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Apprenticeships and Firm Performance an Empirical Investigation Using "Big Data" for All English Businesses

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ABSTRACT

There are quite a few robust estimates of the earnings effects of successful apprenticeships for individuals, but there is a shortage of research concerning the relationship between apprentices and firm performance, and most of this study is qualitative or based on surveys. This paper aims for an empirical investigation of this relationship using quantitative data available from large government registers. We analyse data for all English businesses, which—linked to Individual Learner Record data (ILR) for participants in apprenticeship programmes—provide structural information on apprenticeship firms and other firms for the years 2010 to 2015. The descriptions show that around 10%–15% of all eligible firms undertook apprenticeships and that apprenticeship firms are larger both in terms of turnover and employment than other firms. Regression analysis is used to explore the nature of the relationship between apprenticeships and the firms' turnover. In models employing a range of observable characteristics and using Inverse Probability Weighting to alleviate the selection into apprenticeships, our findings point towards a positive relationship between engaging in apprenticeships and firm growth, but not to a change in business productivity.

JEL Classification: D24, J24

1 | Introduction

1.1 | Motivation and Aims of This Study

Apprenticeships are an established mechanism of recruiting and training employees in the United Kingdom and many other Western economies. By firms providing on-the-job training during the apprenticeship, apprentices gain firm-specific skills relevant to their employers' business models and technologies. However, apprenticeships also create short-term costs because of training expenses, staff time and materials used to train people up to standard. A firm's decision to recruit apprentices is, therefore, made in the belief that employers achieve a higher benefit from employing apprentices—at least in the medium term—compared to alternative recruitment of employees from the local labour market. For Germany and other countries, this has been investigated in several studies (e.g. Wolter et al. 2006; Muehlemann and Wolter 2014; Mohrenweiser and Zwick 2009).

For the UK, a comprehensive evidence base for wage returns of apprenticeships to individuals has emerged in recent years, but firm-level benefits have only been studied in the German-speaking countries, often employing a cost–benefit analysis. However, the apprenticeship system in these countries is very different and unlikely to contextualise well to the United Kingdom, the U.S. or other liberal economies, which do not

involve the tight and corporatist governance of this form of education and the stakeholders involved as in Germany or Switzerland.

In this paper, taking advantage of large administrative data, we identify firms with and without apprentices across the universe of English firms between 2010 and 2015 and create Linked Employer-Employee Data (LEED) for apprenticeship firms, which we describe and analyse. A summary of the results suggests that

- Around 10%–15% of all firms engaged in apprenticeships between 2010 and 2015.
- Firms with apprentices show much larger turnover and employment. However, turnover per person is higher for firms that do not have apprenticeships.
- The results also suggest imbalances by type of business:
  - While private companies account for 68% of all businesses, public sector employers (i.e. Central Government, Local Authorities, and agencies) represent the majority of apprenticeship firms, around 77%.
  - Amongst the firms outside the business sector, education and health-related firms employ more than half of all apprentices.
  - In the private sector businesses, half of all apprentices are employed in production, construction and retail.

The descriptive comparison between firms with and without apprentices motivates an empirical investigation on the relationship between apprenticeships and firm-level outcomes, in particular, turnover per person employed. Our results show positive associations between apprenticeships and turnover ranging between 0.5% and 0.8%. Taking into consideration that structural characteristics differ between the two groups, the re-weighted estimate using Inverse Probability Weighting (IPW) ranges higher (1.7%–2.3%). We implement a range of tests to investigate whether the association found is robust. Moreover, the results also suggest that firms will have a higher positive effect when the apprentices stay longer with the firms. We have found consistent evidence that employing apprentices is positively associated with firm performance. The evidence is not causal because we can't rule out the possibility that the positive relationship is mediated by other determinants unobserved to us. However, given the magnitude and robustness of the results, it is unlikely that the positive effect of apprenticeships on firm performance is fully driven by unobserved factors.

The rest of this paper is organised as follows: Section 2 summarises the literature on apprenticeships and firm performance. Section 3 presents a brief description of the data set. Section 4 describes the empirical methodology. Section 4 presents the main findings using descriptive and regression analyses. Section A concludes.

1.2 | Policy Context

Our research focuses on apprenticeships during the period 2010 to 2015, a time when the vast majority of apprenticeships in England fell into two main categories: "Intermediate" (Level 2) and "Advanced" (Level 3). These programmes were designed to prepare individuals for skilled occupations, typically positioned below professional roles that require a university degree. Such apprenticeships are generally undertaken after the completion of compulsory general education and are primarily chosen by young people who do not intend to pursue an academic degree. The average duration of an apprenticeship is around 12 months, with most being completed within 24 months (Bursnall et al. 2017). In many respects, these characteristics align closely with the widely accepted international understanding of what constitutes an apprenticeship: a structured, work-based training pathway that bridges the gap between school and skilled employment.

In recent years, however, the apprenticeship landscape in England has changed significantly, driven by the introduction of the Apprenticeship Levy in 2017. This levy allowed employers to use funds not only for traditional apprenticeships, but also for university-level education, and often to train existing staff rather than new joiners (Speckesser and Xu 2022). Recent policy shifts aim to redirect funding back to employer-led skills training for young people (e.g. Prime Minister's Office 2024). Measures include ending the use of levy funds for postgraduate degrees and promoting shorter, more targeted programmes. Despite these changes, degree apprenticeships now account for around one-third of all apprenticeships (Department for Education 2024), while the remainder continues to be concentrated at Levels 2 and 3.

Another significant trend is the sharp decline in total apprenticeship starts. Numbers fell from a peak of over 450,000 in 2010/11 to 339,580 in 2023/24, with Level 2 and 3 programmes comprising 64% of the total (Department for Education 2024). A key factor in this decline was the 2010 cut to vocational funding for adults aged 19 + , which was later partially substituted in 2013 with "Advanced Learning Loans" for those 24 and over.

The findings from our study should therefore be understood as representative of apprenticeships during the period of our study. However, they remain broadly indicative of the form of firm-based training that is commonly recognised as an apprenticeship, and also represent the sort of programme the current government seeks to prioritise. Under this model, apprentices normally spend most of the time (around 30 h per week) in the workplace, while attending college for a day per week, or as block release. On completion, successful apprentices then acquire a recognised qualification: Successful completion of Intermediate Apprenticeships results in a Level 2 qualification of the Regulated Qualifications Framework (RQF), while Advanced Apprenticeships entail Level 3 qualifications.

While in the past, the curriculum and assessment of apprenticeships had been created by Sector Skills Councils (SSCs), the recent reforms of vocational education in England moved regulation to a central government agency, the *Institute for Apprenticeships*. At present, apprenticeship standards are available for about 300 roles across many sectors, but many more apprenticeships have been proposed.[1] Most of the apprenticeships started at this moment in time; however, are still very similar to the cohorts studied in this paper and hence, the firm-level analysis of this paper here is still highly relevant to current apprenticeships and their main features.

