure and expected expenditure on IT, respectively. In each case, responses of "N/A" are omitted. In all cases, the most negative spike is clearly at the time of the Great Recession. This is followed by a trend of a more positive outlook which is then somewhat reversed at the time of the Referendum.

Figure 2 plots firms' responses to the question of whether they are more or less optimistic about the general business situation in their sector. The precise wording of the question is reported below the Figure. Here, the two spikes of lower optimism for the Crisis and Referendum are very pronounced. Notice also that there are clear drops in the proportion of firms, which are more optimistic.

Figure 2. Business optimism

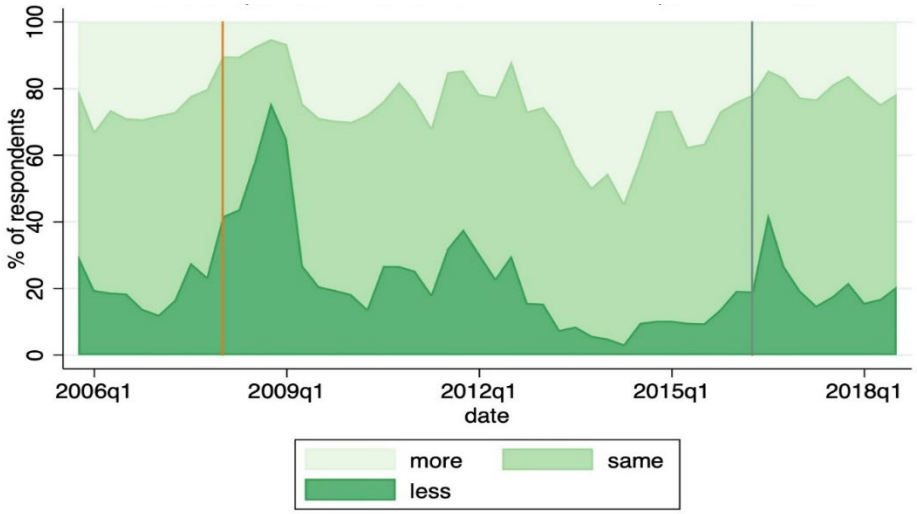


Figure 3 documents changes in training expenditure over the past three months in each quarter. Again, there is a sharp change at the time of the Great Recession. For the Referendum, there is no obvious spike in training going down but the general upward trend of training that had been seen up to the Referendum appears to reverse.

As discussed above, the survey splits capital expenditure into three components. In Figure 4 we plot firms' expected expenditure on IT in the next 12 months for each quarter. Again, the most notable change is during the financial crisis. Following that, there is a trend of more firms reporting increased expenditure on IT which is also somewhat reversed at the time of the Brexit Referendum.

Figure 3. Training expenditure: past 3 months

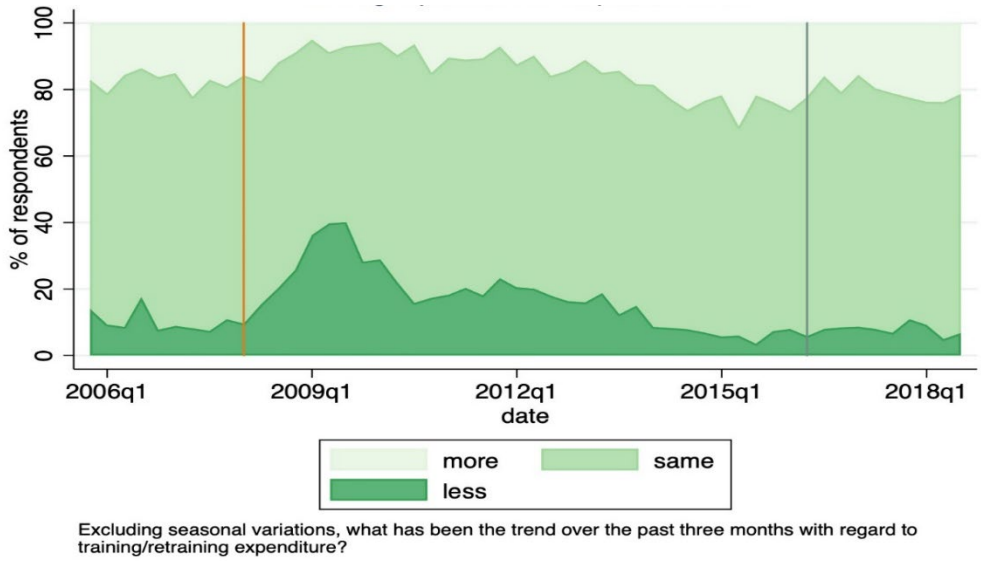
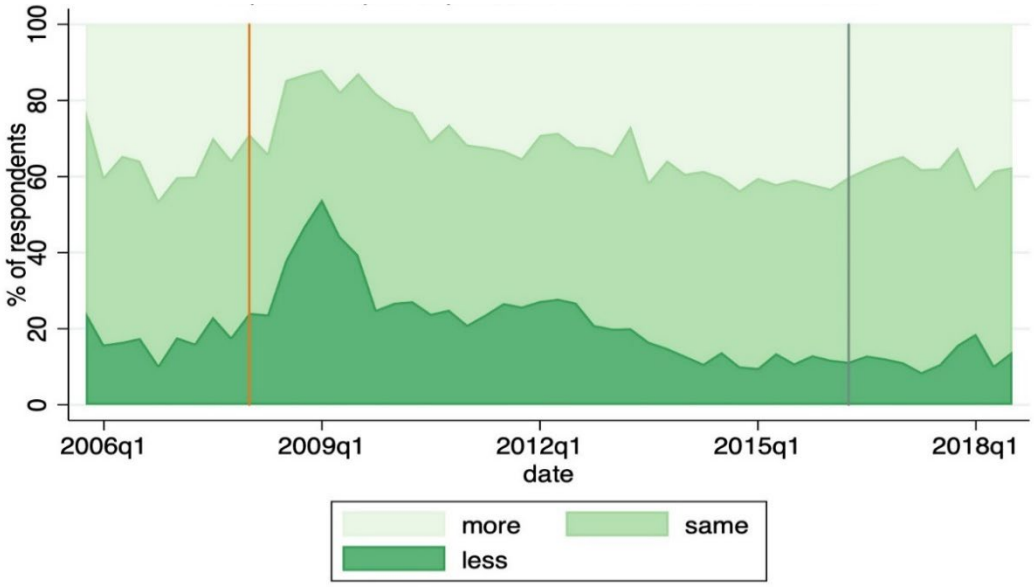


Figure 4. Information technology expenditure: next 12 months



Do you expect to authorise more or less capital expenditure in the next twelve months than you authorised in the past twelve months on information technology?

