Hiring Behaviour and the National Minimum Wage

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Executive summary

The report analyses the effects of the UK National Minimum Wage (NMW) on firms' hiring behaviour, drawing on data scraped weekly from two online job ad services: findajob.gov.uk, which contains ads for any job in the public or private sector (collected for the period July 2020-August 2021), and findapprentice.gov.uk, which contains ads for apprenticeships only (collected for May 2019-August 2021).

In the first section of the analysis we examine whether the changes in the UK minimum wage in 2020 and 2021 affected the number of ads posted. We use a technique pioneered by Cengiz et al. (2019) with employment data in the US, which involves comparing the loss of jobs immediately below the new minimum wage with the gain in jobs immediately above it. We adapt this methodology to the UK setting by exploiting variation in the real level of the minimum wage across local authorities. A drawback of this approach is that it is unable to disentangle changes caused by the minimum wage from national shifts in hiring at specific points in the *nominal* wage distribution that are unrelated to the minimum wage. This may have been a problem during the period analysed, as the UK economy recovered from the effects of the Covid-19 pandemic and resultant lockdowns. We find that the increase in the National Living Wage in April 2021 raised the number of general jobs that were advertised, but by an insignificant amount. In contrast, the upratings of the Apprentice Rate in 2020 and 2021 were associated with large and significant increases in the number of apprenticeships advertised. The elasticity of the number of ads with respect to the minimum wage was 3.7 in 2020 and 5.1 in 2021.

In the second section we examine how the minimum wage affected the number of job ads with specific characteristics. The National Living Wage appeared to raise the quality of the jobs that were advertised, with ads featuring the terms "flexible", "training" or "experience" in the job description becoming relatively more frequent after the 2021 uprating, even though the total number of ads was unaffected. However, depending on the specification used, not all these effects are statistically significant.

In the third section we examine whether the minimum wage uprating in 2021 had an effect on jobs that paid above the minimum wage. We find that the minimum wage increase in April 2021 is associated with an increase in the wages offered for jobs that are higher up the wage distribution, indicative of firms attempting to preserve inherent wage structures. We find that a 10 percentage point increase in the proportion of job offers that specify the minimum wage is associated with roughly half a percent increase in the wages offered for such a job title after the minimum wage increase, while a 10 percentage point increase in the proportion of all *other* jobs that specify the minimum wage is also associated with a 0.5 percent increase in the

wages offered for a given job title. We focus on the care sector as it employs a substantial fraction of minimum wage workers and found a very similar result to our estimates that used all sectors.

In the final section we estimate the Beveridge curve, combining the job ads data with data from the Labour Force Survey. The estimates show that from September-October 2020 there was an increase in the amount of unemployment relative to the number of job vacancies, consistent with an increase in mismatches between employers and workers (or "frictions") in the labour market. However, after October 2020, the curve returned to its initial position. We also found that labour market frictions were higher in London, the North East, Wales and Northern Ireland and in service and elementary occupations.

1. Introduction

To date, Low Pay Commission-funded research on how employers accommodate the costs associated with the minimum wage, beyond changing employment levels, has largely consisted of qualitative studies. In this report we use data on job vacancies, which are an under-exploited resource with which to apply the techniques used by previous quantitative studies looking at total employment levels or flows out of employment to the research questions that have previously been the preserve of qualitative researchers.

The project analyses the effects of the UK National Minimum Wage (NMW) on firms' hiring behaviour, primarily drawing on data scraped weekly from two online job ad services: findajob.gov.uk, which contains ads for any job in the public or private sector (collected for the period July 2020-August 2021), and findapprentice.gov.uk, which contains ads for apprenticeships only (collected for May 2019-August 2021). The primary strength of these datasets is that, in addition to standard variables such as wages and work hours, they contain information on the exact location and exact title of a job, the exact dates the vacancy was advertised and job will begin, and a detailed job description. The data can also be collected in real time, meaning that our data afford an analysis of the April 2021 NMW uprating and the effects of the Covid-19 pandemic.

The weaknesses of the job ads datasets are that they only contain information on firms' hiring choices, not on how they treat existing employees, and they do not contain information on vacancies that are not advertised. Nonetheless, both datasets contain many more observations than the usual datasets used to study workers or apprentices, such as the Labour Force Survey, Annual Survey of Hours and Earnings or the Apprentice Pay Survey.

The empirical analysis consists of four parts. In the first part, we examine the overall effect of a change in the minimum wage on the job vacancy rate. The data are aggregated into bins according to the quantile of the wage offer, within each postcode area and month. The change in vacancies in a wage bin-local authority-month cell after a minimum wage uprating is then compared with the change in employment at the same point in the wage distribution in another postcode.

In the second part of the paper, the same method is used to analyse the effects of the minimum wage on the number of ads specifying various benefits or restrictions, such as flexible working or on-the-job training, and the number of ads that specify experienced or more qualified applicants.

In the third part of the analysis, we regress the wage offer specified on a given job ad on the fraction of ads posted by the employer in question for other job titles that were paid the minimum wage. This allows us to examine whether there are wage spillovers within firms in

response to the minimum wage, as employers either increase or decrease pay differentials. We also aggregate the data into job title-region-month cells and examine how the wage offered to one job title is affected by minimum-wage-induced increases in pay on job titles that tend to be hired by the same firms.

In the final part we examine the relationship between job vacancies and job seekers. Data on the number of unemployed workers in an occupation-region cell are merged in from the Labour Force Survey. This allows for an examination of whether a reduction in the job vacancy rate within a cell brought about by the minimum wage is associated with an increase in the unemployment rate in that cell or an increase in the length of time people remain unemployed.

2. Background

Online job advertisements provide a rich and under-utilised source of data on firms' hiring behaviour. Job ads only provide information about hiring, not job separations, and even then, not all jobs are advertised. However, a 2014 US report found that around 60% of job openings are filled by people from outside the firm and around a third of these were advertised online (Crispin and Mehler 2014). Similar UK evidence does not exist, but in the seven years since that report, online advertising is certain to have increased markedly in this country. An average of around 32,000 ads were posted each week between July 2020 and September 2021 on the larger of the two job listing websites to be used in this study – findajob.gov.uk – despite this period coinciding with the Covid-19 pandemic.

The major benefit of job ads is that they provide much richer information about a job than is typically contained in surveys of workers or firms. Job ads give the exact address of a firm, typically contain a job description that may run to a number of paragraphs, the exact date the ad was posted, and the date the job will start. In pioneering work using US online job ads, Marinescu and Wolthoff (2020) demonstrated the crucial information conveyed by job "titles", i.e. the specific names of the positions given in ads, such as "senior accountant" or "network administrator". Job titles were found to explain 90% of the variance in the wages that firms post, whereas even the most detailed occupational classification commonly used by economists explained only a third of this variance. Most surveys do not collect a person's job title, but this is available in both datasets to be used in this project. This information will allow us to compare ads within more homogenous groups. For example, an "experienced warehouse operative" is likely to perform very similar tasks and have similar skills regardless of where he/she is located in the UK or what wage he/she earns, but these may be very different to a "warehouse yard cleaner" and there may be significant variation in both tasks and ability within the 4-digit SOC2020 category "warehouse operative".

An additional benefit of job ads is that the data can be collected in real time and the quality of the data has not been affected by the Covid-19 pandemic.

3. Data

Job ads data

The Department for Work and Pensions maintains a "Find a job" service, which allows any UK company to advertise its job vacancies. An example of a typical ad is shown in Figure A1b in the Appendix. Data were scraped weekly between July 2020 and September 2021. The information collected includes the job title, weekly wage, hours, start date, date the ad was posted, application deadline, name and address of the employer, hours, permanent/temporary status, and job description.

An average of around 32,000 ads are posted on the service each week. Unlike the apprentice ad data, many more ads have missing wage information (38%), as shown in Figure 1. Around 2,700 ads per week specify that they will pay the National Living Wage (12% of ads with non-missing wage data). As illustrated in Figure 2, there is a large spike in job ads at the National Living Wage, as well as a substantial number of ads paying slightly more than this.

Figure 1: Number of ads in findajob.gov.uk by week and wage level

Source: findajob.gov.uk.

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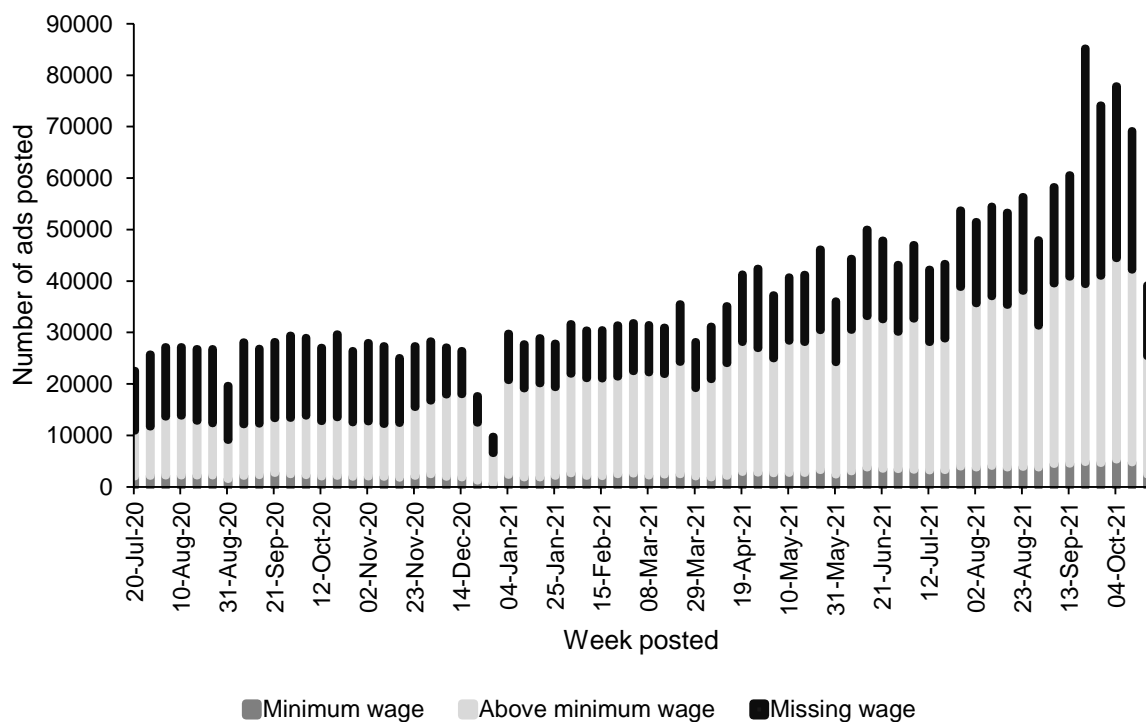
The Annual Survey of Hours and Earnings (ASHE) provides a snapshot of the distribution of earnings of employees each April. Comparing data from findajob.gov.uk for ads posted in April 2021 with data from the 2021 ASHE shows that the former contains relatively more low-paid jobs.[1] The 10th percentile in the two datasets is relatively close (£8.94 in findajob.gov.uk and £9.03 in ASHE), whereas the 90th percentile is significantly lower in findajob.gov.uk (£23.30) than in ASHE (£29.59). This is not surprising, given that job vacancy data only provide an indication of the wages paid to newly hired workers at a firm, missing workers with longer job tenures, who are likely to be paid more on average.

