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Company wage policy in a low-wage labor market

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Abstract
The question of how firms set wages for their employees has been of longstanding interest. In this paper, we investigate what models of wage determination are at play in a low-wage labor market. We exploit a sizable and salient age-specific minimum wage change in the United Kingdom – the National Living Wage (NLW) introduction. Starting in April 2016, the NLW raised the minimum wage rate applying to workers aged 25 and over, leaving unchanged the minimum wage rates for younger workers. Using matched employer-employee data on the English residential care home sector, we document positive wage spillovers on workers aged under 25. Younger workers' wages are shown to have risen in tandem with those of older workers, with no differential employment effects by age at both the market level and the firm level. We probe the inter- vs intra-firm nature of wage spillovers and show that they arise within rather than between firms. Based on empirical tests and qualitative evidence from a survey of care homes in the sample, pay-equity concerns offer the most plausible explanation for the emergence of wage spillovers. The wage spillover effects that we document are shown to emerge in other low-paying sectors of the UK labor market.

Key words: wage determination, minimum wage, fairness
JEL: J31; J38; J42; D63

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1. Introduction

It is now widely accepted that firms play an important role in wage determination. This view is supported by a growing body of empirical work that documents evidence of a significant firm-specific wage component (Card, Heining and Kline, 2013; Card et al., 2018; Song et al., 2018). By contrast, we still know relatively little about *how* firms set wages for their employees and *why* they do so (Card, 2022). Company wage policies may be designed to achieve one or more objectives, such as attracting and retaining a given quantity or quality of talent, meeting employees or societal expectations around fair compensation, or containing administrative and bargaining costs – all objectives that are likely heterogeneous across different segments of the labor market. Importantly, company wage policies can have repercussions on key issues as wage inequality, labor market efficiency and the effectiveness of public policies.

In this paper, we focus on the low-wage, non-union section of the labor market, and investigate (i) what models of wage determination are at play and (ii) what drives their adoption by firms. We exploit a sizable and salient age-specific minimum wage change in the United Kingdom – the National living Wage (NLW) introduction – which raised the minimum wage rate applying to workers aged 25 and over from £6.70 to £7.20 an hour (a 7.5 percent increase) from April 1, 2016, while leaving unchanged the minimum wage rates for younger workers. The size and nature of this age-specific minimum wage change provide a unique 'natural experiment' to study wage (and employment) responses to a quasi-exogenous wage shock targeting a subset of the low-wage workforce. Minimum wages are a prominent example of a public wage policy that can interact with wage setting by firms at the low-end of the pay spectrum.

We analyze wage and employment responses by age at the market level and the firm level. At the market level, we document large, positive wage spillovers of the NLW on workers aged under 25. Younger workers' wages are shown to have risen in tandem with those of older workers, with no differential employment effects by age. At the firm level, we provide evidence that wage spillovers arise within rather than between firms, and that they are stronger in firms with a larger fraction of older workers whose wages are directly affected by the NLW introduction. Both the market-level and firm-level results provide a clear indication of uniform wage setting across workers. Why do firms set wages uniformly across employees? We discuss potential drivers of wage spillovers and assess their relative importance. Based on empirical tests and qualitative evidence from an ad-hoc survey of pay practices, we conclude that fairness norms offer the most plausible explanation for the emergence of wage spillovers.

In the first part of the paper we analyze the market-level wage and employment effects of the NLW introduction. The analysis is based on a monthly panel of matched employer-employee data on the English adult social care sector from the Adult Social Care Workforce Data Set (ASC-WDS). The data includes detailed information on workers' demographics, job role and hourly wages, and spans the period from September 2014 to March 2019. Adult social care covers the provision of personal and physical support to adults – mostly the elderly – affected

by physical, mental or learning disabilities. Social care is a setting especially suited to studying the interaction between company wage policies and minimum wage policy for two reasons. Firstly, social care is traditionally a low-unionized and low-wage sector, characterized by a large fraction of workers paid at the minimum wage and high vulnerability to minimum wage increases (Machin, Manning and Woodland, 1993; Machin, Manning and Rahman, 2003; Machin and Manning, 2004). Secondly, detailed matched employer-employee data with large coverage and precise information on hourly wages is available for this sector, making it a unique setting for studying both market- and firm-level wage effects. To the best of our knowledge, comparable data on other sectors of the economy are not available in the UK.

At the market level, we document strong positive wage spillovers on workers aged under 25 following the NLW introduction. We show that average gross hourly wages and the age profile of wages are smooth at the age-25 cutoff both before and after the NLW introduction. At the same time, no discontinuity emerges in the number of workers employed in the sector around the same age threshold. Using finely-binned gross hourly wage distributions, we show that the NLW introduction generated strong wage compression at the bottom of the distribution and a spectacular spike at the NLW, for under and over 25s alike, corroborating the link between minimum wage policy and spillovers. We can reject that wage spillovers arise due to workforce compositional changes, contractual rigidities, ageing-out effects or frictions in the adjustment of wages to the new 'NLW age-norm'. We probe the external validity of our findings using a large-scale survey of wages and hours covering the entire private sector in the UK labor market. We show that our market-level results hold across the entire UK labor market and, specifically, across low-paying industries and occupations.

The second part of the paper analyzes firm-level effects. While in the market-level analysis we document the existence of wage spillovers, here we investigate whether they arise within or between firms. Wage spillovers are a between-firm phenomenon if they arise as a consequence of younger workers sorting into higher-paying firms; they are a within-firm phenomenon if they reflect company wage policies aimed at retaining talent, preserving equality, controlling administrative costs, and the like. To examine the nature of wage spillovers, we implement a difference-in-differences design and compare the size of wage spillovers across firms that were differentially exposed to the NLW introduction, due to variation in the proportion of workers aged 25 and over paid below the NLW in the pre-reform period. Wage spillovers, we show, are larger precisely in those firms in which larger fractions of older workers had their wages increased as a consequence of the minimum wage reform, pointing to their within-firm nature. Also in this case, no disemployment effects can be tracked down, at neither the extensive nor the intensive margin.

In the third part of the paper, we examine potential determinants of the observed wage effects. Building on Behrend (1960)'s paradigm, our conceptual framework distinguishes two macro drivers of wage spillovers: inter- and intra-firm factors. Inter-firm factors reflect the dynamics of competition between firms to attract and retain workers. If wage spillovers are driven by these inter-firm dynamics, we should observe larger wage spillovers among workers with better

outside options. Intra-firm factors reflect, instead, a cost to the firm of keeping a diversified wage structure, such as the time and resource cost of having to bargain individualized wages, the administrative cost of keeping track of a diversified wage structure, and pay equity constraints. While it is difficult to single out a specific factor, if anything because firms may try to achieve multiple objectives with their wage setting policies, we attempt to gauge the relative importance of the various determinants.

By means of a set of empirical tests, we rule out the hypothesis that wage spillovers are driven by competition among firms and show that the size of a firm's spillovers is not correlated with a broad array of proxies for its workers' outside option. Similarly, we do not find evidence in favor of administrative and bargaining costs playing a significant role in generating uniform pay structures. We provide instead several pieces of evidence on the relevance of fairness norms. First, we show that wage spillovers are larger in firms with a larger share of older workers whose wages increased because of the NLW, even conditional on an equal share of young workers being 'eligible' for a wage spillover (i.e. paid below the NLW in March 2016). Second, and consistent with the notion that horizontal equity concerns are relevant only with respect to a reference group, we show that wage spillovers arise only within – and not across – job roles within the firm. Thirdly, in line with the theoretical prediction that equity concerns generate flatter wage-tenure profiles within the firm (Cabrales, Calvó-Armengol and Pavoni, 2008), we use the pre-NLW firm-specific wage-tenure gradient as a proxy for fairness norms at the firm level, and show that firms with flatter wage-tenure profiles (stronger fairness norms) implement larger wage spillovers. We also document that firms with more compressed pre-NLW wage distributions exhibit larger spillovers. Finally, we complement these quantitative findings with qualitative evidence from the Adult Social Care Survey of Pay Practices (ASC-SPP), an ad-hoc survey of social care providers drawn from the ASC-WDS archives, which we designed to investigate pay practices in the sector. Consistent with the empirical analysis, survey responses indicate that uniform pay/wage spillovers are overwhelmingly motivated by fairness principles.

Our results have important implications for models of the labor market. We show that – even though the institutional setting allows for age-based wage discrimination – firms adopt a uniform pay schedule across workers of different ages within the same reference group, as a result of pay equity constraints. Back-of-the-envelope calculations indicate that those constraints can lead to a genuine profit loss. We estimate that – ceteris paribus – wage spillovers on young workers reduce profit margins by 1.3 percent on average and by up to 3.7 percent in the firms most heavily affected by the NLW introduction. The unwillingness or inability of firms to wage discriminate underscores a central assumption of models of monopsonistic labor markets. When markets are monopsonistic, if employers cannot set wages individually, equilibrium employment will be inefficiently low, as in Manning (2003). Our evidence is also informative of how public policies interact with wage setting within the firm, and can be relevant for the design of a host of wage policies with the potential of affecting the within-firm wage structure (e.g. payroll taxes or minimum wages). In this respect, it is worth noting that, even though the

policy change that we are exploiting is quite singular in nature, the existence of an age-specific minimum wage structure is rather common in countries with minimum wage regulations in place. Hence, the labor market policy considerations drawn from the analysis in this paper are likely widely applicable to similar institutional contexts.

This paper is mainly related to a line of research examining company wage policies. There has been a long-standing interest in labor economics and industrial relations on how firms set wages, what objectives they attempt to achieve and what constraints they face in this process (Behrend, 1960). Recent papers explore how large firms set wages across space, documenting patterns of uniform wage setting across locations in multinational firms (Hjort, Li and Sarsons, 2020) and nation-wide wage setting practices in large multi-establishment firms in the US (Hazell et al., 2022). We complement this literature by examining small-to-medium enterprises in a low-wage labor market and documenting a new form of uniform pricing. In our setting, uniformity arises within job roles within establishments.

Several papers – including those cited above – document wage setting and rent sharing practices that are consistent with within-firm pay equity concerns (Goldschmidt and Schmieder, 2017; Song et al., 2018; Saez, Schoefer and Seim, 2019). The idea that firms are likely constrained by fairness norms is well supported by growing evidence on the labor supply effects of pay inequality within firms (Card et al., 2012; Cohn, Fehr and Goette, 2015; Breza, Kaur and Shamdasani, 2017; Dube, Giuliano and Leonard, 2019) and on the perceived unfairness of inequality in pay (Hvidberg, Kreiner and Stantcheva, 2020). Moreover, various surveys of employers indicate that fairness considerations are an important driver of wage setting (Blinder and Choi, 1990; Katz and Krueger, 1992; Agell and Lundborg, 1995; Campbell and Kamlani, 1997; Galuscak et al., 2012). Combining quasi-experimental and survey results on the same group of firms, we test the role of various wage setting mechanisms and provide direct evidence that fairness considerations play a major role.

In addition, to the best of our knowledge, we are the first to cleanly document the existence of 'downward' wage spillovers – i.e. affecting the portion of the wage distribution *below* the minimum wage – and to characterize their intra-firm nature. In this respect, we contribute to a well-established literature on the wage distributional effects of minimum wage policies – including company-wide ones – and collectively bargained wage floors (DiNardo, Fortin and Lemieux, 1996; Lee, 1999; Manacorda, 2004; Autor, Manning and Smith, 2016; Leonardi, Pellizzari and Tabasso, 2019; Cengiz et al., 2019; Derenoncourt et al., 2021*a*;*b*). Recent work by Giupponi et al. (2022) analyzes the distributional consequences of the NLW in the UK labor market and finds evidence consistent with wage spillovers on workers aged under 25.

Finally, by virtue of the fact that it analyzes the effects of an age-specific policy, this paper is related to prior work analyzing the wage and employment effects of age-specific minimum wage policies (Böckerman and Uusitalo, 2009; Kabátek, 2021; Kreiner, Reck and Skov, 2020) and payroll tax cuts (Saez, Matsaganis and Tsakloglou, 2012; Saez, Schoefer and Seim, 2019). Our

analysis adds to the existing evidence by identifying both market- and firm-level effects from a policy change that is salient, sizable and costly to the firm.

The rest of the paper proceeds as follows. Section 2 outlines the institutional details of the UK minimum wage legislation and illustrates the features of the adult social care sector in England. Section 3 describes the data. Market-level results are discussed in Section 4, while the firm-level analysis is laid out in Section 5. Section 6 investigates potential determinants of wage spillovers and is complemented by a discussion in Section 7. Section 8 concludes.

2. Institutional and economic context

2.1 Minimum wages in the UK

The UK has had a system of age-specific, national minimum wage rates since April 1999.[1] The National Minimum Wage (NMW) was legislated in the National Minimum Wage Act 1998 and came into force on April 1, 1999. Back then, a minimum hourly wage of £3.60 for workers aged 22 and over, and a lower rate of £3.00 for workers aged between 18 and 21 were established. Additional rates have been introduced for workers aged 16-17 in 2004 and for apprentices in 2010. Additionally, in 2010 the adult wage group was expanded to workers aged 21. The National Minimum Wage Act 1998 also appointed the Low Pay Commission (LPC), an independent advisory body charged with advising the Government on minimum wage policy. The LPC's remit is to provide evidence-based advice on minimum wage rates. The body submits its recommendations to the Government, which can accept or reject them.[2] If accepted, the recommended rates subsequently become effective.

On July 8, 2015, the Chancellor of the newly elected conservative government announced the introduction of the National Living Wage (NLW) – a new minimum wage rate for workers aged 25 or above. The NLW raised the minimum wage applying to workers aged 25 and over starting April 1, 2016, while leaving unchanged the minimum wage rates for younger workers. Following the NLW introduction, there are five minimum wages: the NLW for workers aged 25 and over, the NMW for 21-24 year-olds, the youth development rate for 18-20 year-olds, the young worker rate for 16 and 17 year-olds and the apprentice rate for apprentices. Panel A of Appendix Figure A1 shows the evolution of minimum wage rates from 1999 to 2019.

Figure 1 hones in on the policy variation that we exploit for identification. The figure shows the evolution of the minimum wage rate(s) applying to 'adult' workers aged 21 and over between September 2014 and March 2019. Adult workers were subject to the same NMW until the end of March 2016. Starting from April 2016, a different minimum wage rate applies to workers

[1] Prior to that, there used to be industry-level wage floors — the Wage Councils — that were in force between 1909 and 1993. At the time of their repeal, Wage Councils covered only approximately 12 percent of the workforce.
[2] The LPC's recommendations have been always accepted by the UK government, except for two instances in which the Government further increased the apprentice rate.

aged 21-24 (NMW), and aged 25 and over (NLW). Back then, the NMW was set to £6.70 an hour and the NLW to £7.20.

The NLW introduction was a radical political intervention in various ways. Firstly, it generated a minimum wage increase much larger than previous uprates, of 10.8 percent at the time of announcement and of 7.5 percent at the time of implementation. As a result, minimum wage coverage (formally those paid at or below the relevant minimum and up to £0.05 above) grew from 1.6 million to 2.5 million in April 2016. The Government also set a target for the NLW to achieve 60 percent of median wages by 2020.[3] Secondly, the Government announcement departed significantly from the legislative procedure that had been applied since 1999, in which the LPC had a prominent role in the definition of the minimum wage rates. This contributed to making the NLW introduction highly salient.[4] Moreover, the lack of prior publicity and policy discussions highlights the unexpected nature of the reform.[5]

Most importantly for our analysis, the unexpected, sizable and age-specific minimum wage change generated by the NLW introduction provides a unique 'natural experiment' to study the general-equilibrium wage (and employment) response to a quasi-exogenous wage shock targeting a subset of the low-wage workforce. As will be discussed in detail in Sections 4 and 5, the policy variation is suitable to studying wage adjustments at both the market and the firm level.

It is important to stress that in the UK it is not illegal to age-discriminate based on minimum wage rates. The Equality Act 2010 states that it is not unlawful age discrimination to pay workers of different ages at different rates, if the pay structure is based on the age bands set out in the national minimum wage legislation. As such, an employer can pay a younger worker at a lower rate than an older worker, so long as the minimum wage rate for the younger worker is lower than that for the older one, and the younger worker is paid less than the highest minimum wage rate.

2.2 Adult social care in the UK

Adult social care provides support to adults – mostly the elderly – affected by physical or learning disabilities, or physical or mental illnesses. The support provided could be for personal care activities such as eating, cleaning and getting dressed, or for domestic routines such as going to the shops. Adult social care can be provided in care homes (residential care) or in the patient's home (domiciliary care).

[3] Panel B of Appendix Figure A1 shows the evolution of the adult minimum wage as a percent of the median wage from 1999 to 2019.

[4] In the ASC-SPP survey of social care providers – which is described in Section 3 and Appendix C – 9 out of 10 respondents state that they were aware of the features of the NLW at the time in which it was introduced (see Appendix Table C2).

[5] The main justification for the introduction of the NLW was to offset sizable tax credit cuts for individuals aged 25 and over, which were simultaneously announced as part of the emergency budget, but de facto never implemented.

In this paper we focus on workers and firms operating in the *residential care*, or *care home* industry. Residential care refers to the provision of accommodation and personal care to adults in a communal residential center, which may or may not provide nursing facilities. Members of staff in residential care homes are predominantly care assistants, who provide 24-hour supervision, meals and help with personal care needs. The residential care sector is characterized by a large number of small-to-medium enterprises offering a highly labor-intensive and rather homogeneous service, and employing a large number of low-paid workers. Traditionally, the sector has been very low-unionized, with a union coverage rate of 16 percent among all care assistants and of 1 percent among care assistants aged under 25 in 2016 according to Labor Force Survey data.[6] In the UK, adult social care fees are regulated and, for the most part, paid for by local authorities. Indeed, even though approximately 75 percent of residential care places are owned and managed by private-sector, for-profit firms, up to 60 percent of places are funded by local authorities at regulated prices. Taken together, these characteristics make the residential care sector especially vulnerable to the wage-cost shock induced by minimum wage changes, as earlier research on the sector has documented (Machin, Manning and Rahman, 2003; Machin and Manning, 2004).

Apart from being a sector especially suited to studying minimum wage policy, residential care is also an interesting context to study wage-setting practices, since detailed employer-employee matched data with large coverage and precise information on hourly wages is available for this sector. A comprehensive description of the data sources that we adopt is provided in Section 3. To the best of our knowledge, comparable data on other sectors of the economy are not available in the UK.

One obvious drawback of focusing on a single sector of the economy is that the results obtained therein may not extend to other sectors. To overcome this limitation, we replicate the core of our market-level analysis using a large-scale survey of employees for the entire UK labor market. The data used and empirical results are illustrated in Appendix B. It is worth emphasizing that the main objective of this paper is to investigate models of wage determination in the labor market. We document the existence and nature of one such model in a low-wage segment of the labor market. Whilst we show in Appendix B that the model we identify extends to other low-paying industries, it can nonetheless coexist with other wage-setting practices.

3. Data

3.1 Adult Social Care Workforce Data Set (ASC-WDS)

The main data source that is used in the analysis is the Adult Social Care Workforce Data Set (ASC-WDS). This is an online data collection service that covers the adult social care workforce in England. The service is administered by Skills for Care – an independent charity with

[6]The same figures for all workers in the economy are 26 and 13 percent, respectively.

expertise in adult social care workforce development and a delivery partner for the Department for Health and Social Care. For social care providers, ASC-WDS is in essence a human resource management platform, which allows them to store and organize information on their workforce, including payroll data. Through their ASC-WDS account, providers can also view and analyze data on their own workforce, apply for training and development funds, benchmark themselves against other providers locally, regionally or nationally based on key workforce metrics, and directly share their data and returns with governmental authorities such as the Care Quality Commission and the National Health Service. Access to ASC-WDS is free of charge. The data collected within the service is relied upon by the Government, the Department for Health and Social Care, local authorities and the Care Quality Commission to monitor and make planning and funding decisions for the sector.[7]

From the standpoint of a researcher, ASC-WDS is a panel of matched employer-employee data at monthly frequency. For each provider, we have information on the main service provided, service capacity and utilization, number of staff employed, geographic location and dates in which the system is updated by the provider. We observe if the provider is a single firm or if it belongs to a larger parent organization, of which we know the identifier. For workers, we have information on demographics (gender, age, nationality), job role, contractual and additional weekly hours of work, hourly pay rate, qualification and the dates in which the worker's records are updated. We have access to the monthly data files from September 2014 to March 2019, each file including all providers in the system at that date.[8] Skills for Care estimates that at the end of March 2016 – our baseline month – ASC-WDS had 56 percent coverage of English regulated social care establishments and approximately 50 percent coverage of workers employed by registered providers (Davison and Polzin, 2016).

We now define the samples used in the market-level analysis and the firm-level analysis. For the market-level analysis, we consider all workers employed in residential care homes active in any given month between September 2014 and March 2019. As of March 2016, the sample comprises a workforce of close to 332,700 individuals, employed by a total of 9,100 providers belonging to 4,500 single or parent organizations.[9] For the firm-level analysis, we employ a balanced panel of 4,631 providers that have been active throughout the period from March 2016 to March 2017. We restrict the sample to firms having updated their records at least once after March 2016 – a requirement which is not especially restrictive considering that 96 percent of

[7]The Care Quality Commission is the independent regulator of health and adult social care in England.

[8]In order to accurately establish the activity status of each provider and, if present, their parent organization, we link the ASC-WDS data to the Care Quality Commission registry. The latter offers a complete record of all active English care providers regulated by the Care Quality Commission, the independent regulator of adult social care in England. The archive is available at monthly frequency and updated each month. It can be used to precisely identify the activity status of providers at each point in time.

[9]Throughout the manuscript we use the terms 'provider' and 'firm' interchangeably to indicate a single-establishment firm or an establishment within an organization.

employers update their data within a year.[10] Finally, due to the nature of the research question, we consider firms that employed workers under 25 both in March 2016 and March 2017.[11]

Appendix Table A4 reports the mean and standard deviation of a set of individual and firm characteristics for workers in the market-level sample in columns 1 and 2, and for workers and firms in the firm-level sample in columns 3 to 6. All figures are as of March 2016. The statistics confirm the depiction of the residential care sector that was provided in Section 2.2, namely that the industry is characterized by low pay (£7.91 per hour on average) and is highly exposed to minimum wage changes – in March 2016, 51 percent of workers aged 25 and over were paid below the NLW.[12] The average employee is a woman (84 percent of the workforce being female), aged 42 and with approximately 5 years of tenure in the firm. Workers aged under 25 make up 12 percent of the workforce. 82 percent of workers have British nationality. The main occupation in residential care is 'care assistant' (equivalently 'carer'), making up for 55 percent of the workforce, followed by 'ancillary staff' (15 percent), 'senior carer' (9 percent), 'nurse' (6 percent) and 'administrative staff' (2 percent). Carers and senior carers attend to the personal needs of residents, with senior carers potentially overseeing teams of carers. Ancillary staff perform support activities not involving direct personal care, such as cleaning and cooking. Nurses provide skilled care and have nursing qualifications, while the vast majority of (senior) carers do not. Hourly wages are lowest for ancillary staff (£7.13 on average) and care assistants (£7.20), slightly higher for senior carers (£8.05) and administrative staff (£8.62), and in line with national median wages for nurses (£12.82). Almost 9 out of 10 workers are hired on a permanent contract and 8 percent as 'bank' staff, i.e. on a casual contract. Whether permanent or not, 8 percent of workers are on a zero hours contract, a contractual arrangement in which workers are not guaranteed any hours of work in a particular period. Finally 75 percent of firms are private, for-profit entities (even if all the services provided may be purchased by one or more

[10] In Appendix Table A1, we assess the robustness of our main firm-level results to not conditioning the sample on record updating after March 2016. All coefficient estimates are very similar in magnitude to our main ones.

[11] Conditioning the sample of firms to be active between March 2016 and March 2017, and to employ young workers in both periods, may generate endogenous sample selection. We test whether this is the case in Appendix Tables A2 and A3. In Appendix Table A2, we consider all firms active (and employing workers under 25) in March 2016 and estimate linear probability models of the organization being active in March 2017, March 2018 and March 2019, as a function of the bite of the NLW among workers aged 25 and over in March 2016, and conditional on a set of firm-level characteristics at baseline and travel to work area fixed effects. This specification corresponds to the reduced-form specification that we use in the firm-level analysis and that is described in more detail in Section 5.1. The estimates in Appendix Table A2 suggest that there is no systematic relationship between the NLW bite – our 'treatment' variable – and survival over the three years after the NLW introduction. The coefficient in column 1 indicates a modestly significant, negative effect of the NLW bite in 2016 on the probability of survival in March 2017; the effect is small (2 percent of the baseline) and fades away in subsequent years. The results reported in Appendix Table A3 test instead for sample selection with respect to conditionality on youth employment in March 2016 and March 2017. All estimates are based on linear probability models similar to the one described above. Based on the sample of firms active in March 2016, the coefficient in column 1 is an estimate of the effect of the NLW bite on the probability of employing workers under 25 in March 2016. The estimates in columns 2 to 4 are instead based on firms active and employing young workers in March 2016, and represent the association between the NLW bite in March 2016 and the probability of employing young workers in subsequent years (conditional on being active). Taken together, the estimates suggest that conditioning on youth employment is not introducing sample selection with respect to treatment intensity.

[12] In 2016, the tenth percentile of UK hourly wages was approximately £7.30 and the average hourly wage £15.70.

local authorities), 16 percent are non-profit, and 7 percent are fully funded and managed by local authorities.

