The impact of minimum wage upratings on wage growth and the wage distribution

Silvia Avram, University of Essex

Susan Harkness, University of Bristol

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1 Introduction

We study the impact of minimum wage uprating on the wage distribution and wage differentials between 2009 and 2018, focusing especially on the introduction of the National Living Wage (NLW) in April 2016. Sluggish wage growth in the aftermath of the Great Recession coupled with above inflation increases in the minimum wage led to the minimum wage increasing faster than median earnings. In 2018, the adult rate of the minimum wage represented nearly 55% of median full-time hourly earnings, compared to just 48% in 2008. The growth of the minimum wage rate has accelerated since 2016 when the Government introduced the National Living Wage (NLW) and set a target for it of 60% of median earnings to be reached by 2020 subject to sustained economic growth. Thus, significant increases of the relative value of minimum wage rate are likely to continue.

In this report, we quantify the extent to which minimum wage hikes have contributed to changes in wage inequality. Specifically, we examine whether there has been faster wage growth at the bottom of the distribution relative to the middle. Compared to the large body of literature examining the employment effects of a minimum wage, much less attention has been paid to its effects on wage inequality. In particular, while several papers have estimated a reduced form relationship, there have been relatively few attempts to build theoretical models that deal with the issue. In addition to the compliance effects, an important issue is the extent to which the minimum wage affects workers paid above the minimum, i.e. the presence of any spillover effects.

We provide evidence on the causal effect of minimum wage increases between 2009 and 2018 on wage inequality in the bottom half of the distribution. We exploit differences in wage levels across areas to identify the effects. More specifically, we test whether lower wage areas experienced higher wage growth in years when the minimum wage increased considerably in real terms. We examine wage growth at the 5th, 10th, 15th, 20th, 30th and 50th percentile of the local wage distribution, allowing us to identify both direct and spillover effects.

In the textbook competitive model, where workers are paid their marginal labour product, the effect of a minimum wage is to truncate the wage distribution. Workers with low productivity, who would be paid below the minimum wage, become unemployed and as a result wage inequality falls. However, many US and UK studies find no or small positive effects on employment (Dolton, Bondibene, & Wadsworth, 2012; Manning, 2012; Metcalf, 2008; Stewart, 2002, 2004). In contrast, they find falls in wage inequality, usually measured as the distance between the median and the 10th or 5th percentile (Dickens & Manning, 2002, 2004; Lee, 1999; Teulings, 2003) .

More complex job search models, where wages are determined either by employers (wage posting) or by worker-employer bargaining can explain why wage inequality declines even in the absence of any negative employment effects (Butcher, Dickens, & Manning, 2012; Flinn, 2006; Teulings, 2003). In these models, employers have some monopsony, or wage-setting, power and workers are paid below their marginal product of labour. For example, Teulings

(2003) proposes a model where the higher relative price of low skilled workers, induced by minimum wage, increases demand for workers paid above the minimum thereby putting upward pressure on their wages. Butcher et al. (2012) describe a simple wage posting model where heterogeneous employers compete over a fixed supply of workers. Their model predicts ambiguous employment effects and a wage spike at the minimum, with spillover effects that dissipate further up the distribution. Another reason for expecting spill-over effects is that employers may wish to maintain existing wage differentials if they believe these are important for worker morale and productivity (Stewart, 2012b). Finally, minimum wages may increase the reservation wages of all workers. In an experimental setting, Falk, Fehr, and Zehnder (2006) found that the introduction of a minimum wage permanently altered perceptions about what constitutes fair pay. Flinn (2006) shows that minimum wages can affect reservation wages in a context of a search model with individual wage bargaining.

The early US literature has found large negative effects of minimum wages on wage inequality. In an oft cited study, Lee (1999) found that the significant fall in the real value of the minimum wage in the US during the 1980s can explain almost all the increase in lower tail wage inequality over the period. Teulings (2003) reports similar findings. Other studies however find more moderate effects. Neumark, Schweitzer, and Wascher (2004) found that after minimum wage increases in the US in the 1990s, the wages of low paid workers rose but their hours and employment fell. Moreover, in the absence of regular uprating, some of the initial wage gains are lost as employers take advantage of the real value of the minimum wage falling with inflation. Using an enhanced specification, Autor, Manning, and Smith (2016) find positive effects on wages above the minimum, but cannot rule out that these are the result of measurement error.