Figure 2: Distribution of hourly wages in findajob.gov.uk (restricted to under £40)
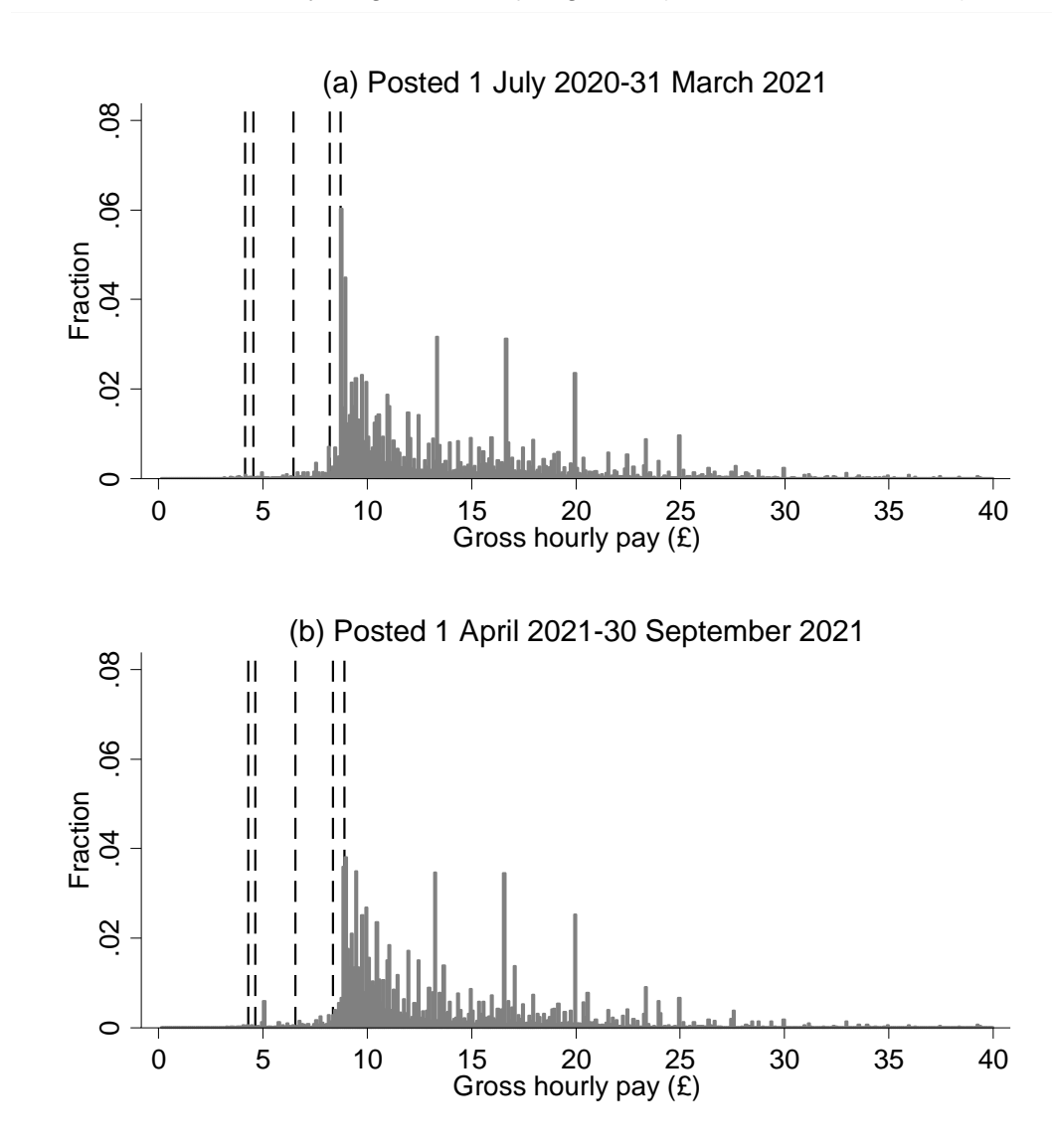
Source: findajob.gov.uk.

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[1] The ASHE data were obtained from www.nomisweb.co.uk and include both full-time and part-time workers.

Notes: From left to right, the vertical dotted lines denote the prevailing rates of the Apprentice rate, 16-17 Year Old Rate, 18-20 Year Old Rate, 21-24 Year Old Rate/21-22 Year Old Rate, and 25 and over rate/23 and over rate (NLW).

The Office for National Statistics (ONS) provides an estimate of the total number of job vacancies in the UK each month. This is based on a survey which asks employers how many vacancies they have for which they are actively seeking recruits from outside their organisation. As such, it is a measure of the "stock" of vacancies, not a measure of the "flow" of vacancies, as in our dataset. To make our data comparable, we calculated the number of ads in the findajob.gov.uk data that were open at any point during a calendar month. This is compared with the ONS estimates in Figure 3. The two follow a very close trend, with the exception of the first month, for which the findajob.gov.uk value is an under-estimate, because we only began scraping the data that month. On average, the number of findajob.gov.uk vacancies per month is equal to 35% of the ONS estimate.

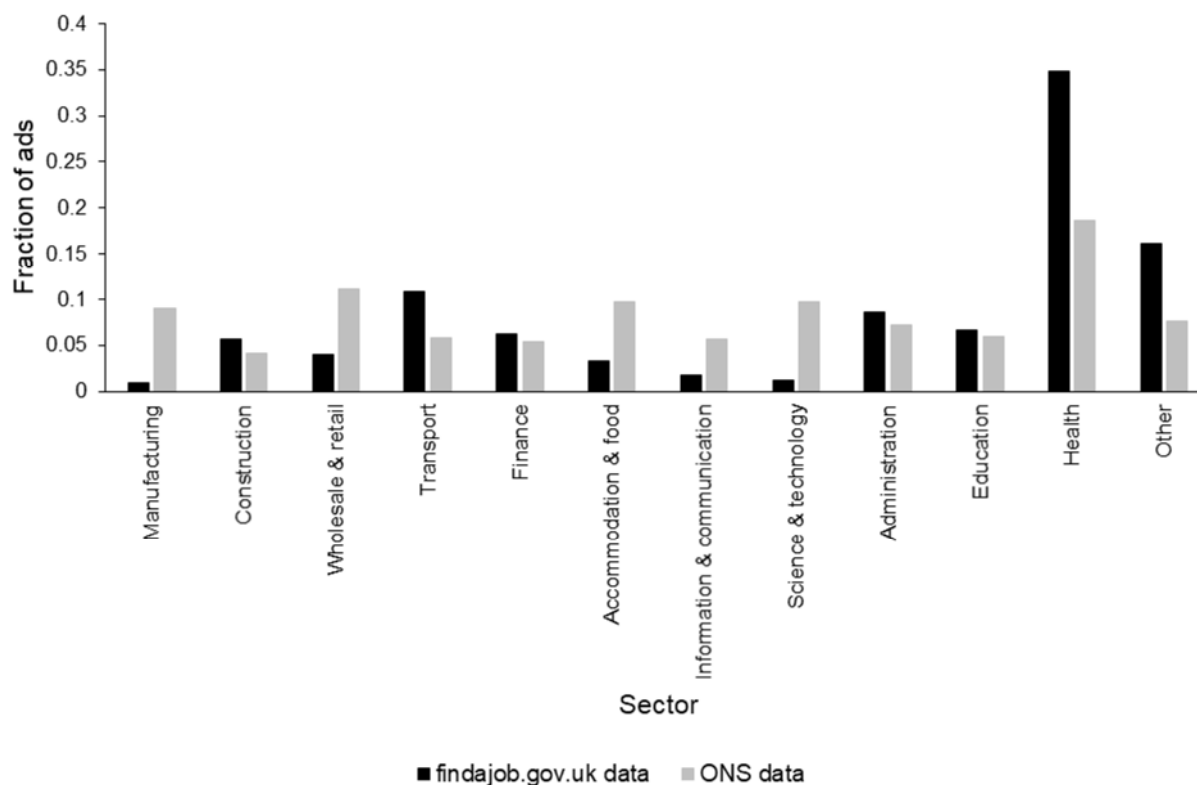Figure 3: Trends in findajob.gov.uk ads versus ONS vacancy data
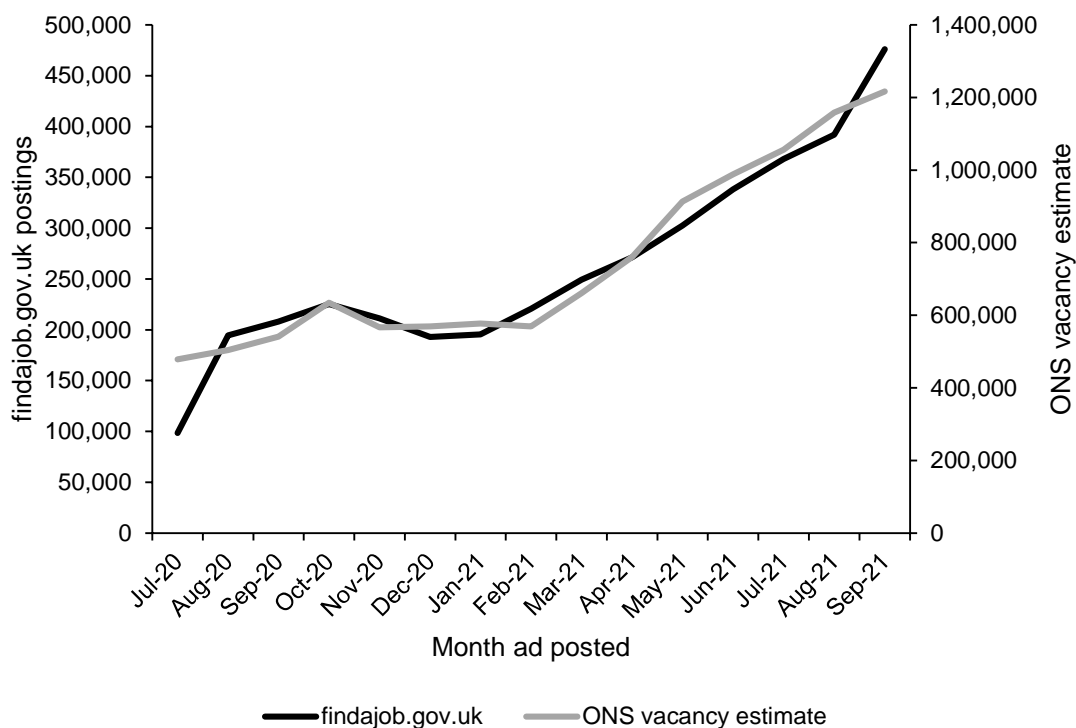
Source: findajob.gov.uk.

The findajob.gov.uk data do not contain a representative sample of job ads in the UK. We compared the distribution of industries in our data with vacancy estimates reported by the

Office for National Statistics.[2] As Figure 4 shows, compared with the official vacancy data, the findajob.gov.uk data appears to overrepresent the Transport and Health sector and underrepresent the Manufacturing, Wholesale & retail, Accommodation & food, and Science & technology sectors.

Figure 4: Distribution of findajob.gov.uk ads versus ONS vacancy data

Source: findajob.gov.uk and ONS vacancy estimates (August 2020-September 2021, https://www.ons.gov.uk/employmentandlabourmarket/peoplenotinwork/unemployment/datasets/x06singlemonthvacanciesestimatesnotdesignatedasnationalstatistics/current).

Apprentice ads data

The Department for Education encourages companies in England to advertise their apprenticeships on the Government's "Find an apprentice" website, which is similar to "Find a job" except that only apprenticeships can be advertised. The ads include information about

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[2] We assign industries to the findajob.gov.uk using the SOC codes, which in turn are assigned from the job title, as described in Section 6. For some job titles, this was uncontroversial. For example, we assigned all job titles under the category of "Teaching and Other Educational Professionals" to the education sector; we also assigned the job titles under "Health Professionals" to the health sector. We assigned less obvious job titles, such as librarians and archivists, to the sector denoted "Other". This is naturally an imperfect mapping as it may be that general job titles are vacancies in a given industry but we have no way of knowing this, particularly when the advertising firm is a recruitment firm. For example, if a firm in the transport industry is hiring a secretary then it is not clear if this vacancy should be mapped to the transport sector or the administration sector.

the weekly wage, hours, apprenticeship duration, start date, date the ad was posted, application deadline, apprenticeship level and framework, number of positions, desired entry qualifications, name and address of the employer, the names of the training provider and organisation handling applications (which might be the employer or training provider, but could be an external recruitment agency) and the number of available positions. An example of an ad is given in Figure A1a in the Appendix. The ads are taken down after the application deadline, so the data must be collected in real time. Web scraping software was used on a weekly basis to collect data on every ad posting from May 2019-September 2021. All the aforementioned information was collected.

The Government reports statistics on the number of new apprentices who start during each academic year, by apprenticeship level.[3] During the 2020/21 year, 84,100 people started an intermediate level apprenticeship, 138,500 people started an advanced level apprenticeship and 98,800 people started a higher-level or degree-level apprenticeship. Compared with this, the findapprenticeship.gov.uk data over-represent lower-level apprenticeships. Apprenticeships that were advertised to start between August 2020 and July 2021 accounted for 46% of intermediate-level apprenticeship starts, 20% of advanced-level apprenticeship starts and 2% of higher- and degree-level starts.

In some cases, a range of possible wage rates is specified. In this case, the lowest hourly wage listed is taken.[4] Of these: 86% specify an exact wage and 14% specify a wage range (for our analysis, we take the bottom of range for these).