2 | Literature Background

2.1 | Findings From Theory

From economic theory, there are several mechanisms suggesting that firms could benefit from apprenticeships. First, they have long been seen as an effective method to screen the productivity of potential future workers: During the extended period of apprenticeships, employers can fully understand the productivity of their potential future employees.

Second, an apprenticeship is an effective way to improve the productivity of the workers compared to other types of education. It allows the employees to obtain industry and firm-specific skills. When the costs of recruiting qualified workers are relatively high, opportunity costs to provide apprenticeships are consequentially lower and employers are more willing to take on non-qualified staff and to train them to the required standard. Costs of apprenticeship training are multi-faceted, for instance, the duration and intensity of training, the proportions of firm-specific and general skills, the nature of production, the labour market competition, the structure of payment (Muehlemann and Wolter 2014). Dustmann and Schönberg (2012) show that the firm-based training is more successful in countries where there is a higher commitment to training provision.

Third, employees engaged in apprenticeships tend to have longer tenure with the firm and hence reduce labour turnover, which lowers recruitment and retraining costs for the firms (Gambin et al. 2010). This also lowers the cost when the firms are recruiting the new employees (Stevens 1994) as any recruiting is time-consuming and risky because newly recruited employees have a higher rate of labour turnover. Mueller and Schweri (2015) argue that 1 year after the apprenticeship, mobility is high and wages do not change significantly after moving to another firm within the same sector in Switzerland. This result implies that the skills within the same occupation are highly transferable and hence, the firm-specific skills seem not to play a major role in determining the wages. The authors conclude that it is the apprentices who bear the burden of most of the cost during the apprenticeships, and that it is the firms that benefit from the apprenticeships in the presence of considerable costs for firms searching for and training recruits from an external labour market. But the costs will be reduced if there are sufficient supplies of mature apprentices on the labour market.

Finally, in an imperfect labour market, firms can benefit from apprenticeships by taking advantage of the difference between the lower wages of the apprentices and their marginal productivity (Stevens 1994; Acemoglu and Pischke 1998).

2.2 | Findings From Empirical Research

While an increasingly comprehensive evidence base is emerging on the individual earnings returns associated with apprenticeships in England (e.g. Cavaglia et al. 2020; Fuller and Unwin 2017 and McIntosh and Morris 2018), there are only a few quantitative papers researching the effect of apprenticeships on firm-level outcomes. Most firm-level studies rely on survey data of employers, which aim to quantify the expenditures and benefits of individual apprenticeships to employers. These studies consider the expenditure related to training, both direct expenses including the apprentices' wages and training costs, as well as indirect costs, i.e. primarily staff time dedicated to apprenticeship training, and contextualise these costs to short-term benefits during the apprenticeships and long-term benefits, subject to discounting.

Regarding short-term firm outcomes, apprenticeships in the UK have been found to create net costs on completion historically (e.g. Woodward and Anderson 1975, and Gambin et al. 2010), although most of this study is primarily descriptive. More recently, research on the firms' response to the apprenticeship levy introduction, including Crowley (2024), points to a drop of apprenticeship vacancies—especially for young people seeking intermediate skills—reinforcing evidence that apprenticeships have not significantly improved workforce productivity or firm profitability. Research at the sector level (biosciences and manufacturing) suggests that apprenticeships are less effective than graduate recruitment for medium-skilled roles due to regulatory demands making apprenticeship pathways longer, costlier and riskier for employers, whereas graduates can be trained for specific roles more quickly (Lewis 2020; Benassi et al. 2022).

Long-term returns to expenditure are also likely in apprenticeship systems, which create net employer costs upon completion of apprenticeships, as seen in Germany. However, Wolter et al. (2006) argue that these costs prevent employer engagement in apprenticeships in Germany or result in reduced training during the apprenticeship. Based on linked employee-employer data for Germany, Mohrenweiser and Zwick (2009) provide some evidence on firm-level benefits from hiring apprentices rather than unskilled workers. Muehlemann et al. (2010) estimate firm net benefits of apprenticeships using firm-level surveys for Germany and Switzerland. They argue that the firms tend to make a substantial net investment in apprenticeships in the presence of strong employment protection law in the short term, but that most firms will recoup the training costs within the training period (Muehlemann and Wolter 2014).[2] Similarly, Kriechel et al. (2014) examine the net benefit of the apprenticeships based on German firm-level data. This study suggests that firms face significant costs of training but experience high benefits after the training because of improved staff retention. There is also some evidence that not only firms operating apprenticeships benefit, but that indirectly, firms in the same local areas also benefit through improved access to a skilled workforce, improving job matching and productivity (Mueller and Schweri 2015).

For England, to our best knowledge, in addition to the descriptive policy research cited above, we don't know of quantitative studies examining the relationship between apprenticeships and firm-level outcomes more generally. Closest to such a design is the study by Gambin et al. (2010), which is based on qualitative research from about 80 businesses from specific sectors engaged in apprenticeships on the costs and benefits of apprenticeships, similar to earlier studies for Germany and Switzerland. Gambin et al. (2010) find significant

net costs to firms when apprenticeships are completed, with substantial variation by the sectors of the firms, which are recouped through extended staff retention and post-apprenticeship benefits to employers, see also Hogarth et al. (2012). As a way of training and recruiting employees, Ryan et al. (2007) discuss the contribution of apprenticeship and argue that apprenticeship is not cost-effective than recruitment and upgrade in the firms they surveyed.

3 | Data

We use large-scale administrative data at the universe level from two different sources. First, we make use of the Individualised Learner Record (ILR) data, i.e. records for every apprentice, which are kept for education funding purposes and statistics on education participation and achievement. These data include beginning and ending dates of the apprenticeships as well as outcome information on completion and achievement of learning aims associated with apprenticeships, all with daily precision.

For this paper, we used a firm identifier included in the ILR to find the firms that record employing apprentices during the academic years 2010/11 and 2014/15. Then, we merge the subgroup of apprenticeship firms into the universe of all British firms, the Business Structure Database (BSD), kept by the UK Office for National Statistics (ONS). The BSD contains only a few characteristics, but these are available for virtually all businesses in the UK. Variables include the entry in the company register, the annual turnover and the number of employees by the end of the financial year, as well as some information on ownership structure, sector, local area, etc. Because the BSD include many very small businesses with only one or a few employees, unlikely to engage in apprenticeships, we exclude micro businesses with fewer than five employees from the analysis.

Using this structure, we construct a panel data set, which includes annual information on firm-level outcomes (sales and the number of employees) as well as participation in apprenticeships for the years 2010–15. While data on business volume is very precise, there is a lack of both information on capital and labour employed in production (and their skills levels, productivity and working hours) as well as intermediate inputs in production, which we plan to further investigate in a subsequent analysis including business survey data.