Table 5 focuses on values before and after the Brexit Referendum. The values in the table are weighted by the mean employment of the firm before the Referendum. The unweighted values are available in Table A.1 of the Data Appendix and have qualitatively similar results. For each response variable, the value is 1 if the firm says that the variable has increased relative to the reference period and -1 if the firm says it has decreased. If it is the same, then it is coded as 0. A mean of 1 would therefore represent every firm in the period stating that the relevant variable has increased and vice versa for -1.

Comparing the pre and post Referendum values, there is a drop in the mean of every response except, interestingly, the value of business in the EU. In the unweighted table in the Data Appendix the mean of value of business in the EU is unchanged pre and post. The most pronounced drops are in business optimism and the value of business in the past three months, which seems to have fallen most in UK markets.

Table 5. Summary statistics by time, weighted by employment

	Pre-Referendum mean	June 2016 mean	Post-Referendum mean
Training expenditure: Past 3 months	0.30	0.41	0.22
Training expenditure: Next 3 months	0.32	0.39	0.22
Capital expenditure on land and buildings: Next 12 months	0.23	0.29	0.07
Capital expenditure on IT: Next 12 months	0.42	0.54	0.29
Capital expenditure on vehicles, plants & machinery: Next 12 months	0.24	0.38	0.08
Business optimism: past 3 months	0.28	-0.04	-0.15
Value of business: at present relative to normal	0.15	0.24	0.00
Value of business: past 3 months	0.35	0.33	0.08
Value of business: next 3 months	0.37	0.26	0.17
Value of business in UK: past 3 months	0.35	0.21	0.09
Value of business in EU: past 3 months	0.06	0.07	0.10
Value of business outside EU: past 3 months	0.16	0.17	0.10
Observations	1590	147	1073

Note: The values represent the mean firm response for each trend variable. Values greater than 0 represent an average increase while values less than 0 represent an average decrease. The values in the table are weighted by the mean employment of the firm before the Referendum
Source: Authors' calculations

Sample attrition

It is important that attrition is not driving our results. If firms were leaving the sample over time or coverage was systematically increasing then the trends could be driven purely by entry and exit from the survey. Table 6 shows that there are roughly the same number of observations for each year and that in each year the mean employment and turnover of firms in the sample is similar. As expected, there are slightly fewer observations in 2018 because Q4 is not included in the data but all analysis is conducted using the quarterly data so this is not an issue. Table A.2 in the Data Appendix replicates this table by quarter rather than year. The number of observations, employees and turnover remain fairly consistent in every quarter.

Table 6. Sample information over time

	Observations	Employees	Turnover
2014	706	1265	84.2
2015	713	1445	83.0
2016	710	1468	82.5
2017	681	1172	74.0
2018	575	1097	71.1

Note: There is no data for 2018Q4
Source: Authors' calculations

Training after the Brexit Referendum

We now focus on comparisons of training expenditure before and after the Brexit Referendum. The survey asks firms whether training expenditure has increased, decreased, or remained the same in the past three months and whether they expect it to increase, decrease or remain the same over the next three months. We use this information to construct four dummy variables which will be our main outcome variables of interest.[7]

We define the pre-Referendum period as 2014Q1 to 2016Q1 and the post-Referendum period as 2016Q3-2018Q3, giving us 9 periods before and after 2016Q2, which we omit from the sample as we cannot untangle pre and post Referendum effects in this quarter. We choose this sample period as the most recent data available to us is 2018Q3 but show in Annex B that the baseline results are broadly robust to a narrower and wider window.

Key finding 1. *Firms were less likely to increase expenditure on worker training in the period after the EU Referendum relative to the period before. There is also tentative evidence to suggest that firms were more likely to reduce expenditure on worker training in the period after the EU Referendum relative to the period before.*

We are interested in how firms have changed their training expenditure since the Brexit Referendum. We therefore estimate the following linear probability model for firm **i** in industry **j** at time **t:**

$$\Delta Y_{ijt} = \alpha + \beta Post_t + E_{ijt} \quad (1)$$

where ΔY_{ijt} is a dummy variable for changes in training expenditure as discussed above. The α term is a constant. $Post_t$ is a dummy which takes the value 1 after 2016Q2 and 0 otherwise and E_{ijt} is an error term. The coefficient of interest is **β** which captures the difference in the average value of the relevant training indicator after the Referendum relative to before. Throughout the analysis, we cluster standard errors at the firm level to account for likely correlations between observations of the same firm. In the baseline model, we do not exploit any firm-specific information as explanatory variables. In the augmented versions of the model that follow, we introduce firm-specific interactions that make use of our detailed survey data.

[7] These are: (1) training expenditure in the past three months increased; (2) training expenditure in the next three months increasing; (3) training expenditure in the past three months decreased; and (4) training expenditure in the next three months decreasing.

The results of this simple comparison of training expenditure trends before and after the Referendum are presented in Table 7. The columns present results for each of the four dependent variables of interest. Column 1 shows that firms are 7.6% less likely to have increased their training in the period after the Referendum than before. Column 2 shows a forward-looking measure of training expenditure. Firms were 6.5% less likely to state that they expect to increase their training expenditure in the next three months in the Post period relative to the Pre period. Columns 3 and 4 examine cases where firms reported reductions or expected reductions in training expenditure, respectively. In Column 3, the magnitude of realised falls in training expenditure is close to zero. Column 4 shows that firms are 3.5% more likely to report an expected fall in training expenditure after the Referendum relative to before.

The R-squared values are low in all specifications. This implies that there is a lot of heterogeneity across firm-time observations in each of the two periods. We also note that the standard errors are relatively large in part due to this variation such that only the Column 4 coefficient is statistically significant, although the magnitudes are economically large.

Throughout the analysis we do not attach causality of these effects to the Brexit Referendum but instead simply document changes in trends. It is also possible that some adjustment occurred in the pre period due to anticipation effects. Indeed, Figure 2 shows that there was a change in the trend of business optimism in the quarter before the Referendum, although this does not appear to be the case for training expenditure and IT expenditure shown in 3 and 4, respectively.

The survey does not account for changes in prices but instead asks firms about the nominal change in value of training expenditure. The vote to the leave the EU caused a devaluation in the value of the pound, which translated into inflation in the UK. The services sector producer price index increased by 3.1% in our post period relative to 1.7% in the pre period. Therefore, our estimated coefficients may underestimate the probabilities of reductions in the *real* value of training expenditure.