3.2 Adult Social Care Survey of Pay Practices (ASC-SPP)

We complement the quantitative evidence based on the ASC-WDS data with qualitative information from the Adult Social Care Survey of Pay Practices (ASC-SPP). The ASC-SPP is an ad-hoc survey of social care providers drawn from the ASC-WDS archives, designed to investigate pay setting, vacancy posting and hiring practices of adult social care providers. The survey design, sampling frame and implementation are described in detail in Appendix C.1, and the survey questionnaire is reported in Appendix C.4. The survey results – reported in Appendix C.3 – will be illustrated in Section 6.

3.3 Care Quality Commission Ratings

The ASC-WDS data can be matched with ratings of the quality of care services by the Care Quality Commission. As the independent regulator of adult social care in England, the commission is responsible for setting standards of care and for monitoring, inspecting and rating adult social care providers, to make sure that they meet fundamental standards of quality and safety. At the heart of its regulatory activity, the rating process is based on periodic inspections of care providers followed by the publication of reports showing the evaluation of the quality of care. The ratings are articulated into an overall judgement and five key lines of enquiry.[13] We have access to the history of ratings starting from October 2014 and we can link them to observations in the ASC-WDS database.

3.4 Annual Survey of Hours and Earnings (ASHE)

The Annual Survey of Hours and Earnings (ASHE) is a large-scale survey of earnings and hours of employed individuals in the UK. The survey collects information on the wages and paid hours of work of nearly one percent of the working population, drawing the sample of individuals from National Insurance records and requesting their employers to fill the survey forms. The survey covers employment in all industries and occupations in the UK and can therefore be used to investigate UK-wide market-level responses to the NLW. ASHE cannot be used to study firm-level responses to the NLW, since the sampling frame does not guarantee that all workers in a given establishment are observed in the data. Using ASHE, we probe the external validity of the market-level results obtained for the adult social care sector. A detailed

[13]The five lines of enquiry ask if the service is safe, effective, caring, responsive to people's needs and well-led, while the overall judgement is an aggregation of these five dimensions. The rating can be outstanding, good, requires improvement or inadequate. Further details can be found at https://www.cqc.org.uk/what-we-do/how-we-do-our-job/ratings.

description of the ASHE data and of the market-level effects estimated therein is provided in Appendix B.

4. Market-level effects

4.1 Wage and employment responses

In this section, we analyze the effects of the NLW introduction on hourly wages and employment by age. We use the sample of all *care assistants* employed in residential care homes in any given month. To evaluate the wage effects of the NLW introduction, we test whether average gross hourly wages by age become discontinuous at the age-25 eligibility cutoff after the policy change. Note that, prior to the NLW introduction, all workers aged 21 and over were legally subject to the same minimum wage (NMW). Under the plausible assumption that workers aged just below and just above 25 are close-to-perfect substitutes in terms of their labor productivity, hourly wages are expected to be smooth around the age-25 cutoff in the pre-reform period. We formally test for the presence of a discontinuity at the eligibility threshold using a regression discontinuity design (RDD). We use the following empirical specification:

$$w_{it} = \alpha_0 + \alpha_1 \cdot \mathbb{I}[age_{it} \geq 25] + f(age_{it} - 25) + g(age_{it} - 25) \cdot \mathbb{I}[age_{it} \geq 25] + \varepsilon_{it} \quad (1)$$

where w_{it} denotes the gross hourly wage for worker i in month-year t, age_{it} is i's age measured at the quarterly level at time t, and ε_{it} is the error term. $f(\cdot)$ and $g(\cdot)$ are polynomials in *age* centered around 25. In this model, the parameter of interest is α_1, which captures the discontinuity in wages at age 25. Following Cattaneo, Idrobo and Titiunik (2020), we treat our running variable as discrete and estimate the model non-parametrically by fitting a local polynomial to a 'collapsed' version of the data, in which we aggregate the individual observations by the discrete values of the running variable and compute the average outcome for all observations with the same value of the running variable. Panel A of Appendix Figure A2 reports the RDD estimate and associated 95 percent confidence interval of a set of McCrary tests for a discontinuity in the density function at the age-25 cutoff for the end-month of each quarter in the sample period. The test fails to reject the null hypothesis of no discontinuity in the density of the running variable at the relevant threshold throughout the period analyzed, supporting the identification assumption of the RDD.[14]

[14]We also conduct a set of falsification tests for the assumption of local randomization in the minimum window around the cutoff $[24.75, 25]$. Firstly, we run a sequence of density tests in the end-month of each calendar quarter in the sample (from September 2014 to March 2019). The statistical tests assess whether the density of observations in the window is consistent with what would be observed if observations where assigned randomly to either side of the threshold. The tests support the assumption of local randomization in 74 percent of cases. Secondly, we run a set of balancing tests on predetermined covariates. We estimate the RDD effect of age on the probability of being employed as carer and – conditional on being a carer – of being female. The balancing tests strongly support the assumption that individuals aged slightly below and slightly above 25 share the same predetermined characteristics throughout the period analyzed. Results available upon request.

Panel A of Figure 2 visualizes the effect of the NLW introduction on average wages of care assistants by age. The graph plots the average gross hourly wage in each age bin (with age measured in quarters) in March 2016 and in March 2017, and reports the RDD estimate and associated standard error for both periods in the top right corner. The figure shows that – prior to the reform – wages were a moderately increasing, smooth function of age and averaged £7.00 around the 25 age threshold. Twelve months after the NLW introduction, the age-profile of wages is a shifted version of the pre-reform one, with a small and moderately significant discontinuity of £0.05 at the cutoff. On the top right corner of the graph, we also report estimates of a regression kink design (RKD) testing for a change in the wage-age profile around the age-25 threshold before and after the policy change.[15] Our estimates reject any significant change in the age-profile of hourly wages. Panel B of Figure 2 shows that the evolution of hourly wages by age continues as a vertical shift two and three years after the reform, with no statistically significant discontinuity in average wages nor in the wage-age gradient at the NLW eligibility threshold. Panel B of Appendix Figure A2 reports the sequence of RDD estimates for the entire period of analysis, confirming the substantial smoothness of the wage profile both before and after the reform.

These results indicate that younger workers' wages rose in tandem with those of older workers, with no detectable differences around the policy cutoff. In other words, the NLW introduction generated positive wage spillovers on young workers who were not legally bound by the minimum wage increase. This is the first clear evidence of 'downward' wage spillovers – i.e. spillovers affecting the portion of the wage distribution *below* the minimum – generated by a minimum wage increase. On the contrary, 'upward' wage spillovers – that is spillovers affecting wages strictly *above* the minimum – have been largely documented at the market level in the minimum wage literature (DiNardo, Fortin and Lemieux, 1996; Lee, 1999; Autor, Manning and Smith, 2016).

To quantify the size of market-level wage spillovers, Appendix Table A5 displays estimates of the coefficient α_1 in model 1 for different wage outcomes. We estimate the model pooling data for March 2017, March 2018 and March 2019, and including time fixed effects in the estimation. Column 1 reports the estimated α_1 using hourly wages of care assistants as outcome variable. In column 2, the outcome variable is a measure of the counterfactual hourly wage that care assistants would have received absent wage spillovers. For workers aged 25 and over, the counterfactual wage is equivalent to their actual wage $w_{i,t}$, where t indexes calendar years. For younger workers, it is defined as $\max\{w_{i,t-1}; NMW_t^{21-24}\}$ if $w_{i,t-1} < NLW_t$, and $w_{i,t}$ otherwise.[16] The results in column 2 indicate that, absent wage spillovers, a discontinuity of £0.20 would have emerged at the age-25 cutoff on average in the post-NLW years. The

[15] More formally, our RKD estimates are based on a non-parametric estimation of the parameter δ_2 in the following specification: $w_{it} = \delta_0 + \delta_1 \cdot (age_{it} - 25) + \delta_2 \cdot (age_{it} - 25) \cdot \mathbb{I}[age_{it} \geq 25] + \mu_{it}$, where all variables are defined as in model 1 and μ_{it} is the error term.

[16] The counterfactual wage for new hires aged under 25 is assumed to be equivalent to NMW_t^{21-24}.

magnitude of wage spillovers can be measured as $\frac{\hat{\alpha}_1^{counterf} - \hat{\alpha}_1^{actual}}{\hat{\alpha}_1^{counterf}}$, which is reported in the bottom row of the table. We estimate a wage spillover of 90 percent among care assistants.[17]

Panel C of Figure 2 shows that the positive wage spillovers were not accompanied by negative employment spillover effects on young workers. The figure reports the employment count for carers by age bin before and after the reform, showing no discontinuity at age 25 nor substantial changes in the profile of employment by age bin. Panel D of Figure 2 rules out the possibility that employment changes occurred in the months between the announcement and the introduction of the NLW. Employment in those months is characterized by the same profile as one month prior to the reform announcement and no discontinuity can be detected at age 25 in the months between announcement and implementation. No discontinuity in employment can be detected up to three years after the policy reform, as Panel C of Appendix Figure A2 shows. Similarly, no discontinuity can be found in average weekly hours worked, as shown in Panel D of Appendix Figure A2.

4.2 Anatomy of wage spillovers

While so far we have focused on average wages, we now turn to analyzing how the hourly wage distribution changed in response to the NLW introduction. Empirically, we construct a set of finely-binned hourly wage distributions, with bins of £0.10 width, and trace out their evolution from before to after the NLW introduction for different subgroups of workers. With this strategy, we can neatly identify where spillover effects are localized along the distribution and establish more convincingly the direct causal relationship between the minimum wage policy and the observed wage effects. We can also test the role played by a set of potential determinants in generating the observed wage responses.

Panel A of Figure 3 reports the hourly wage distribution of care assistants aged 25 and over in March 2016 (gray bars) and March 2017 (unfilled bars). The red dashed vertical line indicates the level of the NLW in March 2017. Among eligible workers, the introduction of the NLW generated strong compression at the bottom of the wage distribution and a spectacular spike at the new minimum. The same phenomenon can be observed when focusing on workers aged under 25, as shown in Panel B of Figure 3. The distribution of younger workers' wages exhibits the same spike at the NLW, corroborating the idea that wage spillovers are arising as a consequence of the NLW change and indicating that a large fraction of young workers had their wages raised exactly at the new minimum.

Aging-out effects. Of the various factors that could generate the observed wage effects, a simple one is 'aging-out' effects. If a large fraction of workers aged under 25 are in fact close to turning 25, firms may bundle their wages with those of older workers and increase them at

[17] Columns 3-4 report analogous estimates for all workers in residential care, where spillovers are equivalent to 92 percent.

the same time for the sake of simplicity. One simple way to test this hypothesis is to look at the evolution of the wage distribution of workers aged well below 25 in March 2017. Panels C-F of Figure 3 report the wage histograms for workers aged under 24, 23, 22 and 21 in the pre- and post-reform periods. All figures resemble closely the results in Panel B, ruling out the possibility that 'aging-out' effects are generating the spillovers.

Compositional changes. Another factor that may give rise to the observed wage response is a change in the composition of the workforce aged under 25. If most firms suddenly laid off the least productive among young workers and/or hired highly productive ones, this could generate the type of uniform pricing that we have seen. To test this idea, Panel A of Figure 4 keeps fixed the composition of the sample, by selecting workers who are in the data both in March 2016 and in March 2017, and who were aged under 24 in March 2016. A spike at the new minimum arises also in this case, excluding substantial composition-driven biases.

Contractual rigidities. Wage adjustments by firms may be constrained by contract- or norm-based wage rigidities. In particular, employment relationships may be characterized by implicit or explicit long-term agreements on the profile of wage increases over time. In the presence of such contractual or norm-based rigidities, employers may be unable to implement age-specific wage adjustments in response to a policy change like the NLW introduction. To assess the role of implicit and explicit contracts in shaping wage spillovers, we restrict the analysis to subgroups of workers aged under 25, for whom contractual rigidities are plausibly non-existent or very weak. Panel B of Figure 4 focuses on workers hired by firms that newly established their activity after the NLW introduction. Panel C covers workers hired after March 2016 and with no prior experience in adult social care. Panel D also focuses on new hires, but considering workers who were previously employed in adult social care. Finally, Panel E restricts the sample to temporary, temp-agency and bank – i.e. casual – workers, who can be considered 'outsiders' of the labor market, typically subject to less rigid and shorter contracts. For all those subgroups of young workers, we can still detect a spectacular spike at the NLW, indicating that contractual rigidities cannot plausibly explain our results.

Adaptation to a new norm. Finally, it may take time for the wage structure to adapt to a new institutional norm. Before the NLW was introduced, the NMW had been the established or 'going' rate applying to all workers aged 21 and over since 2010, and to all workers aged 22 and over since 1999. Departing from a vicennial institutional norm may take more than just 12 months. In Panels A-D of Figure 5, we trace out the dynamics of wage spillovers over time, by reporting the evolution of the hourly wage distribution of young workers from March 2016 to March 2020, thus covering the NLW introduction and its subsequent upratings. The large spike at the NLW remains a persistent feature of the wage distribution throughout the period and up to four years after the policy reform. In light of these results, we can conclude that the wage spillovers do not seem to be the outcome of short-run, norm-based adjustment frictions.

Robustness. In order to keep the sample as homogeneous as possible, the analysis in this section restricts the sample to care assistants. Results are robust to including all occupations in the sample (Appendix Figures A3 and A4) and to analyzing a representative sample of private-sector UK workers (see Appendix B).

5. Firm-level effects

5.1 Empirical strategy

In Section 4, we documented the existence of positive wage spillovers on young workers. Wage spillovers are a between-firm phenomenon if they arise as a consequence of workers sorting to higher-paying firms – younger workers in case of 'downward' spillovers and workers paid above the minimum in case of 'upward' spillovers. They are, instead, a within-firm phenomenon if they reflect company wage policies aimed – for instance – at preserving equality among workers in the case of 'downward' spillovers or at maintaining wage differentials in the case of 'upward' spillovers.

We probe the within- vs between-firm nature of wage spillovers by analyzing the size of wage spillovers on young workers across firms that were differentially exposed to the NLW introduction. Our empirical strategy is based on a difference-in-differences design with continuous treatment, in which we compare the evolution of younger workers' wages across firms that were differentially affected by the policy change, due to variation in the proportion of workers aged 25 and over paid below the NLW in the pre-reform period. For this part of the analysis, we consider a balanced panel of firms active throughout the period between March 2016 and March 2017, and employing at least one worker aged under 25 in both periods, as described in Section 3.1. We also report results for the unbalanced panel of firms active in March 2016. Our empirical model can be formalized as follows:

$$\Delta \ln w_{j,t}^{under25} = \beta_{0,t} + \beta_{1,t} MIN_{j,Mar16}^{25+} + X'_{j,Mar16}\beta_{2,t} + \eta_{j,t} \tag{2}$$

where $\Delta \ln w_{j,t}^{under25}$ is average gross hourly wage growth in firm j between month-year $t-3$ and month-year t; $MIN_{j,Mar16}^{25+}$ is the proportion of workers aged 25 and over paid less than the NLW in firm j in March 2016; $X_{j,Mar16}$ includes a set of firm-level controls (the proportion of female workers, average workers' age, and the proportion of carers, senior carers, ancillary staff, nurses and administrative staff) and travel to work area (TTWA) fixed effects as of March 2016; $\eta_{j,t}$ is the error term.[18] The subscript t indicates the month-year relative to March 2016, which is normalized to take value $t = 0$. The coefficient of interest $\beta_{1,t}$ identifies the effect of the bite of the NLW in $t = 0$ on young workers' wage growth between $t-3$ and t. We estimate the

[18] TTWAs are the official British definition of local labor market areas. The main criterion for defining TTWAs is that at least 75 percent of the area's resident workforce work in the area and at least 75 percent of the people who work in the area also live in the area. As such, TTWAs are based on statistical analysis rather than administrative boundaries. There is a total of 152 TTWAs in our sample.

coefficient $\beta_{1,t}$ for $t = \{-15, -12, ..., 0, 3, ..., 36\}$. The coefficients $\beta_{1,t}$ for $t = \{-15, -12, ..., 0\}$ are treatment leads and provide a way to test for any systematic correlation between young workers' wage growth and the bite of the NLW prior to the NLW introduction. This is analogous to testing for the parallel trends assumption in a traditional difference-in-differences design. To document the evolution of the relationship between the NLW bite and youth wage growth in the post-reform quarters, we measure the outcome variable $\Delta \ln w_{j,t}^{under25}$ as the long difference between $t = 0$ and $t = 3$, $t = 6$, $t = 9$, and so on. This is equivalent to estimating the cumulative effect of the reform over post-reform quarters, i.e. $\sum_{t=3n, n\in\{1,...,12\}} \beta_{1,t}$. We cluster all standard errors at the TTWA level.

The variable $MIN_{j,Mar16}^{25+}$ is constructed as the proportion of workers aged 25 and over that in March 2016 were paid below the age-specific minimum wage rate that would become effective on April 1, 2016. It can be interpreted as the degree of direct exposure of the firm to the policy reform. Panel A of Appendix Figure A5 shows the density distribution of the variable $MIN_{j,Mar16}^{25+}$. There is a spike at zero of close to 12 percent. Over the range $(0, 1]$, the distribution is fairly dispersed and moderately left skewed. The average value of $MIN_{j,Mar16}^{25+}$ in the sample is 0.52, with a standard deviation of 0.32. The share of older workers paid below their next age-specific minimum is highly persistent, as can be seen in Panel B of Appendix Figure A5, which reports the correlation between $MIN_{j,Mar16}^{25+}$ and $MIN_{j,t}^{25+}$ for $t = \{-15, -12, ..., 0, 3, ..., 36\}$.

Our empirical strategy rests on the assumption that, following the NLW introduction, larger fractions of low-paid 25-and-overs are predictive of faster wage growth among older workers at the firm level. To probe this assumption, we estimate model 2 using older workers' wage growth as outcome variable, $\Delta \ln w_{j,t}^{25+}$. Panel A of Figure 6 reports the estimated coefficient $\hat{\beta}_{1,t}$ for $t = \{-15, -12, ..., 0\}$, and the cumulative sum $\sum_{t=3n} \hat{\beta}_{1,t}$ for $n = \{1, ..., 12\}$. The dots indicate the estimated coefficients and the capped vertical bars report 95 percent confidence intervals based on robust standard errors. Results are displayed for the balanced (black circles) and unbalanced (hollow circles) samples. The results show a strong, positive correlation at the firm level between the fraction of older workers paid below the NLW in March 2016 and subsequent wage growth. Moreover, they provide compelling evidence for the causal effect of the NLW introduction on older workers' hourly wage growth: while no systematic correlation between $MIN_{j,Mar16}^{25+}$ and quarterly wage growth can be detected prior to the NLW introduction, a statistically significant correlation emerges following the policy change. Column 1 of Table 1 reports the point estimate of $\sum_{t=3n, n\in\{1,...,4\}} \hat{\beta}_{1,t}$. A one-standard-deviation increase in $MIN_{j,Mar16}^{25+}$ (corresponding to a 32 percentage point change) is associated with 2.3 percentage point faster growth in older workers' hourly wages on a baseline of 3.5 percent.

Model 2 identifies wage spillovers in reduced form. If we define wage spillovers as the elasticity of young workers' wages to older workers' ones, we can obtain a structural-form estimate of wage spillovers by estimating the following model:

$$\Delta \ln w_{j,t}^{under25} = \gamma_0 + \gamma_1 \Delta \ln w_{j,t}^{25+} + X'_{j,Mar16}\gamma_2 + \nu_{j,t} \tag{3}$$

The parameter γ_1 measures the elasticity of young workers' wages to older workers' ones between March 2016 and March 2017. Building on the results presented in the previous paragraph, we can identify γ_1 by instrumenting $\Delta \ln w_{j,t}^{25+}$ with $MIN_{j,Mar16}^{25+}$. A version of model 2 with $\Delta \ln w_{j,t}^{25+}$ as outcome can therefore be considered the first stage of the instrumental variable model. The estimates reported in Panel A of Figure 6 and column 1 of Table 1 demonstrate the relevance of the instrument – the F-statistics on the excluded instrument being above 350. Moreover, the absence of pre-trends in Panel A of Figure 6 provides compelling evidence in favor of the exogeneity of the instrument.[19]

5.2 Results

Wage spillovers. Panel B of Figure 6 provides a compelling visualization of the within-firm nature of wage spillover effects. The graph reports the sequence of estimated $\hat{\beta}_{1,t}$ for $t = \{-15, -12, ..., 0\}$, and the cumulative sum $\sum_{t=3n} \hat{\beta}_{1,t}$ for $n = \{1, ..., 12\}$, from model 2. The results show that the variable $MIN_{j,Mar16}^{25+}$ is predictive not only of wage growth among 25-and-overs (as seen in Panel A of Figure 6), but also of wage growth among younger workers at the firm level. These results indicate that it is precisely in those firms that are more severely affected by the NLW introduction – because of their ex-ante exposure to the policy change – that younger workers' wages are seen to grow faster after the reform. Column 3 of Table 1 reports the reduced-form estimate of $\sum_{t=3n, n\in\{1,...,4\}} \hat{\beta}_{1,t}$, whereby a one-standard-deviation increase in $MIN_{j,Mar16}^{25+}$ is associated with 1.6 percentage point faster wage growth among workers aged under 25, on a baseline growth of 3.5 percent. Column 4 reports the IV estimate of parameter γ_1: the elasticity of younger workers' wages to older workers' ones is close to 0.7, indicating that for every 1 percent increase in older workers' wages, younger workers' ones increase by 0.7 percent. This is one of the central results of this paper, since it uncovers the within-firm nature of wage spillovers.

Our wage spillover effects are robust to a range of different specifications. In columns 1 and 2 of Appendix Table A6, we report the reduced-form and IV estimates of spillover effects, measuring wage growth between March and September 2016, rather than March 2016 and March 2017. This allows us to isolate spillovers net of the wage increase in the NMW that took place in October 2016. We estimate an elasticity of 0.7, extremely close to our headline estimate. In columns 3 and 4, we report reduced-form and IV estimates of wage spillovers using the wage-bill gap

[19] In column 2 of Table 1, we test the relevance of a second instrument, the 'wage-bill gap', which captures the mechanical percent effect of the NLW introduction on the wage bill of the firm. Formally, the gap in firm j at time t is defined as $\frac{\sum_{i\in j|age_i\geq 25} h_{i,j,t} \cdot \max\{NLW_{t+1} - w_{i,j,t}, 0\}}{\sum_{i\in j|age_i\geq 25} h_{i,j,t} \cdot w_{i,j,t}}$, where $h_{i,j,t}$ is the number of weekly hours of work of worker i in firm j at time t. The gap measures by how much the wage bill of the firm would have to increase in percent to comply with the NLW regulations, assuming no changes in employment at the extensive or intensive margin, and no wage spillover effects as a result of the NLW introduction. The results in column 2 indicate that a one-standard-deviation increase in the wage-bill gap in March 2016 (corresponding to a 5 percentage point increase) is associated with a 1.3 percentage point faster growth in older workers' hourly wages on a baseline of 3.5 percent. The wage-bill gap turns out to be a weaker instrument when compared to the proportion of low-paid workers, as can be seen by the low F-statistic reported in the table. We therefore use the low-paid proportion as main instrument for the analysis and report the IV estimates based on the wage-bill gap in Appendix Table A6. See infra for more details.

rather than the low-paid proportion as instrumental variable. We estimate an elasticity of 0.5.[20] In columns 5 and 6, we report the reduced-form and IV estimates of spillover effects, measuring wage growth in levels rather than percent. The estimate of γ_1 in column 6 indicates that young workers' wages increased on average by £0.64 for every £1 change in older workers' wages. Finally, in Appendix Table A7, we estimate versions of our reduced-form and IV models in which we use as outcome the change in the proportion of under 25s paid exactly at the NLW (columns 1-2) or paid at or above the NLW (columns 3-4). The IV regressions use the change in the proportion of workers aged 25 and over paid at the NLW as main regressor, instrumented with the variable $MIN^{25+}_{j,Mar16}$. A 10 percentage point increase in the proportion of older workers paid at the NLW increases the fraction of young workers paid at the NLW by 7 percentage points and that paid at or above the NLW by 11 percentage points. The results indicate that wage spillovers are mainly in the form or raising young workers' wages precisely at the new minimum.

Employment spillovers. Similar to our market-level results, the firm-level analysis reveals that positive wage spillovers did not arise at the cost of negative employment spillover effects for young workers. Columns 5 and 6 of Table 1 report estimates of reduced-form model 2 and IV model 3 using the change in the share of workers aged under 25 between March 2016 and March 2017 as outcome variable. The estimated effects are small in magnitude and statistically insignificant. Additionally, we do not find evidence of negative employment effects at the intensive margin. As reported in column 2 of Appendix Table A8, we estimate a positive, though statistically insignificant, elasticity of weekly hours worked by young workers to older workers' wages of approximately 0.3.

Zero hours contracts. A margin along which care homes have been found to adjust in response to the NLW introduction is the utilization of zero hours contracts (Datta, Giupponi and Machin, 2020). As mentioned before, zero hours contracts are contractual arrangements that give large intensive-margin flexibility to employers, by not obliging them to offer a minimum number of hours. Increased use of zero hours contracts can be an indirect way to reduce employment at the intensive margin (and de facto also at the extensive margin by offering zero hours forever). After the NLW introduction, firms could increasingly use zero hours contracts as a form of self-insurance against future shocks, that – in the face of a larger and downward-rigid wage bill – may require employment reductions. Columns 3 and 4 of Appendix Table A8 reports reduced-form and IV estimates using the change in the share of young workers employed under a zero hours contract as outcome. In addition, column 5 reports the IV estimate of the semi-elasticity of the incidence of zero hours contracts among young workers to young workers' wages (in this case, we are instrumenting $\Delta \ln W^{under25}_{j,t}$ with $MIN^{25+}_{j,Mar16}$). The magnitude of the estimated semi-elasticity is such that for every 1 percent increase in older (younger) workers'

[20]The wage-bill gap is defined in footnote 19. As reported in the bottom line of the table, it is a weak instrument, hence these results should be interpreted with caution.

wages, the share of young workers on zero hours contracts increases by 0.29 (0.43) percentage points on a baseline of 11 percent. Both results are statistically insignificant and not precisely estimated.