To discuss other channels of apprenticeship, we merge the BSD data with the Annual Business Survey (ABS), which contains more detailed information regarding firm's inputs and outputs for a sample of all BSD firms. The ABS, also available from the Office for National Statistics, is used to produce official business statistics outside the financial sectors and includes turnover, purchases, employment costs, capital expenditure and stocks.

4 | Empirical Approach

The effects of existing on-the-job training have been largely examined (Hellerstein et al. 1999; Konings and Vanormelingen 2015). In this paper, we examine the association between employing apprentices and the performance of firms without making any causal claim. In this setting, firms start engaging with apprenticeships at a particular point in time and employ them subsequently, while other firms don't engage with apprenticeships, but the business outcomes of both types of firms develop along a common trend. Firms observed to start employing apprentices in any of the years between 2011 and 2015 adopt the fundamental "treatment" in that year. The other firms from the BSD universe are then used to capture the common trend, caused by other factors which may enter the equation. As the choice of employing apprentices is endogenous, the estimate only suggests the impact of employing apprentices on a firm's turnover. More specifically, we estimate the following empirical relationship:

$$\ln Y_{jt} = \alpha Treat_{jt} + \beta Year_{jt} + \gamma Treat_{jt}{*}Year_{jt} + X_{jt} + \varepsilon_{jt}$$

Where $\ln Y_{jt}$ is the natural log of relevant firm outcomes in firm j at year t. In this study, we examine the impact of apprenticeships on firm performance, using turnover per person as a key measure of labour productivity. This metric, widely recognised at both firm and industry levels, serves as a proxy for performance by dividing total output by employment (Gebreeyesus 2008; Khanna and Sharma 2018; O'Mahony and Timmer 2009; Graetz and Michaels 2018). In the absence of firm value-added data, we rely on annual total output divided by employment to assess firm performance. This approach allows us to effectively evaluate how apprenticeships influence productivity and overall firm success.

$Treat_{jt}$ denotes the "treatment", i.e. the employment of apprentices. As not all the firms are observed with apprentices in all of the years between 2010 and 2015, the variable showing the treatment $Treat_{jt}$ is one in the year a firm is observed to employ apprentices. $Year_{jt}$ denotes the calendar year between 2010 and 2015, and X_{jt} represent important firm characteristics, such as total employment and the age of a firm.

Our final data set is a balanced panel of firms observed from 2011 to 2015. We excluded firms with fewer than five employees and firms established after 2011. The unique nature of apprenticeships, characterised by lower wages during training, presents a complex issue. This can lead to lower labour costs and potentially higher productivity for firms. Additionally, the staggered employment of apprentices causes some firms to transition from the control group to the treatment group. The structure of the sample is shown in Table A1. To address potential endogeneity from sample selection, we included all firms that employed apprentices, regardless of whether their apprentices completed training. Firms in the treatment group have had apprentices since they started employing apprentices, whether in training or completed, which influences productivity changes. To ensure the robustness of our analysis, we also examine the relationship on a 'Reduced Sample' that excludes firms which ceased employing apprentices after initially hiring them. By concentrating on firms with consistent apprenticeship engagement, we aim to provide a clearer understanding of how apprenticeships influence firms' performance.

One fundamental assumption is that both the groups of firms with and without apprentices follow the same "common trend" in the absence of treatment. Since firms observed in the data begin employing over time between the years of 2010 and 2015, this assumption is subject to tests with empirical data for firms in the years they are observed without apprenticeships ("common trends tests").

The decision of a firm to employ apprentices is likely driven by observable and unobservable differences between firms, including firm outcomes like productivity and business volume, and is therefore endogenous in these outcomes. Estimating the relationship between apprentices and firm outcomes requires addressing these differences between groups of firms with and without apprentices. As shown in the descriptive part below, we observe substantial differences in the characteristics of firms with and without apprentices, which should be further addressed. In this paper, we therefore additionally implement an Inverse Probability Weighting (IPW) approach, which constructs a re-weighted group of non-apprenticeship firms, similar in mean observable characteristics to the apprenticeship firms. The "matching" variables of the IPW include predetermined variables of firms, such as annual sales and the number of employees in previous years. We expect that the trajectory of firms will largely capture both observed and unobserved differences between firms with and without apprentices.

This adjusts the empirical model to show that the potential treatment is determined as:

$$T^*_{t+1} = \alpha Z_{it} + \epsilon_{it},$$

$$T_t = 1 \text{ if } T^*_t \geq 0 \text{ and } T_t = 0 \text{ if } T^*_t < 0$$

While the probability of getting treated is:

$$\Pr(T_{it+1} = 0 | X_{it},\ Z_{it_0},\ S_{it}) = \Pr\left(T^*_{t+1} < 0\right) = F_\epsilon(-\alpha Z_{it} - \epsilon_{it})$$

We further assume that ϵ_{it} follows a normal distribution. T^*_t denotes the potential status of employing apprentices, partially determined by observed and unobserved characteristics of firms. We seek to balance the firms with and without apprentices based on historical information of firms. Including the lagged value of the dependent variable in this way, i.e. outside the structural model, has been used extensively in the literature to address the attrition, following Fitzgerald et al. (1998) and Wooldridge (2007). The set of conditioning variables Z_{it} includes predetermined outcomes S_{it}, observables X_{it} and historical information Z_{it_0} of the firms' employment and turnover before 2010.

5 | Empirical Investigation

5.1 | Characteristics of Apprenticeship Firms and Other Firms

Table 1 provides a summary of the data for firms included in this analysis for the two groups with and without apprentices in the time period between 2011 and 2015. We focus on the main firm's demographics available from the BSD, such as turnover and employment. The results show that in any 1 year, between 10% and 15% of all firms engage in apprenticeships. The turnover and employment of firms with apprentices are much larger than firms without apprentices. However, the turnover per person suggests the other way around. The firms which don't engage with apprentices have higher turnover per person. Not much difference was found for the age of firms when comparing both groups.

Figure 1 describes the distribution of firms of different sizes when employing (or not) apprentices over the period of observation. As can be seen from the histograms, firms employing apprentices are more often found to be of larger size, while the smallest firms (between five and ten employees) are underrepresented (15% of the apprenticeship firms are in this size band compared to 33% of the non-apprenticeship firms).

Table 2 describes the proportion of firms with apprentices across types of firms. It shows that of the about 950,000 companies, which represent almost 70% of all businesses, only 13% are employing apprentices in the period 2010–15. Of the next two most frequent types of business (Sole proprietor and partnership, together more than 22% of all businesses), only 8% employ apprentices. In contrast, between 32% and 46% of all public sector organisations employ apprentices.

Table 3 describes the proportions of firms employing apprentices by industries across the commercial and noncommercial sectors. This table shows great imbalances in the sectoral distribution of apprenticeship firms: Amongst the companies, half of the apprenticeship businesses are found in three sectors (production, construction and retail). Another 13% of all apprenticeship firms are operating in the health and care sector. In the noncommercial sector, health, education and arts dominate the apprenticeship employers, representing 70% of all businesses.