In the UK, most studies focus on the introduction of the National Minimum Wage (NMW) in April 1999, using variants of a quasi-experimental DiD design. While virtually all studies find that compliance was high and the direct impact of the NMW on wages was significant, there is less agreement about the magnitude of any spillover effects. Directly comparing wage distributions before and after the introduction of the NMW, Dickens and Manning (2002, 2004) find that the NMW increased the wages of those directly affected substantially (the compliance effect) but had no discernible effect on the hourly pay of workers above the minimum, even in a low wage sector where approximately 40% of workers were paid below the minimum before the NMW introduction. Stewart (2012a, 2012b) compares wage growth at different points in the distribution before and after the introduction of the NMW ('the doubled scale estimator') to determine effects on wage inequality. He finds no or limited spillover effects once possible regression to the mean is taken into account. Swaffield (2014) estimates the effects of the introduction and subsequent uprating of the NMW on the wage growth of low paid workers. She compares the wage growth of workers directly affected by minimum wage increases to that of workers only slightly higher up in the distribution and finds that pay growth for affected workers has become increasingly dependent on the size of the minimum wage hike. Finally, Dolton et al. (2012) and Stewart (2002) use geographical variation in wage levels to quantify the effect of the introduction of the NMW, and subsequent upratings, on the wage distribution. Assuming that low wage areas were more impacted by the NMW, both studies find substantial effects at the 5th percentile and smaller but still significant effects at the 10th percentile. Using a similar design, Butcher et al. (2012) find significant spillover effects going up to the 25th percentile. Older studies using data from the 1980s, when Wage Councils set industry specific minimum wage levels, also find a strong link between the level of the minimum wage and wage inequality (Dickens, Machin, & Manning, 1994; Machin & Manning, 1994).

Finally, one aspect that is relatively under researched is the impact of the NMW on weekly (or monthly earnings). While minimum wage increases might boost hourly wages, they may have adverse effects on other elements of pay such as basic hours, overtime hours, overtime pay, or bonuses and other discretionary payments. In the US, Neumark et al. (2004) finds that the minimum wage had a large negative effect on hours worked. Similarly, in the UK, Stewart and Swaffield (2008) show the NMW had a negative effect on weekly hours.

2 Data and methods

2.1 Sample

Our data come from the Annual Survey of Hours and Earnings (ASHE)[1], the largest earnings survey in the UK. ASHE contains information about hours worked, earnings and other job characteristics such as occupation, industry, sector, firm size etc for approximately 1% of the employee population in Great Britain. Information relates to a reference pay period in April. Since information is reported by employers, it is considered to be more accurate than similar information coming from labour force surveys. ASHE has been widely used in the past to study wages, including how they were affected by the impact of the introduction of the National Minimum Wage (NMW) in 1999 (Butcher et al., 2012; Dolton et al., 2012; Stewart, 2002, 2004, 2012a, 2012b).

In line with previous research, we focus on individuals entitled to the adult rate and whose pay has not been affected by absences. To ensure consistency, we focus on those aged 25 and over who were entitled to the adult rate throughout the period of study. Observations of younger individuals are dropped. When individuals appear more than once in the same year, typically because they hold more than one job, we only keep observations relating to the main job. As a result of this restriction, we lose approximately 2500 observations every year. The date when the minimum wage was uprated moved from 1 October to 1 April in 2016. To ensure that the entire pay period is covered by the April increase from 2016 we delete all observations where the pay period started in March or earlier.

Our sample consists of individuals aged 25 to 70, entitled to the adult rate, whose pay is not affected by absence. After our sample restrictions, we are left with approximately 131,000 –

[1] Office for National Statistics. (2019). *Annual Survey of Hours and Earnings, 1997-2018: Secure Access*. [data collection]. *14th Edition.* UK Data Service. SN: 6689, http://doi.org/10.5255/UKDA-SN-6689-13

145,000 observations per year, or a total sample size of approximately 1.4 million, covering the period 2009 to 2018.

2.2 Earnings

Because the NMW/NLW is established at the hourly level, we first focus on the distribution of hourly earnings. Employers can use multiple margins to adjust employee pay. For example, employers can reduce working hours, bonuses, or overtime pay to counteract mandated increases in hourly earnings. Consequently, we use the same estimation strategy to examine growth in weekly gross earnings, as well as hourly pay. We take both the hourly and weekly earnings directly from ASHE and deflate both variables by CPI (Office for National Statistics, 2019). We thus obtain a consistent series of real hourly and weekly earnings fixed at 2015 prices.

2.3 Local area indicators

We identify the effects of the minimum wage upratings by comparing wage growth at various quantiles of the wage distribution in areas with different wage levels. We use travel to work areas (TTWA) as our local area indicators. TTWAs are geographical units where at least 75% of the resident economically active population works in the area and at least 75% of the actively working population resides in the area (Prothero, 2016). They have been constructed with the specific goal of approximating local labour markets. ASHE provides information about both the work and the home TTWA of an employee. In this analysis, we use the work TTWA.