Turnover. Finally, we look at whether firms that operate larger wage spillovers experience reductions in the turnover rate among young workers. If workers are concerned by relative pay, separation rates among young workers should be higher in firms that age-discriminate across workers by passively adapting their wages to the minimum wage legislation. Evidence of separations reflecting peer-to-peer comparisons in wages in a low-wage setting have been documented by Dube, Giuliano and Leonard (2019). We also find evidence of lower separations in firms where the NLW had a stronger effect on younger workers' wages (column 5 of Appendix Table A9), with a 1 percent increase in young workers' hourly wages leading to a reduction of approximately 7 percent in their separation rate (baseline 10 percent).[21]

Wages and workers' marginal product of labor. The wage effects that we have documented so far suggest that firms have wage setting power and the labor market is characterized by a degree of monopsonistic competition. This notion is corroborated by strong evidence that wages in the sector do not reflect workers' marginal product of labor. If the market was competitive, we would expect workers of a given quality to be paid the same market wage. This implies that workers of identical quality should receive the same wage in different firms, and workers of different quality should receive different wages even if employed by the same firm. One way to test this argument is to decompose the total variance of wages and of proxies of workers' quality into their within- and between-firm components (Machin and Manning, 2004). We focus on care assistants and use tenure as our preferred proxy for workers' quality. Tenure has been shown to improve patients' outcomes significantly more than experience, in team-production environments within the health care system (Bartel et al., 2014). Conditional on TTWA fixed effects, the proportion of total wage variance that is intra-firm is approximately half of that of worker's quality (approximately 43 versus 76 percent).[22] The combination of remarkably little variation in wages and large variation in workers' productivity (as proxied by tenure) within firms strongly suggests that wages are not set competitively in this low-wage labor market.

6. Determinants of wage spillovers

The evidence presented in the previous sections provides a clear indication of uniform wage setting across workers. But why do firms set wages uniformly across employees? The determination of wages by firms has long been of interest to economists in labor economics and

[21] The separation rate is measured as the number of (young) workers leaving the firm between month t and $t+3$, as a share of (young) workers employed in t.

[22] Similarly, we find large proportions of the total variance of age and weekly hours that is intra-firm (90 and 82 percent respectively).

industrial relations. Quoting Hilde Behrend's 1960 paper, "[c]ompany wage-policies, it seems, aim to fulfill one or more of the following objectives: (*a*) To attract and retain employees of the right quality, and in the right quantity. (*b*) To maintain or increase standards of effort. (*c*) To avoid or reduce frictions and discontent by meeting expectations and conceptions of fairness, especially with regard to standard of living, and differentials for status, merit and skills. (*d*) To control costs and reduce administrative complexity" (Behrend, 1960, p. 122).

Building on Behrend (1960)'s paradigm, our conceptual framework distinguishes two macro drivers of the observed wage spillovers: *inter*-firm factors and *intra*-firm factors. Inter-firm factors reflect the dynamics of competition between firms to attract and retain workers. If wage spillovers are driven by inter-firm dynamics, we should observe larger wage spillovers among workers with better outside options. Intra-firm factors reflect, instead, a cost to the firm of keeping a diversified wage structure. Wage dispersion can be costly to the firm for various reasons: (i) the time and resource cost of having to bargain individualized wages, (ii) the administrative cost of keeping track of a diversified wage structure, and (iii) pay equity constraints or fairness norms. The latter can have two different meanings: on the one hand, they may dictate to pay the same wage to workers performing the same job, regardless of efficiency considerations (we label this notion as 'pure fairness' hypothesis); on the other hand, pay equity concerns may be driven by efficiency considerations, based on the idea that a 'fair' wage is required to extract the right amount of effort from a worker (we label this notion as 'fair wage-effort' hypothesis). In what follows, we will not distinguish between those two notions.

In the remainder of this section, we attempt to assess empirically the relevance of these potential drivers of the observed wage spillovers. While it may be difficult to single out a specific factor, if anything because firms may try to achieve multiple objectives with their wage setting policies, we can nonetheless gauge the relative importance of the various determinants.

6.1 Inter-firm factors

If wage spillovers are driven by competition for workers among firms, we would expect that firms with more 'attractive' workers – i.e. with better outside options – exhibit larger wage spillovers. A worker's outside option is not observable, but theoretically it depends on both their individual characteristics and the characteristics of their local labor market. In fact, the latter have been empirically shown to systematically correlate with workers' outside options (Caldwell and Danieli, 2021). Local labor markets also appear to be the relevant geography within which firms can reasonably compete for workers. It follows that a simple way to test the relevance of inter-firm factors in determining the emergence of wage spillovers is to estimate our wage spillover regressions with and without local labor market fixed effects. If inter-firm competition is the main driver of wage spillovers, we would expect the inclusion of local labor market fixed effects to attenuate our parameter estimate of firm-level wage spillovers.

Table 2 reports the reduced-form estimate $\sum_{t=3n,n\in\{1,...,4\}} \hat{\beta}_{1,t}$ from model 2 in odd-numbered columns, and the IV estimate $\hat{\gamma}_1$ from model 3 in even-numbered ones. All estimates are conditional on firm-level controls, but only those in columns 3 to 6 are conditional on local labor market fixed effects. We consider two different definitions of local labor markets: travel to work areas (TTWA) in columns 3 and 4, and local authority districts in columns 5 and 6. TTWAs are the official British definition of local labor market areas. There is a total of 152 TTWAs in our sample.[23] Local authorities are the level of subnational division of England used for the purposes of local government and have statutory responsibility for social care services. There is a total of 326 local authority districts in England, of which 322 covered by our sample. The inclusion of either type of local labor market fixed effects does not affect our parameter estimates. If anything, the estimated coefficients become slightly larger. These results suggest that local labor market factors do not seem to drive wage spillovers.

To further corroborate the idea that wage spillovers are not driven by inter-firm competition, we show that firm-level wage spillovers do not correlate with proxies for the average outside option of young workers in the firm. To this end, we first need a definition of wage spillovers at the firm level. Adapting the formula proposed by Butcher, Dickens and Manning (2012) for upward spillovers, we define downward wage spillovers in firm j, as follows:

$$\theta_j(w^{NMW}) = \frac{F_j^*(w^{NMW}) - F_j(w^{NMW})}{F_j^*(w^{NMW})} \tag{4}$$

where $F_j(\cdot)$ is the *observed* cumulative distribution function of gross hourly wages of workers aged under 25 in firm j in the post-NLW period; $F_j^*(\cdot)$ is the *counterfactual* cumulative distribution function of gross hourly wages of workers aged under 25 in firm j in the post-NLW period, *absent* wage spillovers; and w^{NMW} is the NMW rate legally binding for workers aged under 25 in the post-NLW period. Since the counterfactual wage distribution cannot be observed, we take the distribution in March 2016 as our counterfactual. Appendix Figure A6 illustrates the components of θ_j for a representative firm in March 2017: the solid line corresponds to $F_j^*(\cdot)$ as represented by the March 2016 distribution, and the dashed line corresponds to $F_j(\cdot)$ in March 2017. The red vertical line indicates the level of w^{NMW} in March 2017. The variable θ_j is an increasing function of the size of wage spillovers on young workers over the $[0, 1]$ interval. If a firm implements a no-spillover policy, we would expect the solid and dashed lines in Appendix Figure A6 to overlap in the range $w_{ij} < w^{NMW}$ (i.e. $F_j^*(w^{NMW}) = F_j(w^{NMW})$), resulting in $\theta_j = 0$. On the other hand, in case a firm operates a full-fledged spillover policy, the dashed line would lay entirely to the left of the red vertical line (i.e. $F_j(w^{NMW}) = 0$), leading to $\theta_j = 1$.[24] In all the analyses that follow, we consider the value of θ_j in March 2017.

Figure 7 reports a set of binned scatter plots that visualize the relationship between θ_j and proxies for the average outside option of workers aged under 25 in firm j. All estimates are

[23] See footnote 18 for a definition of TTWA.
[24] We assume $\theta_j = 0$ in firms with $F_j^*(w^{NMW}) = 0$.

conditional on $MIN^{25+}_{j,Mar16}$, $MIN^{under25}_{j,Mar16}$ (the fraction of under 25s paid below the NLW in March 2016) and firm-level controls $X_{j,Mar16}$, with the exclusion of TTWA fixed effects. Each graph reports the estimated coefficient (and associated standard error in parentheses) of an OLS regression of θ_j on the variable reported on the x-axis. Panel A proxies the outside option with the average hourly wage of carers aged under 25 in the TTWA of firm j in March 2016, excluding wages in firm j from the computation of the average. Panel B uses the median hourly wage of private-sector employees in the TTWA in March 2016.[25] Panel C employs a measure of the 'potential' wage of carers in the TTWA. To construct it, we take the average of gross hourly wages of workers aged under 25 in each 4-digit occupation and TTWA, and we compute a weighted average of occupation-specific wages, weighted by the probability of a care worker transitioning to that occupation.[26] Panel D uses the unemployment insurance claimant rate among individuals aged under 25 as an indirect measure of the workers' outside option. The claimant rate is computed as the number of people aged 16-24 claiming Jobseeker's Allowance or Universal Credit for the reason of being unemployed, as a percent of the population in the TTWA in March 2016.[27] None of our measures of the workers' outside option is significantly correlated with the size of firm-level wage spillovers. Taken together, the evidence presented so far rules out inter-firm dynamics as a relevant driver of wage spillovers. In the next section, we investigate the role of intra-firm factors.

6.2 Intra-firm factors

Pay equity concerns. Common wisdom, as well as anecdotal and empirical evidence, suggest that internal equity is important for an organization to operate efficiently and smoothly. The lack of pay equity within the firm can have disruptive effects and impose implicit costs to employers, in the form of efficiency losses or other costs of departing from social preferences for fairness. To assess the role of preferences for fairness in generating wage spillovers, we ideally would like to have a measure of fairness norms at the firm level and correlate it with the size of wage spillovers within the firm. Not having a direct measure of norms at our disposal, we provide four pieces of indirect evidence of the role of fairness norms.

First, Panel A of Figure 8 is a binned scatter plot of the correlation between θ_j and $MIN^{25+}_{j,Mar16}$, conditional on firm-level controls $X_{j,Mar16}$ (including TTWA fixed effects) and – importantly – the proportion of under 25s paid below the NLW in March 2016 ($MIN^{under25}_{j,Mar16}$). By conditioning on the latter, we are implicitly comparing the size of wage spillovers across firms with an identical share of young workers 'eligible' for wage spillovers, but with different shares of older

[25] The median hourly wage of private-sector employees in the TTWA is based on ASHE data elaborated by the UK Office for National Statistics.

[26] Transition probabilities are calculated using Labor Force Survey five-quarter longitudinal data for the UK. To boost sample size, we use data from 2010 to 2016. The vector of transition probabilities from care assistant in year t to 4-digit occupation k 12 months after includes the probability of remaining in the same occupation. Occupation- and TTWA-specific gross hourly wages are calculated using ASHE data.

[27] The data is based on Department for Work and Pensions administrative data elaborated by the UK Office for National Statistics.

workers directly affected by the policy. The graph reveals a positive and linear association, which is strongly statistically significant as shown by the coefficient estimate and standard error reported in the bottom right corner of the chart. The evidence indicates that, for an equal share of eligible young workers, wage spillovers are larger in those firms in which a larger share of older workers have their wages increased as a consequence of the NLW introduction. In other words, it is precisely in those firms in which the NLW disrupts the wage structure of older workers the most that we see larger wage increases among younger workers. This is a first piece of evidence consistent with pay equity norms within the firm.

Second, preferences for fairness can be modeled by making one's utility depend on that of other individuals or their outcomes. In their model of fairness norms, skills segregation and wage dynamics, Cabrales, Calvó-Armengol and Pavoni (2008) sensibly characterize the group of individuals to which the utility comparison applies as the *reference group*, that is the group of individuals whom a worker more closely identifies with. Workers are likely to identify the most with co-workers at their same level, as opposed to superiors or workers of lower rank. As a result, the relevant group over which fairness norms apply does not coincide with all workers inside the firm, but only with individuals with similar job roles. Consistent with this notion, we can show, firstly, that – in multi-establishment firms – wage spillovers are eminently a within-establishment phenomenon. Secondly, we document that wage spillovers arise within a 'job role' or 'occupation' within the firm. Table 3 reports estimates of an augmented version of IV model 3, which jointly captures the elasticity of young workers' wages in establishment j of firm $k(j)$ to older workers' wage growth in j, and a similar elasticity to older workers' wages in all other establishments in firm $k(j)$. The evidence in column 4 clearly underscores the within-establishment nature of wage spillovers. Table 4 reports IV estimates of γ_1 from versions of model 3 in which the outcome variable is gross hourly wage growth among carers aged under 25 ($\Delta \ln w_{j,t}^{under25,carer}$), and the main regressor of interest is gross hourly wage growth among older workers in different job roles k ($\Delta \ln w_{j,t}^{25+,k}$), specifically carers (column 1), senior carers (column 2), ancillary staff (column 3), administrative staff (column 4) and nurses (column 5).[28] In our IV model, we instrument each $\Delta \ln w_{j,t}^{25+,k}$ with $MIN_{j,Mar16}^{25+,k}$, and use $MIN_{j,Mar16}^{25+,-k}$ – i.e. the fraction of older workers paid below the NLW in each of the other job roles – as included instruments.[29] The results in Table 4 show that young carers' wages are only responsive to wage growth among older carers, but not among older workers in other job roles. Similar results are obtained for senior carers (Appendix Table A11) and ancillary staff (Appendix Table A12), the other two job roles with a relatively high fraction of workers paid around the minimum. This is a second piece of evidence consistent with pay equity concerns. For completeness, we also report estimates of the within- and cross-occupation wage spillovers for administrative staff and

[28] Sample size varies across the different specifications since not all firms have all job roles represented among their workers.

[29] Appendix Table A10 reports the first-stage estimates of the IV models. The dependent variable is gross hourly wage growth among older workers between March 2016 and March 2017 for carers (column 1), senior carers (column 2), ancillary staff (column 3), administrative staff (column 4) and nurses (column 5). Each of these variables is regressed against the set of included and excluded instruments. As can be seen from the table, the excluded instrument – that is $MIN_{j,Mar16}^{25+,k}$ – is highly predictive of wage growth in job role k across all specifications.

nurses in Appendix Tables A13 and A14. The within-occupation wage elasticities are imprecisely estimated and not statistically significant. It is worth noting that, due to the relatively high wages in these occupations (see Appendix Table A4), the IV estimation suffers from a weak instrument problem, as revealed by the partial F-statistics on the excluded instrument reported in Appendix Table A10. The results may also reflect differences in inequality aversion between 'low' and 'high' wage earners, with the former holding stronger preferences for equal treatment, as shown in prior work (Fehr and Schmidt, 1999).

Third, inequality aversion is expected to generate wage compression within occupations within the firm. We can therefore use the standard deviation of hourly wage before the NLW introduction as a proxy of the degree of inequality aversion within the firm. Panel B of Figure 8 shows a robust negative correlation between θ_j and wage dispersion, where both are computed on the sample of care assistants to abstract from compositional changes.

Fourth, a direct consequence of the wage compression generated by inequality aversion within a job type is that the occupation-specific wage-tenure profile will be flatter in organizations with stronger preferences for fairness (Cabrales, Calvó-Armengol and Pavoni, 2008). We can use this simple prediction to indirectly characterize providers' (relative) fairness norms by the (relative) steepness of the wage-tenure profile of carers and senior carers in the firm in the pre-NLW period. To this end, we estimate firm-specific Mincerian regressions of the natural logarithm of the hourly wage on a quadratic function of tenure for the sample of carers and senior carers in the pre-NLW period.[30] For each firm, we compute the estimated return to a one year of tenure, and use it as an inverse proxy of the degree of fairness of the firm. Panel C of Figure 8 shows the conditional correlation between θ_j and the firm-specific wage-tenure gradient. Consistent with fairness norms being drivers of wage spillovers, we see larger spillovers among firms with lower returns to tenure. In this case, though, the association is not highly statistically significant.

Finally, responses to the ASC-SPP questionnaire also lend support to inequality aversion being the main driver of wage spillovers. According to the results reported in Appendix Table C3, of the 60 percent of respondents who do not pay under 25s below the NLW, 54 percent say that they do so because it would otherwise be 'unfair to the workers', and 11 percent to 'motivate workers'. Thus, 65 percent of those who practice a full wage-spillover policy declare to do so for reasons ascribable to fairness norms. This is the fourth piece of evidence of the importance of pay equity concerns.

Cost of individual bargaining. Firms might decide to implement a uniform wage structure to avoid the cost of bargaining individualized wages with their employees. Before taking this hypothesis to the test, it is important to re-emphasize that the adult social care sector in the UK has been traditionally very low unionized, with a union coverage rate of 16 percent among all care assistants and of 1 percent among care assistants aged under 25 in 2016 according to Labor Force Survey data. We can therefore exclude any role for collective bargaining in the

[30]The Mincerian regressions are conditional on calendar month fixed effects.

determination of wages, especially among young workers. Turning to individual bargaining, the survey evidence that we collected through the ASC-SPP reveals that, when a job offer is made, the offer is in the vast majority of times 'take-it-or-leave-it', while individual bargaining remains sporadic (Appendix Table C4). As such, the labor market model that seems to best characterize wage setting in social care is that of wage posting, in which the cost of individual bargaining is likely immaterial.

Administrative complexity. Keeping track of a diversified wage structure can be administratively burdensome and costly to the employer, up to the point that she may find it more convenient to pay all workers a uniform, productivity-unrelated wage rate. The impact of downward wage spillovers on firms' costs is twofold: on the one hand, wage-bill costs increase due to raising younger workers' wages to the NLW; on the other, there is a reduction in administrative costs, due to lower administrative complexity. The wage-bill cost is a linear, increasing function of the share of young workers in the firm. The administrative cost of dealing with a diversified wage structure can be modeled as a fixed cost, e.g. the fixed cost of hiring human resource staff or of outsourcing payroll administration. It seems plausible that this fixed cost will be more negligible, as a share of total costs, for larger firms. Hence, if wage spillovers are used to lower administrative costs, we would expect larger wage spillovers in smaller firms, conditional on the wage-bill cost. Appendix Figure A7 reports the conditional correlation of θ_j and measures of firm size. In Panel A, we use the size of the parent organization of firm j (in natural logarithm), conditional on $MIN^{25+}_{j,Mar16}$, $MIN^{under25}_{j,Mar16}$, firm-level controls $X_{j,Mar16}$ (including TTWA fixed effects) and a measure of the wage-bill cost of wage spillovers. The latter is the percent increase in wage-bill costs required to increase all younger workers' wages to the NLW as of March 2016.[31] In Panel B, we replace the parent-organization size with provider size. Contrary to what the 'administrative cost' hypothesis would predict, we find a mild positive correlation between the magnitude of wage spillovers and organization/firm size. This suggests that administrative cost savings are unlikely to be a major driver of wage spillovers. This notion is confirmed by our survey results: of the respondents who declared to pay the NLW rate to their under 25s, only 3 percent said that they do so because it is administratively simpler or cheaper (Appendix Table C3).

Two main results emerge from the evidence presented in this section. First, that intra-firm factors are the main determinant of wage spillovers. Second, that – among those – pay equity concerns offer the most plausible explanation for the emergence of wage spillovers within firms.

[31] See footnote 19 for a definition of the wage-bill gap.

7. Discussion

7.1 Notions of fairness

In the previous section, we noted that pay-related fairness norms can have two acceptations: the 'pure fairness' one, which calls for an identical wage being paid to workers performing the same job, regardless of efficiency considerations; and the 'fair wage-effort' one, according to which paying a 'fair' wage is necessary to extract the right amount of effort from a worker.[32] In our setting, we cannot directly assess what the underlying source of fairness norms is. The survey results in Appendix Table C3 seem to point more towards the first interpretation, given that respondents emphasize the fairness dimension of wage spillovers ('Unfair to the workers') more than the efficiency one ('To motivate workers'), but we view these results as merely suggestive.

What could be argued, though, is that rules of fairness appear to be rather specific, as noted in the seminal work by Kahneman, Knetsch and Thaler (1986). In our setting, it appears that the minimum wage paid to older employees serves as a reference for evaluating the fairness of wages paid to younger workers in the same job role, but not necessarily for those in other similarly-paid job roles. In the words of Kahneman, Knetsch and Thaler (1986), only employees within the same job role are entitled to the 'reference transaction' – here the higher minimum in the occupation.

7.2 Impact of wage spillovers on profits

Wage spillovers generate additional wage bill costs and can, as a result, lower profits. We carry out a back-of-the-envelope calculation of the profit hit associated with wage spillovers. According to our data, the NLW introduction increased wage bill costs for workers aged 25+ by 3.5 percent in the average firm in our sample, and by 8.1 percent in highly treated firms with 100 percent of old workers paid below the NLW in March 2016. For a wage bill share of total costs of 60 percent (Competition and Markets Authority, 2017), our estimate of wage spillovers from Table 1 ($\widehat{\gamma}_1 = 0.7$) and of the share of under 25s (15 and 18 percent, respectively) imply that wage spillovers increase total costs by 0.2 percent on average and 0.6 percent in highly treated firms. These, in turn, translate into a 1.3 and 3.7 percent reduction in the profit margin, from a baseline of 14 percent (Competition and Markets Authority, 2017).[33]

If wage spillovers increase productivity, or if firms pass the higher wage bill costs onto prices, our estimates of the profit hit provide an upper bound of the true impact. The ability of increasing prices is limited, since residents' fees are capped by local authorities. As for productivity effects,

[32] The fair wage-effort hypothesis is a version of the efficiency wage theory first introduced in Akerlof and Yellen (1990). According to this hypothesis, workers have an idea of what a fair wage is; if the wage they receive is less than the fair wage, workers supply a proportional fraction of normal effort and a wage increase can raise workers' effort.

[33] Unfortunately, ASC-WDS data do not include information on firms' balance sheets. For our computation, we use sector-level data on average costs, revenues and profit margins (EBIDTA) published by the Competition and Markets Authority (2017).

we examine them in two ways. First, following Machin, Manning and Rahman (2003), we measure productivity as the number of residents per worked hour in the firm. Column 2 of Appendix Table A15 reports the IV estimate of parameter γ_1 of model 3 using productivity as outcome. The IV estimate is positive, but statistically insignificant. Column 3 reports the estimated coefficient of a regression of productivity on younger workers' wage growth instrumented with $MIN^{25+}_{j,Mar16}$, where we also obtain a positive effect, but not statistically significant. Second, we complement our measure of productivity with an index of overall care quality obtained from the Care Quality Commission (CQC) routine inspections. Also here we find a positive, yet statistically insignificant effect of wage growth on care quality. Whilst our results on productivity effects are inconclusive, we note that increased staff retention rates (see Appendix Table A9) have been shown to improve service quality in the care sector in the US (Ruffini, 2022).

7.3 Implications for models of the low-wage labor market

The results have several implications for models of the labor market. First, we show that – even though the institutional setting allows for age-based wage discrimination – firms adopt a uniform pay schedule across workers of different ages within the same reference group, suggesting that they are either unable or unwilling to discriminate. This finding underscores a central assumption of models of monopsonistic labor markets. When employers can perfectly wage-discriminate across workers, workers' idiosyncratic preferences toward amenities will generate variation in wages in the form of 'compensating differentials' (Rosen, 1986). Workers who value less one particular firm-specific amenity will be compensated with higher wages and equilibrium employment will be efficient. On the other hand, if employers cannot set wages individually, equilibrium employment will be inefficiently low, as in Manning (2003). The efficiency properties of equilibrium employment in the labor market have implications for the welfare consequences of policies that can directly affect that equilibrium, including the minimum wage itself.

Second, we provide direct evidence that wages are set at the reference-group level and based on a principle of fairness.

Third, our evidence is also informative of how public policies interact with wage setting within the firm, and can be relevant for the design of a host of wage policies with the potential of affecting the within-firm wage structure (e.g. payroll taxes or minimum wages). In this respect, it is worth noting that, even though the policy change that we are exploiting is quite singular in nature, the existence of an age-specific minimum wage structure is rather common in countries with minimum wage regulations in place. Hence, the labor market policy considerations drawn from the analysis in this paper are likely widely applicable to similar institutional contexts.

8. Conclusion

In this paper, we focus on the low-wage section of the labor market, and investigate (i) what models of wage determination are at play and (ii) what drives their adoption by firms. To pin these down, we exploit the National living Wage (NLW) introduction to the UK labor market, which generated a sizable increase in the minimum wage rate applying to workers aged 25 and over from April 1, 2016. At the market level, there is evidence of large, positive wage spillovers of the NLW on workers aged under 25. At the firm level, we provide evidence of the within-firm nature of these wage spillovers. Both the market-level and firm-level results provide a clear indication of uniform wage setting that is plausibly driven by pay-equity constraints.

These results are relevant for models of the low-wage, non-union labor market, since they provide direct evidence that wages are not set individually, but rather at the reference-group level and based on a principle of fairness. They also have important implications for the efficiency properties of equilibrium employment in models of monopsonistic competition. The evidence is also informative of how public policies, such as minimum wages or payroll taxes, interact with wage setting within the firm. The findings are especially relevant in the context of contemporary UK minimum wage policy. Starting in 2021, the age threshold for the NLW has been reduced from 25 to 23, and it will be further reduced to 21 by 2024. The results in this paper suggest that these changes are unlikely to have major consequences on the wage distribution of young workers in the UK.