5.2 | Business Development of Apprenticeship Firms and Other Firms

To show the differences in firm-level outcomes of apprenticeship firms and other firms, we describe the development of turnover per person employed during the period 2010–2015, see Figure 2. As over time more businesses become employers of apprentices, we describe the apprenticeship firms separately for groups of firms observed in the particular years the first time as employers of apprentices. The graph shows that firms, which never employ apprentices, follow a similar trend like firms starting to employ apprentices during this time period. The firms with apprentices are grouped into five groups based on the year of starting to employ apprentices.

Panel A describes the turnover per person[3] over the years based on these firms compared to the firms that never employ apprentices. Overall, the lines suggest a very similar development, with firms never employing apprentices, which suggests that the firms follow a common trend. Across all groups, turnover

TABLE 1 | Summary of variables.

	Apprenticeship firms		Other firms	
	Mean	**Standard Dev.**	**Mean**	**Standard Dev.**
Turnover (million £)	42.55	728.8	6.88	292.2
Number of employees	323	2916.9	37	291.1
Turnover per person (million £)	0.10	1.1	0.15	7.4
Age of firm (years)	22	11.2	21	11.3
Historical information				
Turnover in 2010 (million £)	50.42	907.5	7.7	332.1
Employment in 2010	330	3052.1	36	297.5
Turnover in 2009 (million £)	44.9	740.6	6.7	256.3
Employment in 2009	324	3009.1	35	308.1
Turnover in 2008 (million £)	42.3	773.5	6.3	256.0
Employment in 2008	319	2994.8	34	297.2
Calendar years	% of firms with apprentices			
2011	7.8%			
2012	12.1%			
2013	14.6%			
2014	15.8%			
2015	11.2%			

Note: Firms registered after 2011 have been excluded. The final data set selected for this analysis is a balanced panel of firms observed in all years (2011–15), i.e. firms which ceased trading between 2011 and 2015 were excluded. Firms with fewer than five employees had been excluded.

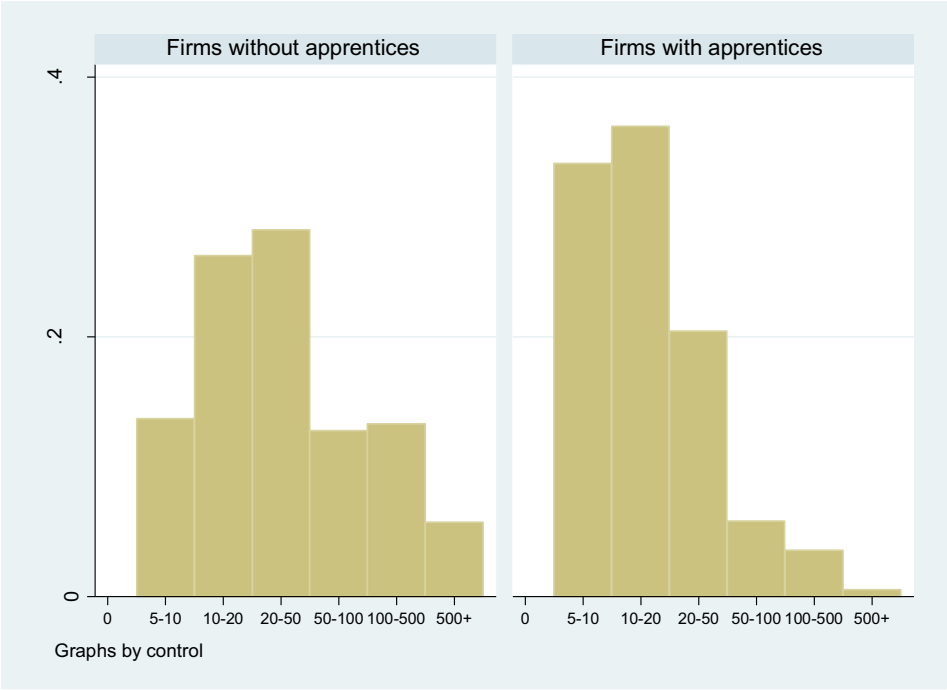


FIGURE 1 | Histogram of sizes of firm. *Source:* ILR-BSD.

per person decreased between 2011 and 2014 and increased again from 2015.

Panel B describes percentage differences in the measure of turnover per person among firms with apprentices (and by year when they started employing them) compared to the non-apprenticeship firms. This graph exhibits changes in this outcome following the decision to employ apprentices relative to the trend of non-apprenticeship firms. Over time, the turnover per person increases after firms start to employ apprentices

TABLE 2 | Firms with or with apprentices by type of business, 2011–15.

Types of firm	Proportion of firms with apprentices	Observations	Column % all firms
Company	13%	949,253	69.0%
Sole proprietor	8%	109,257	8.0%
Partnership	8%	194,669	14.2%
Public corporation	39%	901	0.1%
Central government	46%	6512	0.5%
Local authority	32%	8942	0.6%
Non-profit bodies	15%	105,501	7.7%
Total	12%	1,375,035	100%

Note: The first column describes the proportions of firms that have apprentices under each category.

TABLE 3 | Apprenticeship and non-apprenticeship businesses by of industry.

	Company		Non-company	
Industry	Apprenticeship firms	Other firms	Apprenticeship firms	Other firms
Agriculture	0.7%	1.5%	1.2%	5.7%
Production	18.8%	16.3%	1.1%	3.3%
Construction	10.8%	9.5%	1.3%	2.8%
Wholesale and retail	18.9%	23.0%	5.3%	15.2%
Transport	3.2%	4.2%	0.8%	2.5%
Accommodation	7.3%	7.3%	7.9%	13.7%
Information	3.2%	5.1%	0.2%	0.4%
Finance	1.6%	2.4%	0.3%	0.6%
Property	1.5%	2.6%	1.8%	2.0%
Professional	7.1%	10.5%	5.7%	8.9%
Business admin	6.3%	8.2%	1.0%	3.3%
Public admin	—	—	2.4%	0.8%
Education	2.4%	1.3%	15.3%	5.1%
Health	12.7%	3.5%	43.0%	24.4%
Arts	5.5%	4.8%	12.5%	11.5%
Total	100%	100%	100%	100%