We wish to compare wage growth at different percentiles of the distribution across areas over time. To accomplish this, we need a consistent set of area indicators that covers the entire period between 2009 and 2018. TTWA codes based on 2001 census data are available for the years 2009 to 2013. From 2014, ASHE provides TTWA codes based on the 2011 census. The 2001 based TTWAs have been constructed using criteria that are slightly different from the more recent set. There are 232 TTWAs based on the 2001 census and 218 TTWAs based on the 2011 census in our data which covers Great Britain only (Northern Ireland is not covered by ASHE data). There is no one-to-one correspondence between the 2001 and 2011 TTWA codes. We have nevertheless manually matched the 2001 codes to the newer set based on maximizing the area of overlap. We thus obtain a consistent series of area indicators that covers the entire period in our analysis.

To ensure sufficient wage variation in a TTWA, we drop individuals in TTWAs with fewer than 50 observations in any year. As a result of this restriction, we lose between 26 and 37 TTWAs, depending on year, corresponding to approximately 1000 observations per year. The final numbers of TTWAs vary slightly from year to year and are shown in Table 1 in section 3.3.

2.4 Share of minimum wage earners

We measure the local wage level using the share of earners receiving the minimum wage in 2009. This is preferable to using aggregate wage indicators such as mean or median wages because first, the share of minimum wage workers more accurately captures the salience of minimum wage upratings at the local level and, second, we avoid endogeneity problems associated with using the wage level as both the dependent variable and as a predictor.

We consider a worker to be receiving the minimum wage if her hourly wage is within 5 pence of the national minimum wage that was in force at the time of the survey. The minimum wage is set at the national level so variations in the level of the minimum wage exist only over time and not across geographical units. However, the share of individuals receiving the minimum wage varies both across time and space.

2.5 Covariates

One concern is the possibility that TTWAs with different shares of minimum wage workers also differ in terms of other characteristics that might influence wage growth. We control for compositional differences between TTWA in terms of gender, age, occupation (2 digit), sector, firm size, industry (14 categories), share of part-time and temporary contract workers. We do not control for occupation and industry at a finer level to avoid degrees of freedom problems in TTWAs with small sample sizes.

2.6 Estimation strategy

We start by presenting descriptive evidence on wage growth between 2009 and 2018 focusing on the bottom half of the wage distribution. We first present estimates of real wage growth, for the entire sample, by percentile, as well as real change at various quantiles of the wage distribution by gender, region and industry.

A number of studies have estimated the effect of the introduction of the minimum wage, in April 1999, on employment and earnings using variants of the difference-in-difference estimator (Butcher et al., 2012; Dickens & Manning, 2002, 2004; Dolton et al., 2012; for a review of the literature see Manning, 2012; Stewart, 2012a, 2012b; Swaffield, 2014). This methodological approach involves constructing a counterfactual wage growth based on a group of workers that are unlikely to be affected by changes in the minimum wage (usually because their earnings are higher up in the distribution). To account for possible reversion to the mean, differential wage growth between the treated and the control groups is compared before and after the introduction of the minimum wage. The period before the introduction serves as a baseline measure of mean reversion. Stewart (2002) takes a different approach, using variations in the local 'bite' of the minimum wage, i.e. the share of workers paid below the NMW rate one year before its introduction. He compares (adjusted) wage growth at the 5th, 10th and 25th percentile in 'high impact' areas (i.e. areas where high shares of workers were paid below the minimum before its introduction) with 'low impact' areas. Dolton et al. (2012) employ a similar strategy to examine the impact of the introduction of the minimum wage, and its yearly uprating, between 1999 and 2007.

We wish to examine the impact of minimum wage uprating between 2009 and 2018. Unlike previous studies, we do not have a 'no minimum wage' period to use as a benchmark as the minimum wage was introduced a decade before the start of the period we are interested in.

Moreover, unlike the noughties, the period we study corresponds to a period of recession with falling or stagnant real wages (Bovill, 2014). Relative differences in wage growth since 1998 are thus unlikely to be a good approximation for relative differences in wage growth that would have occurred in the absence of increases in minimum wage in 2009 and later. An alternative strategy would be to use the fact that the minimum wage increased at a different rate relative to median hourly earnings across the period. However, this strategy is also unappealing as it is relatively underpowered and assumes that the effect of minimum wage uprating is linear and constant over time. Instead, we take an area-based approach to assessing the influence of recent uprating in the minimum wage on the distribution, which we describe below.

Following Stewart (2002) and Dolton et al. (2012) we estimate the effect of the minimum wage on the wage distribution using geographical variation in the **share of employees earning the minimum wage** (Butcher et al., 2012; Stewart, 2002). Assuming that wage growth relative to the median is similar across local labour markets in the absence of the minimum wage changes, we expect increases in the NMW/NLW to generate stronger wage growth at the bottom of the distribution in areas where the share of minimum wage jobs is higher, and in periods when relative increases in the minimum wage are stronger.