Figure 5 shows the number of new ads paying the April 2021 Apprentice Rate (£4.30) or higher each week from May 2019 to September 2021. The number of new ads declined substantially in late March 2020 due to the Covid-19 pandemic, but the fraction of minimum wage ads each week has remained roughly constant.

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[3] These data were obtained from https://explore-education-statistics.service.gov.uk/find-statistics/apprenticeships-and-traineeships/2020-21.

[4] Our results do not change if the midpoint of the interval is used.

Figure 5: Number of ads in findapprentice.gov.uk by week and wage level


Minimum wage Above minimum wage
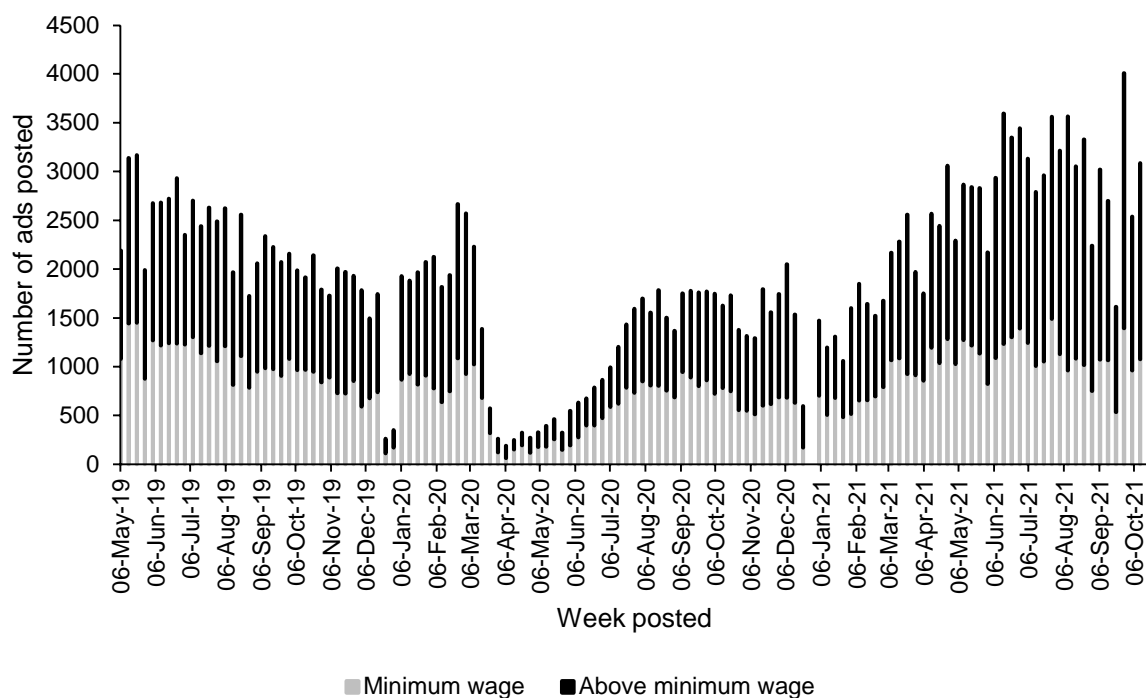
Source: findapprentice.gov.uk.

We have 199,186 observations, of which 94% give wage information. Figure 6 shows the wage distribution in the data, with the five NMW rates indicated by vertical dotted lines. Prior to 1 April 2020, when new NMW rates took effect, around 37% of apprenticeship ads specified the apprentice minimum wage rate (£3.90). Among those paying a higher amount, the most common single wage rate was the 16-17 Year Old Rate (£4.35), followed by £5. Among ads posted between 1 April 2020 and 31 March 2021, a slightly higher fraction specified the new Apprentice Rate (£4.15) than in the previous year. Between 1 April 2021 and 30 September 2021, the fraction of ads paying the Apprentice Rate rose slightly more.

Wage data on actual apprentices, as reported by the Apprentice Pay Survey, is much less concentrated on the Apprentice Rate than Figure 6, with many apprentices reporting that they are paid below the Apprentice Rate and others reporting that they are paid more than the Apprentice Rate (Papps 2020).

Figure 6: Distribution of hourly wages in findapprentice.gov.uk (restricted to under £10)

(a) Posted 1 April 2019-31 March 2020

(b) Posted 1 April 2020-31 March 2021

(c) Posted 1 April 2021-30 September 2021
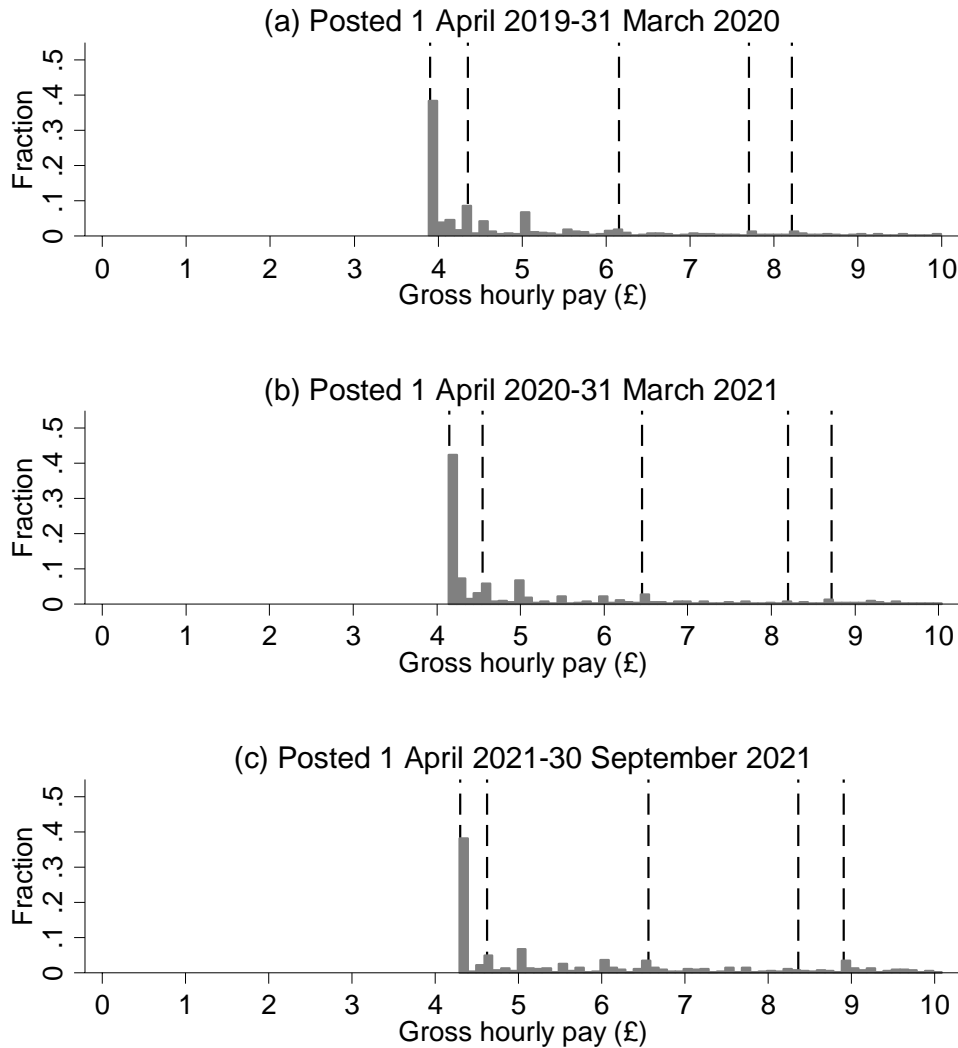
Source: findapprentice.gov.uk.
Notes: From left to right, the vertical dotted lines denote the prevailing rates of the Apprentice rate, 16-17 Year Old Rate, 18-20 Year Old Rate, 21-24 Year Old Rate/21-22 Year Old Rate, and 25 and over rate/23 and over rate (NLW).

Trends in general job vacancy rates and pay throughout the pandemic

In response to the Covid-19 pandemic, the UK Government imposed a series of lockdowns in England from March-June 2020, November-December 2020 and January-March 2021, with a similar pattern of restrictions introduced by the devolved administrations in Scotland, Wales and Northern Ireland. The Coronavirus Job Retention Scheme was announced on 20 March 2020 and provided grants to employers to pay 80% of their staffing costs, up to a total of £2,500 per person per month. The scheme closed on 30 September 2021.

From the point we began collecting data from findajob.gov.uk in July 2020 the number of job ads grew steadily, reflecting the recovery of the labour market from the initial shock of the

pandemic, as seen in Figure 7. The number of ads in September 2021 was over four times higher than in July of the previous year.

Figure 7: Job ads by month
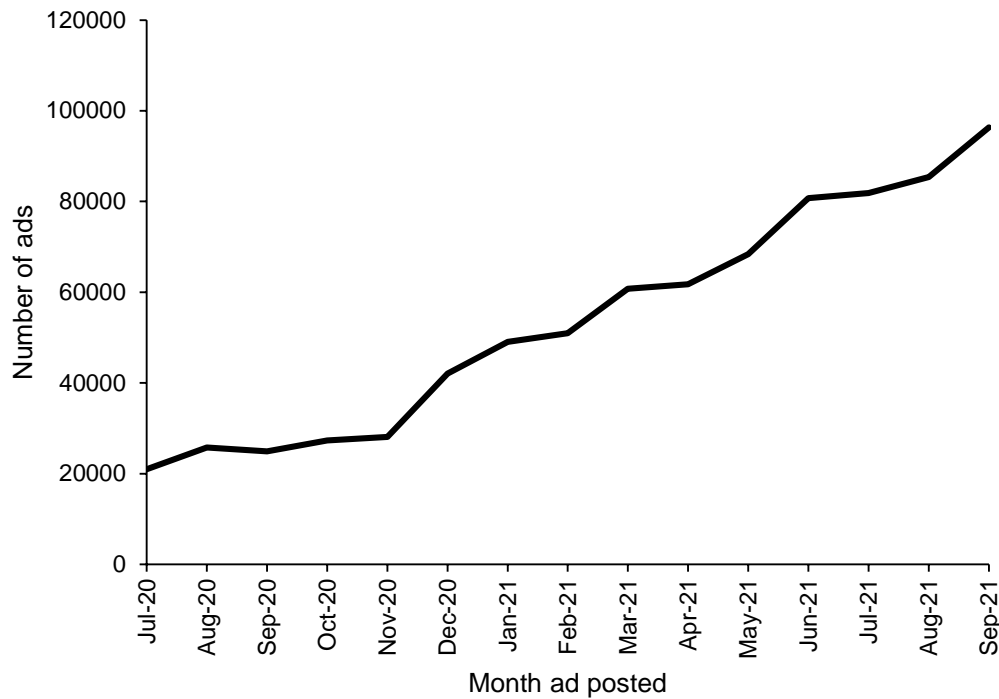
Source: findajob.gov.uk.

As shown in Table 1, relatively few employers in the findajob.gov.uk data advertise their vacancies at the minimum wage and even then, they almost exclusively use the National Living Wage.

Table 1: Fraction of ads specifying each minimum wage rate by year

Year posted	Apprentice rate	16-17 Year Old Rate	18-20 Year Old Rate	21-24 Year Old Rate/21-22 Year Old Rate	25 and over rate/23 and over rate (NLW)	Other wage
1 July 2020-31 March 2021	0.001	0.000	0.000	0.000	0.036	0.964
1 April 2021-30 September 2021	0.000	0.000	0.000	0.001	0.025	0.974

Source: findajob.gov.uk.

The average hourly wage rate in the findajob.gov.uk data fell between July and September of 2020, before rising sharply until February, as depicted in Figure 8. From then, it fell steadily. Rather than indicating falling wages on each occupation, this largely reflects the fact that a higher fraction of relatively low-paid jobs were advertised during this period.