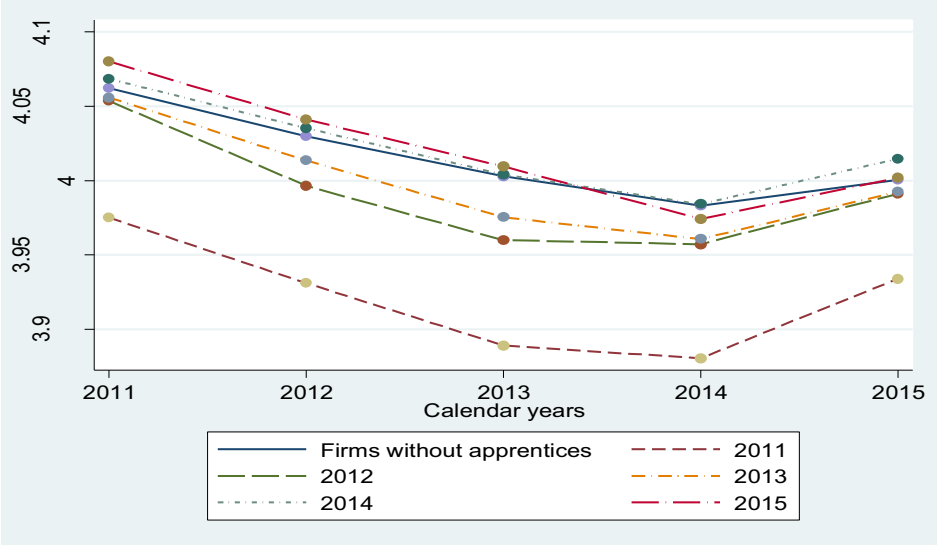
Note: Non-companies include sole proprietor, partnership, public corporation, central government, local authority, and non-profit bodies.

compared to non-apprenticeship firms, at least in the year after they first started employing them, while it is lower in the year when this happens. Such a pattern would indeed be plausible as the (mainly) Intermediate Apprenticeships are completed after about a year, causing short-term costs to businesses, shown by reduced business activity, until a year later, business performance starts to benefit from the investment in apprenticeships, shown by higher turnover per person.

To directly describe the impacts of apprentices on firms, Figure 3 presents the changes in a firm's employment and annual sales per person based on years of employing apprentices, including only firms with apprentices. The negative numbers in the Figure represent the years before employing apprentices, from minus four, and the positive numbers denote the years after employing apprentices. In the first panel, the firm's employment significantly increases when starting to employ apprentices, and then it decreases in the first year as apprentices may leave the firm after finishing their apprenticeships. And the employment starts to grow in the second year.

In the second panel, it shows that the firm's performance decreases over time, possibly due to the macroeconomic environment after the Great Recession, and experiences a significant decrease at the year of starting to employ apprentices. This might be due to the fact that there is intensive training at the beginning of apprenticeships. But the firm's performance quickly regains to the original level after the first year of employing apprentices, and the performance slowly increases after employing apprentices. Firms can either modify the production process or replace the normal employees with apprentices to fully leverage the advantages of employing apprentices. However, the structural changes within the firm remain unobserved as no further information on the composition of the firm's

Panel A, Log of turnover per person employed.



Panel B, Percentage differences in turnover per person employed between apprenticeship firms and other firms.

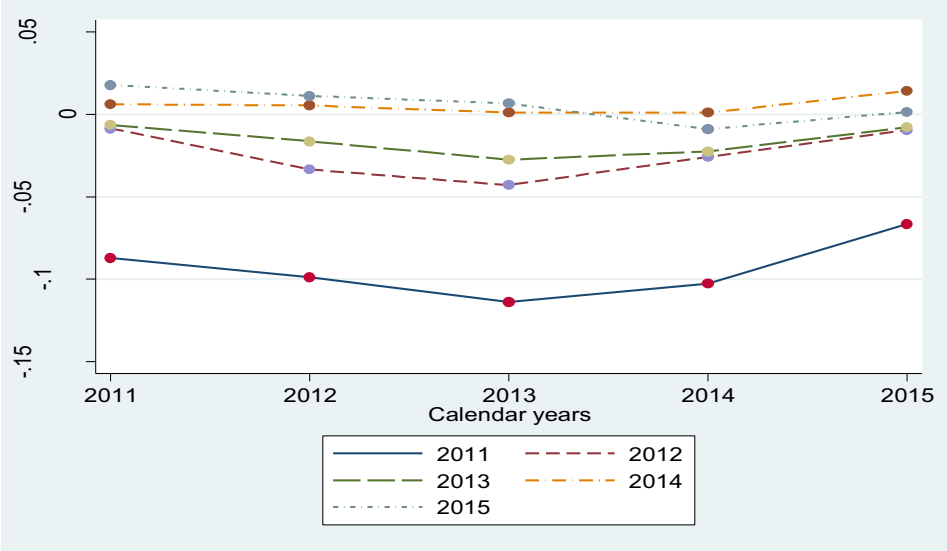


FIGURE 2 | Log of turnover and changes in the log of turnover over the years. Panel A, Log of turnover per person employed. Panel B, Percentage differences in turnover per person employed between apprenticeship firms and other firms. *Notes:* Each line represents the corresponding group. The control group includes firms which don't have apprentices. Other lines refer to the firms when they start employing apprentices. For instance, "2012" refers to the firms which start employing apprentices at 2012. *Source:* ILR-BSD.

employment is available. It suggests that the apprenticeships could be a promising approach to help firms improve the turnover per person.

5.3 | Association of Apprenticeship Employment and Firm-Level Outcomes

Based on the approach outlined above, we estimate the empirical relationship between apprenticeship employment and firm-level outcomes. The findings are summarised in Table 4. Due to the limited number of firm outcomes available from the Business Structure Database, we focus on turnover and turnover per person employed as a crude measure of business performance and productivity. We show OLS and IPW-adjusted regressions in columns 1 and 2, comparing estimates of an unconditional specification with one including control variables (log of employment, location of firms, age, industries and types of firms). Furthermore, we show results when restricting the treatment group by excluding firms that no longer employ apprentices ("reduced sample") in columns 3 and 4. As discussed previously, apprenticeship firms and other (i.e. the unadjusted "control group") look very different, which supports the IPW adjustment. In implementing IPW, we condition on information before the period observed with apprenticeships, in particular, turnover and employment between 2008 and 2010.