Table 7. Post-Referendum training expenditure

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m down	(4) Training next 3m down
Post Brexit Referendum=1	-0.0762	-0.0646	0.0108	0.0349**
	(0.0498)	(0.0524)	(0.0103)	(0.0168)
Observations	2663	2663	2663	2663
R2	0.006	0.005	0.001	0.007
Industry 2 digit FE	No	No	No	No
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses
Standard errors are clustered at firm level.
$*p < 0.10$, $**p < 0.05$, $***p < 0.01$
Source: Authors' calculations

For the remainder of the analysis, we introduce a 2 digit industry fixed effect to control for time-invariant differences in responses across industries. The results therefore capture within-industry effects. The new specification can be written:

$$\Delta Y_{ijt} = \alpha + \beta Post_t + \mu_j + E_{ijt} \quad (2)$$

where μ_j is the industry fixed effect.

The results for Specification 2 are presented in Table 8. The results are similar to the gross comparisons reported in Table 7. Notably, within industries, firms were 9.0% less likely to increase training expenditure

after the Referendum. Firms were also 7.7% less likely to increase expected training expenditure and 3.2% more likely to decrease it.

All regressions are weighted by each firm's mean pre-period employment to more accurately capture aggregate training effects. An unweighted version of our baseline Model 2 is presented in Table B.6 of the Annex B. The results are qualitatively similar although the R-squared is noticeably lower. We also conduct a variety of robustness checks, the results of which are presented in Annex B.

Table 8. Post-Referendum training expenditure within industries

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m down	(4) Training next 3m down
Post Brexit Referendum=1	-0.0897** (0.0404)	-0.0774* (0.0427)	0.00444 (0.0121)	0.0323* (0.0185)
Observations	2663	2663	2663	2663
R^2	0.229	0.184	0.069	0.049
Industry 2 digit FE	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses
Standard errors are clustered at firm level.
$*p < 0.10, **p < 0.05, ***p < 0.01$
Source: Authors' calculations

Any changes in training expenditure may vary over time. To examine when the changes in training expenditure kick in, we regress $\boldsymbol{Y_{ijt}}$ on a set of time dummies and the industry fixed effect. We omit the constant such that the year dummies together represent the average effect conditional on the industry fixed effects. The results are presented in Figure 5. Panel 5a shows regressions where the dependent variables are dummies for increases in actual and expected expenditure while Panel 5b shows the results for decreases. The results are also presented in Table B.8 of the Annex. In all four specifications, notable changes occur immediately in 2016, while the coefficients before and after this period are fairly stable. Since the survey question asks about relative changes in training expenditure, the coefficients refer to ongoing trends as opposed to levels.

The changes in training expenditure that followed the Brexit Referendum is likely to vary with characteristics of the firm. In this section, we explore these possible dimensions of heterogeneity by interacting the $\boldsymbol{Post_t}$ dummy with characteristic $\boldsymbol{X_{it}}$. Given the information in the survey, $\boldsymbol{X_{it}}$ can be industry, region, or firm size indicators. In every case explored in this paper, $\boldsymbol{X_{it}}$ will be a set of mutually exclusive categorical variables. The new specification is therefore:

$$\Delta Y_{ijt} = \alpha + \beta Post_t \cdot X_{it} + \gamma X_{it} + \mu_j + E_{ijt} \qquad (3)$$

Note that $\boldsymbol{Post_t}$ is not included as a separate regressor. Instead, we interact all elements of $\boldsymbol{X_{it}}$ with $\boldsymbol{Post_t}$ such that, together, the $\boldsymbol{\beta}$ coefficients represent the aggregate post-Referendum effect.[8]

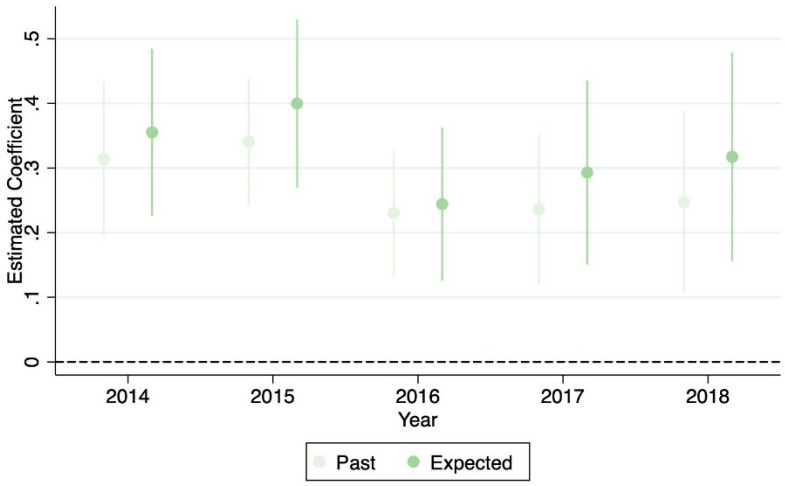
Key finding 2. *The changes in training expenditure that have occurred since the Referendum have varied across industries. Real estate, professional, scientific and technical activities are among those most likely to reduce expenditure in training while firms in administrative activities and accommodation services were more likely to increase training expenditure*.

[8] Here, β is a row vector of coefficients and $\mathbf{X_{it}}$ is a column vector of characteristics, where the dimension of both is determined by the number of different characteristics. $\boldsymbol{Post_t}$ is still a scalar which equals 0 or 1.

We might expect that the changes in training expenditure vary by industry. We therefore interact the Post dummy with 1 digit industries. This can be thought of as defining $\mathbf{X}_{it}$ = $\mathbf{Industry}_{it}$ in Specification 3. The regression results are presented in Table 9. The key takeaway is that there appears to be significant heterogeneity in the changes to training expenditure across industries. The industries that appear to have made the most significant negative changes to their training expenditure are: Real Estate Activities; Professional, Scientific and Technical Activities; and Arts, Entertainment and Recreation. On the other hand, some industries such as Accommodation and Food Service Activities have seen little change in training expenditure in the post period.

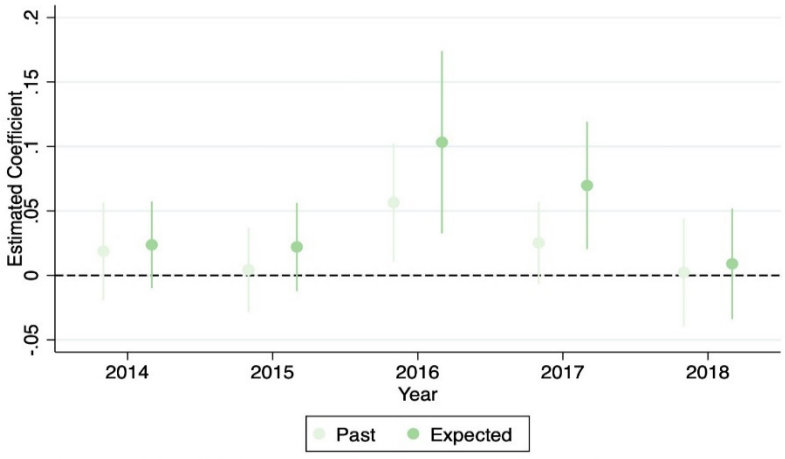
Figure 5. Training expenditure by year

(a) Expenditure increases



The graph plots coefficients from a regression of increases in training expenditure on year dummies and 2 digit industry fixed effects. For each year, the paler left hand side coefficient shows expenditure for the past three months while the darker right hand side coefficient shows expected expenditure. The lines show 95% confidence intervals.