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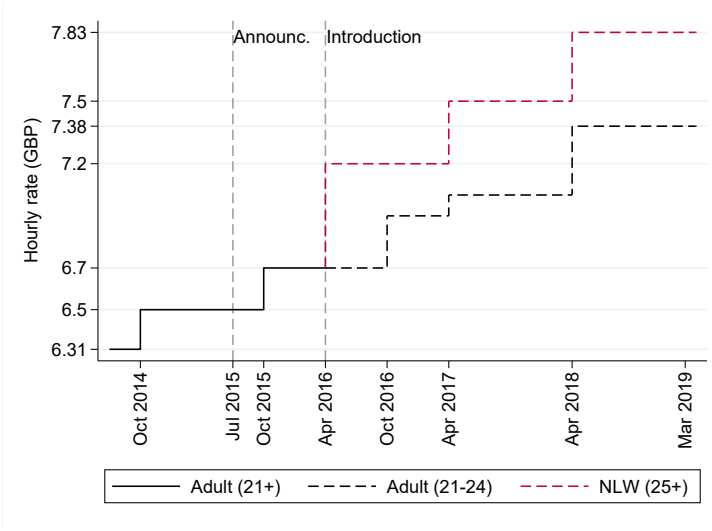
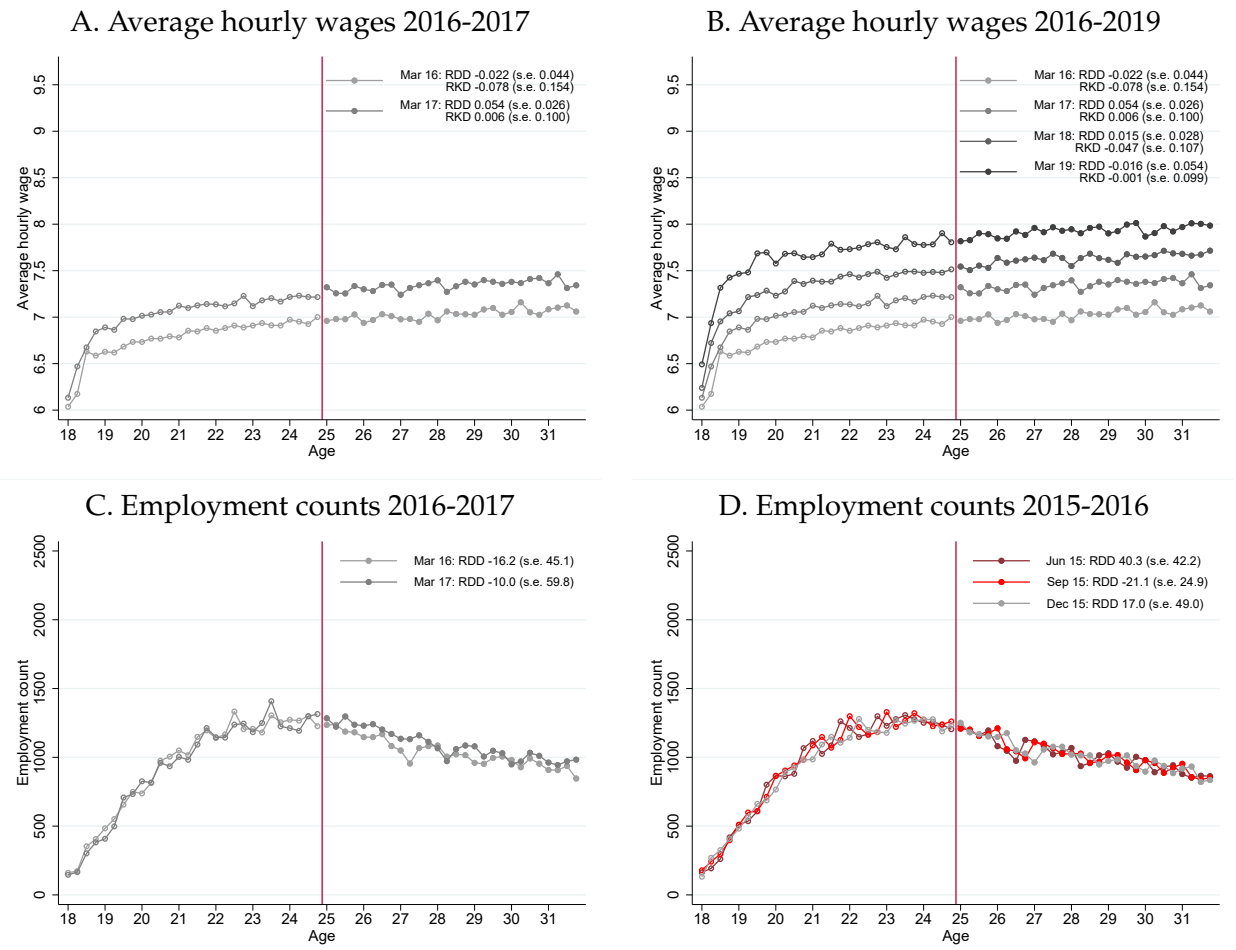
Figures

Figure 1. NATIONAL LIVING WAGE (NLW) INTRODUCTION



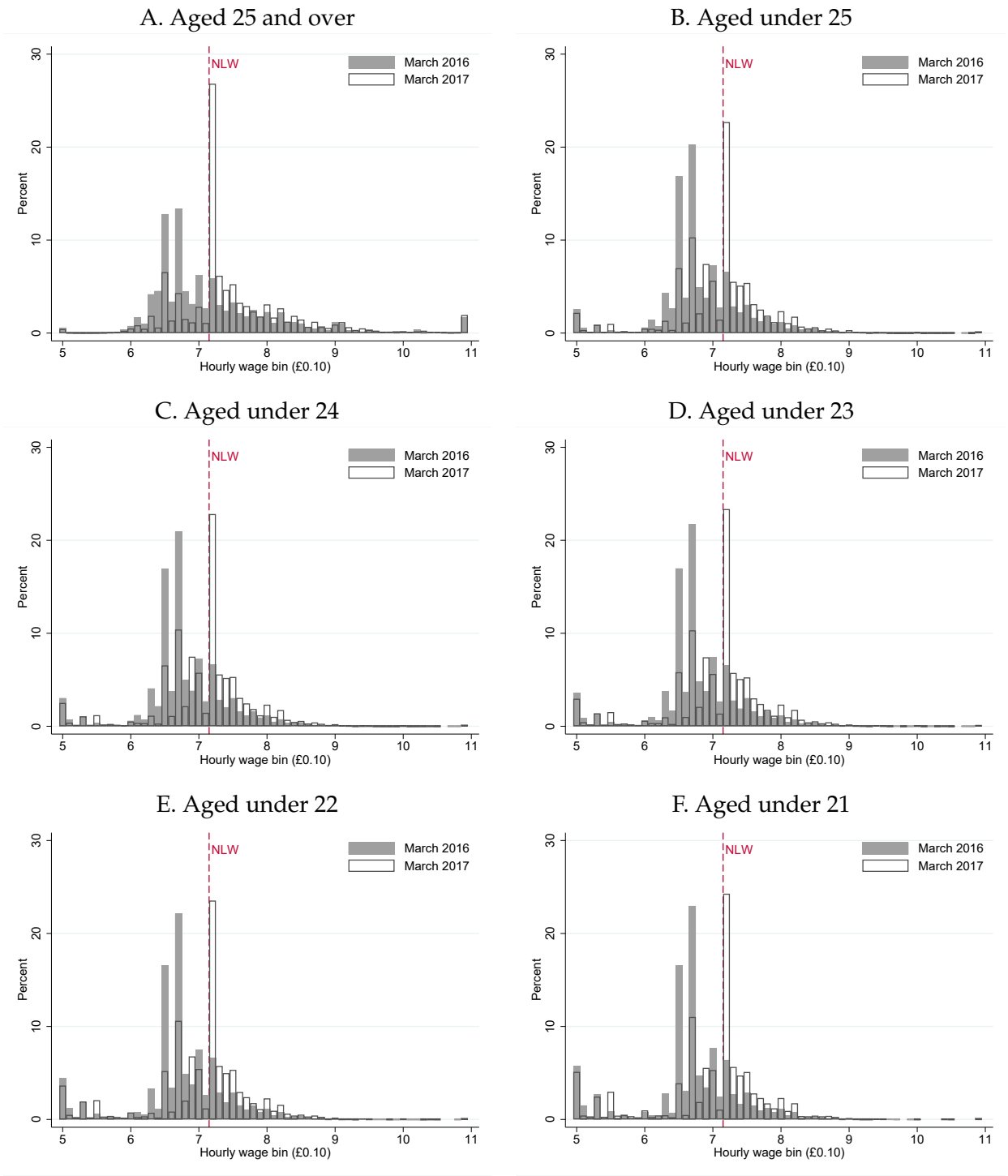
Notes: The graph reports the level of the UK minimum wage applying to the adult population aged 21 and over from September 2014 to March 2019. The solid black line corresponds to the National Minimum Wage (NMW) applying to workers aged 21 and over until April 2016. The dashed black line corresponds to the NMW applying to workers aged 21-24 starting from April 1, 2016. The dashed red line represents the National Living Wage (NLW), which was introduced on April 1, 2016 and applies to workers aged 25 and over. The vertical dashed lines illustrate the time of announcement (July 8, 2015) and introduction (April 1, 2016) of the NLW.

Figure 2. MARKET-LEVEL EFFECT OF NLW INTRODUCTION ON CARE ASSISTANTS' WAGES AND EMPLOYMENT BY AGE



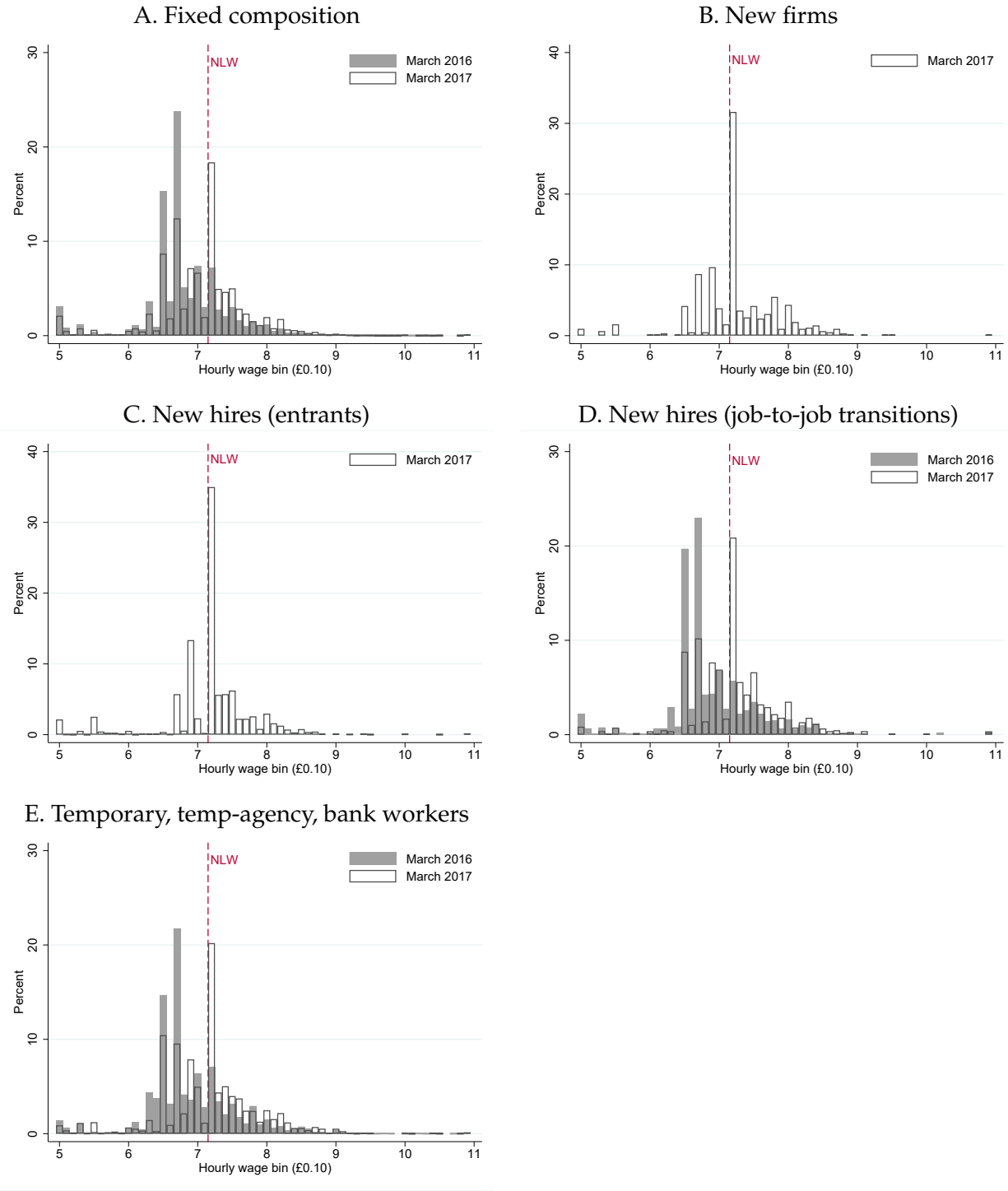
Notes: Panel A reports the average gross hourly wage by age bin (with age measured in quarters) in March 2016 and in March 2017. The graph is based on the market-level sample of care assistants. The non-parametric RDD estimate of α_1 of model 1 and the associated robust standard error are reported in the top right corner, for March 2016 and March 2017 respectively. The graph also reports non-parametric RKD estimates of the change in the age profile of hourly wages at the age-25 threshold. See footnote 15 for more details. The red vertical line indicated the age-25 threshold. Panel B is an extension of Panel A, including data for March 2018 and March 2019. Panel C is constructed in an analogous way as Panel A, but reports the employment count of care assistant by age bin at the market level in March 2016 and March 2017. Panel D reports similar data and estimates for June, September and December 2015.

Figure 3. DISTRIBUTION OF HOURLY WAGES OF CARE ASSISTANTS BY AGE



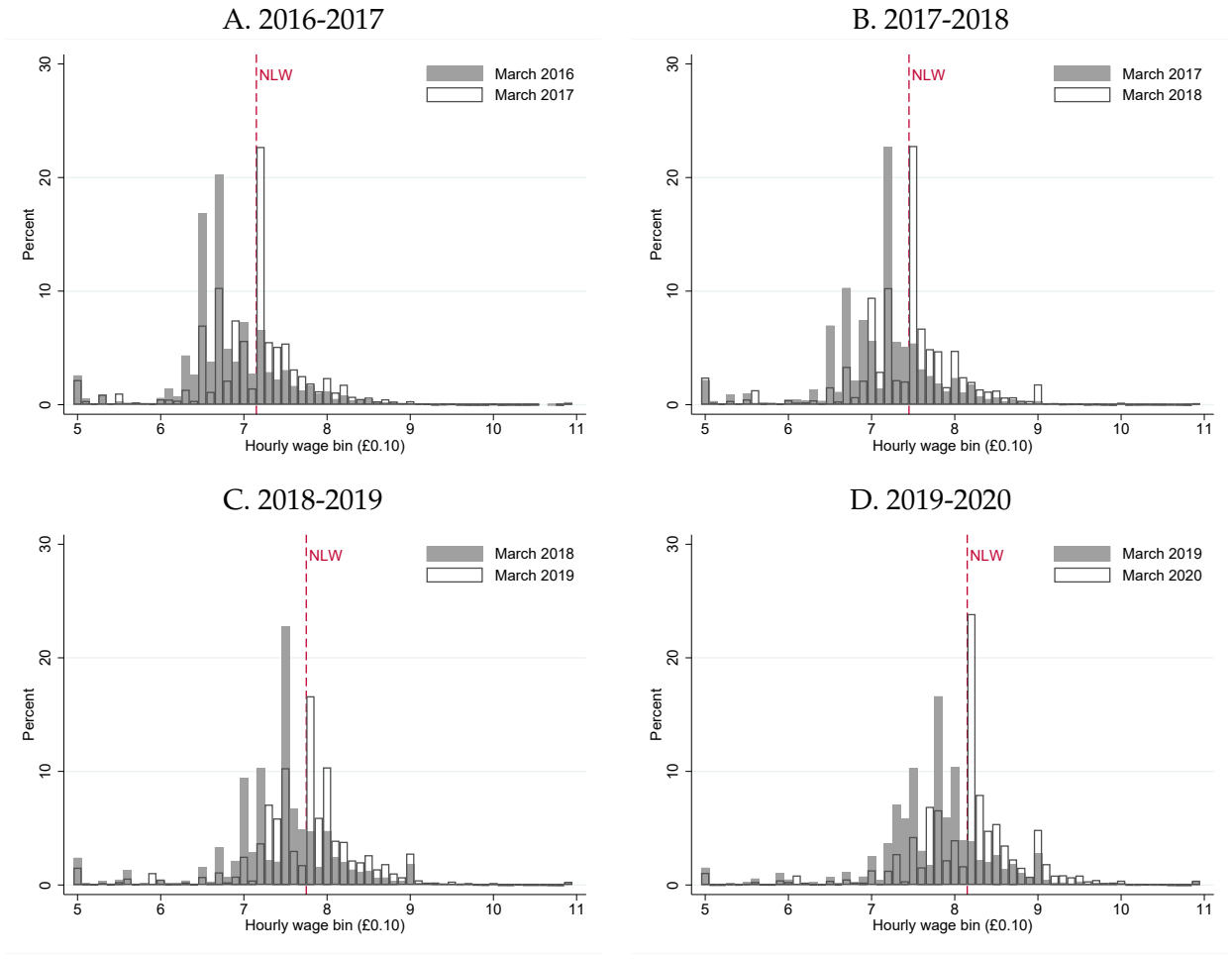
Notes: The figure reports a set of hourly wage distributions for care assistants in March 2016 (gray bars) and March 2017 (unfilled bars). Hourly wages are binned into £0.10 bins. The red dashed vertical line indicates the level of the NLW in March 2017. Panel A reports the hourly wage distribution for care assistants aged 25 and over, Panel B for those aged under 25, Panel C for those under 24, Panel D for those under 23, Panel E for those under 22 and Panel F for those under 21.

Figure 4. DISTRIBUTION OF HOURLY WAGES OF CARE ASSISTANTS: TESTING FOR COMPOSITIONAL CHANGES AND CONTRACTUAL RIGIDITIES



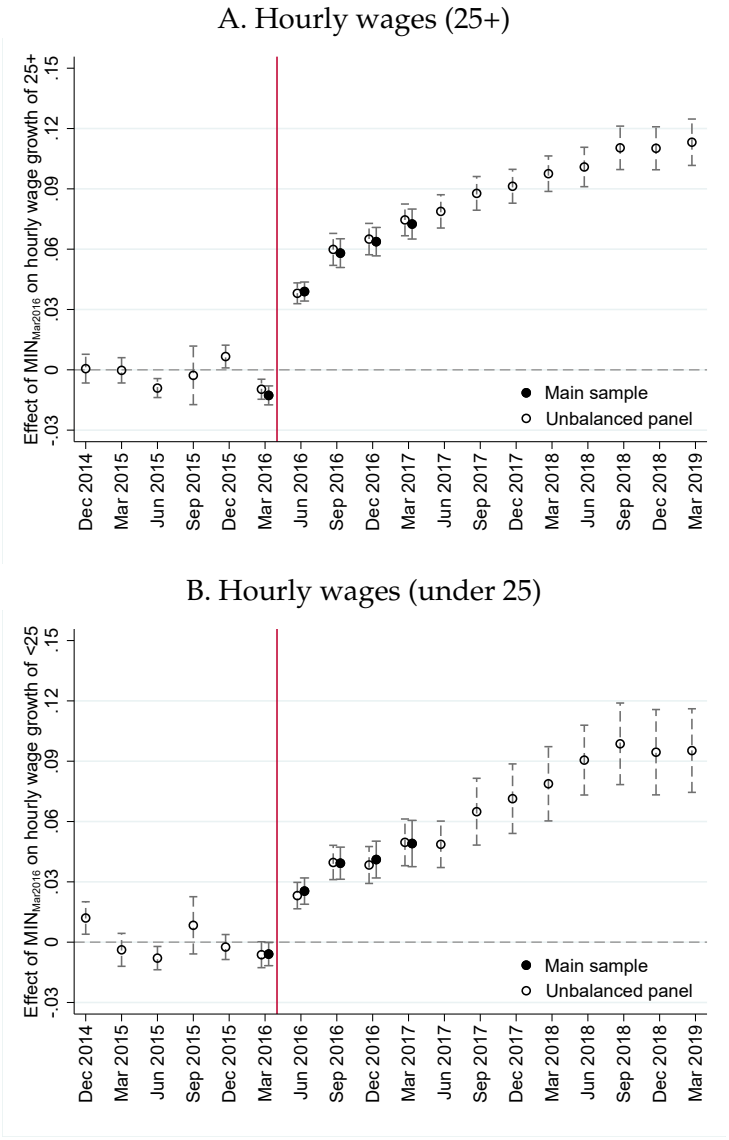
Notes: The figure reports a set of hourly wage distributions for care assistants aged under 25 in March 2016 (gray bars) and March 2017 (unfilled bars). Hourly wages are binned into £0.10 bins. The red dashed vertical line indicates the level of the NLW in March 2017. Panel A is based on the sample of workers who are observed both in March 2016 and March 2017, and who were aged under 24 in March 2016. Panel B is based on the sample of workers employed by firms that established their activity after the NLW introduction. Panel C is based on the sample of workers hired after March 2016 and with no prior experience in adult social care. Panel D also refers to new hires, but considering workers who were previously employed in adult social care. Panel E restricts the sample to temporary, temp-agency and bank – i.e. casual – workers.

Figure 5. DISTRIBUTION OF HOURLY WAGES OF CARE ASSISTANTS: IMPACT OF NLW INTRODUCTION AND SUBSEQUENT UPRATINGS



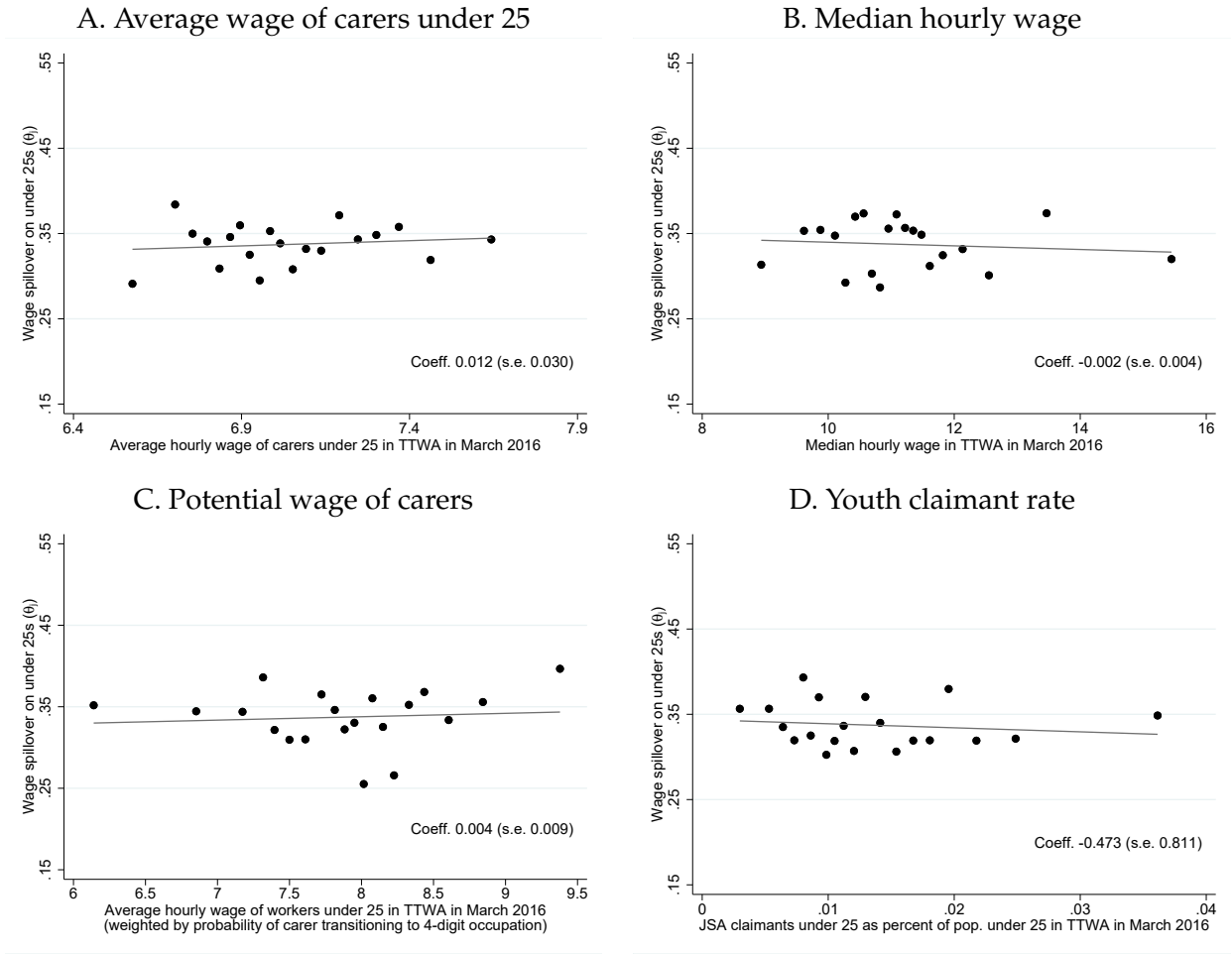
Notes: The figure traces out the dynamics of wage spillovers over time, as generated by the NLW introduction in 2016 and its subsequent upratings. Each panel reports the hourly wage distributions for care assistants aged under 25 in year t (gray bars) and $t+1$ (unfilled bars). Hourly wages are binned into £0.10 bins. The red dashed vertical line indicates the level of the NLW in $t+1$. Panel A refers to March 2016 and March 2017, Panel B to March 2017 and March 2018, Panel C to March 2018 and March 2019, Panel D to March 2019 and March 2020.