Figure 8: Average hourly pay offer
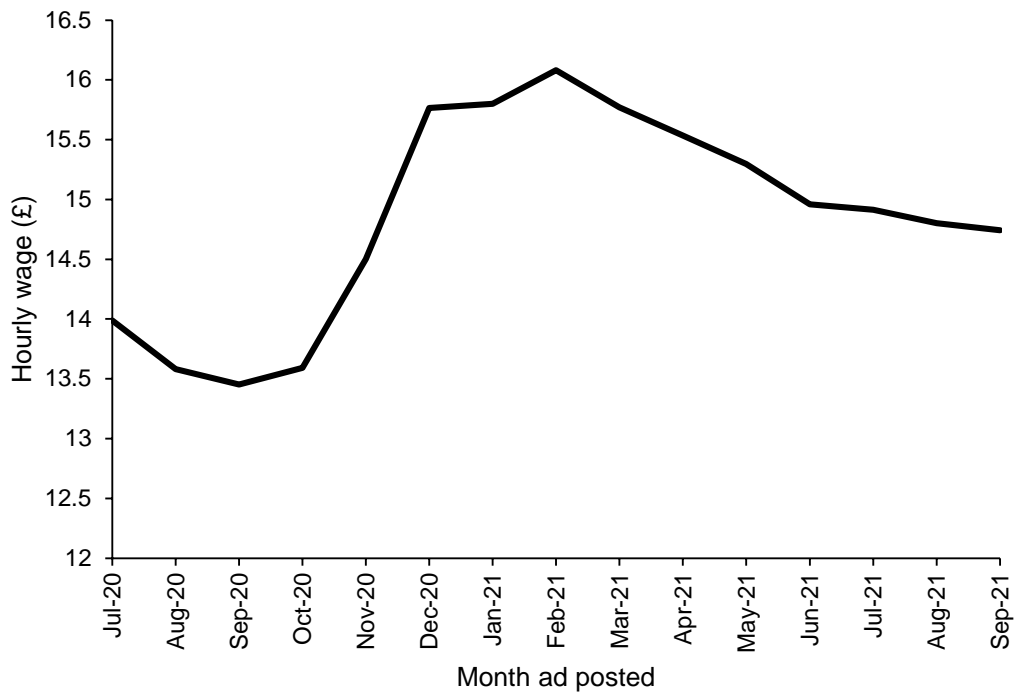
Source: findajob.gov.uk.

Trends in apprentice vacancy rates and pay throughout the pandemic

The number of apprenticeship ads was already on a downward trend before March 2020, as seen in Figure 9. It fell by 87% between February and April 2020, before recovering. Ads fell again during the third lockdown but surpassed the immediate pre-pandemic level in March 2021 and kept growing.

Overall, 40% of observations pay the Apprentice Rate, 52% pay a wage above the Apprentice Rate but no more than the NLW and 8% pay a wage above the NLW.

The fraction of ads specifying the Apprentice Rate (as opposed to a higher wage) has been remarkably stable throughout the pandemic, although in recent months it has fallen somewhat (Figure 10). Many companies begin advertising apprenticeships at the incoming Apprentice Rate in the month or two months before an uprating.

Figure 9: Apprentice ads by month
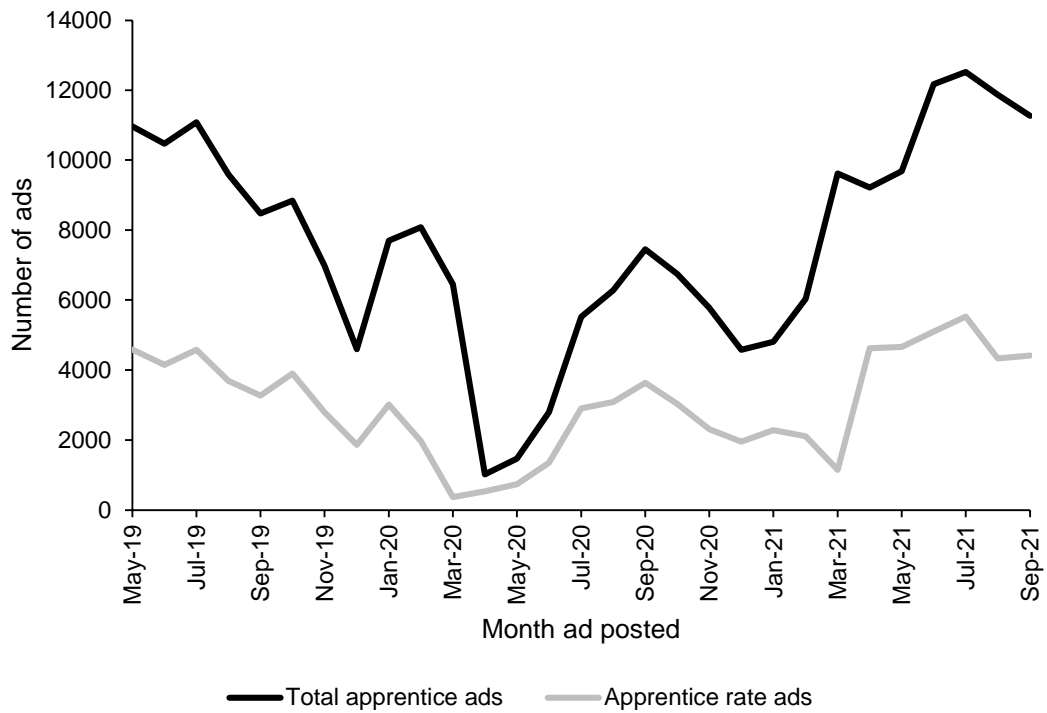
Source: findapprentice.gov.uk.

Figure 10: Fraction paying the minimum wage
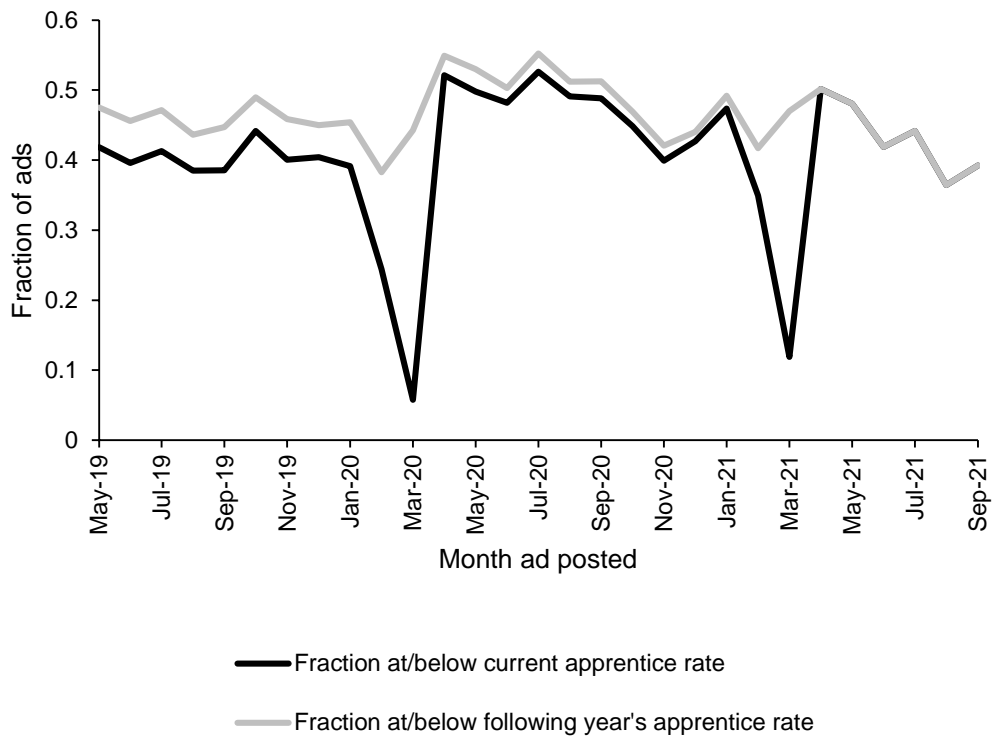
Source: findapprentice.gov.uk.

Table 2 shows that very few companies advertise at other minimum wage rates and the usage of these has fallen over time.

Table 2: Fraction of ads specifying each minimum wage rate by year

Year posted	Apprentice rate	16-17 Year Old Rate	18-20 Year Old Rate	21-24 Year Old Rate/21-22 Year Old Rate	25 and over rate/23 and over rate (NLW)	Other wage
1 May 2019-31 March 2020	0.366	0.071	0.015	0.010	0.009	0.528
1 April 2019-31 March 2020	0.403	0.049	0.016	0.005	0.010	0.517
1 April 2021-30 September 2021	0.429	0.029	0.017	0.002	0.014	0.509

Source: findapprentice.gov.uk.

Average pay rates on apprentice ads grew throughout the pandemic but have fallen since May 2021, as seen in Figure 11.

Figure 11: Average hourly pay offer

Source: findapprentice.gov.uk.

16
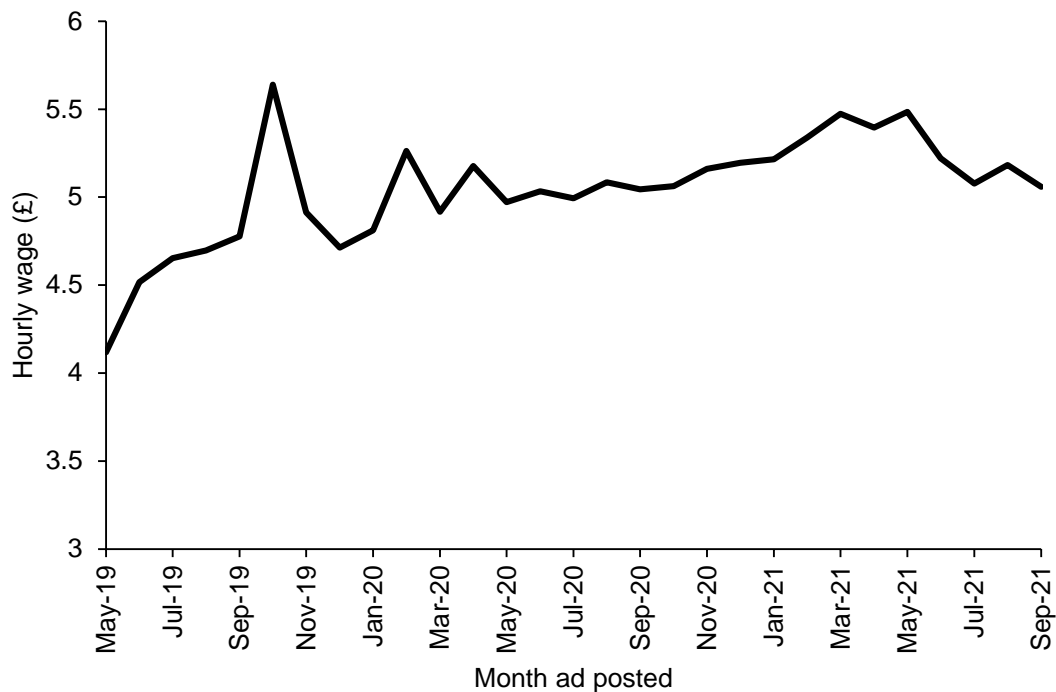
Between July 2020 and September 2021, the growth in vacancies for apprenticeships closely matched the growth in general job vacancies, as seen in Figure 12.

Figure 12: Trends in apprenticeship and general job vacancies
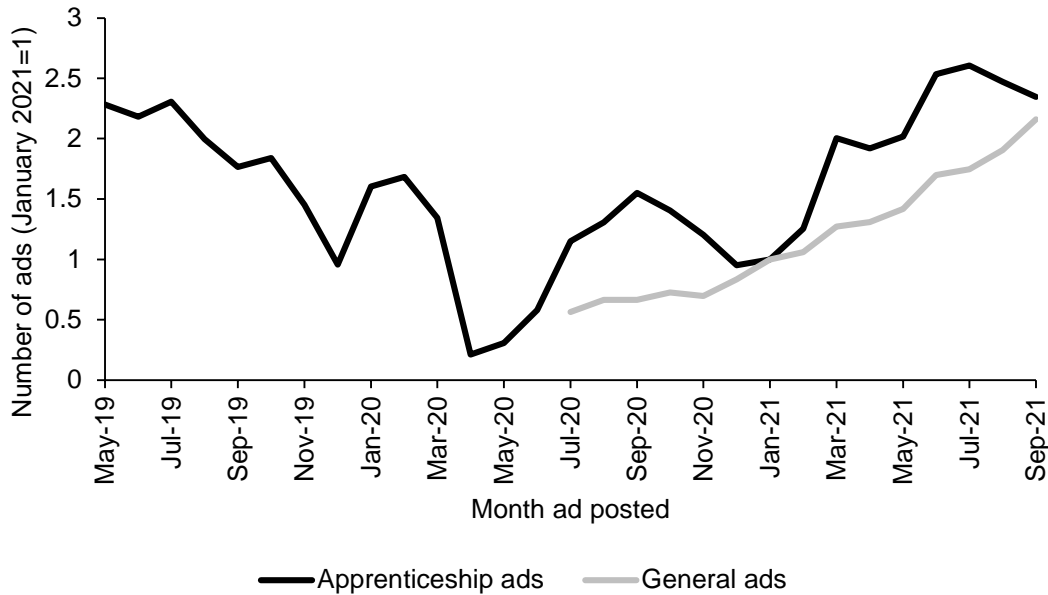
Source: findapprentice.gov.uk and findajob.gov.uk.