(b) Expenditure decreases



The graph plots coefficients from a regression of decreases in training expenditure on year dummies and 2 digit industry fixed effects. For each year, the paler left hand side coefficient shows expenditure for the past three months while the darker right hand side coefficient shows expected expenditure. The lines show 95% confidence intervals.

Table 9. Post Referendum training expenditure by industry

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m down	(4) Training next 3m down
Post x Transportation and Storage	-0.00544 (0.0992)	0.0368 (0.0894)	0.0298 (0.0306)	0.0838** (0.0381)
Post x Accommodation and Food Service Activities	0.0375 (0.0883)	0.0485 (0.0926)	-0.0260** (0.0121)	-0.0229** (0.0114)
Post x Information and Communication	-0.336*** (0.0588)	-0.243*** (0.0664)	-0.0339*** (0.00993)	-0.0314*** (0.00882)
Post x Real Estate Activities	-0.325*** (0.0596)	-0.345*** (0.0562)	0.134** (0.0681)	0.222 (0.146)
Post x Professional, Scientific and Technical Activities	-0.259*** (0.0667)	-0.279*** (0.0621)	0.0312 (0.0360)	0.0230 (0.0351
Post x Administrative and Support Service Activities	-0.0504 (0.0947)	-0.0701 (0.0836)	-0.0132 (0.0152)	0.0344 (0.0355)
Post x Human Health and Social Work Activities	-0.142** (0.0593)	0.237*** (0.0594)	-0.0346*** (0.00990)	-0.0319*** (0.00880)
Post x Arts, Entertainment and Recreation	-0.314*** (0.0605)	-0.291*** (0.0623)	0.126 (0.0980)	0.106* (0.0606)
Post x Other Service Activities	-0.0792 (0.0762)	-0.109* (0.0566)	-0.0346*** (0.00990)	-0.0319*** (0.00880)
Observations	2663	2663	2663	2663
R^2	0.036	0.039	0.020	0.031
Industry 1 digit FE	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses Standard errors are clustered at firm level. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$
Source: Authors' calculations

Key finding 3. *The changes in training expenditure that have occurred since the Referendum have varied across regions. The largest decline in the probability of increasing training expenditure has been in London and the South East.*

It is also likely that trends in training expenditure vary across regions. We therefore interact the **Post$_t$** dummy with the region of the firm. We see a large amount of heterogeneity across regions but also large standard deviations within regions, implying that there is a lot of variation in training expenditure within regions. Based on the results in Table 10, we tentatively suggest that firms in Wales and Northern Ireland have on average reduced training expenditure less after the Referendum while those based in London and the South East and which cover the whole of the UK appear to have been less inclined to promote training expenditure. These findings are consistent with the expected reduction in economic activity projected by Dhingra et al. (2017) which are larger for London and the South East of England.

Table 10. Post Referendum training expenditure by region

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m down	(4) Training next 3m down
Post x Wales	0.0691	-0.0891	-0.103*	-0.0766
	(0.104)	(0.225)	(0.0591)	(0.0540)
Post x Scotland	-0.0780	0.0353	-0.0231	-0.0466
	(0.0866)	(0.0902)	(0.0465)	(0.0431)
Post x Northern Ireland	0.192	-0.134	-0.0722*	-0.0690
	(0.150)	(0.0834)	(0.0407)	(0.0641)
Post x North	0.00389	0.0144	0.0303	-0.00978
	(0.0770)	(0.0492)	(0.0298)	(0.0153)
Post x Midlands	0.00125	-0.0170	0.0648	0.00450
	(0.0945)	(0.153)	(0.0612)	(0.0115)
Post x South West	0.102	0.0770	-0.0108	0.0230
	(0.0922)	(0.0914)	(0.0181)	(0.0173)
Post x East	-0.0773	-0.0339	-0.0101	-0.0518
	(0.0575)	(0.0266)	(0.0104)	(0.0629)
Post x London and South East	-0.223**	-0.133	-0.0195	-0.00197
	(0.104)	(0.0957)	(0.0342)	(0.0297)
Post x Whole UK	-0.0914	-0.101	0.00533	0.0658**
	(0.0629)	(0.0665)	(0.0153)	(0.0295)
Observations	2660	2660	2660	2660
R^2	0.240	0.192	0.085	0.068
Industry 2 digit FE	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes

Source: Authors' calculations

Key finding 4. *Larger firms were most likely to stop increasing or reduce their expenditure on worker training.*

We might also expect that the changes in training expenditure seen after the Brexit Referendum vary by the size of firms. Table 11 presents results for the interaction of the $\boldsymbol{Post_t}$ dummy with an aggregated employment band. The effects of changes in training expenditure are more pronounced for medium and large firms with over 50 employees, compared to those employing fewer than 50 employees. Firms with 50-499 employees were on average 10.1% less likely to increase their training expenditure after the Referendum relative to the pre period, while the comparable decrease for firms with 500 or more employees was 8.9%.

Similarly, Table 12 also shows that the negative training effects are most significant for larger firms, as measured here by turnover.

Table 11. Post Referendum training expenditure by employment

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m down	(4) Training next 3m down
Post x 1-49	0.0183 (0.0784)	0.0765 (0.0828)	0.0193 (0.0360)	0.0185 (0.0391)
Post x 50-499	-0.101** (0.0394)	-0.0680* (0.0375)	0.0518 (0.0501)	0.00724 (0.0215)
Post x 500+	-0.0894** (0.0435)	-0.0789* (0.0460)	0.00122 (0.0115)	0.0346* (0.0198)
Observations	2663	2663	2663	2663
R^2	0.229	0.185	0.072	0.051
Industry 2 digit FE	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses. Standard errors are clustered at firm level. $*\ p < 0.10,\ **\ p < 0.05,\ ***\ p < 0.01$
Source: Authors' calculations