Figure 6. FIRM-LEVEL EFFECT OF NLW ON WORKERS' HOURLY WAGES



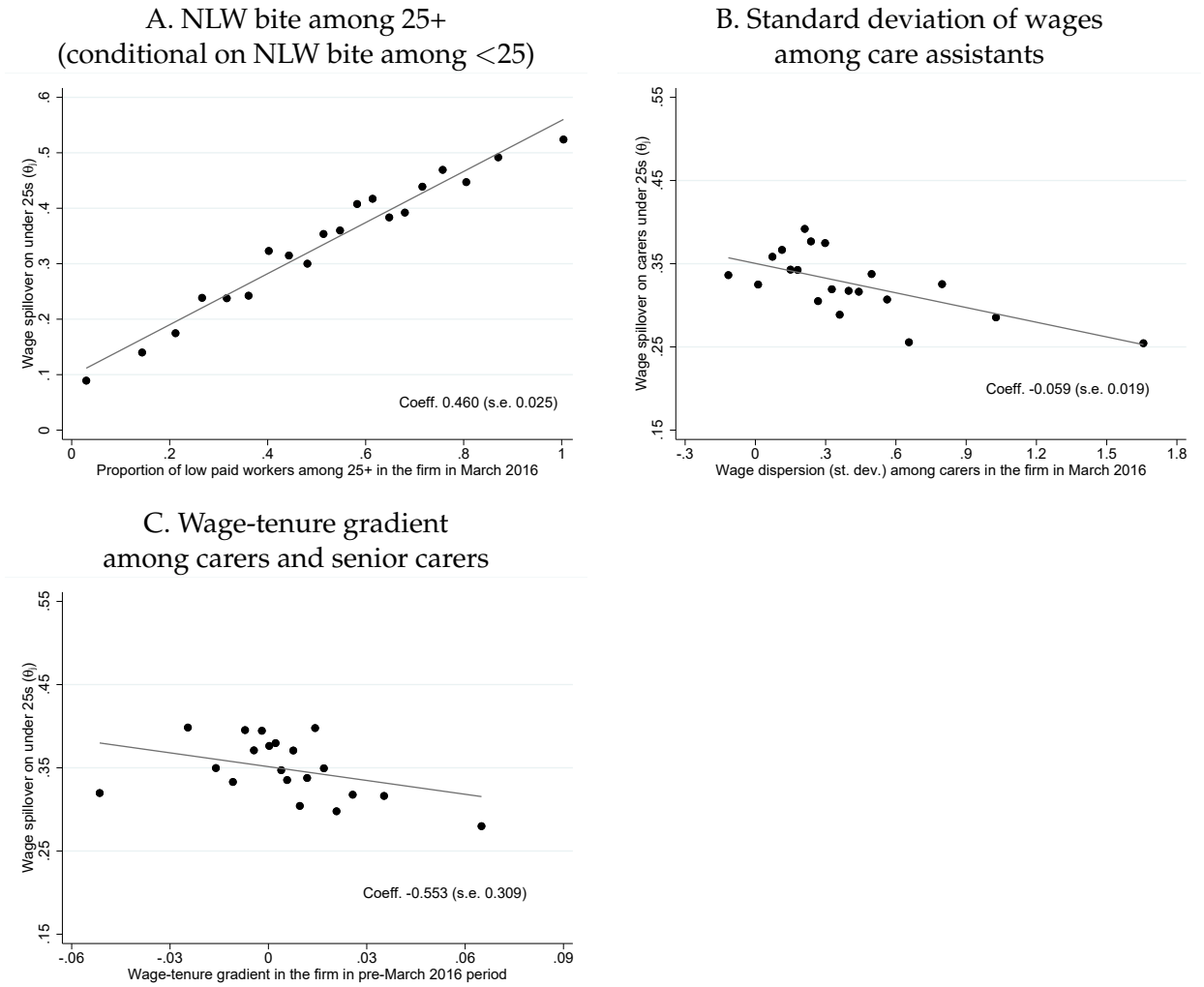
Notes: Panel A reports the estimated coefficient $\hat{\beta}_{1,t}$ for $t = \{-15, -12, ..., 0\}$, and the cumulative sum $\sum_{t=3n} \hat{\beta}_{1,t}$ for $n = \{1, ..., 12\}$ from model 2, using the firm-level change in log average hourly wages of workers aged 25 and over as outcome. Panel B reports the same coefficients or combinations thereof from model 2, using the firm-level change in log average hourly wages of workers aged under 25 as outcome. The dots indicate the estimated coefficients and the capped vertical bars 95 percent confidence intervals based on robust standard errors clustered at the TTWA level. Results are displayed for the balanced (black circles) and unbalanced (hollow circles) firm-level samples.

Figure 7. WAGE SPILLOVERS AND WORKERS' OUTSIDE OPTION



Notes: The figure reports a set of binned scatter plots of the relationship between θ_j (as defined in equation 4) and proxies for the average outside option of workers aged under 25 in firm j. All correlations are conditional on $MIN^{25+}_{j,Mar16}$, $MIN^{under25}_{j,Mar16}$ and $X_{j,Mar16}$, with the exclusion of TTWA fixed effects. Each graph reports the estimated coefficient (and associated standard error clustered at the TTWA level) of an OLS regression of θ_j on the variable reported on the x-axis, conditional on covariates. Panel A proxies the outside option with the average hourly wage of carers aged under 25 in the TTWA of firm j in March 2016, excluding wages in firm j from the computation of the average. Panel B uses the median hourly wage of private-sector employees in the TTWA in March 2016. The median hourly wage of private-sector employees in the TTWA is based on ASHE data elaborated by the UK Office for National Statistics. Panel C employs a measure of the 'potential' wage of carers in the TTWA. To construct it, we take the average of gross hourly wages of workers aged under 25 in each 4-digit occupation and TTWA, and we compute a weighted average of occupation-specific wages, weighted by the probability of yearly transition of a care worker to that occupation. Transition probabilities are calculated using Labor Force Survey five-quarter longitudinal data for the UK. To boost sample size, we use data from 2010 to 2016. The vector of transition probabilities from care assistant in year t to occupation k 12 months after includes the probability of remaining in the same occupation. Occupation- and TTWA-specific gross hourly wages are calculated using ASHE data. Panel D uses the unemployment insurance claimant rate among individuals aged under 25 as an indirect measure of workers' outside option. The claimant rate is computed as the number of people aged 16-24 claiming Jobseeker's Allowance or Universal Credit for the reason of being unemployed, as a percent of the population under 25 in the TTWA in March 2016. The data are based on Department for Work and Pensions administrative data elaborated by the UK Office for National Statistics.

Figure 8. WAGE SPILLOVERS AND PROXIES FOR FAIRNESS NORMS



Notes: Panel A is a binned scatter plot of the correlation between θ_j (as defined in equation 4) and $MIN^{25+}_{j,Mar16}$, conditional on the set of firm-level covariates $X_{j,Mar16}$ including TTWA fixed effects and the proportion of under 25s paid below the NLW in March 2016 $MIN^{under25}_{j,Mar16}$. Each graph reports the estimated coefficient (and associated standard error clustered at the TTWA level) of an OLS regression of θ_j on the variable reported on the x-axis, conditional on covariates. Panel B reports a binned scatter plot of the correlation between θ_j in the sample of carers and the firm-specific standard deviation of wages among carers in March 2016, conditional on $MIN^{under25}_{j,Mar16}$ and $X_{j,Mar16}$. Panel C reports a binned scatter plot of the correlation between θ_j and the firm-specific wage-tenure gradient, conditional on $MIN^{under25}_{j,Mar16}$ and $X_{j,Mar16}$. Firm-specific returns to tenure are estimated via firm-specific Mincerian regressions of the natural logarithm of the hourly wage on a quadratic function of tenure, a dummy for being female and a quadratic function of age, for the sample of carers and senior carers in the pre-NLW period. The Mincerian regressions are conditional on year-month fixed effects.

Tables

Table 1. WAGE AND EMPLOYMENT SPILLOVERS

	Change in log average hourly wage 25 and over		Change in log average hourly wage under 25		Change in share of under 25s	
	(1)	(2)	(3)	(4)	(5)	(6)
Low-paid proportion (25+)	0.072***		0.049***		0.004	
	(0.004)		(0.006)		(0.004)	
Wage-bill gap (25+)		0.261***				
		(0.099)				
Change in log average hourly wage (25+)				0.677***		0.056
				(0.079)		(0.055)
Observations	4,631	4,631	4,631	4,631	4,631	4,631
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Mean of dep. var. (level)	7.93		6.93		0.15	
Model	OLS	OLS	OLS	IV	OLS	IV
F-stat (IV)	369.33	7.01				

Notes: Columns 1 and 2 report first-stage estimates of the effect of firm-level NLW bite on hourly wage growth among workers aged 25 and over. Column 1 reports the point estimate of $\sum_{t=3n,n\in\{1,...,4\}} \hat{\beta}_{1,t}$, obtained from estimating model 2 using the firm-level change in the log average hourly wage of workers aged 25 and over between March 2016 and March 2017 as outcome variable. Column 2 uses an alternative measure of $MIN^{25+}_{j,Mar16}$, the 'wage-bill gap', which captures the mechanical percent effect of the NLW introduction on the wage bill of the firm. Formally, the gap in firm j at time t is defined as $\frac{\sum_{i\in j|age_i\geq 25} h_{i,j,t}\cdot \max\{NLW_{t+1}-w_{i,j,t}\ ,0\}}{\sum_{i\in j|age_i\geq 25} h_{i,j,t}\cdot w_{i,j,t}}$. The gap measures by how much the wage bill of the firm would have to increase in percent to comply with the NLW regulations, assuming no changes in employment at the extensive or intensive margin, and no wage spillover effects as a result of the NLW introduction. The table also reports the F-statistics on $MIN^{25+}_{j,Mar16}$, the excluded instrument in IV model 3. Columns 3 and 5 report the reduced-form estimate of $\sum_{t=3n,n\in\{1,...,4\}} \hat{\beta}_{1,t}$ from model 2, using young workers' wages and employment share as outcome, respectively. In column 3, the outcome variable is the firm-level change in log average hourly wages of workers aged under 25 between March 2016 and March 2017. In column 5, it is the firm-level change in the share of employees aged under 25 between March 2016 and March 2017. Columns 4 and 6 report the IV estimate of parameter γ_1 from model 3, where $\Delta \ln w^{25+}_{j,t}$ is instrumented using the proportion of low-paid workers aged 25 and over in the firm in March 2016. All estimates are conditional on firm-level controls (the proportion of female workers, average workers' age, and the proportion of carers, senior carers, ancillary staff, nurses and administrative staff) and TTWA fixed effects. Robust standard errors clustered at the TTWA level are reported in parentheses.

Table 2. WAGE SPILLOVERS AND LOCAL LABOR MARKET FACTORS

	Change in log average hourly wage of under 25s					
	(1)	(2)	(3)	(4)	(5)	(6)
Low-paid proportion (25+)	0.041***		0.049***		0.049***	
	(0.005)		(0.006)		(0.006)	
Change in log average hourly wage (25+)		0.622***		0.677***		0.674***
		(0.071)		(0.079)		(0.081)
Observations	4,631	4,631	4,631	4,631	4,631	4,631
Adjusted R-squared	0.018	0.074	0.020	0.064	0.033	0.074
Controls	Yes	Yes	Yes	Yes	Yes	Yes
TTWA FE	No	No	Yes	Yes	No	No
Local authority FE	No	No	No	No	Yes	Yes
Model	OLS	IV	OLS	IV	OLS	IV
F-stat		80.27		70.94		67.78

Notes: The odd columns in the table report the reduced-form estimate of $\sum_{t=3n, n\in\{1,\ldots,4\}} \hat{\beta}_{1,t}$ from model 2. The outcome variable is the firm-level change in log average hourly wages of workers aged under 25 between March 2016 and March 2017. The even columns report the IV estimate of parameter γ_1 from model 3, where $\Delta \ln w_{j,t}^{25+}$ is instrumented using the proportion of low-paid workers aged 25 and over in the firm in March 2016. Robust standard errors clustered at the TTWA level are reported in parentheses. Columns 1 and 2 are conditional on firm-level covariates, but do not include local labor market fixed effects. Columns 3 and 4 include firm-level covariates and TTWA fixed effects. Columns 5 and 6 include firm-level covariates and local authority district fixed effects. The bottom row reports the F-statistics on $MIN_{j,Mar16}^{25+}$, the excluded instrument in IV model 3.

Table 3. CROSS-ESTABLISHMENT WAGE SPILLOVERS

	Change in log average hourly wage			
	25+ in j	25+ in $k(j)$	under 25 in j	
	(1)	(2)	(3)	(4)
Low-paid proportion in j (25+)	0.096***	0.017**	0.064***	
	(0.009)	(0.008)	(0.012)	
Low-paid proportion in $k(j)$ (25+)	-0.008	0.056***	-0.000	
	(0.009)	(0.009)	(0.010)	
Change in log average hourly wage in j (25+)				0.646***
				(0.148)
Change in log average hourly wage in $k(j)$ (25+)				0.086
				(0.171)
Observations	2,324	2,324	2,324	2,324
Controls	Yes	Yes	Yes	Yes
Mean of dep. var. (level)	8.28	8.25	7.62	
Model	OLS	OLS	OLS	IV
F-stat (IV)	100.84	76.37		

Notes: Column 1 reports estimates of $\sum_{t=3n,n\in\{1,...,4\}} \hat{\beta}_{1,t}$, obtained from estimating model 2 using as outcome variable the firm-level change in the log average hourly wage of workers aged 25 and over between March 2016 and March 2017, and as explanatory variables $MIN^{25+}_{j,Mar16}$ and $MIN^{25+}_{k(j),Mar16}$. The latter is the proportion of workers aged 25 and over paid below the NLW in March 2016 across all firms belonging to the same organization k as firm j, excluding j from the computation. Column 2 reports similar estimates, using as outcome variable the change in the log average hourly wage of workers aged 25 and over between March 2016 and March 2017 across all firms belonging to the same organization k as firm j, excluding j from the computation. Column 3 reports estimates from an analogous specification, using as outcome variable the firm-level change in the log average hourly wage of workers aged under 25 between March 2016 and March 2017. Finally, column 4 reports IV estimates of a version of model 3 in which the main regressors of interest are the average hourly wage growth among workers aged 25 and over in firm j and in firms belonging to the same organization k as j (excluding j). The former is instrumented with $MIN^{25+}_{j,Mar16}$, while the latter with $MIN^{25+}_{k(j),Mar16}$. The bottom row reports the F-statistics on $MIN^{25+}_{j,Mar16}$ and $MIN^{25+}_{k(j),Mar16}$, the excluded instruments in the IV model reported in column 4. Robust standard errors clustered at the TTWA level are reported in parentheses.

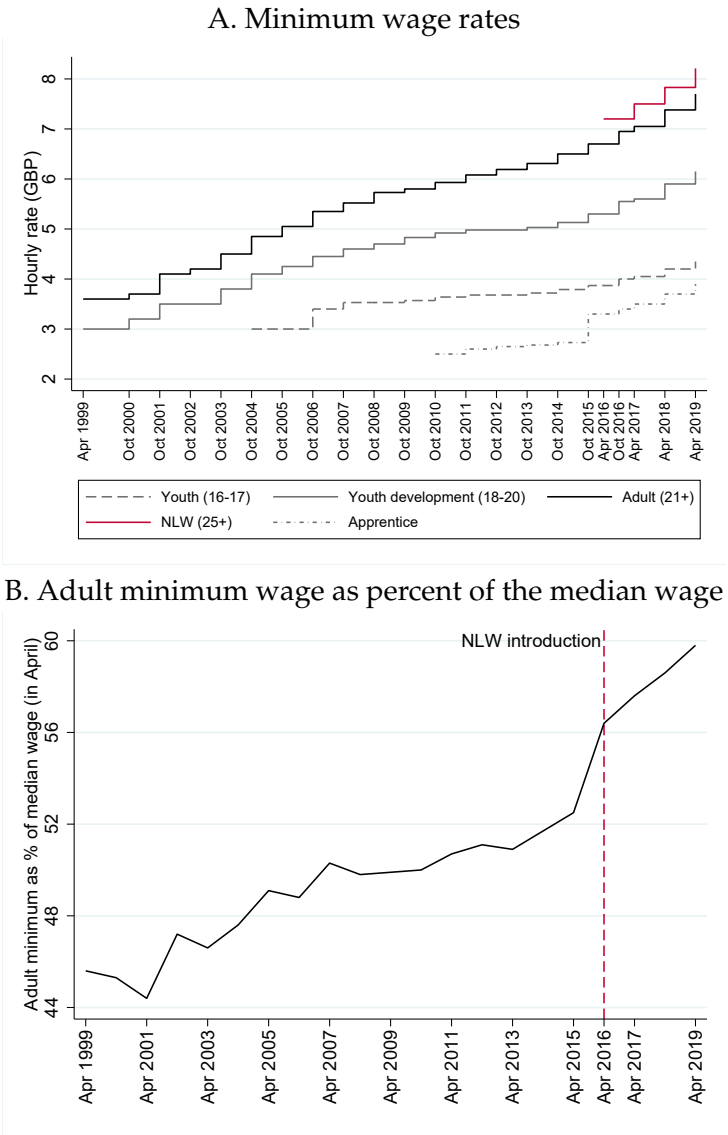
Table 4. CROSS-OCCUPATION WAGE SPILLOVERS: CARE ASSISTANTS

	Change in log average hourly wage of carers under 25				
	(1)	(2)	(3)	(4)	(5)
Change in log average hourly wage of carers (25+)	0.733***				
	(0.065)				
Change in log average hourly wage of senior carers (25+)		-0.385*			
		(0.231)			
Change in log average hourly wage of ancillary staff (25+)			0.140		
			(0.133)		
Change in log average hourly wage of admin staff (25+)				-0.038	
				(0.097)	
Change in log average hourly wage of nurses (25+)					-0.010
					(0.049)
Observations	3,939	2,954	2,600	1,874	1,181
Controls	Yes	Yes	Yes	Yes	Yes
Mean of dep. var. (level)	6.90				

Notes: The table reports IV estimates of γ_1 from versions of model 3 in which the outcome variable is gross hourly wage growth among carers aged under 25 ($\Delta \ln w_{j,t}^{under25,carer}$), and the main regressor of interest is the average hourly wage growth among workers aged 25 and over in different job roles k ($\Delta \ln w_{j,t}^{25+,k}$), specifically carers (column 1), senior carers (column 2), ancillary staff (column 3), administrative staff (column 4) and nurses (column 5). Each $\Delta \ln w_{j,t}^{25+,k}$ is instrumented using $MIN_{j,Mar16}^{25+,k}$ as excluded instrument and $MIN_{j,Mar16}^{25+,-k}$ – i.e. the fraction of older workers paid below the NLW in each of the other job roles – as included instruments. Robust standard errors clustered at the TTWA level are reported in parentheses.

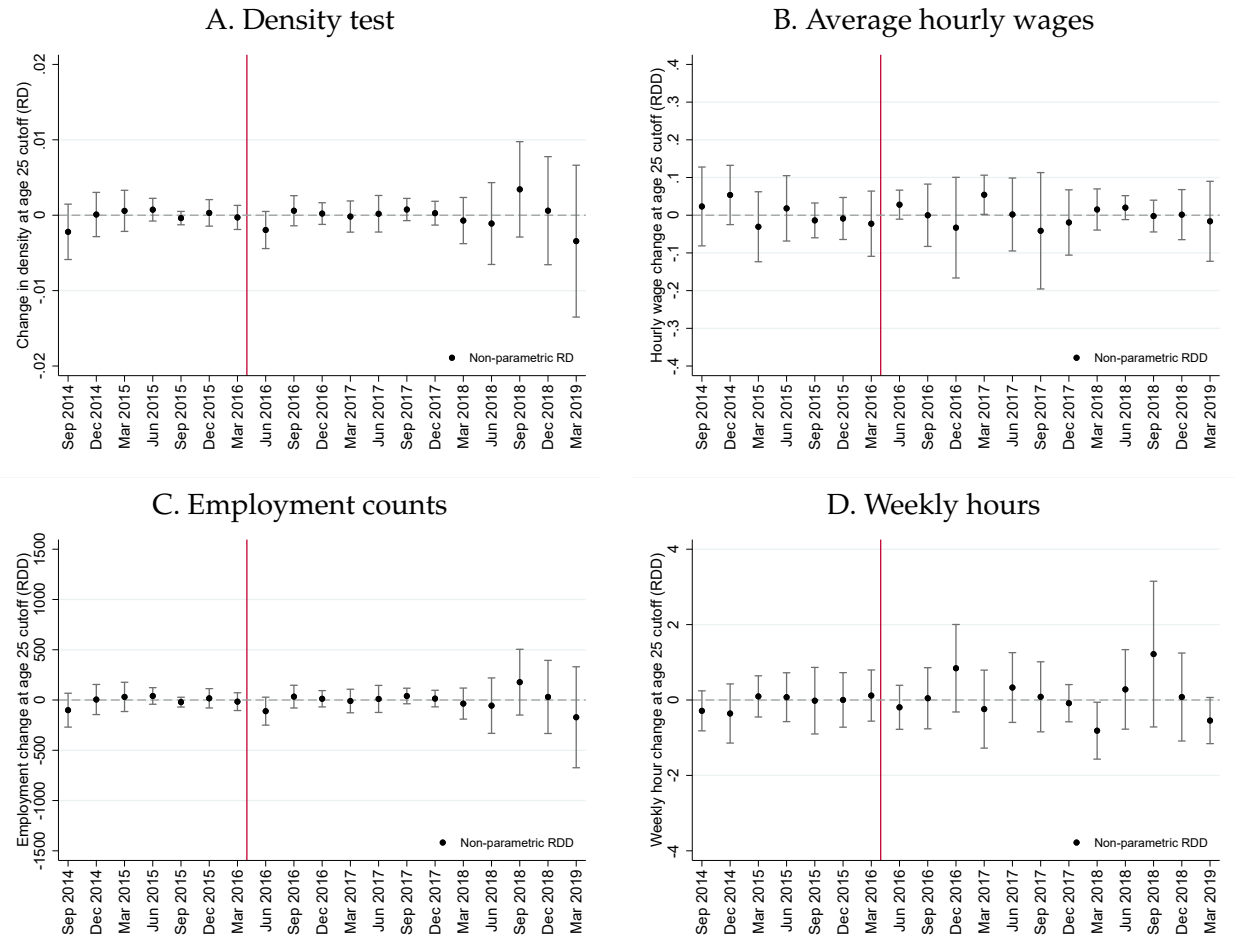
Appendix A. Additional Figures and Tables

Figure A1. MINIMUM WAGE RATES IN THE UK 1999-2019



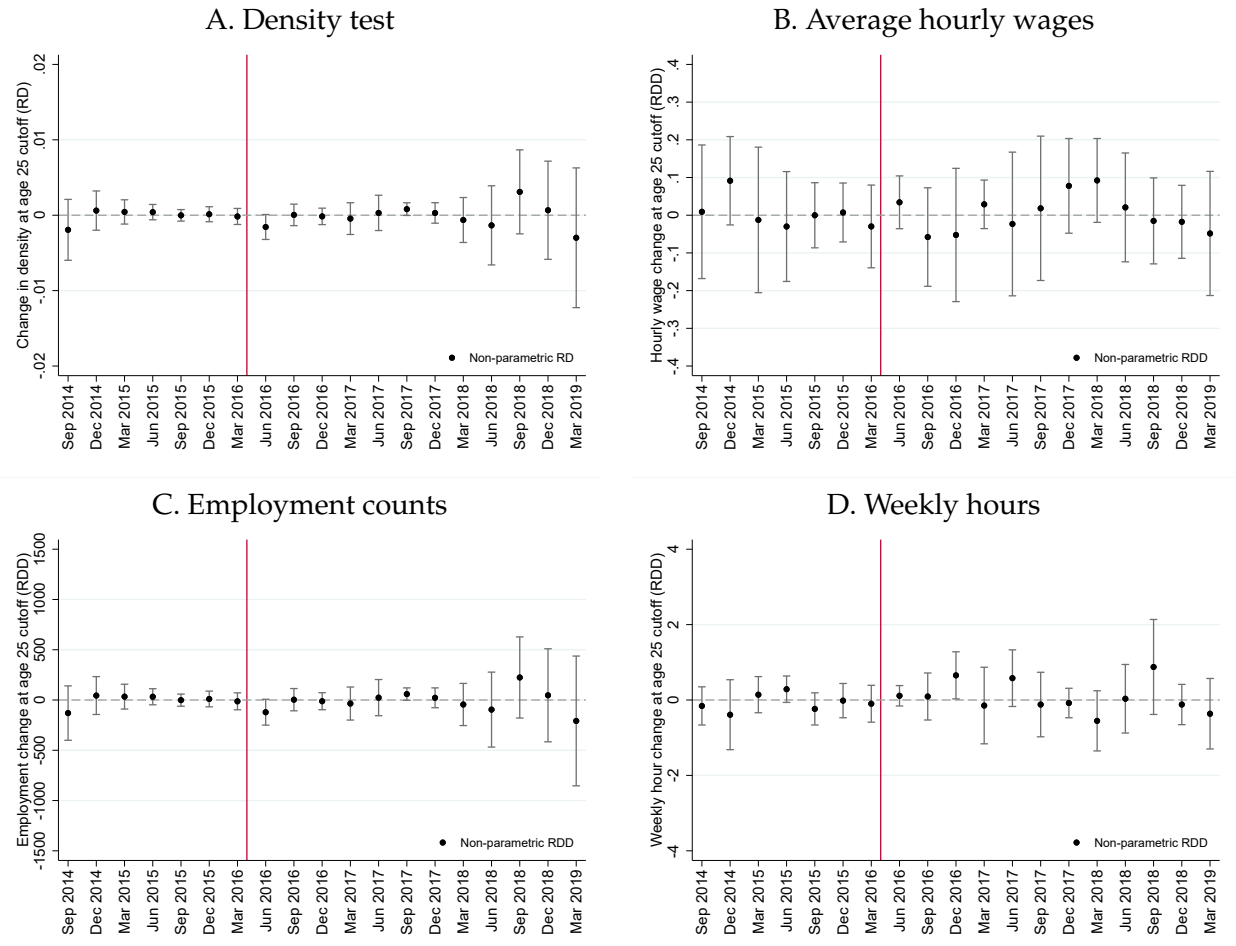
Notes: Panel A reports the levels of the minimum wage rates applying to workers of different ages in the UK between April 1999 and April 2019. The apprentice rate applies to apprentices. The 16-17 year-old rate to workers aged 16 and 17. The youth development rate to workers aged 18-20. The adult rate (National Minimum Wage) applied to workers aged 21 and over until March 2016. From April 2016, the NMW applies to workers aged 21-24 and the National Living Wage (NLW) to those aged 25 and over. Panel B shows the adult minimum wage as a percent of the median wage. The dashed red line corresponds to the NLW introduction on April 1, 2016.