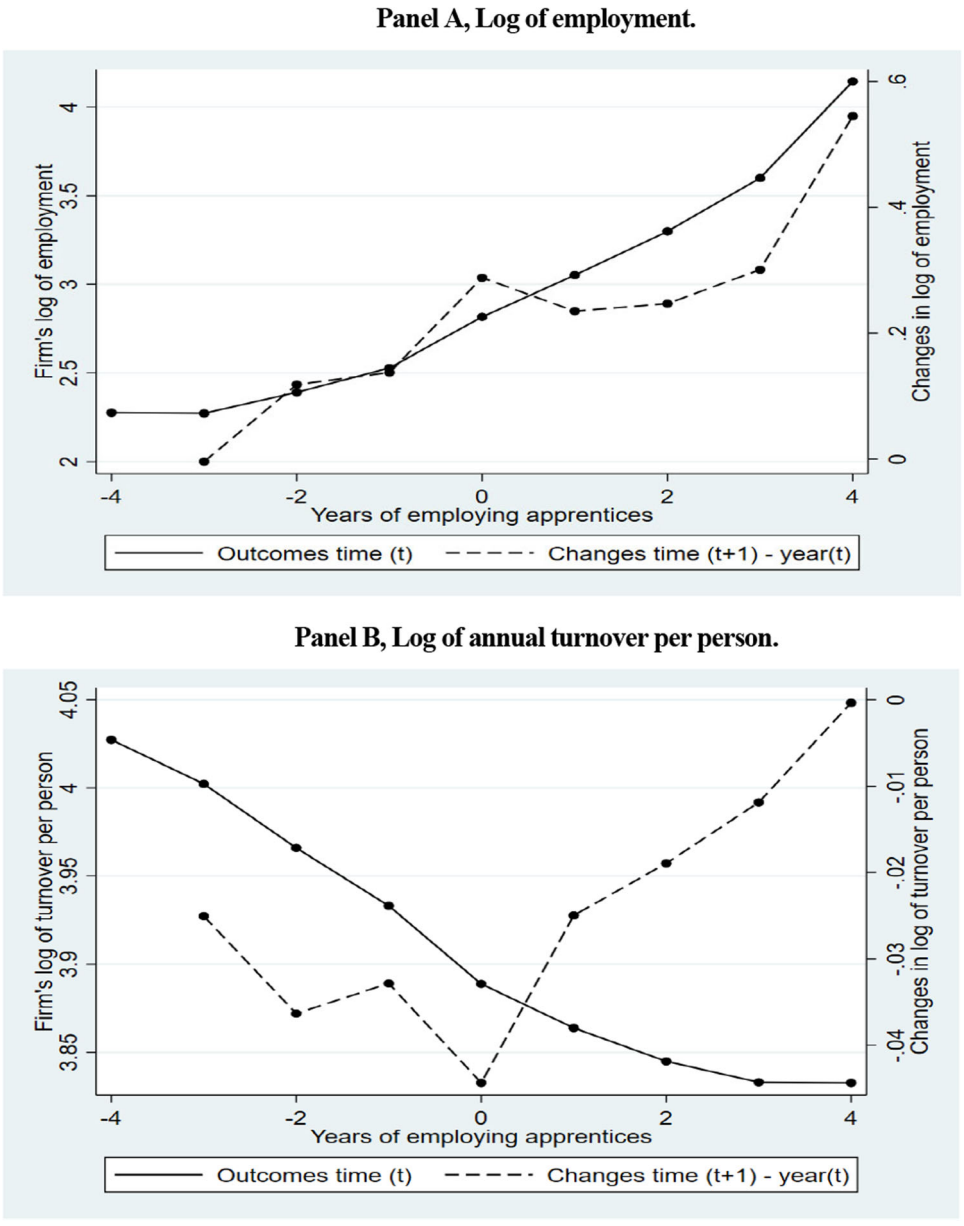


FIGURE 3 | Changes in the firm's performance after employing apprentices. Panel A, Log of employment. Panel B, Log of annual turnover per person. *Note:* The log of employment and turnover may help reduce the skewness in the distribution. *Sources:* ILR-BSD.

The unconditional regression results show that starting to employ apprentices has a positive association with firm growth and—compared to counterfactual—the turnover increases by 0.5%–0.8%. The results between turnover and turnover per person display a very similar pattern. After accounting for observable characteristics, the impact of employing apprentices increased by 0.3%, and this is consistent based on the reduced sample after excluding firms that lost apprentices during our sample period.

When adjusting historically observable differences with IPW, the relationship remains significant and the magnitude increases (to 1.7–2.3%). In general, the magnitude of the effect of employing apprentices on turnover increases significantly after re-weighting from 0.6% to 2.3% without controls and from 0.8% to 1.8% with controls, respectively. The effect on turnover per person without controls increases from 0.6% to 2.2% after being adjusted by IPW (0.8% to 1.8% when including control variables). By using historical variables including a firm's fixed characteristics, turnover, and employment between 2008 and 2010, IPW aims to balance the observed differences in firms between treatment and control groups. The sharp difference between OLS and IPW suggests that the firms differ between the treatment and control groups even after controlling the observables. The decision of taking on apprentices is complex and doesn't depend only on the observed characteristics. The historical information is predictive in the decision on employing apprentices. We believe that IPW estimates provide a robustness check and a less biased estimate due to their ability to address the imbalance between the treatment and the control groups based on the historical trajectory. The larger effects of IPW compared to OLS also imply that historical

TABLE 4 | The impact of apprenticeships on firms' turnover.

Log of turnover	(1)	(2)	(3)	(4)
OLS				
Apprenticeship effect on turnover	0.00590***	0.00804***	0.00612***	0.00824***
	(3.31)	(5.25)	(3.49)	(5.35)
Apprenticeship effect on turnover per person	0.00590***	0.00807***	0.00621***	0.00826***
	(3.31)	(5.27)	(3.54)	(5.36)
N	1,375,035	1,375,035	1,338,667	1,338,667
IPW				
Apprenticeship effect on turnover	0.0230***	0.0177***	0.0232***	0.0177***
	(9.48)	(7.97)	(9.56)	(7.98)
Apprenticeship effect on turnover per person	0.0219***	0.0183***	0.0222***	0.0183***
	(8.84)	(8.21)	(8.95)	(8.23)
N	1,282,955	1,282,955	1,248,886	1,248,886
Specifications				
Controls	No	Yes	No	Yes
Reduced sample	No	No	Yes	Yes

Note: The reduced sample excludes firms which lose apprentices during the period. The control variables include log of employment, location of firms, age of firms, industries, and types of firms. The IPW is based on the historical information, including the firm's fixed characteristics and turnover and employment between 2008 and 2010. Since firms between treatment and control groups are seriously unbalanced, the IPW is used to relax the unbalanced observable characteristics. There are fewer firms in the IPW sample which excludes firms without historical information. *t* statistics in parentheses, $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

TABLE 5 | Firms' outcomes before employing apprentices ("placebo" tests).

	(1)	(2)	(3)	(4)
OLS				
Apprenticeship effect on turnover	0.00331	−0.00545	0.00861	0.000572
	(0.56)	(−1.11)	(0.85)	(0.07)
Apprenticeship effect on employment	−0.0607***	0.00194	−0.0303**	−0.000734
	(−9.39)	(0.63)	(−2.73)	(−0.10)
Apprenticeship effect on turnover per person	0.00209	−0.00548	0.00798	0.000562
	(0.36)	(−1.12)	(0.79)	(0.07)
N	1,169,544	1,169,544	1,137,187	1,137,187
IPW				
Apprenticeship effect on turnover	0.0225**	0.00113	0.0175	0.000473
	(2.99)	(0.18)	(1.43)	(0.05)
Apprenticeship effect on employment	−0.151***	0.00112	−0.0891***	−0.00937
	(−11.73)	(0.30)	(−4.23)	(−1.17)
Apprenticeship effect on turnover per person	0.0144	0.00244	0.0125	0.00126
	(1.95)	(0.39)	(1.04)	(0.12)
N	1,089,897	1,089,897	1,059,722	1,059,722
Specifications				
Controls	No	Yes	No	Yes
Setting	One year before	One year before	Two years before	Two years before

Note: The dependent variable is the log of turnover, employment and turnover per person one year or two years before employing apprentices. The placebo treatment variable consists of the year before firms actually employ apprentices. The sample for placebo regressions includes the years before firms employ apprentices. The aim of the placebo test is to examine whether firms have erratically behaviours shortly before employing apprentices. *t* statistics in parentheses, $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

performance is negatively associated with the decision to take on apprentices.