Table 12. Post Referendum training expenditure by turnover

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m down	(4) Training next 3m down
Post x up to GBP 500k	0.0599 (0.0831)	0.106 (0.0866)	0.251 (0.167)	0.250 (0.162)
Post x GBP 500k-GBP 10m	0.0969 (0.0717)	0.109 (0.0780)	-0.0309 (0.0447)	0.0379 (0.0425)
Post x GBP 10m+	-0.106** (0.0434)	-0.0948** (0.0453)	0.00858 (0.0123)	0.0329* (0.0196)
Observations	2663	2663	2663	2663
R^2	0.233	0.189	0.076	0.052
Industry 2 digit FE	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses. Standard errors are clustered at firm level. $*\ p < 0.10,\ **\ p < 0.05,\ ***\ p < 0.01$
Source: Authors' calculations

We define an SME as a firm with fewer than 200 employees and turnover below GBP 20m. All other firms are defined as large. We then interact the $\boldsymbol{Post_t}$ dummy with both the $\boldsymbol{SME_{it}}$ and $\boldsymbol{Large_{it}}$ dummies. The results, which are presented in Table 13, again suggest that it is larger firms that are driving the negative trends of training expenditure. Large firms were on average 9.3% less likely to increase their training after the Referendum whereas there is no discernible difference for SMEs.

Table 13. Post Referendum training expenditure for SMEs

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m down	(4) Training next 3m down
Post x SME=1	0.0105	-0.00840	-0.0333	0.00248
	(0.0394)	(0.0339)	(0.0223)	(0.0249)
Post x Large=1	-0.0927**	-0.0795*	0.00556	0.0332*
	(0.0416)	(0.0439)	(0.0125)	(0.0191)
Observations	2663	2663	2663	2663
R^2	0.229	0.184	0.070	0.049
Industry 2 digit FE	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses. Standard errors are clustered at firm level. $*\ p < 0.10,\ **\ p < 0.05,\ ***\ p < 0.01$
Source: Authors' calculations

This section has shown that the extent to which training expenditure changed after the Referendum relative to before varied across industries, regions and firm size, with differences in both magnitude and direction. It is not surprising that larger firms have responded more strongly to the Brexit vote given that they are more likely to engage in international trade in services (Breinlich and Criscuolo, 2011) and FDI (Helpman et al., 2004) and are therefore more exposed to international shocks.

Capital investment and training

Alongside human capital, firm-level physical capital accumulation is an important driver of productivity growth. The CBI Survey asks firms about expected trends in their expenditure over the next 12 months on three forms of physical capital: Land and Buildings; Information Technology (this includes hard-ware/software/personnel and any other expenses related to IT); and Vehicles, Plants and Machinery. In this Section, we document post-Referendum changes in expenditure on these three forms of capital. Note that the reference period for capital expenditure changes is 12 months whereas for training it was three months. We might expect that adjustments over a 12 month period are more likely than over a three month period. If this is the case, then the longer reference period of 12 months would lead to greater magnitudes of changes than if the question had asked for the three month period.

Key finding 5. *Firms were more likely to reduce expenditure on all forms of physical capital in the period after the Referendum relative to before.*

We estimate the same linear probability model as in Equation 2, where Y_{ijt} now represents the measure of expected expenditure on each form of physical capital. The results are presented in Table 14.

The results are qualitatively similar across all three measures of physical capital and the measure of training that was presented in Table 8. Looking first at Columns 1, 3 and 5, we see that firms were 11.9% less likely to increase expected IT expenditure, 12.7% less likely to increase expenditure on vehicles, plants and machinery, and 11.4% less likely to increase expenditure on land and buildings in the period after the Referendum relative to the period before.

Turning to Columns 2, 4 and 6 we see that there is some heterogeneity in the expected reductions in expenditure across capital types. For IT, there is no change in reductions in expected expenditure after the Referendum and there is only a 2.4% change for machinery. There was a 7.6% increase in firms

reporting a reduction in expected expenditure on land and buildings after the Referendum relative to before. The comparable change in the firms reporting a reduction in expected training expenditure was 3.2%.

Overall, the expected expenditure trends on both physical and human capital are negative and the magnitudes are similar for their different adjustment periods.

Table 14. Post Referendum expected expenditure on physical capital

	(1) IT next 12m up	(2) IT next 12m down	(3) Machinery next 12m up	(4) Machinery next 12m down	(5) Land & buildings next 12m up	(6) Land & buildings next 12m down
Post Brexit Referendum=1	-0.119**	0.00274	-0.127**	0.0243	-0.114***	0.0765**
	(0.0498)	(0.0424)	(0.0536)	(0.0203)	(0.0321)	(0.0347)
Observations	2663	2663	2663	2663	2663	2663
R^2	0.196	0.096	0.193	0.061	0.196	0.089
Industry 2 digit FE	Yes	Yes	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses. Standard errors are clustered at firm level. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$
Source: Authors' Calculations

Training after the Financial Crisis

It is clear from Figure 3 that the most notable shift in training expenditure occurred during the Great Recession. In this Section, we use our regression framework to compare the changes in training seen after the Brexit Referendum with those experienced following the Financial Crisis.

It is slightly more difficult to precisely define the onset of the Financial Crisis. The decision of the UK Electorate to vote to leave the EU was largely unexpected, as detailed in the introduction, so the responses are concentrated around the Referendum date, 2016Q2. On the other hand, the onset of the Financial Crisis was not confined to one quarter but for our analysis we define its beginning as 2007Q4. We then define the pre period as 2005Q4-2007Q3 and the Post period as 2008Q1-2010Q1. Unfortunately, our data begins at 2005Q4 so we are restricted to 8 quarters in the pre-period while we opt for 9 quarters in the post period. For the Referendum analysis, we have 9 quarters in both the pre and post period.[9]

Key finding 6. *Firms were more likely to reduce training expenditure in the period following the Financial Crisis relative to the period before*.

The results are presented in Tables 15 and 16. The number of firm-time observations is very similar across the two sample periods. The main takeaway from the tables is that the qualitative trends of training expenditure are similar for both the Financial Crisis and the Brexit Referendum, although the magnitudes are noticeably larger for the Great Recession. Column 1 of Table 15 shows that firms were 9.9% less likely to increase their training expenditure in the period after the Financial Crisis relative to the period before, while Column 3 shows that the change that followed the Referendum was very similar at 9.0%. For expectations of training expenditure, there was a 16.0% decline following the Crisis compared with a 7.7%

[9] One other difference between the two sample periods is that there is a change in the industry classification system from SIC92 to SIC07. Fortunately, every firm continues to report its SIC92 industry until 2010Q1, so we have no problem with our fixed effects specification. The main point of note is that the exact classification of the industry fixed effects differs across the two sample periods.

decline after the Referendum. This is consistent with the findings of Dhingra et al. (2017) who predict that the economic impact of Brexit is likely to be less severe than that of the Financial Crisis.