Figure A2. MARKET-LEVEL EFFECT OF NLW INTRODUCTION ON WAGE AND EMPLOYMENT OUTCOMES FOR CARE ASSISTANTS



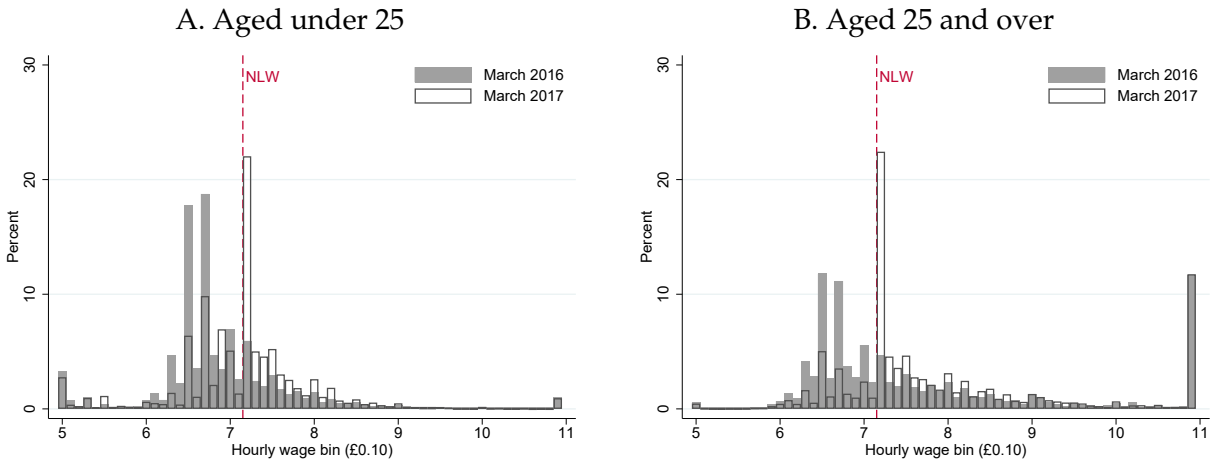
Notes: The figure reports a set of RDD estimates (indicated by dots) and associated 95 percent confidence intervals (capped vertical bars). The sample analyzed is the market-level sample of care assistants. Panel A reports the RDD estimates of a set of McCrary tests for a discontinuity in the density function of age at the age-25 cutoff for the end-month of each quarter in the sample period. Panel B reports the RDD estimate of α_1 from model 1 using average gross hourly wages as outcome variable. Panels C and D are analogous to Panel B, but use employment counts and average weekly hours worked as outcome variable, respectively.

Figure A3. MARKET-LEVEL EFFECT OF NLW INTRODUCTION ON WAGE AND EMPLOYMENT OUTCOMES FOR WORKERS IN THE CARE HOME SECTOR



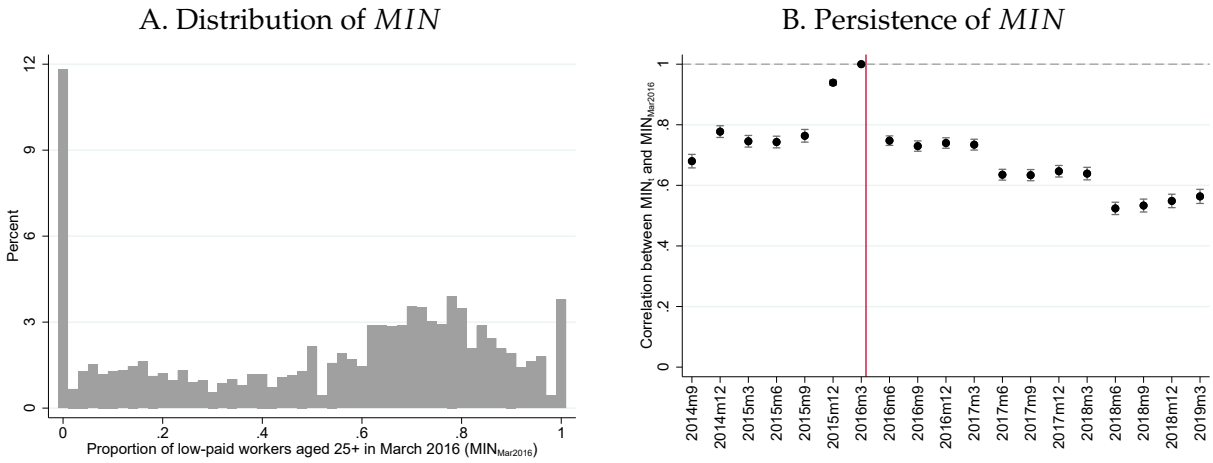
Notes: The figure reports a set of RDD estimates (indicated by dots) and associated 95 percent confidence intervals (capped vertical bars). The sample analyzed is the market-level sample of workers in the residential care home sector. Panel A reports the RDD estimates of a set of McCrary tests for a discontinuity in the density function of age at the age-25 cutoff for the end-month of each quarter in the sample period. Panel B reports the RDD estimate of α_1 from model 1 using average gross hourly wages as outcome variable. Panels C and D are analogous to Panel B, but use employment counts and average weekly hours worked as outcome variable, respectively.

Figure A4. DISTRIBUTION OF HOURLY WAGES FOR WORKERS IN THE CARE HOME SECTOR



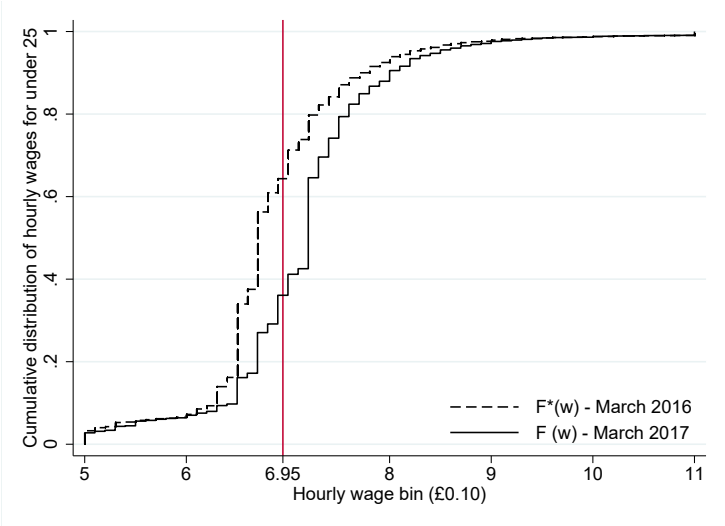
Notes: The figure reports a set of hourly wage distributions for workers in the care sector (any occupation) in March 2016 (gray bars) and March 2017 (unfilled bars). Hourly wages are binned into £0.10 bins. The red dashed vertical line indicates the level of the NLW in March 2017. Panel A reports the hourly wage distribution for workers aged 25 and over, Panel B for those aged under 25.

Figure A5. DISTRIBUTION AND PERSISTENCE OF FIRM-LEVEL NLW BITE



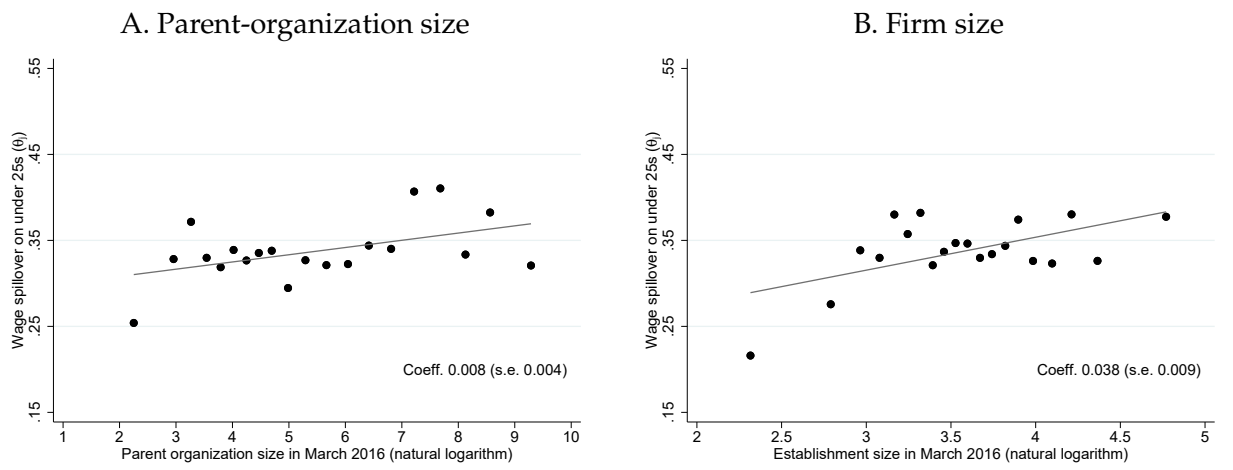
Notes: Panel A reports the density distribution of the variable $MIN^{25+}_{j,Mar16}$. The variable $MIN^{25+}_{j,Mar16}$ is constructed as the proportion of workers aged 25 and over that in March 2016 were paid below the age-specific minimum wage rate that would become effective on April 1, 2016. The average value of $MIN^{25+}_{j,Mar16}$ in the sample is 0.52 (with a standard deviation of 0.32). Panel B reports the correlation between $MIN^{25+}_{j,Mar16}$ and $MIN^{25+}_{j,t}$ for $t = \{-15, -12, ..., 0, 3, ..., 36\}$.

Figure A6. MEASURE OF WAGE SPILLOVERS AT THE FIRM LEVEL



Notes: The figure illustrates the components of θ_j – defined as $\theta_j(w^{NMW}) = \frac{F_j^*(w^{NMW}) - F_j(w^{NMW})}{F_j^*(w^{NMW})}$ in 4 – for a representative firm in March 2017. The solid line corresponds to $F_j^*(\cdot)$ as represented by the March 2016 distribution, and the dashed line corresponds to $F_j(\cdot)$ in March 2017. The red vertical line indicates the level of w^{NMW} in March 2017. The variable θ_j is an increasing function of the size of wage spillovers on young workers over the $[0, 1]$ interval. If a firm implements a no-spillover policy, we would expect the solid and dashed lines to overlap in the range $w_{ij} < w^{NMW}$ (i.e. $F_j^*(w^{NMW}) = F_j(w^{NMW})$), resulting in $\theta_j = 0$. On the other hand, in case a firm operates a full-fledged spillover policy, the dashed line would lay entirely to the left of the red vertical line (i.e. $F_j(w^{NMW}) = 0$), leading to $\theta_j = 1$.

Figure A7. WAGE SPILLOVERS AND PROXIES FOR THE ADMINISTRATIVE COST OF KEEPING A DIVERSIFIED WAGE STRUCTURE



Notes: Panel A is a binned scatter plot of the conditional correlation of θ_j (as defined in equation 4) and the size of the parent organization of firm j (in natural logarithm), conditional on $MIN^{25+}_{j,Mar16}$, $X_{j,Mar16}$, the proportion of under 25s paid below the NLW in March 2016, and a measure of the wage-bill cost of wage spillovers. The latter is the percent increase in wage-bill costs required to increase all younger workers' wages to the NLW as of March 2016. Formally, the wage-bill gap in firm j at time t is defined as $\frac{\sum_{i \in j | age_i < 25} h_{i,j,t} \cdot \max\left\{ NLW_{t+1} - w_{i,j,t} \ , 0 \right\}}{\sum_{i \in j} h_{i,j,t} \cdot w_{i,j,t}}$. Panel B is a binned scatter plot of the correlation of θ_j and the size of firm j (in natural logarithm), conditional on the same factors as above. Each graph reports the estimated coefficient (and associated standard error in parentheses) of an OLS regression of θ_j on the variable reported on the x-axis, conditional on covariates.

Table A1. TESTING FOR SAMPLE SELECTION: CONDITIONALITY ON RECORD UPDATING BETWEEN APRIL 2016 AND MARCH 2017

	Update (1)	$\Delta \ln w^{25+}$ (2)	$\Delta \ln w^{<25}$ (3)	$\Delta N^{<25}/N$ (4)
Low-paid proportion (25+)	-0.055***	0.067***		
	(0.012)	(0.004)		
Change in log average hourly wage (25+)			0.662***	0.044
			(0.080)	(0.058)
Observations	4,839	4,839	4,839	4,839
Controls	Yes	Yes	Yes	Yes
Model	OLS	OLS	IV	IV
Mean of dep. var. (level)	0.96	7.91	6.92	0.15
F-stat		332.55		

Notes: Column 1 reports a linear probability model for the probability of a firm updating its records on ASC-WDS between April 2016 and March 2017. The estimate is based on the reduced-form model illustrated in equation 2 and are conditional on firm-level characteristics and TTWA fixed effects. Estimates are based on the sample of firms active in March 2016 and employing workers aged under 25 in March 2016 and March 2017. Using the same sample, column 2 reports estimates of equation 2 using wage growth among workers aged 25 and over as outcome. Columns 3 and 4 report IV estimates of model 3 using wage growth among workers aged under 25 and the change in the share of under 25 employed in the firm as outcome variables. Robust standard errors clustered at the TTWA level are reported in parentheses.

Table A2. TESTING FOR SAMPLE SELECTION: CONDITIONALITY ON SURVIVAL

	Probability of being active in:		
	March 2017 (1)	March 2018 (2)	March 2019 (3)
Low-paid proportion (25+)	-0.015	-0.017	-0.015
	(0.010)	(0.014)	(0.018)
Observations	6,519	6,519	6,519
Controls	Yes	Yes	Yes
Mean of dep. var.	0.95	0.91	0.88

Notes: The table reports linear probability models for the probability of the organization being active in March 2017, March 2018 and March 2019, on the sample of all firms active (and employing workers under 25) in March 2016. The estimates are based on the reduced-form model illustrated in equation 2 and are conditional on firm-level characteristics and TTWA fixed effects. Robust standard errors clustered at the TTWA level are reported in parentheses.

Table A3. TESTING FOR SAMPLE SELECTION: CONDITIONALITY ON YOUTH EMPLOYMENT

	Probability of employing under 25s in:			
	March 2016	March 2017	March 2018	March 2019
	(1)	(2)	(3)	(4)
Low-paid proportion (25+)	0.025*	0.001	-0.013	-0.020
	(0.015)	(0.013)	(0.019)	(0.021)
Observations	8,293	5,712	5,027	4,750
Controls	Yes	Yes	Yes	Yes
Mean of dep. var.	0.79	0.93	0.89	0.86

Notes: The table reports linear probability models for the probability of employing workers aged under 25 in March 2016, March 2017, March 2018 and March 2019. The estimates are based on the reduced-form model illustrated in equation 2 and are conditional on firm-level characteristics and TTWA fixed effects. The estimate in column 1 is based on the sample of firms active in March 2016, irrespective of whether they employ workers aged under 25 or not. The estimates in columns 2 to 4 are instead based on firms active and employing young workers in March 2016, and still active in March 2017 (column 2), March 2018 (column 3) and March 2019 (column 4). Robust standard errors clustered at the TTWA level are reported in parentheses.

Table A4. DESCRIPTIVE STATISTICS

	Full sample [Worker-level]		Balanced panel [Worker-level]		Balanced panel [Firm-level]	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
	(1)	(2)	(3)	(4)	(5)	(6)
Firm size					45.18	34.43
Share under 25	0.12	0.33	0.15	0.35	0.15	0.09
Hourly wage	7.91	2.56	7.86	2.47	7.78	0.94
Paid below NLW (25+)	0.51	0.50	0.52	0.50	0.52	0.32
Paid hourly wage	0.85	0.36	0.87	0.33	0.85	0.30
Weekly hours	28.01	13.21	28.07	13.02	28.70	5.28
Female	0.84	0.37	0.84	0.37	0.84	0.12
Age	42.20	13.45	41.38	13.64	41.24	4.03
Tenure (months)	64.92	65.94	60.14	63.40	61.78	26.65
British	0.82	0.38	0.83	0.37	0.85	0.18
Carer	0.55	0.50	0.55	0.50	0.57	0.19
Senior carer	0.09	0.28	0.08	0.28	0.10	0.09
Ancillary staff	0.15	0.36	0.17	0.37	0.14	0.17
Nurse	0.06	0.24	0.06	0.24	0.04	0.07
Administrative staff	0.02	0.14	0.02	0.14	0.02	0.02
Wage carer	7.20	1.35	7.13	1.11	7.09	0.76
Wage senior	8.05	1.73	8.08	1.61	8.16	1.64
Wage ancillary	7.13	1.46	7.17	1.49	7.07	0.86
Wage nurse	12.82	2.43	12.87	2.59	12.99	1.66
Wage admin	8.62	2.38	8.63	2.44	8.51	1.98
ZHC	0.08	0.27	0.08	0.27	0.07	0.12
Permanent	0.88	0.32	0.89	0.32	0.90	0.11
Temporary	0.01	0.12	0.02	0.12	0.02	0.05
Bank	0.08	0.27	0.08	0.27	0.07	0.09
Agency	0.00	0.05	0.00	0.03	0.00	0.02
Other	0.01	0.09	0.01	0.09	0.01	0.04
Local authority funded	0.07	0.25	0.05	0.22	0.05	0.21
Private	0.75	0.43	0.78	0.41	0.79	0.41
Voluntary	0.16	0.36	0.15	0.35	0.14	0.35
Other type of provider	0.02	0.14	0.02	0.15	0.02	0.14
Observations	332,671		209,219		4,631	

Notes: The table reports the mean and standard deviation of a set of individual and firm characteristics for workers in the market-level sample in columns 1 and 2, and for workers and firms in the firm-level sample in columns 3 to 6. All figures are as of March 2016.

Table A5. MARKET-LEVEL WAGE SPILLOVERS

	Care assistants		All workers	
	Hourly wage	Counterf. hourly wage	Hourly wage	Counterf. hourly wage
	(1)	(2)	(3)	(4)
$\hat{\alpha}_1$	0.020	0.195***	0.024	0.301***
	(0.023)	(0.017)	(0.029)	(0.030)
Observations	168	168	168	168
Mean of dep. var.	7.51	7.34	7.71	7.46
Spillover onto under 25		0.90		0.92

Notes: The table displays estimates of the coefficient α_1 in model 1 for different wage outcomes. We estimate the model pooling data for March 2017, March 2018 and March 2019, and including time fixed effects in the estimation. Column 1 reports the estimated α_1 using hourly wages of care assistants as outcome variable. In column 2, the outcome variable is a measure of the counterfactual hourly wage that care assistants would have received absent wage spillovers. For workers aged 25 and over, the counterfactual wage is equivalent to their actual wage $w_{i,t}$, where t indexes a calendar year. For younger workers, it is defined as $\max(w_{i,t-1}\ ;\ NMW_t^{21-24})$ if $w_{i,t-1} < NLW_t$, and $w_{i,t}$ otherwise. The counterfactual wage for new hires aged under 25 is assumed to be equivalent to NMW_t^{21-24}. The magnitude of wage spillovers is measured as $\frac{\hat{\alpha}_1^{counterf} - \hat{\alpha}_1^{actual}}{\hat{\alpha}_1^{counterf}}$, and is reported in the bottom row of the table. Columns 3 and 4 report analogous estimates for all workers in residential care. Robust standard errors are reported in parentheses.

Table A6. WAGE SPILLOVERS: ROBUSTNESS

	Change in log average hourly wage of under 25s				Change in average hourly wage of under 25s	
	[Mar16-Sep16]		[Mar16-Mar17]		[Mar16-Mar17]	
	(1)	(2)	(3)	(4)	(5)	(6)
Low-paid proportion (25+)	0.039***				0.349***	
	(0.004)				(0.047)	
Change in log average hourly wage (25+)		0.671***		0.495***		
		(0.069)		(0.117)		
Wage-bill gap (25+)			0.129**			
			(0.059)			
Change in average hourly wage (25+)						0.643***
						(0.085)
Observations	4,578	4,578	4,631	4,631	4,631	4,631
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Mean of dep. var. (level)	6.93		6.93		6.93	
Model	OLS	IV	OLS	IV	OLS	IV
F-stat		257.76		7.01		276.01

Notes: Columns 1 and 2 replicate the main reduced-form and IV estimates of spillover effects from Table 1 (columns 3 and 4 therein) using the change in log average wages of 25+ and under 25 between March 2016 and September 2016. The bottom row reports the F-statistics on $MIN^{25+}_{j,Mar16}$, the excluded instrument in IV model 3. Column 3 reports the reduced-form estimate of $\sum_{t=3n,n\in\{1,...,4\}} \hat{\beta}_{1,t}$ from model 2, using the 'wage-bill gap' in the firm in March 2016 as measure of the NLW bite. Formally, the gap in firm j at time t is defined as $\frac{\sum_{i\in j|age_i\geq 25} h_{i,j,t}\cdot\max\{NLW_{t+1}-w_{i,j,t}\ ,\ 0\}}{\sum_{i\in j|age_i\geq 25} h_{i,j,t}\cdot w_{i,j,t}}$. The gap measures by how much the wage bill of the firm would have to increase in percent to comply with the NLW regulations, assuming no changes in employment at the extensive or intensive margin, and no wage spillover effects as a result of the NLW introduction. Column 4 reports the IV estimate of parameter γ_1 from model 3, where $\Delta \ln w^{25+}_{j,t}$ is instrumented with the wage-bill gap. The bottom row reports the F-statistics on the wage-bill gap, the excluded instrument in IV model 3. Column 5 reports the reduced-form estimate of $\sum_{t=3n,n\in\{1,...,4\}} \hat{\beta}_{1,t}$ from a version of model 2, where the outcome variable is the firm-level change in average hourly wages of workers aged under 25 between March 2016 and March 2017, in levels. Column 6 reports the IV estimate of parameter γ_1 from a version of model 3, where $\Delta w^{25+}_{j,t}$ is the main regressor and is instrumented using the proportion of low-paid workers aged 25 and over in the firm in March 2016. The bottom row reports the F-statistics on $MIN^{25+}_{j,Mar16}$, the excluded instrument in IV model 3. All estimates are conditional on firm-level covariates and TTWA fixed effects. Robust standard errors clustered at the TTWA level are reported in parentheses.

Table A7. WAGE SPILLOVERS: UPGRADING TO NLW

	Change in proportion of under 25s paid at NLW		at or above NLW	
	(1)	(2)	(3)	(4)
Low-paid proportion (25+)	0.271***		0.419***	
	(0.016)		(0.025)	
Change in proportion paid at NLW (25+)		0.711***		1.099***
		(0.040)		(0.074)
Observations	4,631	4,631	4,631	4,631
Controls	Yes	Yes	Yes	Yes
Mean of dep. var.	0.02		0.30	
Model	OLS	IV	OLS	IV
F-stat		689.99		689.99

Notes: Columns 1 and 3 report the reduced-form estimate of $\sum_{t=3n,n\in\{1,\ldots,4\}} \hat{\beta}_{1,t}$ from model 2, using as outcome variable the firm-level change in the proportion of workers aged under 25 being paid at the NLW (£7.20) between March 2016 and March 2017, or being paid at or above the NLW. Columns 2 and 4 reports the IV estimate of parameter γ_1 from model 3, where the treatment is the change in the proportion of workers aged 25 and over being paid at the NLW and it is instrumented with $MIN^{25+}_{j,Mar16}$. The bottom row reports the F-statistics on $MIN^{25+}_{j,Mar16}$, the excluded instrument in IV model 3. All estimates are conditional on firm-level controls and TTWA fixed effects. Robust standard errors clustered at the TTWA level are reported in parentheses.