In addition, as some firms lose apprentices and become "non-apprenticeship" businesses (especially small firms, which employ only one or two apprentices), some attrition bias may affect the empirical relationship. We test for the sensitivity of this by excluding such firms (Columns 3 and 4), but the results remain broadly in line with the full database.

To further test whether the relationship is robust, we carry out "pretreatment" tests to explore whether increasing turnover of apprentices might be driven by idiosyncratic factors or unobserved characteristics. These tests should not bring any significant findings if firms—in the absence of the decision to engage in apprenticeships—are following common trends. In practical terms, the tests are carried out in samples of apprenticeship firms in the time period before they actually recruit apprentices and the control group of firms never employing apprentices (IPW adjusted). Table 5 presents the pretreatment tests for firm outcomes one and 2 years before they begin employing apprentices. Columns 1 and 2 display outcomes from 1 year prior, both with and without control variables. Columns 3 and 4 extend this analysis to 2 years before employing apprentices. The upper panel displays the robustness tests using OLS, while the lower panel shows results from IPW. The results show insignificant coefficients for turnover and turnover per person employed in all specifications. For the employment and turnover, the results suggest a negative relationship in the pretreatment period, which is, however, not significant when including control variables. The magnitude of the coefficient also decreases close to zero when adding fixed effects.

Finally, we explore whether the relationship between apprenticeships and firm-level outcomes is time-constant or varies over the time observed for firms after first adopting apprenticeships. Table 6 presents such "cumulative effects" for up to 4 years after firms initially engage with apprenticeships, again with and without controlling for differences in firm characteristics, which – when included – suggest that the relationship is largely driven by firm differences. The first two columns use the full sample, while columns 3 and 4 are based on the reduced sample. As expected, the positive empirical association increases over time, from 3% in the first year to 11% in the fourth year after the inclusion of control variables (Column 2). The estimates based on the "reduced sample" are comparable to findings for all firms (Columns 3 and 4). This aligns with our expectation that the positive effect of apprentices increases over time, particularly after the completion of those who are still in training during the first two years. The smaller yet positive effect observed in the first year may be associated with the adoption of high-performance work practices associated with the employment of apprentices.

Table 7 summarises some of the heterogeneity explored in the association between apprenticeships and firm-level outcomes (based on all firms and IPW-adjustments). The first two columns report the effects for firms in the service versus non-service sectors. Columns 3 and 4 present the results by firm age, distinguishing between 'old' and 'new' firms. Finally, columns 5 and 6 show the results by firm size. This table shows that the relationship is stronger for businesses outside the service sector. We also find that "old firms" (operating for more than 10 years) are driving the positive outcomes found in the overall group, and that the association is stronger for larger firms of 500 employees or more, compared to small firms.

5.4 | Apprenticeships and Productivity

To explore a wider set of firm outcomes affected by employing apprentices, we merged the ILR-BSD universe data to the Annual Business Survey (ABS), which contains detailed data on inputs and costs. We are particularly interested in whether a firm's productivity is influenced by employing apprentices, as is suggested by some of the literature and whether the firms experience a change in labour costs. The summary of the sample of firms retrieved in the ABS can be found in Tables A2 and A3

TABLE 6 | Relationship between employing apprentices and turnover growth over time.

Log of turnover	(1)	(2)	(3)	(4)
Apprenticeship effect in year 1	0.0993***	0.0304***	0.0992***	0.0302***
	(15.48)	(6.64)	(15.52)	(6.61)
Apprenticeship effect in year 2	0.126***	0.0362***	0.126***	0.0361***
	(14.03)	(5.65)	(14.06)	(5.63)
Apprenticeship effect in year 3	0.188***	0.0678***	0.188***	0.0676***
	(12.42)	(5.81)	(12.45)	(5.79)
Apprenticeship effect in year 4	0.264***	0.110***	0.264***	0.111***
	(9.71)	(5.71)	(9.74)	(5.72)
N	1,282,955	1,282,955	1,248,886	1,248,886
Specifications				
Controls	No	Yes	No	Yes
Reduced sample	No	No	Yes	Yes

Note: The effects are much larger than the main results. That might be due to the fact that many firms do not have stable apprentices. *t* statistics in parentheses, $*p < 0.05$; $**p < 0.01$; $***p < 0.001$.

TABLE 7 | The heterogenous impacts of apprenticeships on firms' turnover.

	(1) Service	(2) Non-service	(3) Young firms	(4) Old firms
Apprenticeship effect on turnover	0.0163***	0.0182***	−0.00821	0.0197***
	(5.99)	(6.85)	(−1.25)	(8.12)
Apprenticeship effect on turnover per person	0.0137***	0.0204***	−0.00284	0.0197***
	(4.93)	(7.64)	(−0.43)	(8.06)
N	295,431	987,524	156,279	1,126,676
	(5)	(6)		
	Small firms	Large firms		
Apprenticeship effect on turnover	0.0145***	0.0587***		
	(7.49)	(3.81)		
Apprenticeship effect on turnover per person	0.0145***	0.0581***		
	(7.50)	(3.79)		
N	1,262,005	20,950		

Note: The results are re-weighted by IPW. The control variables include log of employment, location of firms, age of firms, industries, and types of firms. The IPW is based on the historical information, including the firm's fixed characteristics and turnover and employment between 2008 and 2010. *t* statistics in parentheses, $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

TABLE 8 | Effects on productivity and labour cost.

	(1)	(2)	(3)	(4)
Apprenticeship effect on turnover	0.117*	0.0845**	0.196*	0.196*
	(2.59)	(2.30)	(2.59)	(2.62)
N	103143	103143	103143	103143
Apprenticeship effect on added value	−0.00878	−0.00307	−0.0138	−0.0127
	(−0.70)	(−0.27)	(−1.00)	(−0.97)
N	29704	29704	29704	29704
Apprenticeship effect on labour cost	0.0967***	0.0358**	0.192***	0.0916***
	(3.64)	(2.18)	(3.76)	(3.45)
N	101696	101696	101696	101696
Specifications				
Controls	No	Yes	No	Yes
IPW	No	No	Yes	Yes

Note: All results are re-weighted by the sample weights between BSD and ABS. The control variables include log of employment, age of firms, industries, and types of firms, and sizes of firms. The IPW is based on the historical information, including the firm's fixed characteristics and turnover and employment between 2008 and 2010. Dependent variables include log of turnover, log of value added per unit turnover, and log of labour cost per head. *t* statistics in parentheses, $^{*}p < 0.01$; $^{**}p < 0.05$; $^{***}p < 0.001$.

in the Appendix. Since the ABS includes a higher proportion of large firms, the linked ILR–BSD–ABS sample consequently comprises firms with greater turnover and larger workforces. As a result, the sample contains a higher share of firms that employ apprentices.