Columns 1 and 2 of Table 16 show that there were very large increases in firms reporting reductions in actual and expected expenditure after the crisis relative to before. Firms were 15.0% more likely to report reductions in actual training expenditure and 20.1% more likely to report falls in expected training expenditure after the Crisis. Here, the effects seen during the Great Recession were greater than the effects seen following the Brexit Referendum, which are represented in Columns 3 and 4.

In Annex B, we replicate Tables 15 and 16 with a sample restriction that the firm must exist in both of the estimation periods. The results are qualitatively similar, which is reassuring for the above comparisons. Interestingly, the response of these firms to Brexit is stronger than the full sample. One possible explanation for this is that the firms that survived are likely to be larger and we have shown that larger firms have responded more strongly. Another possible explanation is that these firms are behaving differently as a result of having experienced the Financial Crisis. We do not expect the results to be driven by sample selection changes as the sample size and sampling methodology has been fairly consistent over the entire period.

During the period that followed the Financial Crisis, productivity growth has been slow. One possible explanation for this is lower worker training. That training has again dropped following the Brexit Referendum is concerning for future productivity growth.

Table 15. Increases in training expenditure post financial crisis and Brexit Referendum

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m up	(4) Training next 3m up
Post Financial Crisis=1	-0.0989**	-0.160***		
	(0.0499)	(0.0466)		
Post Brexit Referendum=1			-0.0897** (0.0404)	-0.0774* (0.0427)
Observations	2790	2790	2663	2663
R^2	0.058	0.076	0.229	0.184
Industry 2 digit FE	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses. Standard errors are clustered at firm level. $*\ p < 0.10,\ **\ p < 0.05,\ ***\ p < 0.01$
Source: Authors' Calculations

Table 16. Decreases in training expenditure post financial crisis and Brexit Referendum

	(1) Training past 3m down	(2) Training next 3m down	(3) Training past 3m down	(4) Training next 3m down
Post Financial Crisis=1	0.0149***	0.201***		
	(0.0382)	(0.0485)		
Post Brexit Referendum=1			0.00444**	0.0323*
			(0.0404)	(0.0185)
Observations	2790	2790	2663	2663
R^2	0.090	0.091	0.069	0.049
Industry 2 digit FE	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses. Standard errors are clustered at firm level. $*\ p < 0.10,\ **\ p < 0.05,\ ***\ p < 0.01$
Source: Authors' Calculations

Conclusion

Investment in human capital and R&D are the key drivers of long run economic growth. We have shown in this paper that there has been a significant downturn in the proportion of firms increasing expenditure on worker training and on expectations of expenditure on all forms of capital, including IT, in the services sector since the Brexit Referendum. The changes in training expenditure that followed the Referendum are somewhat smaller than those that occurred after the Financial Crisis. In this paper, we focus on the services sector but, having checked comparable data for manufacturing, the trends appear to be robust beyond services. While we do not yet have the data to study changes associated with the Covid-19 pandemic, it is likely that similar mechanisms will act to cause a comparable, or bigger, contraction in investments in human and physical capital.

The Brexit Referendum has had wide-ranging economic impacts that have already been observed and documented. These include a slowing of GDP growth, reductions in real wages, and a contraction of international trade and inward FDI. It is therefore unsurprising that firms facing these adverse economic changes have to cut back on their investments.

This is relevant to policy makers in the United Kingdom, and its importance is amplified by the economic contraction caused by COVID-19. Costa et al. (2018) document the role of government in supporting firm-level investments. Government support can reduce the gap between the private and social returns to investment and mitigate the risk taken on by firms when making an investment. For human capital, government support can also help workers who might wish to invest in their own education and training but are credit constrained. In particular, governments are more likely to provide funding for general training than specific training relative to firms, which is important for adjusting to structural shocks such as Brexit.

The UK fiscal system has different incentives for R&D investment relative to human capital investment. It provides tax credits to increase firm level investment in R&D but, unlike in many other countries, it lacks a counterpart for human capital investment. In addition, the proportion of R&D spending to GDP in the UK is still among the lowest in the G7 and relatively low compared to many countries in the OECD (Costa et al., 2018).

The reduction of human capital investments documented in this paper will not only affect productivity growth but may also restrict the ability of workers to adapt to changes in the structure of the economy that will occur after Brexit and with ongoing technological change (De Lyon et al., 2018).

In light of the important role of capital accumulation in long run growth, the evidence presented in this paper is of particular concern for the long-run prosperity of the UK economy. The downturn in investments has reinforced the UK's trends of weak productivity and wage growth (De Lyon and Dhingra, 2019).

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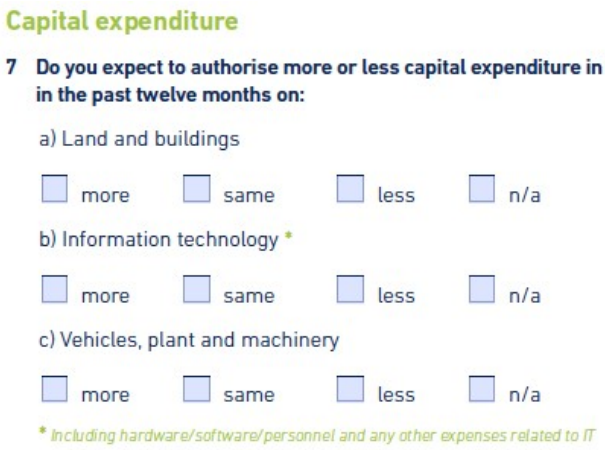
Annex A. Data

Figure A.1. CBI Services Sector Survey capital question



Source: CBI.

Table A.1. Summary statistics by time, unweighted

	Pre-Referendum mean	sd	June 2016 mean	sd	Post-Referendum mean	sd
Training expenditure: Past 3 months	0.16	0.52	0.16	0.50	0.12	0.51
Training expenditure: Next 3 months	0.20	0.54	0.24	0.52	0.15	0.54
Capital expenditure on land and buildings: Next 12 months	0.07	0.64	0.03	0.65	0.00	0.62
Capital expenditure on IT: Next 12 months	0.28	0.66	0.29	0.66	0.24	0.66
Capital expenditure on vehicles, plants & machinery: Next 12 months	0.09	0.59	0.05	0.59	0.01	0.56
Business optimism: past 3 months	0.25	0.63	0.03	0.64	-0.02	0.65
Value of business: at present relative to normal	0.08	0.64	-0.03	0.66	-0.07	0.61
Value of business: past 3 months	0.23	0.69	0.16	0.75	0.07	0.70
Value of business: next 3 months	0.26	0.62	0.12	0.65	0.10	0.62
Value of business in UK: past 3 months	0.22	0.67	0.10	0.70	0.05	0.66
Value of business in EU: past 3 months	0.03	0.40	-0.01	0.40	0.03	0.41
Value of business outside EU: past 3 months	0.06	0.39	0.06	0.38	0.05	0.40
Observations	1590		178		1617	