Table A8. WEEKLY HOUR SPILLOVERS AND ZERO HOURS CONTRACTS

	Change in log average weekly hours of under 25s		Change in share of under 25s on zero hours contracts		
	(1)	(2)	(3)	(4)	(5)
Low-paid proportion (25+)	0.022		0.021		
	(0.020)		(0.013)		
Change in log average hourly wage (25+)		0.302		0.294*	
		(0.274)		(0.178)	
Change in log average hourly wage (<25)					0.433
					(0.268)
Observations	4,453	4,453	4,399	4,399	4,399
Controls	Yes	Yes	Yes	Yes	Yes
Mean of dep. var. (level)	27.21		0.11		
Model	OLS	IV	OLS	IV	IV
F-stat		365.16		324.08	60.10

Notes: Column 1 reports the reduced-form estimate of $\sum_{t=3n,n\in\{1,...,4\}} \hat{\beta}_{1,t}$ from model 2, using the firm-level change in log average weekly hours worked by workers aged under 25 between March 2016 and March 2017 as outcome variable. For the same outcome, column 2 reports the IV estimate of parameter γ_1 from model 3, where $\Delta \ln w_{j,t}^{25+}$ is instrumented using the proportion of low-paid workers aged 25 and over in the firm in March 2016. The bottom row reports the F-statistics on $MIN_{j,Mar16}^{25+}$, the excluded instrument in IV model 3. Column 3 reports the reduced-form estimate of $\sum_{t=3n,n\in\{1,...,4\}} \hat{\beta}_{1,t}$ from model 2 using the firm-level change in the share of workers aged under 25 employed with a zero hours contract between March 2016 and March 2017 as outcome variable. For the same outcome, column 4 reports the IV estimate of parameter γ_1 from model 3, where $\Delta \ln w_{j,t}^{25+}$ is instrumented using the proportion of low-paid workers aged 25 and over in the firm in March 2016. Column 5 instead reports the IV estimate of parameter γ_1 from model 3, using $\Delta \ln w_{j,t}^{under25}$ as main regressor and instrumenting it using the proportion of low-paid workers aged 25 and over in the firm in March 2016. The bottom row reports the F-statistics on $MIN_{j,Mar16}^{25+}$, the excluded instrument in IV model 3. All estimates are conditional on firm-level controls and TTWA fixed effects. Robust standard errors clustered at the TTWA level are reported in parentheses.

Table A9. SEPARATION RATE

	Change in separation rate				
	all workers			under 25	
	(1)	(2)	(3)	(4)	(5)
Low-paid proportion (25+)	-0.025***		-0.033**		
	(0.009)		(0.015)		
Change in log average hourly wage (25+)		-0.365***		-0.476**	
		(0.127)		(0.208)	
Change in log average hourly wage (<25)					-0.677**
					(0.303)
Observations	4,519	4,519	4,519	4,519	4,519
Controls	Yes	Yes	Yes	Yes	Yes
Mean of dep. var. (level)	0.07		0.10		
Model	OLS	IV	OLS	IV	IV
F-stat		406.65		406.65	69.90

Notes: Columns 1 and 3 report the reduced-form estimate of $\sum_{t=3n, n\in\{1,...,4\}} \hat{\beta}_{1,t}$ from model 2, using the firm-level change in the separation rate among all workers and workers aged under 25 between March 2016 and March 2017, respectively. The separation rate is measured as the number of (young) workers leaving the firm between month t and $t+3$, as a share of (young) workers employed in t. For the same outcomes, columns 2 and 4 report the IV estimate of parameter γ_1 from model 3, where $\Delta \ln w_{j,t}^{25+}$ is instrumented using the proportion of low-paid workers aged 25 and over in the firm in March 2016. Column 5 reports the IV estimate of parameter γ_1 from model 3, using $\Delta \ln w_{j,t}^{under25}$ as main regressor and instrumenting it using the proportion of low-paid workers aged 25 and over in the firm in March 2016. All estimates are conditional on firm-level controls and TTWA fixed effects. The bottom row reports the F-statistics on $MIN_{j,Mar16}^{25+}$, the excluded instrument in IV model 3. Robust standard errors clustered at the TTWA level are reported in parentheses.

Table A10. CROSS-OCCUPATION WAGE SPILLOVER EQUATIONS: FIRST STAGE

	Change in log average hourly wage of 25+				
	Carer	Senior carer	Ancillary staff	Admin staff	Nurse
	(1)	(2)	(3)	(4)	(5)
Low paid proportion of carers (25+)	0.052***	0.000***	0.000	0.000	0.000**
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)
Low paid proportion of senior carers (25+)	-0.000	0.040***	0.000	-0.000**	-0.000**
	(0.000)	(0.004)	(0.000)	(0.000)	(0.000)
Low paid proportion of ancillary staff (25+)	0.000	0.000	0.065***	0.000	0.000***
	(0.000)	(0.000)	(0.006)	(0.000)	(0.000)
Low paid proportion of admin staff (25+)	0.000***	0.000**	-0.000	0.063***	-0.000
	(0.000)	(0.000)	(0.000)	(0.008)	(0.000)
Low paid proportion of nurses (25+)	-0.000	-0.000	0.000	-0.000	0.229***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.046)
Observations	4,168	3,225	2,771	2,097	1,244
Controls	Yes	Yes	Yes	Yes	Yes
Partial F-stat	463.81	86.19	132.51	56.12	24.58

Notes: The table reports the first-stage estimates of versions of IV model 3, in which the outcome variable is gross hourly wage growth among workers aged under 25 in occupation k ($\Delta \ln w_{j,t}^{under25,k}$), and the main regressor of interest is average hourly wage growth among workers aged 25 and over in different job roles k and $-k$ ($\Delta \ln w_{j,t}^{25+,k}$ and $\Delta \ln w_{j,t}^{25+,-k}$). In the first stage reported in the table, the dependent variable is gross hourly wage growth among older workers between March 2016 and March 2017 for carers (column 1), senior carers (column 2), ancillary staff (column 3), administrative staff (column 4) and nurses (column 5). Each of these variables is regressed against the set of included and excluded instruments. In particular, $MIN_{j,Mar16}^{25+,k}$ is the excluded instrument and $MIN_{j,Mar16}^{25+,-k}$ – i.e. the fraction of older workers paid below the NLW in each of the other job roles – are the included instruments. The bottom row reports the partial F-statistics on $MIN_{j,Mar16}^{25+,k}$, the excluded instrument. Robust standard errors clustered at the TTWA level are reported in parentheses.

Table A11. CROSS-OCCUPATION WAGE SPILLOVER EQUATIONS: SENIOR CARE ASSISTANTS

	Change in log average hourly wage of senior carers under 25				
	(1)	(2)	(3)	(4)	(5)
Change in log average hourly wage of carers (25+)	0.006				
	(0.342)				
Change in log average hourly wage of senior carers (25+)		0.795***			
		(0.258)			
Change in log average hourly wage of ancillary staff (25+)			-2.182		
			(2.200)		
Change in log average hourly wage of admin staff (25+)				-0.230	
				(0.314)	
Change in log average hourly wage of nurses (25+)					0.319
					(0.529)
Observations	446	442	331	259	131
Controls	Yes	Yes	Yes	Yes	Yes
Mean of dep. var. (level)	7.78				

Notes: The table reports IV estimates of γ_1 from versions of model 3 in which the outcome variable is gross hourly wage growth among senior carers aged under 25 ($\Delta \ln w_{j,t}^{under25,senior}$), and the main regressor of interest is the average hourly wage growth among workers aged 25 and over in different job roles k ($\Delta \ln w_{j,t}^{25+,k}$), specifically carers (column 1), senior carers (column 2), ancillary staff (column 3), administrative staff (column 4) and nurses (column 5). Each $\Delta \ln w_{j,t}^{25+,k}$ is instrumented using $MIN_{j,Mar16}^{25+,k}$ as excluded instrument and $MIN_{j,Mar16}^{25+,-k}$ – i.e. the fraction of older workers paid below the NLW in each of the other job roles – as included instruments. Robust standard errors clustered at the TTWA level are reported in parentheses.

Table A12. CROSS-OCCUPATION WAGE SPILLOVER EQUATIONS: ANCILLARY STAFF

	Change in log average hourly wage of ancillary staff under 25				
	(1)	(2)	(3)	(4)	(5)
Change in log average hourly wage of carers (25+)	0.203				
	(0.323)				
Change in log average hourly wage of senior carers (25+)		-0.189			
		(0.412)			
Change in log average hourly wage of ancillary staff (25+)			0.627***		
			(0.199)		
Change in log average hourly wage of admin staff (25+)				-0.284	
				(0.181)	
Change in log average hourly wage of nurses (25+)					0.109
					(0.080)
Observations	1,022	786	1,023	790	551
Controls	Yes	Yes	Yes	Yes	Yes
Mean of dep. var. (level)	6.56				

Notes: The table reports IV estimates of γ_1 from versions of model 3 in which the outcome variable is gross hourly wage growth among ancillary staff aged under 25 ($\Delta \ln w_{j,t}^{under25,ancillary}$), and the main regressor of interest is the average hourly wage growth among workers aged 25 and over in different job roles k ($\Delta \ln w_{j,t}^{25+,k}$), specifically carers (column 1), senior carers (column 2), ancillary staff (column 3), administrative staff (column 4) and nurses (column 5). Each $\Delta \ln w_{j,t}^{25+,k}$ is instrumented using $MIN_{j,Mar16}^{25+,k}$ as excluded instrument and $MIN_{j,Mar16}^{25+,-k}$ – i.e. the fraction of older workers paid below the NLW in each of the other job roles – as included instruments. Robust standard errors clustered at the TTWA level are reported in parentheses.

Table A13. CROSS-OCCUPATION WAGE SPILLOVER EQUATIONS: ADMINISTRATIVE STAFF

	Change in log average hourly wage of administrative staff under 25				
	(1)	(2)	(3)	(4)	(5)
Change in log average hourly wage of carers (25+)	-0.353				
	(1.808)				
Change in log average hourly wage of senior carers (25+)		10.030			
		(8.931)			
Change in log average hourly wage of ancillary staff (25+)			0.118		
			(1.242)		
Change in log average hourly wage of admin staff (25+)				-0.122	
				(0.261)	
Change in log average hourly wage of nurses (25+)					0.443**
					(0.221)
Observations	122	90	102	113	83
Controls	Yes	Yes	Yes	Yes	Yes
Mean of dep. var. (level)	6.75				

Notes: The table reports IV estimates of γ_1 from versions of model 3 in which the outcome variable is gross hourly wage growth among administrative staff aged under 25 ($\Delta \ln w_{j,t}^{under25,admin}$), and the main regressor of interest is the average hourly wage growth among workers aged 25 and over in different job roles k ($\Delta \ln w_{j,t}^{25+,k}$), specifically carers (column 1), senior carers (column 2), ancillary staff (column 3), administrative staff (column 4) and nurses (column 5). Each $\Delta \ln w_{j,t}^{25+,k}$ is instrumented using $MIN_{j,Mar16}^{25+,k}$ as excluded instrument and $MIN_{j,Mar16}^{25+,-k}$ – i.e. the fraction of older workers paid below the NLW in each of the other job roles – as included instruments. Robust standard errors clustered at the TTWA level are reported in parentheses.

Table A14. CROSS-OCCUPATION WAGE SPILLOVER EQUATIONS: NURSES

	Change in log average hourly wage of nurses under 25				
	(1)	(2)	(3)	(4)	(5)
Change in log average hourly wage of carers (25+)	3.008**				
	(1.295)				
Change in log average hourly wage of senior carers (25+)		1.377			
		(1.400)			
Change in log average hourly wage of ancillary staff (25+)			2.030		
			(3.023)		
Change in log average hourly wage of admin staff (25+)				0.151	
				(0.449)	
Change in log average hourly wage of nurses (25+)					0.560
					(0.424)
Observations	57	33	53	48	57
Controls	Yes	Yes	Yes	Yes	Yes
Mean of dep. var. (level)	12.07				

Notes: The table reports IV estimates of γ_1 from versions of model 3 in which the outcome variable is gross hourly wage growth among nurses aged under 25 ($\Delta \ln w_{j,t}^{under25,nurse}$), and the main regressor of interest is the average hourly wage growth among workers aged 25 and over in different job roles k ($\Delta \ln w_{j,t}^{25+,k}$), specifically carers (column 1), senior carers (column 2), ancillary staff (column 3), administrative staff (column 4) and nurses (column 5). Each $\Delta \ln w_{j,t}^{25+,k}$ is instrumented using $MIN_{j,Mar16}^{25+,k}$ as excluded instrument and $MIN_{j,Mar16}^{25+,-k}$ – i.e. the fraction of older workers paid below the NLW in each of the other job roles – as included instruments. Robust standard errors clustered at the TTWA level are reported in parentheses.

Table A15. PRODUCTIVITY AND CARE QUALITY EQUATIONS

	Change in log residents per hour worked			Change in quality of care		
	(1)	(2)	(3)	(4)	(5)	(6)
Low-paid proportion (25+)	0.015			0.041		
	(0.015)			(0.040)		
Change in log average hourly wage (25+)		0.205			0.555	
		(0.200)			(0.522)	
Change in log average hourly wage (<25)			0.287			0.803
			(0.283)			(0.780)
Observations	4,567	4,567	4,567	2,733	2,733	2,733
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Mean of dep. var. (level)	0.03			0.70		
Model	OLS	IV	IV	OLS	IV	IV
F-stat		64.32	83.54		231.17	42.79

Notes: Column 1 reports the reduced-form estimate of $\sum_{t=3n,n\in\{1,...,4\}} \hat{\beta}_{1,t}$ from model 2, using the firm-level change in log residents per hour worked between March 2016 and March 2017 as outcome variable. For the same outcome, column 2 reports the IV estimate of parameter γ_1 from model 3, where $\Delta \ln w_{j,t}^{25+}$ is instrumented using the proportion of low-paid workers aged 25 and over in the firm in March 2016. Column 3 reports the IV estimate of parameter γ_1 from model 3, using $\Delta \ln w_{j,t}^{<25}$ as main regressor and instrumenting it using the proportion of low-paid workers aged 25 and over in the firm in March 2016. The bottom row reports the F-statistics on $MIN_{j,Mar16}^{25+}$, the excluded instrument in IV model 3. Column 4 reports the reduced-form estimate of $\sum_{t=3n,n\in\{1,...,4\}} \hat{\beta}_{1,t}$ from model 2, using the firm-level change in an index of overall quality of care from before to after March 2016 as outcome variable. For the same outcome, column 5 reports the IV estimate of parameter γ_1 from model 3, where $\Delta \ln w_{j,t}^{25+}$ is instrumented using the proportion of low-paid workers aged 25 and over in the firm in March 2016. Column 6 reports the IV estimate of parameter γ_1 from model 3, using $\Delta \ln w_{j,t}^{under25}$ as main regressor and instrumenting it using the proportion of low-paid workers aged 25 and over in the firm in March 2016. The bottom row reports the F-statistics on $MIN_{j,Mar16}^{25+}$, the excluded instrument in IV model 3. All estimates are conditional on firm-level controls and TTWA fixed effects. Estimates in columns 4-6 are conditional on a dummy variable taking value one if the firm received a new assessment after March 2016. Robust standard errors clustered at the TTWA level are reported in parentheses.

Appendix B. Market-level effects for the entire UK labor market

B.1 Annual Survey of Hours and Earnings (ASHE)

The Annual Survey of Hours and Earnings (ASHE) is the most comprehensive data source on the structure and distribution of earnings in the UK. ASHE is based on a 1 percent sample of public- and private-sector employee jobs taken from HM Revenue and Customs' (HMRC) Pay As You Earn (PAYE) records. PAYE is the system used by HMRC to collect income tax and national insurance contributions from employment. Once the sample of individual identifiers is drawn from the HMRC records, the ASHE survey is sent to their employers to complete. Run on an annual basis, the survey is dispatched in the second week of April and has to be returned by the second week of May each year. The final sample covers approximately 140,000-185,000 individuals per year.

ASHE provides information about the levels, distribution and make-up of earnings (e.g. basic pay and incentive pay), and about paid hours worked for employees in all industries and occupations, and in both the public and private sector. The dataset also includes variables for age, gender, contract type and full/part-time status. Since information on a given individual is collected over time, the data have longitudinal form starting from 1997.

B.2 Market-level effects based on ASHE

We replicate the market-level analysis presented in Section 4 on ASHE data for the entire UK labor market, which allows us to assess the external validity of the market-level effects identified in the adult social care sector. The analyses reported in this section are based on private-sector employee records from ASHE for the years 2015-2019.

In Appendix Figure B1, each panel reports the estimated discontinuity and associated 95 percent confidence interval at the age-25 cutoff in each year for a set of outcomes. All estimates are based on a parametric quadratic RDD in age measured in years. Panel A reports the estimates of a test for the absence of a discontinuity in the density of the running variable at the age-25 threshold. The results support the key assumption of no discontinuity in the density function at the relevant cutoff. Panels B, C and D show, respectively, the RDD estimates for hourly wages, employment counts and paid weekly hours. No discontinuity is detected for wages and employment throughout the period analyzed. A positive and significant discontinuity is estimated for weekly hours in 2015 and 2016, but not thereafter.

Appendix Figure B2 shows a set of histograms of finely-binned hourly wage distributions for private sector workers of different age groups. The gray bars report the hourly wage distribution discretized in bins of £0.10 in April 2015; the unfilled bars show the distribution in April 2016. The distributions are left-censored and, for visual purposes, right-trimmed. The red vertical lines indicate the level of the National Minimum Wage applying to workers aged 21-24

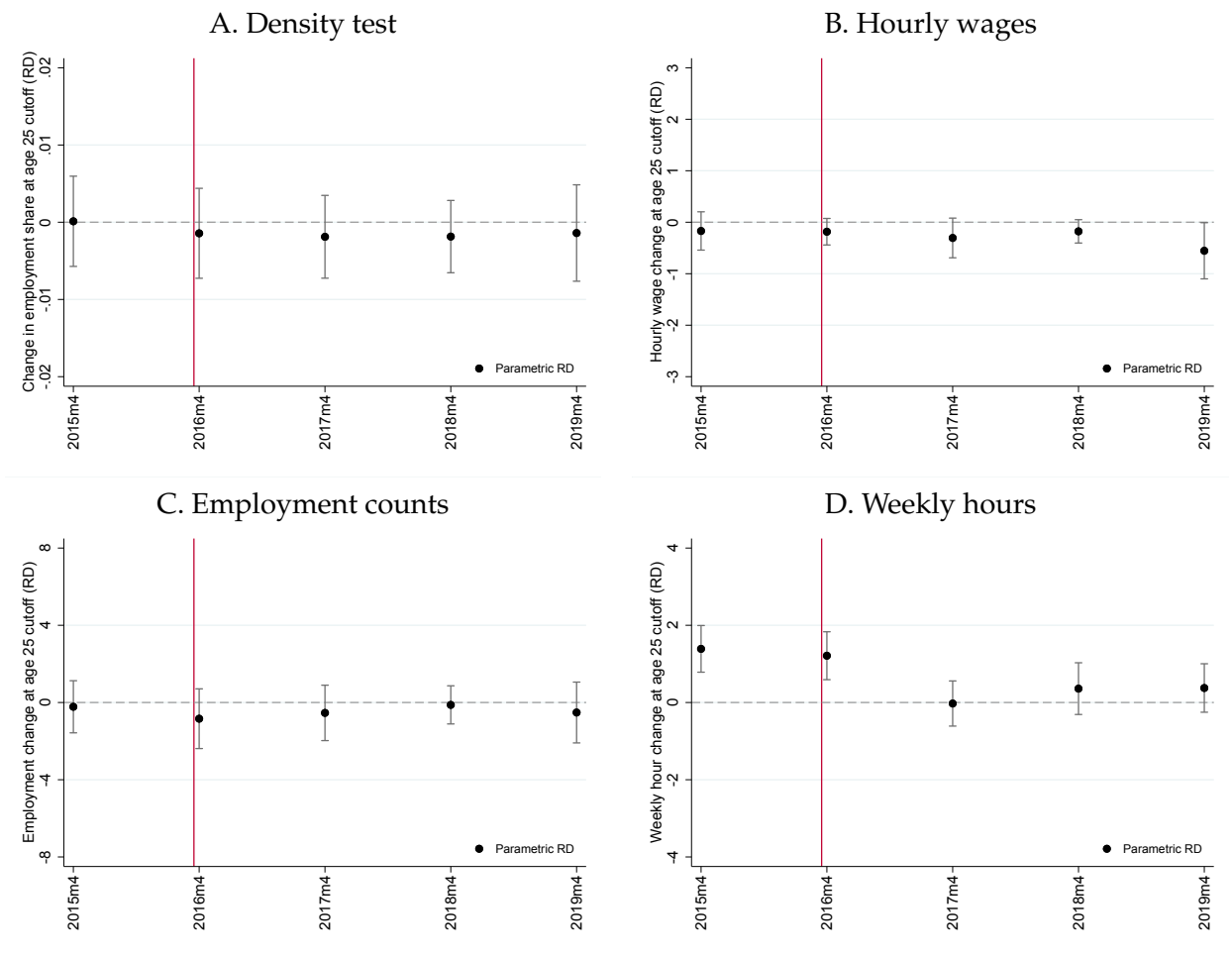
(solid line) and of the National Living Wage (dashed line) in April 2016. Panel A illustrates the evolution of the hourly wage distribution for workers aged 25 and over, showing a spectacular spike at prevailing minimum in both years. Panel B reveals that the downward wage spillovers that we document for the adult social care sector extend to the entire UK labor market. The hourly wage distribution for workers aged under 25 features a spike at the NLW, albeit smaller than for older workers. Panels C to F confirm that the spillovers apply consistently to workers aged well below 25, rejecting the hypothesis that spillovers are simply due to aging out effects.

Appendix Figure B3 shows that the conclusion that wage spillovers are not due to compositional changes or contractual rigidities holds on the UK-wide labor market. The spike at the NLW persists when fixing the sample analyzed (Panel A), when looking at new entrants (Panel B) and individuals who moved to a new firm (Panel C), and finally when looking at workers on temporary contracts who are traditionally considered the outsiders of the labor market (Panel D). Moreover, as shown in Appendix Figure B4, wage spillovers do not die out over time.

Finally, Panel A of Figure B5 restricts the sample to workers employed in industries or occupations defined as low-paying by the Low Pay Commission.[34] Panel B instead restricts the sample to workers employed in the care industry. Due to a high concentration of low-wage jobs, in both charts the size of the spikes is more pronounced as compared to what found for all industries and occupations in the UK.

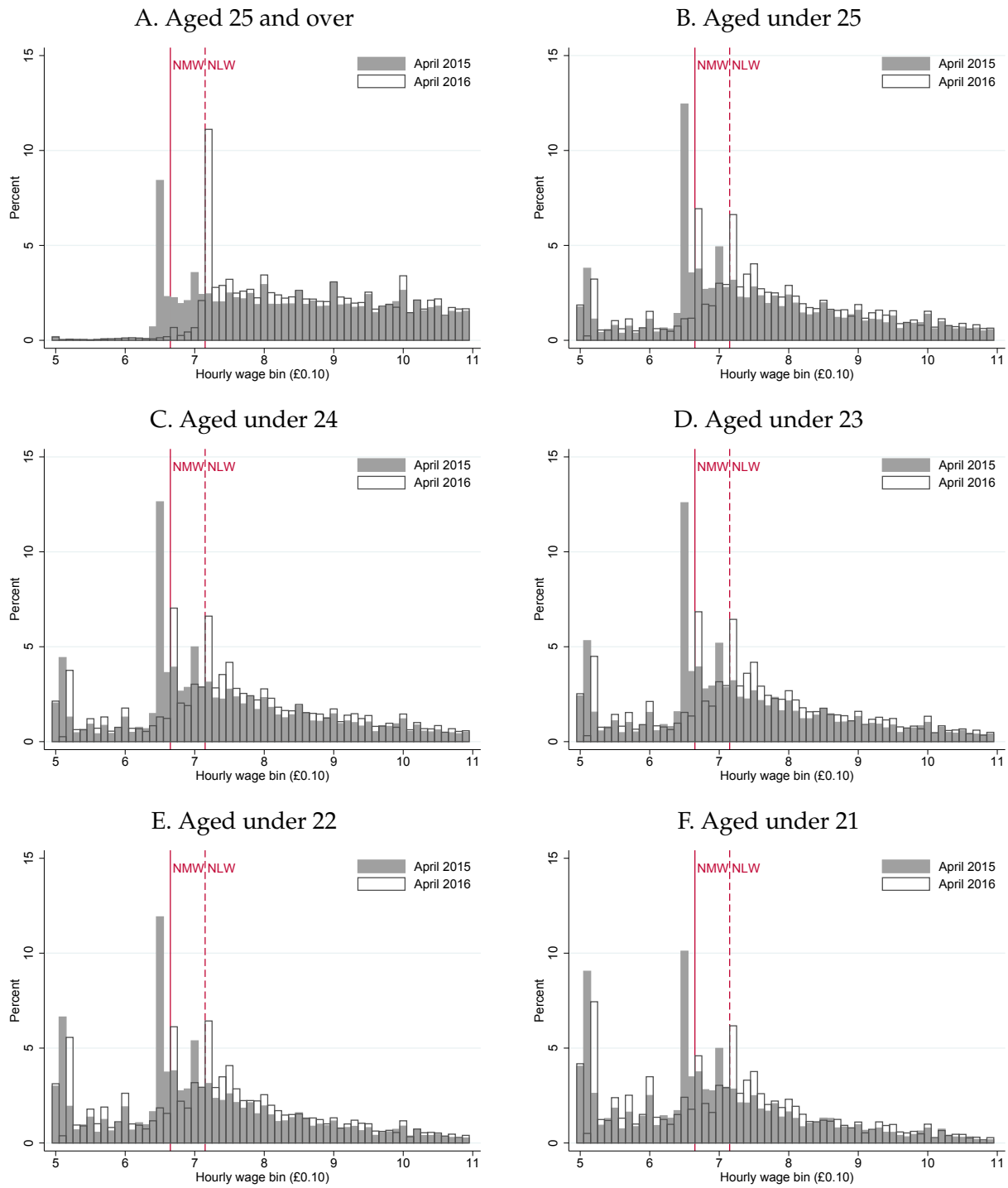
[34]The list of SIC 2007 and SOC 2010 codes defining low-paying industries and occupations is set out in Table A3.1 of the Low Pay Commission Report 2017 (Low Pay Comission, 2017).