Due to the survey design of ABS, the larger firms are more likely to be surveyed and included over the years. Therefore, employment, turnover and turnover per person are larger in the ABS sample compared to the BSD universe. To address such differences, we created weights to address the differences in probabilities of being included in the ABS relative to the universe. We then employ the same model as in the BSD and estimate associations between employing apprentices and alternative performance measures available from ABS (turnover, value added per person as a productivity measure, and labour cost per head).

The results are summarised in Table 8. The first two columns present the results based on OLS with and without the inclusion of control variables, while columns 3 and 4 show the results based on the IPW strategy. Empirical findings for firm turnover are similar to estimates obtained from the BSD universe, while a significant association between apprenticeships and value added per person was not found. In contrast, there was a rather strong association between apprenticeships and labour cost.

After employing apprentices, the labour cost per head increases by around 4% to 9% compared to their counterparts.

6 | Conclusions

In recent years, apprenticeships have been discussed as a key mechanism to provide the economy with intermediate and advanced technical and vocational skills. They gained more recognition and support by public policy in the U.S. as well as many European countries, which have not been using them to the same extent as, e.g. the German-speaking countries, where they dominate much of the vocational education (Cavaglia et al. 2020). This has been, in particular, the case in the U.K., where an "Apprenticeship Levy" was introduced in 2017 to increase the number of apprenticeships and to provide consistent funding.

While there is a wealth of studies estimating individual wage effects of apprenticeships, few studies have looked explicitly into the relationship between apprenticeships and firm-level outcomes (Mohrenweiser and Zwick 2009; Muehlemann and Wolter 2014). Our paper aims to provide estimates on this relationship using data available from the British Business Structure Database linked to the Individualised Learner Records, which provide information on apprenticeships for all English businesses. We make full use of this innovative linked employer–employee data set for all English apprenticeship employers, which also includes characteristics of the individual apprentices.

In this paper, taking advantage of the universe administrative data, we can compare firms with and without apprentices. We find that

- Around 10%–15% of all firms engage with apprentices among during the time period 2010–15.
- Firms with apprentices show much larger turnover and employment. However, turnover per person is higher for firms that do not have apprenticeships.
- The results also suggest imbalances by type of business:
  - While private companies account for 68% of all businesses, public sector employers (i.e. Central Government, Local Authorities, and agencies) represent the majority of apprenticeship firms, around 77%.
  - Amongst the firms outside the business sector, education and health-related firms employ more than half of all apprentices.
  - In the commercial sectors, half of all apprentices are employed in production, construction and retail.

The comparison between firms with and without apprentices motivates an empirical investigation on the relationship between apprenticeships and firm-level outcomes, in particular, turnover per person employed. Based on regression estimates, we find positive associations between apprenticeships and turnover ranging between 0.5% and 0.8%. Taking into consideration that structural characteristics differ between the two groups, the re-weighted regression estimate after ranges higher (1.7%–2.3%) after accounting for the observed differences between two groups of firms through IPW. We run a couple of pretreatment tests to investigate whether the association is robust and the central assumption of a similar development in outcomes in the absence of apprenticeships holds.

Moreover, the results suggest that the positive association between apprenticeships and firm-level outcomes increases over time. Further firm-level outcome data from the more detailed Annual Business Survey (ABS) provides evidence on increasing labour cost per head resulting from employment of apprentices (between 4% and 9%), but no significant relationship to overall firm-level productivity when using a value-added per person measure.

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Data Availability Statement

The study makes use of confidential data from His Majesty's Revenue and Customs (HMRC), and Department for Education (DfE). The data for this project were initially provided through a data share agreement with the Department for Education (UK) and can now be access through the ONS Secure Research Service (SRS) under the Digital Economy Act and the Open Government Licence (OGL).

Endnotes

[1] http://cver-blog.blogspot.com/2018/03/apprenticeships-are-changing-levy-year.html.

[2] Schumann (2017) examines the effect of the introduction of the minimum wage on firm-financed apprenticeships on the basis of Difference-in-Differences analysis. The results suggest that the introduction of a minimum wage decreased the number of apprentices, while the wages of existing apprentices were not affected. But the increase in the total costs for firms will defer them from financing the apprenticeships. Besides the cost in the training, the retention rate is also a key factor that determines the benefit of the apprenticeship.

[3] Adjusted to 2010 price levels using the Consumer Price Index.

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Appendix A

TABLE A1 | Structure of sample.

	Calendar years				
	2011	**2012**	**2013**	**2014**	**2015**
Treatment group (16.7%)	+	+	+	+	+
	−	+	+	+	+
	−	−	+	+	+
	−	−	−	+	+
	−	−	−	−	+
Control group (83.3%)	−	−	−	−	−

Note: "+" and "−" refer to the firms that have and do not have apprentices, respectively. There are 16.7% of all firms that have apprentices between 2011 and 2015.

TABLE A2 | Summary of variables based on ABS.

	Treatment		Control	
	Mean	**SD**	**Mean**	**SD**
Turnover (million £)	142.25	940.8	38.21	675.2
Number of employees	1027	5435.3	161	607.5
Turnover per person (million £)	0.19	1.2	0.53	17.1
Age of firm (month)	27	10.7	23	10.9
Historical information				
Turnover in 2010 (million £)	164.67	1371.1	40.8	818.1
Employment in 2010	963	5393.1	147	581.0
Turnover in 2009 (million £)	147.8	1034.7	34.9	583.9
Employment in 2009	961	5385.4	146	594.5
Turnover in 2008 (million £)	141.30	1206.5	31.4	506.1
Employment in 2008	930	5331.0	140	572.0
Calendar years (observations)	Percentage of Firms with apprentices			
2011 (20,176)	19%			
2012 (21,106)	25%			
2013 (20,929)	29%			
2014 (21,175)	31%			
2015 (19,757)	27%			

Note: The firms that started after 2011 have been excluded. The firms that became inactive between 2011 and 2015 are excluded. The sample excludes firms that have less than 5 employees and most of them only have a single employee.

TABLE A3 | Percentage of firms with apprentices within different types of business, 2011–2015 based on ABS.

Types of firm	Percentage of treatment	Observations	Percentage
Company	26%	85,290	82.69%
Sole proprietor	7%	2503	2.43%
Partnership	10%	5193	5.03%
Public corporation	53%	429	0.42%
Central government	47%	508	0.49%
Local authority	43%	170	0.16%
Non-profit bodies	38%	9050	8.77%
Total	26%	103,143	100%

Note: The first column describes the proportions of firms that have apprentices under each category.