Average pay rates for the apprentice ads also have also closely followed those for the general job ads, as seen in Figure 13.

Figure 13: Trends in apprenticeship and general job hourly wage offers

Source: findapprentice.gov.uk and findajob.gov.uk.

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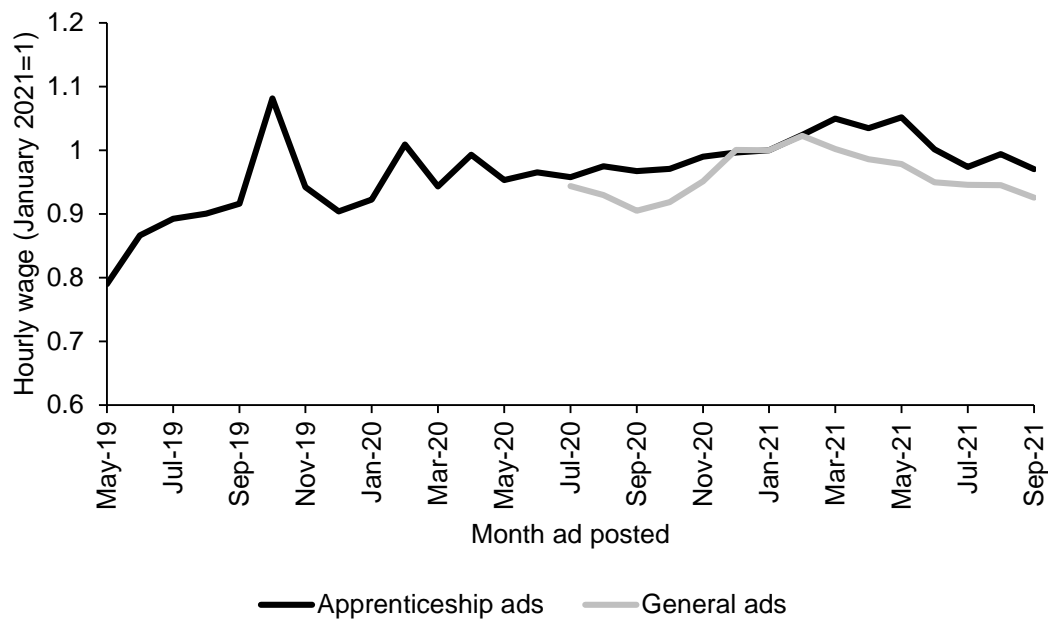
Other apprentice ad characteristics

As seen in Table 3, the length of time a job was posted fell in 2020/21 and again in 2021/22. Ads posted since April 2021 have had a significantly shorter gap between the closing date and the start date, perhaps reflecting difficulties in hiring or employers delaying hiring decisions. Since the start of the pandemic, advertised apprenticeships have been longer on average. Compared to 2020/21, during 2021/22 ads were more likely to be posted by frequent hirers of apprentices (defined in terms of how many ads they posted on findapprentice.gov.uk during the sample period). However, since April 2021, more ads were posted by less frequent hirers of apprentices.

Table 3: Means of ad characteristics by year, findapprentice.gov.uk data

Variable	Posted 1 May 2019-31 March 2020	Posted 1 April 2020-31 March 2021	Posted 1 April 2021-1 October 2021
Wage (£)	5.12	5.33	5.60
Days ad posted	32.27	30.98	27.07
Days between closing and starting dates	20.95	21.90	15.62
Length of apprenticeship (weeks)	81.90	88.08	89.57
Percentage using recruiter	0.51	0.50	0.51
Ads per company	41.60	48.39	36.99
Percentage requiring GCSEs	0.73	0.76	0.72
Intermediate level	0.56	0.46	0.46
Advanced level	0.40	0.49	0.50
Higher level	0.02	0.03	0.03
Degree level	0.02	0.02	0.02
Number of observations	93,239	62,079	67,334

Source: findapprentice.gov.uk.

4. The effects of the minimum wage on vacancies

We use the methodology developed by Cengiz et al. (2019) to estimate the effect of the minimum wage on the number of job openings posted in a given month. This approach has previously been applied to employment and gives the overall effect of an increase in the minimum wage on the number of jobs by breaking the wage distribution into small bins and examining the different changes in employment in bins near the new minimum wage. To the best of our knowledge, this method has not been applied to job vacancy data in any country yet. However, it is highly suitable in this context since the job ads dataset is so large, meaning that there are many observations in each bin.

Since there is no regional variation in the nominal level of the minimum wage in the UK, we follow Giupponi et al.'s (2020) recent application of this method to study UK total employment and construct bins by exploiting variation in the real value of the minimum wage across the country. Specifically, we run an initial regression of the wage listed on an ad on a set of local authority and month dummies, and potentially also other controls. We then subtract the estimated local authority and month effects from the wage and allocate this adjusted wage to a set of 10p wage bins.

Next, we regress the number of vacancies in a wage bin j, local authority i and posting month t, divided by the estimated population of the local authority in 2019, N, on a series of indicator variables that identify whether a bin-postcode-month combination is bound by the minimum wage, plus local authority-month and bin-month fixed effects:

$$\frac{V_{ijt}}{N_{i2019}} = \sum_{\tau} \alpha_{\tau} I_{ijt}^{\tau} + \eta_{ij} + \lambda_{jt} + \varepsilon_{ijt}. \tag{1}$$

The α terms here pick up the separate effects of the minimum wage on vacancy rates at different parts of the wage distribution (indexed by τ).[5] The sum of the α terms gives the overall effect.

Equation 1 relies on the local authority-month and bin-month fixed effects capturing any differences in hiring rates across regions or across the wage distribution that are driven by factors other than the minimum wage. During the period under analysis, a particular concern is whether these fully capture the effects of the Covid-19 pandemic on hiring. The local authority-month effects capture any trends in hiring from month to month that vary by location but are constant across the wage distribution. The bin-month effects capture any differences in the pattern of hiring across the real wage distribution that vary by location but are constant over time. However, if Covid-19 had effects on hiring that varied by location, real wage *and* time, the estimates of the α terms will be biased.

We will apply this methodology separately to the two datasets, allowing for a separate examination of the effects of the minimum wage on hiring rates among apprentices and among all workers. The findapprentice.gov.uk data span two upratings (April 2020 and April 2021), so we are able to compare the effects of each. The findajob.gov.uk data only span the April

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[5] τ can be negative (reflecting the effect of a minimum wage uprating on the number of vacancies paying less than the new minimum wage), zero (reflecting the effect on an uprating on the number of vacancies paying exactly the new minimum wage) or positive (reflecting the spillover effects of an uprating on the number of vacancies paying more than the new minimum wage). Unlike in Cengiz et al., our choice of values for τ is constrained by the fact that the minimum wage rose by the same amount everywhere, so there are a limited number of possible negative values that τ can take.
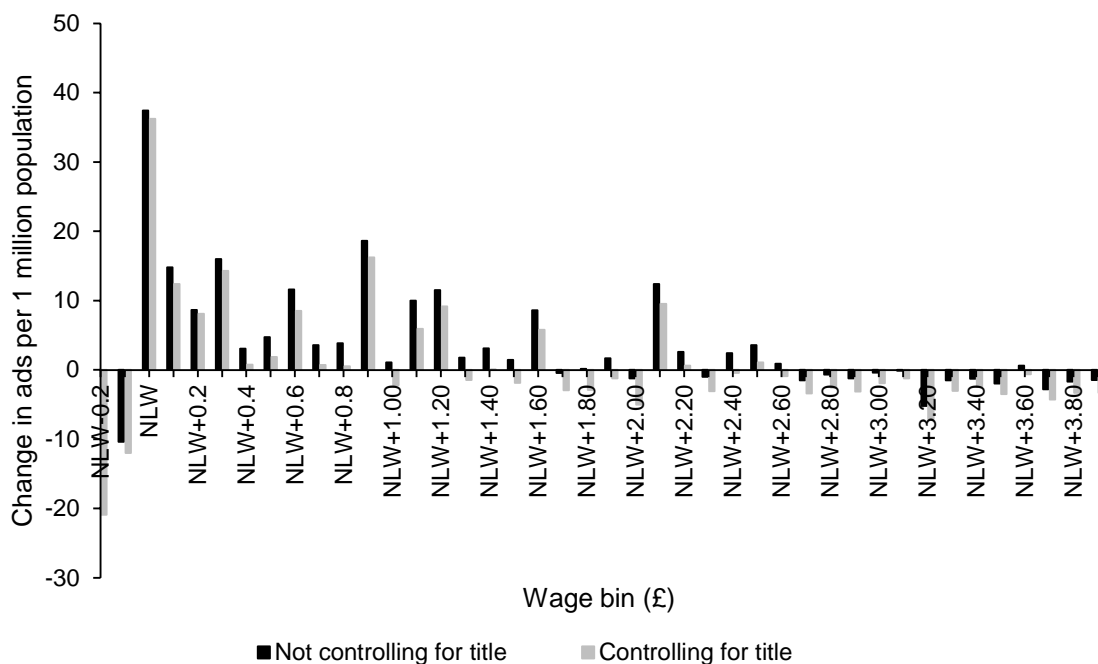
2021 uprating.

Results using general job ads

The findajob.gov.uk data are analysed first. As seen in Figure 14, the National Living Wage is by far the most common minimum wage rate mentioned in ads. Therefore, we examine how the change in this rate in April 2021, from £8.72 to £8.91, affected the number of ads immediately below and above £8.91. We allow $τ$ to vary between -2 and 40, meaning that we examine the effects of the minimum wage on ads specifying a wage rate between 20p below and £4 above the new National Living Wage. We restrict the regression to ads specifying wages between £3 and £100.

To start with, we do not control for anything other than local authority and posting month in the initial regression. The estimates of $α$ are presented in the black bars in Figure 14. Here the wage bins are indicated by their relative position to £8.72 ('NLW'). As expected, the uprating of the National Living Wage reduced the number of ads specifying a wage rate in the two 10p wage bins below the bin containing the new National Living Wage. It also increased the number of ads at the new National Living Wage and in the wage bins above this rate. These positive effects decline as the wage increases and are very small above £3 above the National Living Wage.

Figure 14: Estimated effects of NLW on general job ads per population by wage bin, July 2020-September 2021

Source: findajob.gov.uk.

The total estimated effect of the April 2021 uprating is the sum of black bars in Figure 14. This is equal to 0.00013 ads per population per month. The average number of ads per month prior to April 2021 was 0.0006. Therefore, the April uprating was associated with a 22.8% increase in the number of ads. Since the National Living Wage rose by 2.2%, this implies an elasticity of ads per population with respect to the minimum wage of 10.4.

When dummies for job title are added to the initial regression, the effects of the minimum wage on hiring at each wage level are reduced somewhat. The estimates of α obtained in this case are depicted by the grey bars in Figure 14. The elasticity of ads per population with respect to the minimum wage drops significantly to 2.9.

Even when job title is controlled for in the initial regression, the elasticity remains implausibly large. One potential explanation is that there may have been national trends in hiring that were specific to the nominal wage posted (not the real wage). Such trends would have effects on hiring that vary by location, real wage bin and time that would not be captured by the local authority-month and bin-month fixed effects. For example, if there was a pick-up in hiring at wage rates just above the new National Living Wage as the economy recovered throughout the summer of 2021, these would be incorrectly attributed to the effects of the April 2021 National Living Wage uprating. To address this, the post-treatment period was reduced to April-May 2021. By focusing on only the immediate post-uprating period, the effects of trends in hiring at specific points in the nominal wage distribution should be minimised. As seen in Figure 15, similar negative effects are found below the new National Living Wage as in Figure 14, but the positive effects above the National Living Wage are smaller. The elasticity of ads per population with respect to the minimum wage drops to 4.0 when only local authority and month dummies are included in the initial wage regression and to 0.2 when job title dummies are added. The latter is no longer significant at the 10% level.