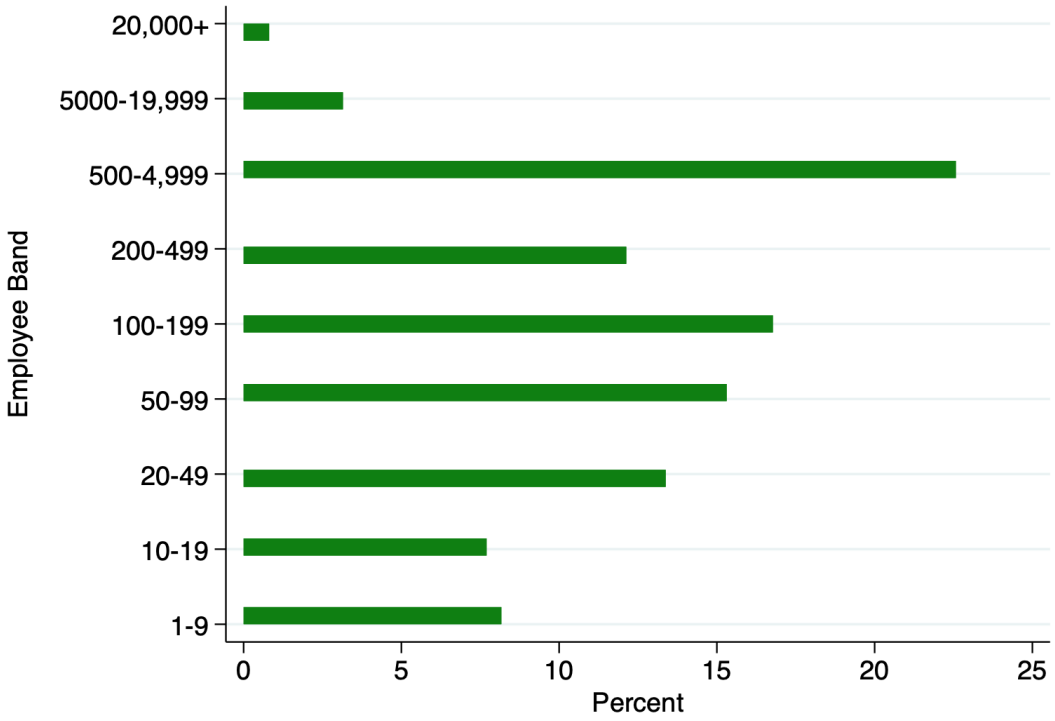
Source: Authors' calculations.

Table A.2. Sample information by quarter

	Employees	Turnover
2014q1	1400	94.4
2014q2	1175	73.2
2014q3	1275	89.9
2014q4	1226	79.1
2015q1	1322	79.9
2015q2	1416	84.7
2015q3	1618	87.6
2015q4	1428	79.7
2016q1	1557	86.2
2016q2	1227	78.2
2016q3	1642	82.8
2016q4	1426	83.1
2017q1	1293	70.4
2017q2	1181	76.7
2017q3	985	75.7
2017q4	1224	73.4
2018q1	1111	83.1
2018q2	1200	72.5
2018q3	986	60.6

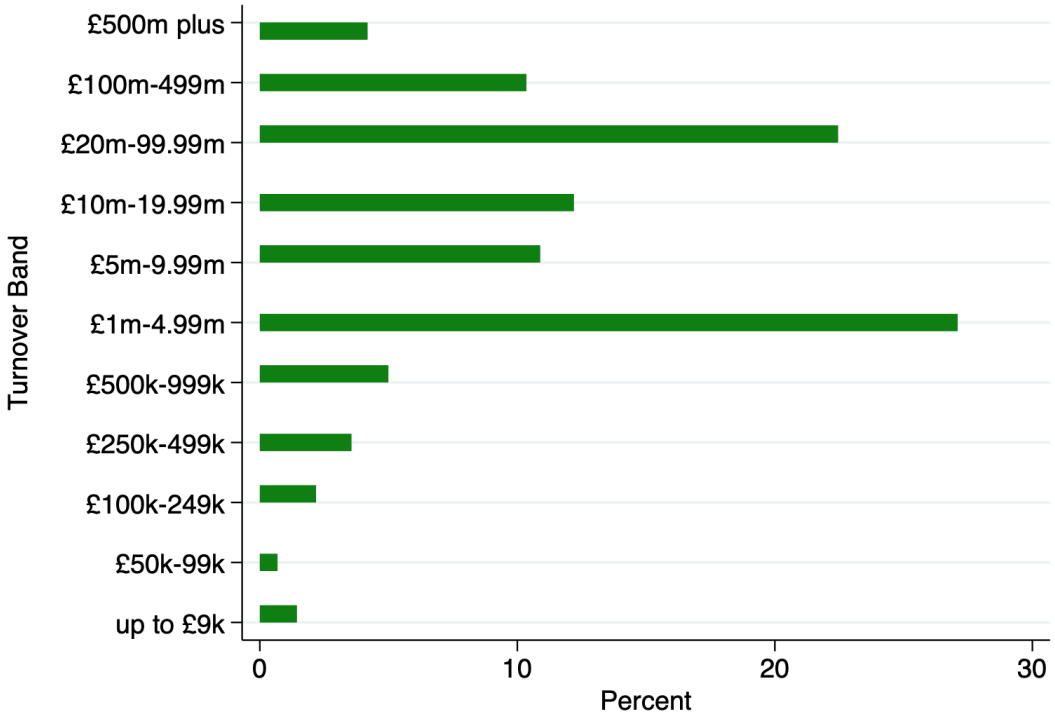
Source: Authors' calculations.

Figure A.2. Firm Employment



The sample period is 2014Q1 to 2018Q3

Figure A.3. Firm Turnover



The sample period is 2014Q1 to 2018Q3

Annex B. Robustness checks

Table B.1. Post-Referendum training expenditure with 4 digit industry FE

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m down	(4) Training next 3m down
Post Brexit Referendum=1	-0.0843**	-0.0776*	-0.0126	0.0210
	(0.0409)	(0.0433)	(0.0151)	(0.0215)
Observations	2663	2663	2663	2663
R^2	0.270	0.224	0.155	0.112
Industry FE	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses. Standard errors are clustered at firm level. $*\ p < 0.10,\ **\ p < 0.05,\ ***\ p < 0.01$
Source: Authors' calculations.