Figure B1. MARKET-LEVEL EFFECT OF NLW INTRODUCTION ON WAGE AND EMPLOYMENT OUTCOMES FOR UK PRIVATE-SECTOR EMPLOYEES



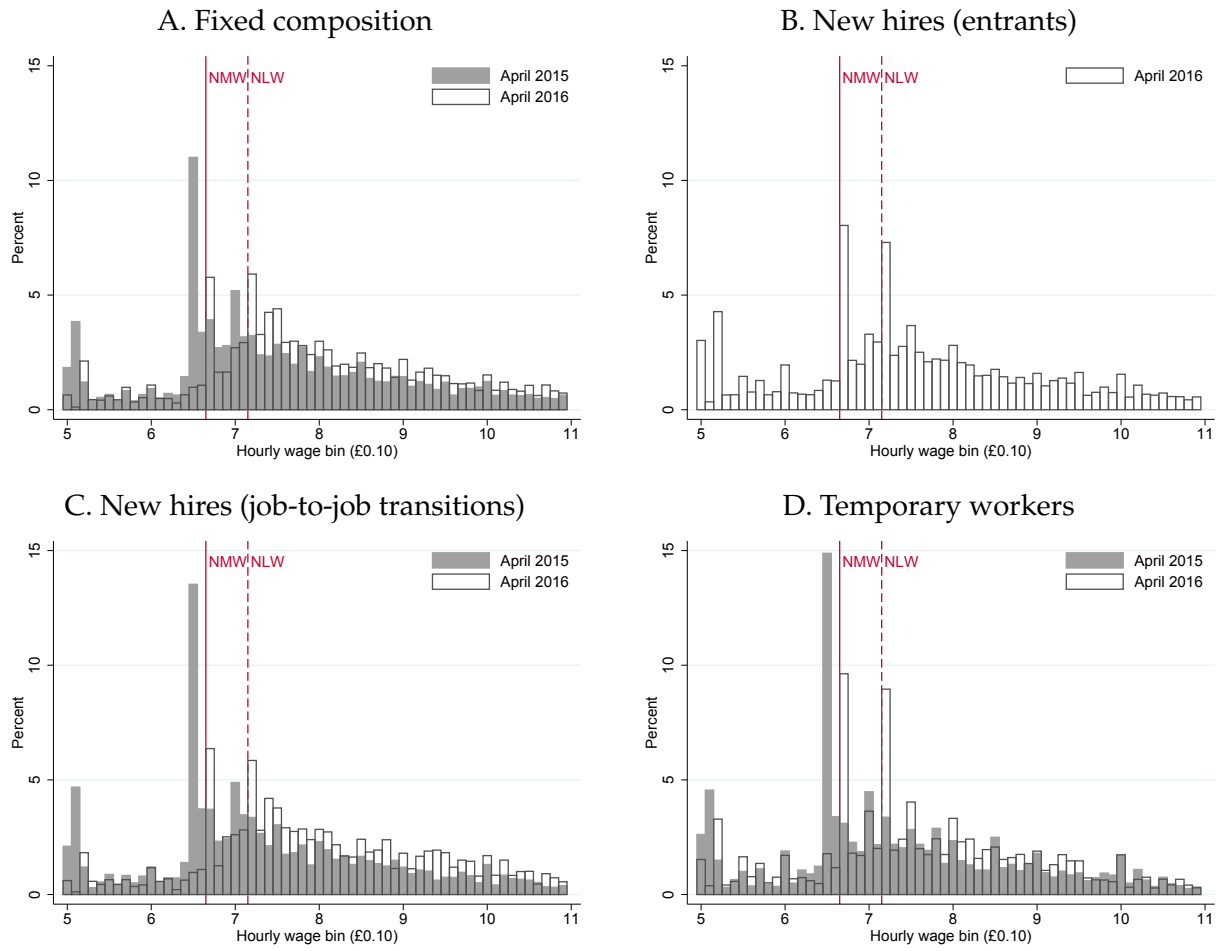
Notes: The figure reports a set of RDD estimates (indicated by dots) and associated 95 percent confidence intervals (capped vertical bars). The sample analyzed is the ASHE sample of UK private-sector employees. All estimates are based on a parametric quadratic RDD in age measured in years. Panel A reports the RDD estimates of a set of McCrary tests for a discontinuity in the density function of age at the age-25 cutoff from April 2015 to April 2019. Panel B reports the RDD estimate at the age-25 cutoff for average gross hourly wages. Panels C and D are analogous to Panel B, but use employment counts and average weekly hours worked as outcome variable, respectively.

Figure B2. DISTRIBUTION OF HOURLY WAGES OF UK PRIVATE-SECTOR EMPLOYEES



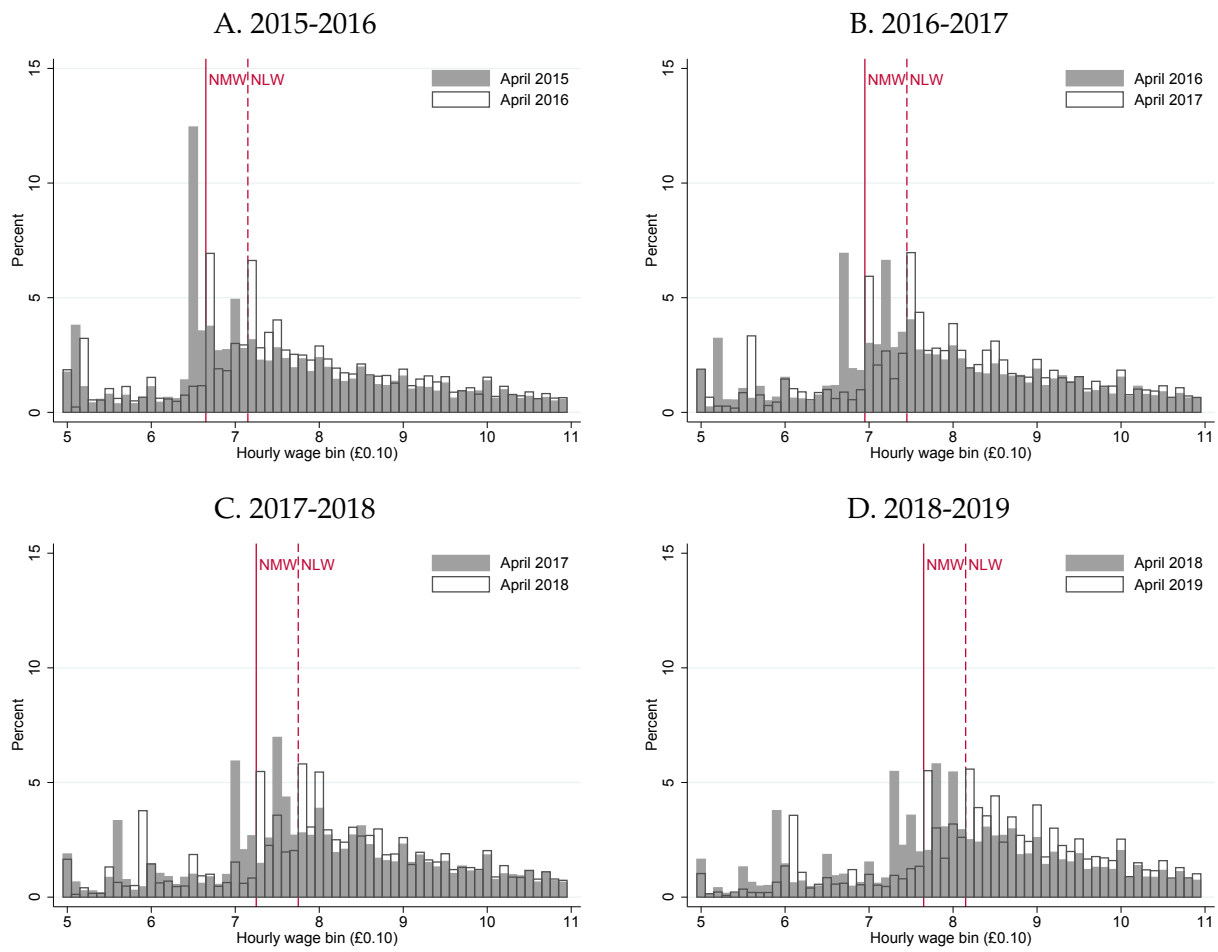
Notes: The figure reports a set of hourly wage distributions for employees in the UK private sector in April 2015 (gray bars) and April 2016 (unfilled bars). Hourly wages are binned into £0.10 bins. The red solid vertical line indicates the level of the NMW in April 2016, while the red dashed vertical line indicates the level of the NLW in April 2016. Panel A reports the hourly wage distribution for employees aged 25 and over, Panel B for those aged under 25, Panel C for those under 24, Panel D for those under 23, Panel E for those under 22 and Panel F for those under 21.

Figure B3. DISTRIBUTION OF HOURLY WAGES OF UK PRIVATE-SECTOR EMPLOYEES: TESTING FOR COMPOSITIONAL CHANGES AND CONTRACTUAL RIGIDITIES



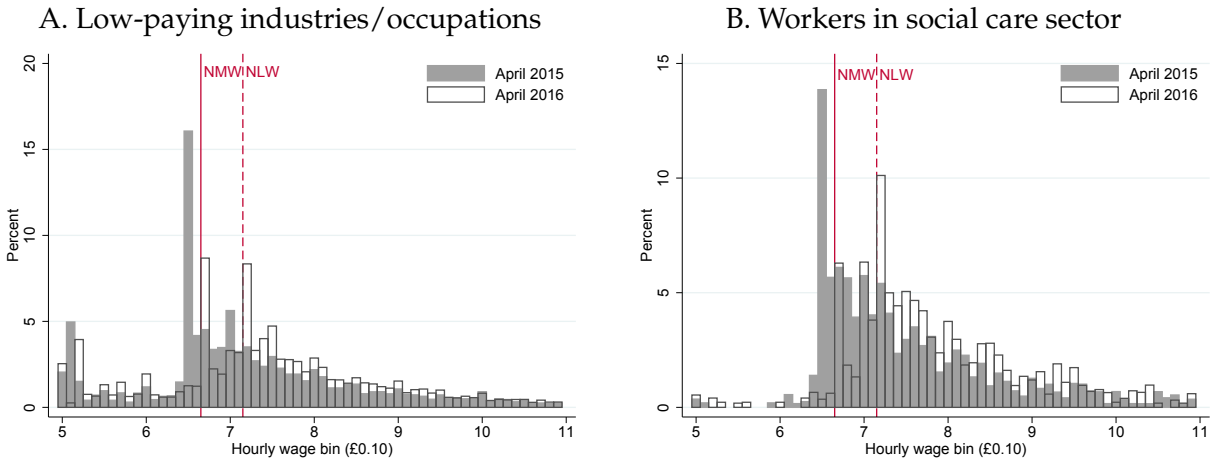
Notes: The figure reports a set of hourly wage distributions for employees in the UK private sector in April 2015 (gray bars) and April 2016 (unfilled bars). Hourly wages are binned into £0.10 bins. The red solid vertical line indicates the level of the NMW in April 2016, while the red dashed vertical line indicates the level of the NLW in April 2016. Panel A is based on the sample of workers who are observed both in April 2015 and April 2016, and who were aged under 24 in April 2015. Panel B is based on the sample of new hires who appear for the first time in the sample in April 2016. Panel C is based on the sample of employees who have been hired by their firm after April 2015, but who were employed in a different firm in April 2015. Panel D restricts the sample to temporary workers.

Figure B4. DISTRIBUTION OF HOURLY WAGES OF UK PRIVATE-SECTOR EMPLOYEES: IMPACT OF NLW INTRODUCTION AND SUBSEQUENT UPRATINGS



Notes: The figure traces out the dynamics of wage spillovers over time, as generated by the NLW introduction in 2016 and its subsequent upratings. Each panel reports the hourly wage distributions for UK private-sector employees aged under 25 in year t (gray bars) and $t+1$ (unfilled bars). Hourly wages are binned into £0.10 bins. The red solid vertical line indicates the level of the NMW in $t+1$, while the red dashed vertical line the level of the NLW in $t+1$. Panel A refers to April 2015 and April 2016, Panel B to April 2016 and April 2017, Panel C to April 2017 and April 2018, Panel D to April 2018 and April 2019.

Figure B5. DISTRIBUTION OF HOURLY WAGES OF UK PRIVATE-SECTOR EMPLOYEES: LOW-PAYING INDUSTRIES AND OCCUPATIONS, AND SOCIAL CARE WORKERS



Notes: The figure reports a set of hourly wage distributions for UK private-sector employees aged under 25 in April 2015 (gray bars) and April 2016 (unfilled bars). Hourly wages are binned into £0.10 bins. The red solid vertical line indicates the level of the NMW in April 2016, while the red dashed vertical line indicates the level of the NLW in April 2016. Panel A reports the hourly wage distribution for employees in low paying industries and occupations as defined by the Low Pay Commission, Panel B for employees in the social care sector.

Appendix C. Adult Social Care Survey of Pay Practices (ASC-SPP)

C.1 Survey design and implementation

The Adult Social Care Survey of Pay Practices (ASC-SPP) has been designed to investigate the pay setting, vacancy posting and hiring practices of organizations in the English adult social care sector. The survey was conducted online and distributed via email by Skills for Care in September 2020. The survey questionnaire is reported in Appendix C.4 below and includes 17 questions. The average completion time was 5 minutes (median 7 minutes). The sampling frame for the survey includes all care homes and domiciliary care agencies registered in ASC-WDS and employing at least one worker under 25 as of July 2020. For establishments with ASC-WDS accounts managed by a parent organization, the survey was distributed only to the parent organization. The sample of survey recipients comprised 5,073 providers, of which 284 completed the questionnaire leading to a 6 percent response rate.[35] The survey has been undertaken in accordance with the London School of Economics ethics review procedure and ethics approval has been obtained from the Centre for Economics Performance at the London School of Economics.

C.2 Representativeness of survey respondents

Out of the 284 respondents, 97 provided their ASC-WDS Workplace ID, which allows us to identify them in the July 2020 ASC-WDS data. We assess the representativeness of the sample of respondents in Appendix Table C1. The table reports the mean of a set of firm-level characteristics for the sample of surveyed providers in column 1 and for the sample of respondents matched to the ASC-WDS data in column 2. Column 3 reports the difference in means and column 4 the p-value of a two-sample t-test of equality in means.

The t-tests do not reject the null hypothesis of equality in means in the vast majority of cases. The sample of matched respondents has a higher fraction of domiciliary care agencies compared to the surveyed sample. As a consequence, it displays slightly higher hourly wages among carers and a larger fraction of workers on zero hours contracts. All other characteristics are aligned in the two groups, indicating a good degree of representativeness of the survey respondents.

[35] Due to the continued pressure of the COVID-19 pandemic on the adult social care sector, in agreement with Skills for Care, it was deemed appropriate to minimize additional pressure on the sector by sending multiple survey reminders. For this reason only one reminder could be sent and the survey was open for two weeks.

Table C1. REPRESENTATIVENESS OF SURVEY RESPONDENTS

	Survey sample	Matched respondents	Difference in means	P-value of difference
	Mean	Mean		
	(1)	(2)	(3)	(4)
Care home (vs. domiciliary care)	0.626	0.464	0.162	0.001
Firm size	50.22	48.94	1.277	0.804
Share under 25	0.116	0.123	-0.006	0.431
Hourly wage	9.067	9.381	-0.314	0.006
Paid hourly wage	0.936	0.935	0.001	0.946
Weekly hours	25.92	25.44	0.481	0.620
Female	0.864	0.871	-0.008	0.506
Age	42.60	42.64	-0.044	0.919
Tenure (months)	60.50	55.47	5.035	0.072
Carer	0.639	0.673	-0.035	0.092
Wage carer	8.509	8.830	-0.320	0.000
Wage senior	9.145	9.307	-0.162	0.272
Wage ancillary	8.330	8.544	-0.214	0.172
Wage nurse	16.10	17.22	-1.112	0.094
Wage admin	9.658	9.467	0.190	0.547
Zero hours contract	0.234	0.324	-0.091	0.008
Permanent	0.896	0.920	-0.025	0.189
Temporary	0.026	0.014	0.012	0.294
Bank	0.052	0.040	0.012	0.220
Agency	0.013	0.018	-0.005	0.615
Other	0.014	0.007	0.006	0.437
Local auth funded	0.015	0.021	-0.005	0.667
Private	0.885	0.887	-0.002	0.955
Voluntary	0.077	0.093	-0.015	0.574
Other provider type	0.023	0.000	0.023	0.134
London area	0.066	0.093	-0.027	0.287
Observations	5,073	97		

Notes: The table reports the mean of a set of firm-level characteristics for the sample of surveyed providers in column 1 and for the sample of respondents matched to the ASC-WDS data in column 2. Column 3 reports the difference in means and column 4 the p-value of a two-sample t-test of equality in means.

C.3 Survey results

Table C2. CHARACTERISTICS OF SURVEY RESPONDENT AND POLICY AWARENESS

	Fraction (1)	Observations (2)
Respondent's job role		
Admin staff in charge of pay	0.14	283
Human resources manager	0.09	283
Manager/Owner/Director	0.68	283
Other	0.09	283
Respondent's job tenure		
Less than one year	0.06	283
One to four years	0.24	283
More than four years	0.70	283
Respondent's firm tenure		
Less than one year	0.05	284
One to four years	0.20	284
More than four years	0.75	284
Aware that NLW only applies to 25+		
Before receiving questionnaire	0.94	284
When NLW introduced	0.87	281

Notes: The table reports survey answers to questions Q1, Q2, Q3, Q4 and Q5 of the ASC-SPP questionnaire reported in Appendix C.4.

Table C3. DOWNWARD WAGE SPILLOVERS

	Fraction (1)	Observations (2)
Does organization pay at least some under 25s below NLW?		
Yes, it pays at least some under 25s below NLW	0.41	282
No, it does not pay under 25s below NLW	0.59	
Reason for paying NLW to under 25s		
Unfair to the workers not to do so	0.54	153
To attract/retain qualified workers	0.23	153
To motivate workers	0.11	153
Administratively simpler/cheaper	0.03	153
Do not know about the law	0.00	153
Other	0.09	153
Reason for not paying NLW to under 25s		
It is fair	0.31	100
To contain labour costs	0.26	100
Compensates for additional training provided	0.27	100
Younger workers typically less effective	0.04	100
Other	0.12	100

Notes: The table reports survey answers to questions Q6, Q7 and Q9 of the ASC-SPP questionnaire reported in Appendix C.4.

Table C4. JOB-VACANCY POSTING AND WAGE BARGAINING

	Fraction (1)	Observations (2)
How are job vacancies typically advertised?		
Online platforms	0.93	284
Word of mouth	0.63	284
Newspapers	0.12	284
Employment agencies	0.22	284
Other	0.03	284
Is a wage rate or salary usually specified in job ad?		
Yes	0.77	284
No	0.23	284
Is compensation tied to the applicant's age in job ad?		
If specified, wage tied to applicant's age	0.09	214
Even if wage not specified, pay tied to applicant's age	0.09	66
When making a job offer, is there bargaining over pay?		
Mostly bargain	0.03	284
Mostly take-it-or leave-it	0.75	284
Both happen equally often	0.16	284
Don't know	0.06	284

Notes: The table reports survey answers to questions Q13, Q14, Q15, Q16 and Q17 of the ASC-SPP questionnaire reported in Appendix C.4.

C.4 ASC-SPP questionnaire

Skills for Care, in partnership with the Centre for Economic Performance at the London School of Economics, would like you to take part in a research study on pay setting in care homes. This survey should take around 10 minutes to complete.

The survey asks about your job role and about your views on how your organisation has responded to minimum wage changes in recent years. If you feel you are not the correct person to contact from your organisation, please forward this email to the relevant person.

There are no risks associated with participation in this survey. Your responses will not be used to identify you or your organisation. All information collected for this study is confidential and will be used only for the purposes of this research study. If you have questions, please contact [redacted].

I understand the information above and that:

A. My participation is voluntary and I may withdraw my consent and discontinue participation in the project at any time. My refusal to participate will not result in any penalty.
B. By agreeing to take this survey, I do not waive any legal rights or release the Centre for Economic Performance, its agents, or you from liability for negligence.

Do you agree to take part in this survey?

- ○ Yes, I agree to take part in this research → Go to Q1
- ○ No, I do not give my consent to participate in your research → Thank-you page

[Insert page break here]

The following questions ask about your job role and tenure in your current organisation:

Q1. What is your job role in the organisation?

- ○ Registered manager
- ○ Human resources manager
- ○ Administrative staff in charge of pay-related matters
- ○ Other. Please specify: _____

Q2. How long have you been in this position in this organisation?

- ○ Less than one year
- ○ One to four years
- ○ More than four years

Q3. How long have you been working in this organisation?

- ○ Less than one year
- ○ One to four years
- ○ More than four years

[Insert page break here]

On April 1, 2016 the National Living Wage was introduced. The National Living Wage sets a higher minimum wage for workers aged 25 and over. Lower minimum wage rates apply to workers aged under 25.

Q4. Before receiving this questionnaire, were you aware that the National Living Wage is legally binding only for workers aged 25 and over?

- ○ Yes

- No

Q5. At the time in which the National Living Wage was introduced in April 2016, were you aware that the National Living Wage is legally binding only for workers aged 25 and over?

- Yes
- No

[Insert page break here]

IMPORTANT NOTE: when responding to the following questions, please base your answers on how your organisation used to operate before the onset of the COVID-19 crisis.

The minimum wage rates that apply to workers under 25 are lower than the National Living Wage. The following table shows what minimum wage rates were in place from April 2019 to March 2020, and from April 2020 to today:

	April 2019 to March 2020	April 2020 (current)
Aged 16 to 17	£4.35	£4.55
Aged 18 to 20	£6.15	£6.45
Aged 21 to 24	£7.70	£8.20
Aged 25 and over	£8.21	£8.72

Q6. Does your organisation follow the provision of the law by paying at least some workers under 25 a minimum wage below £8.72?

- Yes → Go to Q8
- No → Go to Q7

If Q6=No, ask Q7
Q7. If no, what is the main reason for this? [Randomise order of answers, leave 'Other' last]

- We did not know about the law
- It is too difficult/costly to pay different wages from an administrative perspective
- It is unfair to the workers
- It is necessary to attract and retain qualified workers
- It is necessary to motivate workers
- Other. Please specify: _____

If Q6=Yes, ask Q8 and Q9
Q8. If yes, to which age groups does your organisation apply the lower minimum wage? Tick all that apply.

- ☐ Aged 16 to 17
- ☐ Aged 18 to 20
- ☐ Aged 21 to 24

Q9. What is the main reason why your organisation applies lower minimum wages to workers under 25? [Randomise order of answers, leave 'Other' last]

- It is fair
- It allows our organisation to contain labour costs
- It compensates for the additional training we provide to younger workers
- Younger workers are typically less effective at their job
- Other. Please specify: _____

[Insert page break]

From April 2019 to March 2020, the National Living Wage was £8.21 for workers aged 25 and above. In April 2020 this increased to £8.72.

Q10. If you had workers aged 25 or over who were paid between £8.21 and £8.72 in 2019/20, how did their wage change when the National Living Wage increased in April 2020?

- ○ We raised it to exactly £8.72 per hour
- ○ We raised it above £8.72 per hour and maintained the differential with the National Living Wage
- ○ We raised it above £8.72 per hour, but reduced the differential with the National Living Wage
- ○ It depends on the worker's role and performance
- ○ I don't know

Q11. If you had a worker aged 25 and over who was already paid above £8.72 an hour before the National Living Wage increased to £8.72 in April 2020, did you increase that worker's pay after April 2020?

- ○ Yes
- ○ No
- ○ It depends on the worker's role and performance
- ○ I don't know

Q12. Since the National Living Wage was introduced, has your organisation had to cut back on pay scales above the minimum wage level? This could be either through lower pay rises or slower career progression.

- ○ Yes
- ○ No
- ○ I don't know

[Insert page break here]

We would like to now ask you how your organisation recruits workers and sets wages. In answering the following questions, please think about recruitment and compensation of carers and senior carers.

Q13. How are job vacancies typically advertised by your organisation? Tick all that apply. [Randomise order of answers, leave 'Other' last]

- ☐ Online platforms
- ☐ Word of mouth
- ☐ Newspapers
- ☐ Employment agencies
- ☐ Other. Please specify: _____

Q14. When advertising a job, is a wage rate or salary usually specified?

- ○ Yes → Go to Q15
- ○ No → Go to Q16

If Q14=Yes
Q15. If so, is the wage rate or salary offered in the ad explicitly tied to the applicant's age?

- ○ Yes
- ○ No

If Q14=No
Q16. Even though a wage rate or salary is not usually specified, is the compensation offered in the ad explicitly tied to the applicant's age?

- Yes
- No

Q17. When offering a job to a prospective worker, does your organisation typically make a 'take-it-or leave-it' offer or does some bargaining take place over pay?

- Mostly 'take-it-or-leave-it'
- Mostly 'bargain'
- Both happen equally often
- I don't know

[Insert page break here]

With your consent, we would like to link your responses to this survey with information your organisation has provided to the Adult Social Care Workforce Dataset (ASC-WDS). If you consent, please provide your ASC-WDS Workplace ID:

- I am happy for my responses to be linked to the ASC-WDS. Your ASC-WDS Workplace ID is one letter followed by five, six or seven numbers. E.g. E##### _____
- I do not wish to provide / don't know my Workplace ID.

[Thank-you page]

Thank you for your time spent taking this survey.
Your feedback will be a valuable input into our research.

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