Figure 15 illustrates that there are very few spillovers of the National Living Wage further up the wage distribution. Sizeable positive effects are found at 10p and 20p above the new level of the National Living Wage but not at higher wages, with two exceptions. There are large positive effects on hiring levels at 90p above the new minimum – possibly driven by employers who always pay 10% above the National Living Wage – and £2.10 above the new minimum – presumably the result of increased hiring at exactly £11. Compared to hourly wages calculated from survey data, the job ads data give much more accurate pay measures and there is little chance that an ad specifying a wage slightly above the National Living Wage is actually a mismeasured minimum wage job.

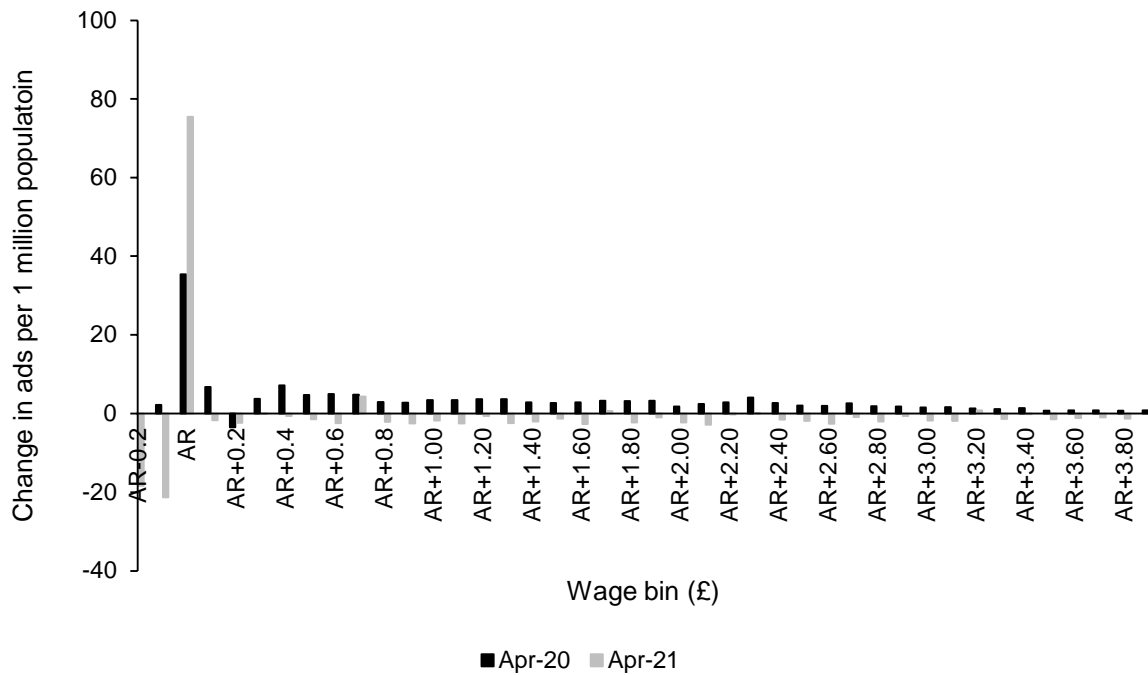Figure 15: Estimated effects of NLW on general job ads per population by wage bin, July 2020-May 2021

Source: findajob.gov.uk.

Results using apprentice ads

The results of estimating Equation 1 using the findapprenticehip.gov.uk data are depicted in Figure 16. Here the two sets of bars report the results of a regression using data for May 2019-March 2020, analysing the effects of the April 2020 uprating (depicted in black), and the results of a regression using data for April 2020-September 2021, analysing the effects of the April 2021 uprating (depicted in grey). The overall elasticity of apprenticeship vacancies with respect to the apprentice rate was 12.4 in 2020 and -4.2 in 2021.

As with the general job ads, the high elasticities found with the apprentice ads may reflect trends in hiring that are dependent on the nominal wage. However, Figure 16 reveals an additional problem, in that the bars remain large relative to the spike at the Apprentice Rate, even much further up the wage distribution. Therefore, the regression sample was limited to two months after the Apprentice Rate uprating each year and the number of wage bins allowed above the Apprentice Rate was limited to 20. The estimated effects are depicted in Figure 17. The elasticities of apprenticeship vacancies with respect to the apprentice rate are now 2.1 in 2020 and 4.9 in 2021.

Figure 16: Estimated effects of NLW on apprenticeship ads per population by wage bin

Source: findapprentice.gov.uk.

Figure 17: Estimated effects of NLW on apprenticeship ads per population by wage bin, two-month post-treatment windows
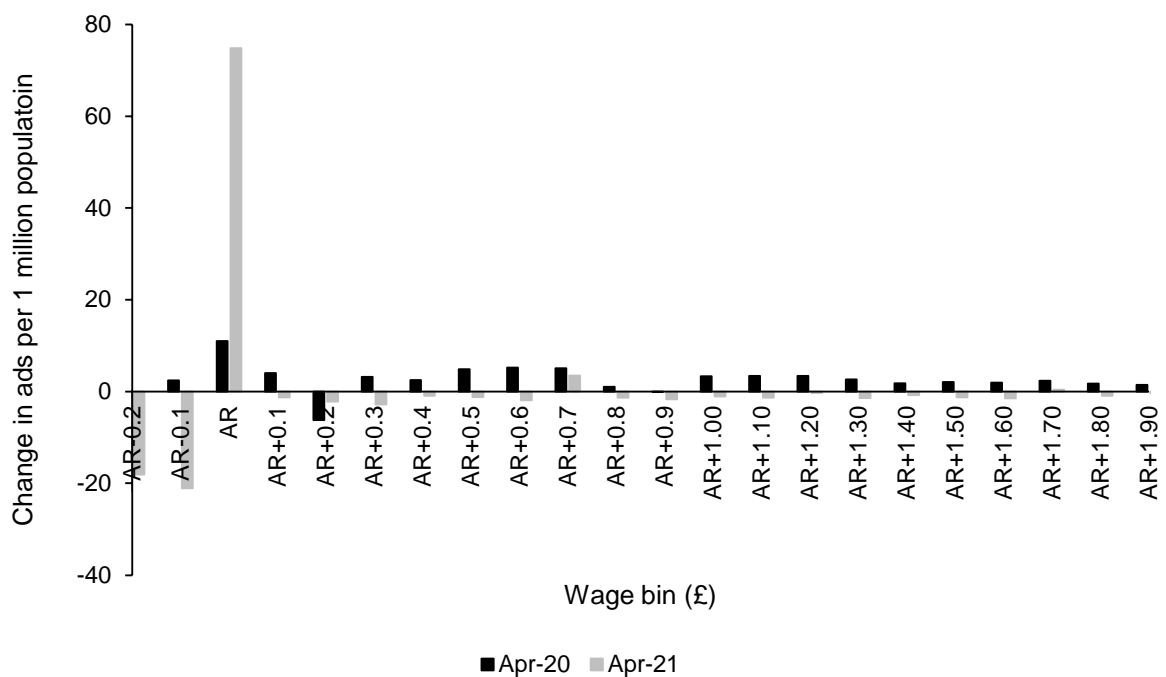
Source: findapprentice.gov.uk.

5. The effects of the minimum wage on job and applicant characteristics

We can also use the basic Cengiz et al. approach described above to examine whether jobs advertised in the two datasets that specify certain characteristics change in response to the

minimum wage. Gregg and Papps (2014) found little evidence that employers cut back on non-wage benefits when the minimum wage rises, but recent work by Adams-Prassl et al. (2020) using job vacancy data found that an increase in the minimum wage resulted in firms requiring more flexible working arrangements in an effort to reduce labour costs.

We replace the dependent variable used in Section 4 with the number of jobs per capita in a bin-local authority-month in the findajob.gov.uk data that mention various attributes in the job details. Specifically, we counted ads that mentioned the words "flexible", "training", "bonus" or "experience", excluding as best as possible those ads where the wording in the job details meant that the job did *not* feature the particular attribute.[6] This approach is admittedly crude, in particular with regard to flexible employment, because many ads use the word "flexible" to describe jobs where the worker is expected to be flexible in terms of hours. These cases are wrongly included in our measure of flexible jobs. The detailed job description potentially allows for a distinction between the two types of job flexibility and future research should investigate this, perhaps using content analysis or machine learning techniques.

Table 4 reports the elasticity of the number of job ads featuring the four attributes with respect to the National Living Wage, using only April-May 2021 data from the post-treatment period. The 2021 uprating had a significant positive effect on the number of ads specifying any of the four key words. Hence, employers appeared to be more likely to advertise jobs that featured flexible conditions, provided training and paid bonuses but required experienced applicants as a result of the uprating, even though there was no significant change in the total number of ads.

Table 4: Elasticities of number of ads with respect to the National Living Wage, findajob.gov.uk data

| | Total ads | Ads mentioning | | | | Long posting time |
		Flexible	Training	Bonus	Experience	
Elasticity	0.221 (0.757)	5.075*** (1.905)	4.504*** (1.608)	18.848*** (4.194)	3.711*** (1.287)	1.351*** (0.776)
Fraction of jobs	1.000	0.264	0.404	0.074	0.609	0.632

Source: findajob.gov.uk.
Notes: Robust standard errors clustered by local authority in parentheses. *** $p<0.01$; ** $p<0.05$; * $p<0.10$. Fraction of jobs gives the fraction of ads in the full sample that has the attribute in a particular column.

[6] Specifically, we exclude ads using the phrases "no experience", "experience not", "to be flexible", "requires flexibility", "no training" or "no bonus" from our measures.

One way employers might respond to the minimum wage is by advertising posts for longer in an attempt to attract a better pool of applicants. Conversely, if employers perceive that the applicant pool is sufficiently better at the higher wage rate, they may decide to reduce costs by cutting the length of time they advertise. As noted in Table 4, the average length of time each ad was posted on findajob.gov.uk was relatively close to three weeks. When we included only ads that were posted for longer than 21 days in the regression, the elasticity of the number of jobs with respect to the minimum wage is significant and positive, suggesting that the uprating increased the length of time vacancies were advertised.

Table 5 reports elasticities for the number of ads in the findapprentice.gov.uk data with certain characteristics, using the same specification as in Figure 17. These are ads that specify GCSEs as a desired entry qualification, ads posted for more than 30 days and ads with more than 14 days between the closing date and the job start date. None of these were found to react differently to the minimum wage than did the number of ads as a whole, either in 2020 in 2021.

Table 5: Elasticities of number of ads with respect to the apprentice rate, findapprentice.gov.uk data

	Total ads	GCSEs required	Long posting time	Long lead time
Elasticity, 2020	2.068** (0.868)	2.683*** (0.912)	2.235** (0.915)	3.406*** (0.865)
Elasticity, 2021	4.911*** (1.361)	4.854*** (1.033)	3.890** (1.780)	3.903** (1.735)
Fraction of jobs	1.000	0.754	0.280	0.241

Source: findapprentice.gov.uk.
Notes: Robust standard errors clustered by local authority in parentheses. *** p<0.01; ** p<0.05; * p<0.10. Fraction of jobs gives the fraction of ads in the full sample that has the attribute in a particular column.

As noted in the previous section, a drawback of the approach used here is that any trends in hiring that affect a given point in the nominal wage distribution in all regions may be mistakenly attributed to a minimum wage uprating. This may be responsible for the very large elasticities reported in Tables 4 and 5. To examine this further, an alternative approach is taken using the findajob.gov.uk data. This involves using the original data collected on individual ads and comparing how the probability of each attribute being offered changes after an uprating on ads that were affected by the minimum wage relative to ads for the same job title that paid more than the minimum wage (presumably mostly because of regional variation in wage levels). Hence, a series of linear probability models are run, as follows:

$$ATTRIBUTE_{hijt} = \alpha MWAD_{hijt} + \beta MWAD_{hijt} POST_t + \gamma_{it} + \mu_{jt} + \varepsilon_{hijt}. \tag{2}$$

where *ATTRIBUTE* is a dummy variable for whether flexibility, training, bonus or experience, in turn, are mentioned in the job description for ad h for job title j in local authority i in month t, *MWAD* is a dummy for whether the ad specified a wage less than or equal to £8.91 (the NLW rate from 1 April 2021), *POST* is a dummy for months after April 2021. γ is a local authority-month fixed effect and controls for any local trends in hiring rates across all jobs. μ is a job title-month fixed effect and controls for national trends in hiring of particular types of jobs.