We have also tried including a firm fixed effect, whereby the baseline model can be specified:

$$\Delta Y_{ijt} = \alpha + \beta Post_t + \mu_i + E_{ijt} \quad (4)$$

where μ_i is a firm fixed effect. Other than the fixed effect, the specification is comparable to Specification 2 with 2-digit industry fixed effects for which the results are presented in Table 8. The results are qualitatively similar although there is less variation when looking within firms and the results become statistically insignificant.

Table B.2. Post-Referendum training expenditure with firm FE

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m down	(4) Training next 3m down
Post Brexit Referendum=1	-0.0368	-0.0397	-0.0106	0.0216
	(0.0396)	(0.0463)	(0.0171)	(0.0243)
Observations	2663	2663	2663	2663
R2	0.507	0.444	0.323	0.233
Industry 2 digit FE	No	No	No	No
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses, Standard errors are clustered at firm level. $*\ p < 0.10,\ **\ p < 0.05,\ ***\ p < 0.01$
Source: Authors' calculations.

Table B.3. Post-Referendum training expenditure with shorter sample period

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m down	(4) Training next 3m down
Post Brexit Referendum=1	-0.161***	-0.151***	0.0209	0.0432
	(0.0488)	(0.0568)	(0.0165)	(0.0270)
Observations	1199	1199	1199	1199
R^2	0.332	0.266	0.243	0.210
Industry 2 digit FE	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses. Standard errors are clustered at firm level. $*\ p < 0.10$, $**\ p < 0.05$, $***\ p < 0.01$
Source: Authors' calculations.

Table B.4. Post-Referendum training expenditure with longer sample period

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m down	(4) Training next 3m down
Post Brexit Referendum=1	-0.0547	-0.0566	-0.00873	0.0199
	(0.0433)	(0.0450)	(0.0117)	(0.0163)
Observations	3500	3500	3500	3500
R^2	0.250	0.202	0.070	0.058
Industry 2 digit FE	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses. Standard errors are clustered at firm level. $*\ p < 0.10$, $**\ p < 0.05$, $***\ p < 0.01$
Source: Authors' calculations.

It might be expected that training expenditure depends on macroeconomic conditions. We therefore augment Specification 2 to include the lagged growth rate of GDP as an explanatory variable.[10] The results are reported in Table B.5. The coefficients are very similar to those presented in Tables 7 and 8.

Table B.5. Post-Referendum training expenditure with GDP growth control

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m down	(4) Training next 3m down
Post Brexit Referendum=1	-0.0973**	-0.0918*	0.00355	0.0267
	(0.0484)	(0.0472)	(0.0153)	(0.0265)
Lag quarterly GDP growth	-3.123	-5.902	-0.363	-2.286
	(9.763)	(10.71)	(3.305)	(6.195)
Observations	2663	2663	2663	2663
R^2	0.229	0.185	0.069	0.049
Industry 2 digit FE	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses. Standard errors are clustered at firm level. $*\ p < 0.10$, $**\ p < 0.05$, $***\ p < 0.01$
Source: Authors' calculations.

[10] We use the lag as we expect some delay in pass-through to training.

Table B.6. Post-Referendum training expenditure without employment weight

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m down	(4) Training next 3m down
Post Brexit Referendum=1	-0.0307*	-0.0302*	0.0100	0.0179*
	(0.0179)	(0.0179)	(0.00984)	(0.00934)
Observations	3207	3207	3207	3207
R2	0.074	0.072	0.028	0.028
Industry 2 digit FE	Yes	Yes	Yes	Yes
Employment weight	No	No	No	No

Note: Standard errors in parentheses. Standard errors are clustered at firm level. $*\ p < 0.10,\ **\ p < 0.05,\ ***\ p < 0.01$
Source: Authors' calculations.

Table B.7. Post-Referendum training expenditure using minimum of employment band as weights

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m down	(4) Training next 3m down
Post Brexit Referendum=1	-0.116**	-0.117**	0.00222	0.0362
	(0.0566)	(0.0556)	(0.0102)	(0.0224)
Observations	2663	2663	2663	2663
R^2	0.229	0.189	0.088	0.064
Industry 2 digit FE	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses. Standard errors are clustered at firm level. The employment weight in these regressions takes the minimum of the firm's band instead of the median. $*\ p < 0.10,\ **\ p < 0.05,\ ***\ p < 0.01$
Source: Authors' calculations.

Table B.8. Training expenditure by year

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m down	(4) Training next 3m down
year=2014	0.314***	0.355***	0.0188	0.0237
	(0.0608)	(0.0656)	(0.0192)	(0.0171)
year=2015	0.341***	0.400***	0.00439	0.0221
	(0.0497)	(0.0661)	(0.0166)	(0.0174)
year=2016	0.230***	0.244***	0.0564**	0.103***
	(0.0495)	(0.0602)	(0.0233)	(0.0360)
year=2017	0.236***	0.293***	0.0252	0.0698***
	(0.0589)	(0.0724)	(0.0161)	(0.0251)
year=2018	0.247***	0.317***	0.00231	0.00900
	(0.0715)	(0.0820)	(0.0212)	(0.0218)
Observations	2663	2663	2663	2663
R_2	0.467	0.454	0.114	0.111
Industry 2 digit FE	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses. Standard errors are clustered at firm level. $*\ p < 0.10,\ **\ p < 0.05,\ ***\ p < 0.$
Source: Authors' calculations.

Table B.9. Increases in training expenditure post financial crisis and Brexit Referendum, with sample restriction

	(1) Training past 3m up	(2) Training next 3m up	(3) Training past 3m up	(4) Training next 3m up
Post Financial Crisis=1	-0.120***	-0.135***		
	(0.0444)	(0.0468)		
Post Brexit Referendum=1			-0.169*** (0.0557)	-0.142** (0.0666)
Observations	1374	1374	1330	1330
R^2	0.063	0.061	0.207	0.215
Industry 2 digit FE	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses. Standard errors are clustered at firm level. The samples are restricted to include only firms that are surveyed in both periods. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$
Source: Authors' calculations.

Table B.10. Decreases in training expenditure post financial crisis and Brexit Referendum, with sample restriction

	(1) Training past 3m down	(2) Training next 3m down	(3) Training past 3m down	(4) Training next 3m down
Post Financial Crisis=1	0.146***	0.175***		
	(0.0445)	(0.0336)		
Post Brexit Referendum=1			0.0103	0.176
			(0.0151)	(0.0181)
Observations	1374	1374	1330	1330
R^2	0.207	0.083	0.147	0.107
Industry 2 digit FE	Yes	Yes	Yes	Yes
Employment weight	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses. Standard errors are clustered at firm level. The samples are restricted to include only firms that are surveyed in both periods. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$
Source: Authors' calculations.