Equation 2 improves on the results in Tables 4 and 5 because it compares hiring within very narrowly defined job titles before and after the uprating and therefore controls for any improvements in hiring rates for each job title after April 2021. The results of estimating equation 2 are reported in Table 6. The April 2021 uprating raised the probability of an ad mentioning flexibility, training or experience by 3.0 percentage points (or 10.5% at the mean), 2.0 percentage points (or 3.5%) and 3.6 percentage points (or 5.9%), respectively, and lowered the probability of an ad mentioning bonuses by 0.5 percentage points (or 5.2%). Since the National Living Wage rose by 2.2% in April 2021, these results imply quite large elasticities, as in Table 4. However, now only the elasticity of the probability of mentioning experience with respect to the minimum wage is significant (and equal to 2.73). The National Living Wage is also found to have an insignificant effect on the probability of posting a job for more than 21 days.

Table 6: Regressions of attribute variables, findajob.gov.uk data

	Ads mentioning				Long posting time
	Flexible	Training	Bonus	Experience	
MWAD	0.033**	0.020	0.011	0.012	-0.007
	(0.013)	(0.016)	(0.013)	(0.010)	(0.009)
POST×MWAD	0.030	0.016	-0.005	0.036**	0.012
	(0.021)	(0.021)	(0.008)	(0.015)	(0.018)
Observations	518,096	518,096	518,096	518,096	518,096
R squared	0.582	0.631	0.576	0.601	0.650

Source: findajob.gov.uk.
Notes: Robust standard errors clustered by job title in parentheses. Month-local authority and month-job title fixed effects are included in all regressions. *** $p<0.01$; ** $p<0.05$; * $p<0.10$.

6. The effects of the minimum wage on pay structure within the firm

In this section, we examine whether firms increase the wages offered for jobs that pay above the minimum wage. There is evidence that unequal pay raises may lead to increased job separation (Dube et al. 2019), and negatively impact morale, job satisfaction, and effort (Breza et al. 2018; Card et al. 2012, Cohn et al. 2014). Therefore, firms may seek to maintain pay differentials after a minimum wage uprating. In addition, employees may increase their

reservation wages in response to a minimum wage increase as their perceptions of fair pay are changed (Falk et al. 2006). However, it is also possible that a company may attempt to offset the costs associated with the minimum wage by reducing the pay of high-paid workers.

The evidence on whether pay differentials exist is quite mixed. Dickens and Manning (2004) found that an increase in the minimum wage had no effects on the hourly pay of workers who were paid above the minimum wage. Autor et al. (2016) found some evidence of spillover effects but they argue that this could be due to measurement error. On the other hand, Butcher et al. (2012) found that the minimum wage had effects on wages as far up as the 25th percentile of the wage distribution. Recent work commissioned by the Low Pay Commission (Avram and Harkness, 2019) found that minimum wage increases had a significant negative effect on wage inequality and found evidence of spillover effects of the minimum wage as far up as the 30th percentile of the wage distribution. In particular, they found that a 1 percentage point increase in the proportion of minimum wage workers in an area was associated with 1 to 1.5 percentage growth at the 30th percentile.

The job vacancy data offers a great opportunity to study whether the minimum wage increase has positive spillover effects within a firm. The findajob.gov.uk data include the exact name and address of the employer and many firms post multiple job advertisements for different job titles. Since the job ads data contain the name of the employer, we can study how a given firm responds to an increase in the minimum wage in terms of the wage offers it posts. Specifically, we can study whether firms that are significantly exposed to the minimum wage raise or lower the wages offered to new workers further up the wage distribution.

Methodology

We use variation in the proportion of minimum wage jobs at a given job title across both firms and also across regions. Since the jobs ads data contain rich information on the number of ads posted within a specific firm and given that many firms post multiple job offers, this allows us to use variation in the proportion of job offers posted by a particular firm that specify the minimum wage. However, the ads data also contain data whereby a particular firm may only post a single job offer and therefore it is not feasible to conduct the analysis at the firm level. Instead, we use variation in the proportion of minimum wage job offers across regions. This allows us to study whether we see larger increases in job offers for job titles that pay above the minimum wage in regions where minimum wage jobs are more prevalent. We use the 12 NUTS1 regions that exist within the UK. For both analyses, we omit job ads that were posted by recruitment firms as in many cases the jobs are in a different region than where the

recruitment firm is based. In addition, we do not know the individual specific firm for ads that were posted by recruitment firms.

Firm variation

When using the variation in minimum wage jobs across firms, the outcome variable is the wage offer in ad h for job title j at firm i in month t. The main control variables are the fraction of ads posted by firm i before April 2021 for job title j that specified the minimum wage (*OWNFRAC*) and the fraction of ads posted by firm i before April 2021 for job titles other than j that specified the minimum wage (*CROSSFRAC*), both interacted with a dummy for being after April 2021 (*POST*):

$$w_{hijt} = \alpha OWNFRAC_{ij} POST_t + \beta CROSSFRAC_{ij} POST_t + \eta_j + \mu_j POST_t + \lambda_i + \varepsilon_{hijt}. \qquad (3)$$

In this regression, η and λ control for differences in wages by firm and job title, respectively, and μ controls for differences in wage growth by job title. The estimate of α indicate the direct effect of the minimum wage on the pay of those occupations for which the minimum wage binds, whereas the estimate of β indicates whether there are spillover effects of the minimum wage to high-paid occupations within a firm. A positive effect of β would indicate that firms increase pay on these jobs to maintain pay differentials; a negative effect would indicate that firms attempt to offset the minimum wage by reducing pay further up the wage distribution. Hence, did the pay of, say, care home managers go up by more or less at care homes that employed relatively more minimum-wage workers?

Regional variation

Since smaller firms do not advertise many jobs, but we have many low-paid job titles across the full dataset, we will also aggregate the data within job title-NUTS1 region cells and run a similar regression to the previous one, but this time for the average wage offer in job title j and region i in month t:

$$w_{ijt} = \alpha OWNFRAC_{ij} POST_t + \beta CROSSFRAC_{ij} POST_t + \eta_j + \mu_j POST_t + \lambda_i + \varepsilon_{ijt}. \qquad (4)$$

This time, *OWNFRAC* is the fraction of ads for job title j that specified the minimum wage before April 2021 and *CROSSFRAC* is the fraction of ads that specified the minimum wage among all *other* ads posted by firms in that region that hired job title j.

Results

Table 7 below shows the results using variation across firms. The first column shows the effects when we use the exact job title provided in the data as the job offer. However, in some cases the exact job title is quite idiosyncratic and therefore where possible we mapped all job titles to the SOC 2020 codes.[7] The second column shows the results when we use this more aggregated measure of job titles. The coefficient on *POST* is as expected and implies that after the minimum wage increase on April 1st 2021 that the average wage offered increases by approximately 3 percent. The coefficient on the interaction of *OWNFRAC* and *POST* implies that a 10 percentage point increase in the proportion of ads that specified the minimum wage for a given job title is associated with a 0.4 percent increase in the wages offered for that job title after April 1st. In order to look at whether firms seek to maintain pay differentials, we need to look at the coefficient on the interaction of *CROSSFRAC* and *POST*. The estimates using the SOC 2020 job titles in column 2 suggest that a 10 percentage point increase in the proportion of ads that specified the minimum wage for all *other* ads posted by the firm is associated with an increase in wages by approximately 0.5 percent. This suggests that spillover effects exist and that firms offer higher wages to jobs that pay above the minimum wage in response to a minimum wage hike.

Table 7: Effect of minimum wage uprating on pay differentials

Variables	(1) Log Wage	(2) Log Wage
OWNFRAC	-0.070***	-0.097***
	(0.005)	(0.009)
POST	0.030***	0.026***
	(0.003)	(0.005)
POSTxOWNFRAC	0.034***	0.038***
	(0.005)	(0.008)
CROSSFRAC	-0.013	-0.003
	(0.008)	(0.014)
POSTxCROSSFRAC	0.017	0.048***
	(0.011)	(0.013)
Observations	266,105	207,067
R-squared	0.939	0.758

Source: findajob.gov.uk.
Note: Robust standard errors clustered by region by job title in parentheses. Firm, month, region, and job title fixed effects are included in all regressions. *** p<0.01; ** p<0.05; * p<0.10

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[7] For example, we could see a job title say "waitress" and another job title say "café worker" or "barista" and so we map those to the same SOC 2020 code. In other cases there may different spellings such as "care assistant" and "care assistant" or variations in spacing such as "forklift driver" and "fork lift driver". In some cases it was unclear what the job title referred to and so the sample size using SOC 2020 titles is smaller than the regression using all job titles.

In Table 8 below we use variation in the fraction of minimum wage jobs that exists across the 12 NUTS 1 regions in the UK. Given that firms in different regions may use idiosyncratic names for specific job titles, we focus our attention on the job ads that we have converted to the SOC 2020 code. The results again suggest that firms are seeking to maintain pay differentials. A 10 percentage point increase in the proportion of jobs that offer minimum wages for a given job title is associated with a 1.2 percent increases in wages offered for that job title after the minimum wage uprating. Similarly, a 10 percentage point increase in the proportion of all *other* jobs that specify the minimum wage is associated with an increase of 1.3 percent in the wage offered for that particular job. However, this result is not statistically significant at any of the conventional levels, in part, due to the larger standard errors that we get when using the variation across regions. Nonetheless, given the magnitude of the effect is the same whether we look at interaction of *OWNFRAC* with *POST* or *CROSSFRAC* with *POST* suggests that firms are seeking to maintain pay differentials.

Table 8: Effect of minimum wage on pay differentials

Variables	(2) Log Wage
OWNFRAC	-0.180***
	(0.017)
POST	0.009
	(0.010)
POSTxOWNFRAC	0.123***
	(0.015)
CROSSFRAC	-0.084
	(0.092)
POSTxCROSSFRAC	0.129
	(0.083)
Observations	10,178
R-squared	0.785

Source: findajob.gov.uk.
Note: Robust standard errors clustered by region by job title in parentheses. Month, region, and job title fixed effects are included in all regressions. *** $p<0.01$; ** $p<0.05$; * $p<0.10$. Job titles are based on the SOC 2020 classification.

Care sector analysis

The care sector is one of the largest employers of minimum wage workers in the UK. Recently, Giupponi and Machin (2021) found evidence of positive wage spillovers on younger workers when the minimum wage increased for workers who were aged over 25. Therefore, in this

section we limit our sample to firms that are in the care sector.[8] Another advantage of looking specifically at the care sector is that the care sector was less impacted by lockdowns and furlough and so the effect of the minimum wage increase for care sector workers is less likely to be contaminated by the effects of the pandemic.

Table 9 below shows the results when we limit our analysis to the care sector and use the regression that leverages variation in the proportion of minimum wage jobs across firms. It is clear that whether we use the exact job title given in the data or use the SOC 2020 classification that the same pattern emerges with clear evidence of wage spillovers after the increase in the minimum wage. If we look at the results using the actual job titles, we see that a 10 percentage point increase in the proportion of minimum wage job offers for a given job title is associated with a 0.6 percent increase in the hourly pay offered for that particular title after the minimum wage increase. Similarly, a 10 percentage point increase in the proportion of *other* job titles that offer the minimum wage is associated with a 0.5 percent increase in the wage offered for that particular job. We find similar estimates if we use the SOC 2020 job titles.

Table 9: Effect of minimum wage on pay differentials in the care sector

Variables	(1) Log Wage	(2) Log Wage
OWNFRAC	-0.084***	-0.094***
	(0.010)	(0.013)
POST	0.021***	0.029***
	(0.006)	(0.011)
POST×OWNFRAC	0.056***	0.067***
	(0.008)	(0.013)
CROSSFRAC	-0.036***	-0.051***
	(0.012)	(0.010)
POST×CROSSFRAC	0.046***	0.034***
	(0.016)	(0.013)
Observations	66,009	43,550
R-squared	0.937	0.905

Source: findajob.gov.uk.
Note: Robust standard errors clustered by region by job title in parentheses. Firm, month, region, and job title fixed effects are included in all regressions. *** p<0.01; ** p<0.05; * p<0.10

This suggests that within the care sector there is evidence of firms maintaining pay differentials in response to an increase in the minimum wage by increasing the wage offered in job ads that pay above than the minimum wage. Table A1 in the Appendix shows that if we use

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[8] In some cases it is clear that the firm is in the care sector, due to the specific name of the firm but in other cases it is not so clear. Therefore, for each firm, we calculate the modal SOC code of all the jobs posted by that firm and use the modal occupation to assign whether the firm is in the care sector or not.

regional variation in the fraction of minimum wage workers within the care sector we get a similar estimates although the results are not significant due to the larger standard errors when we conduct our analysis at the regional level.

7. Comparing vacancies and job seekers

To examine how vacancies relate to the number of job seekers, we merge in data from the Labour Force Survey data on the number of workers, E, and number of job seekers, U, at the region-occupation level (using the occupation of the most recent job a job seeker had in the LFS).[9] The unemployment rate in a region (i)-occupation (j)-month (t) cell is then regressed on the vacancy rate in that cell (calculated as the number of vacancies in that cell from the job ads data divided by the sum of vacancies and employed workers), plus cell dummies and month dummies, as follows:

$$U_{ijt}/(U_{ijt} + E_{ijt}) = \alpha V_{ij(t-1)}/(V_{ij(t-1)} + E_{ij(t-1)}) + \eta_{ij} + \lambda_t + \varepsilon_{ijt.} \tag{5}$$

The estimate of α from this regression gives an estimate of the slope of the Beveridge curve and the estimates of η and λ give an estimate of the position of the Beveridge curve in a given region, occupation and month. These give an indication of the degree of variation in frictional unemployment, that is, the extent of mismatches between the jobs demanded by employers and the jobs that workers are willing to take. Higher values indicate a less efficient labour market.

Since we need the lagged vacancy and employment rate, the earliest month we can use in the job ads data is August 2020; we use the most recent release of the Labour Force Survey that was available at the time of conducting our analysis, which has data up to July 2021.

Results

To begin with we estimate the coefficient on the vacancy rate and find that it is -0.14 which confirms the typical inverse relationship between unemployment and vacancies that exemplifies the Beveridge curve. Figure 18 below shows shifts in the Beveridge curve over time relative to August 2020. The positive and significant effects for September and October 2020 imply that the Beveridge curve shifted out in those months, meaning that unemployment was higher relative to the number of vacancies in those months than in August 2020. This may be due to the effects of the Coronavirus Job Retention Scheme, which allowed workers to stay in their jobs, despite being inactive. The scheme was originally intended to end on 31 October

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[9] One drawback of this approach is that we cannot include new entrants to the labour market.

and the fraction of wages covered by the scheme fell in September and again in October. However, on 31 October an extension to the scheme was announced in response to the second national lockdown. This sequence of events may have had the effect of displacing some workers in September and October. However, this effect was short lived, and the insignificant coefficients on the month dummies after October 2020 imply that the Beveridge curve moved back to its initial position.

Figure 18: Shifts in Beveridge curve over time
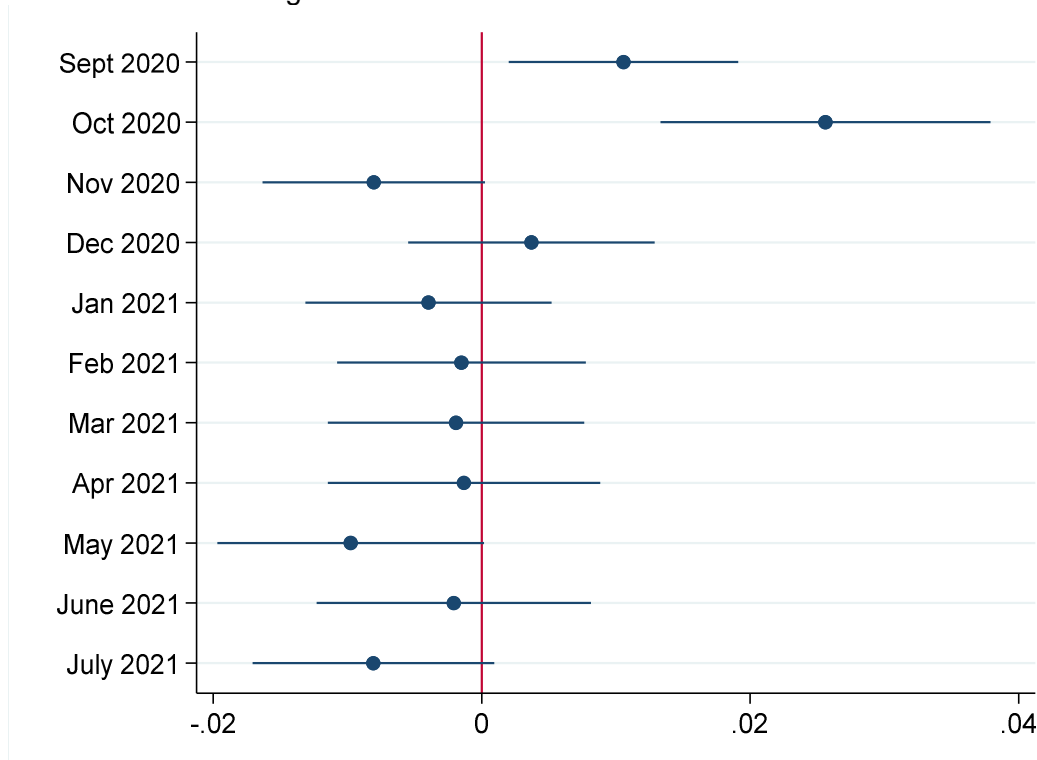
Source: findajob.gov.uk.
Note: Estimates based on Beveridge curve using job ads data and the Labour Force Survey. The base category is August 2020.

Figure 19 shows the position of the Beveridge curve across the 12 NUTS1 regions in the UK. Here, the base category is the South West. The figure highlights the variations in the relationship between vacancies and unemployment across the different regions. We see that unemployment is much higher relative to vacancies in London, the North East, Wales and Northern Ireland, compared with the South West. This could be due to the composition of jobs that exist in these regions.

Figure 19: Position of Beveridge curve across regions

Figure 20 shows the position of the Beveridge curve across the main occupation groups in our dataset. We aggregated the SOC codes to a 2-digit classification and the figure shows the position of the Beveridge curve relative to Health Professionals. The figure is ordered such that professional occupations are at the top of the figure and non-professional occupations are at the bottom of the figure. It is clear from the figure that non-professional type occupations have much higher unemployment relative to the number of vacancies, indicating that there are more mismatches between workers and employers in these occupations.

Figure 20: Position of Beveridge curve across occupation groups
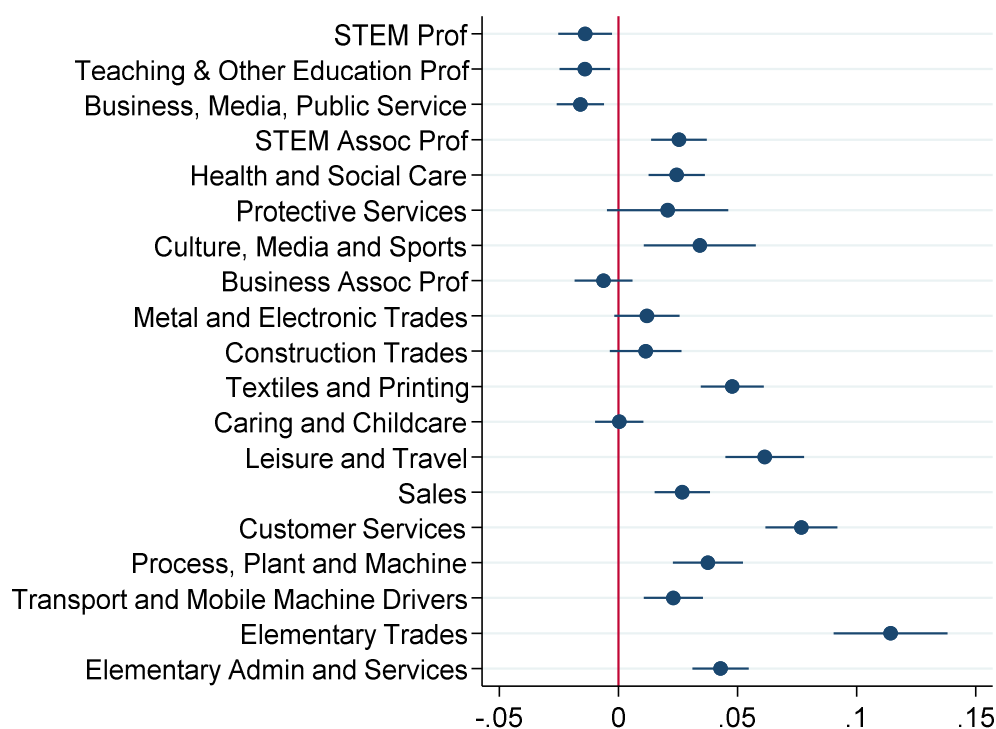
Source: findajob.gov.uk.
Note: Estimates based on Beveridge curve using job ads data and the Labour Force Survey. The base category is Health Professionals.

8. Conclusion

The project has analysed the effects of the UK National Minimum Wage (NMW) on firms' hiring behaviour, drawing on data scraped weekly from two online job ad services: findajob.gov.uk, which contains ads for any job in the public or private sector (collected for the period July 2020-August 2021), and findapprentice.gov.uk, which contains ads for apprenticeships only (collected for May 2019-August 2021). We have looked at four interrelated questions using these data.

In the first section of the analysis, we examined whether the changes in the UK minimum wage in 2020 and 2021 affected the number of ads posted. We used a technique pioneered by Cengiz et al. (2019) with employment data in the US, which involves comparing the loss of jobs immediately below the new minimum wage with the gain in jobs immediately above it. We adapt this methodology to the UK setting by exploiting variation in the real level of the minimum wage across local authorities. However, a shortcoming of this approach is that there appear to be sizeable trends in hiring that are driven by the nominal wage, which will be incorrectly attributed to the effect of the National Minimum Wage. When we minimise these effects as much as possible, we find that the increase in the National Living Wage in April 2021 raised the number of general jobs that were advertised, but by an insignificant amount. In contrast,

the upratings of the Apprentice Rate in 2020 and 2021 were associated with large and significant increases in the number of apprenticeships advertised. The elasticity of the number of ads with respect to the minimum wage was 3.7 in 2020 and 5.1 in 2021.

We extended the Cengiz et al. methodology in the second section to examine how the minimum wage affected the number of job ads with specific characteristics. The National Living Wage appeared to be associated with an increase in the quality of the jobs that were advertised, with ads featuring the terms "flexible", "training", "bonus" or "experience" in the job description becoming relatively more frequent as a consequence of the 2021 uprating, even though the total number of ads was unaffected.

In the third section we exploited the fact that our job ads data contain information on both the exact name of a particular employer and the location of the employer to examine whether the minimum wage uprating in 2021 had an effect on jobs that paid above the minimum wage. The presence of spillover effects suggests that firms seek to maintain pay differentials after a minimum wage uprating. We used variation in the proportion of minimum wage job titles across firms and also across regions to study this question. We found evidence that wage spillovers exists: a 10 percentage point increase in the proportion of job offers that specify the minimum wage is associated with an approximately one half percent increase in the wages offered for such a job title after the minimum wage increase while a 10 percentage point increase in the proportion of all *other* jobs that specify the minimum wage is also associated with a 0.5 percent increase in the wages offered for a given job title. We then focused on the care sector as it employs a substantial fraction of minimum wage workers and found a very similar result to our estimates that used all sectors. Overall, our estimates suggest that the minimum wage increase in April 2021 is associated with an increase in the wages offered for jobs that are higher up the wage distribution which is indicative of firms attempting to preserve inherent wage structures.

In the final section, we estimated the Beveridge curve by combining the job ads data with data from the Labour Force Survey. The estimates show that in September and October 2020 the curve moved out, meaning that unemployment increased relative to the number of job vacancies, consistent with increasing frictions in the labour market. However, the curve shifted back to its initial position after October 2020. We also found that London, the North East, Wales and Northern Ireland and service and elementary occupations displayed higher levels of unemployment relative to vacancies.

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Appendix
Figure A1: Examples of ad postings

(a) findapprentice.gov.uk

(b) findajob.gov.uk

Table A1: Effect of minimum wage on pay differentials

Variables	(1) Log Wage
OWNFRAC	-0.111***
	(0.015)
POST	0.006
	(0.011)
POSTxOWNFRAC	0.101***
	(0.021)
CROSSFRAC	-0.055
	(0.045)
POSTxCROSSFRAC	0.057
	(0.076)
Observations	2,355
R-squared	0.792

Source: findajob.gov.uk.

Note: Robust standard errors clustered by region by job title in parentheses. Month, region, and job title fixed effects are included in all regressions. *** $p<0.01$; ** $p<0.05$; * $p<0.10$. Job titles are based on the SOC 2020 classification.