Increases in the NMW/NLW affect the wage distribution in two ways. First, assuming employer compliance, hourly wages for workers earning below the newly mandated minimum should increase at least to the level of the new NMW/NLW. We will call this the **direct effect**. Second, increases in the NMW/NLW may also have spillover or 'ripple' effects for workers paid above the new minimum wage. Employers may wish to pay their workforce above the minimum or preserve pay differentials to maintain worker morale. They may also re-organize their work practices to increase the productivity of workers on minimum wage and this may affect the productivity of other workers as well. For these reasons, increases of the NMW/NLW may trigger increases in wages for workers who are initially paid more than the newly mandated minimum. We call these **indirect effects.**

We seek to capture both types of effects by examining wage growth at different quantiles in the wage distribution. We estimate quantile regressions to examine wage growth at the 5th, 10th, 15th, 20th, 30th and 50th percentiles to capture both these direct and spill-over effects. Conditional quantile regressions have been used in the past to estimate the effect of the minimum wage on wage inequality (Stewart, 2012a). However, their interpretation is somewhat more complicated when other controls are introduced. In particular, once we add individual and employer characteristics, we are comparing quantiles of individuals with the same characteristics on the control variables (for example, comparing low and high paid graduates). These may be quite different from the unconditional quantiles. We therefore use unconditional quantile regressions (Firpo, Fortin, & Lemieux, 2009) based on the re-centred influence function (RIF), which examines different points of the wage distribution independent of characteristics . In these, quantile levels remain unchanged even when control variables are added (Rios-Avila, 2019). In our specifications, quantiles are defined at the TTWA and year level. We include results from conditional quantile regressions as a robustness check.

The estimation of unconditional quantile regressions is done in two steps. The first step consists of calculating a recentred influence function (RIF). The RIF captures the change in a distributional statistic (in our case a quantile) when the distribution of the underlying variable changes slightly. The RIF value for the p-th quantile of a variable y, $q_y(p)$, can be calculated as follows (Firpo, Fortin, & Lemieux, 2018)

$$RIF\big(y, q_y(p)\big) = \ q_Y(p) + \frac{p - 1(y \leq q_y(p))}{f(q_y(p))}$$

In the second step, RIF values can be modelled using standard OLS regression techniques. The resulting coefficients capture the partial impact of a one unit change in X on the unconditional quantile of y. Unlike CQRs, conditioning on X does not change the absolute value of the quantile being estimated.

Our specification is very similar to that used by Dolton and his co-authors and takes the form:

$$RIF \ \ (w_{i,a,t}, q_w(p)_{a,t}) = \beta^p X_{i,a,t} + \delta^p W_{i,a,t} + \theta_t D_t + \ \eta_a D_a + \textstyle\sum_{t=2009}^{2018} \gamma_t^p Mshare_{a,t} + \varepsilon_{i,a,t}$$

where $q_w(p)_{a,t}$ is p-th percentile (p=5,10,15,20, 30, 50) of the wage distribution in area a and year t, X_{iat} is a vector of individual employee characteristics at time *t,* W_{iat} is a vector of employer characteristics, θ_t is a set of year fixed effects, η_a is a set of area fixed effects and $Mshare_{a,t}$ is the share of minimum wage workers in area *a* at time *t*. The year fixed effects absorb variations across years that are common to all areas (for example, as a result of the economic cycle) while the area fixed effects absorb heterogeneity across areas that are time invariant. Individual and employment characteristics further absorb any changes in wage growth associated with changes in the composition of an area's workforce or employer pool.

Assuming that changes in the minimum wage do not affect median earnings, we then take our estimate of interest to be:

$$(1)\ \Delta_t = \gamma_t^p - \gamma_t^{50} \quad .$$

The identifying assumption is of no differential trends in local wage growth relative to the median. We compute this estimate for every year between 2010 and 2018.

Despite the extensive set of controls we use, it is possible that our estimates are confounded by the existence of local labour demand shocks. For example, a negative shock would put downward pressure on wages, which would both increase the share of individuals paid at the minimum and depress wage growth. Note that such a shock would be problematic in our case to the extent it has a differential effect on different parts of the wage distribution. To minimize this problem, we use the share of minimum wage workers in the first year of our data, i.e. 2009 and interact this with time fixed effects. Our strategy is numerically equivalent to using a Bartik shift-share instrument, where 'initial' shares are defined as the shares observed in 2009 (Goldsmith-Pinkham, Sorkin, & Swift, 2018).

We estimate the same models first using hourly wages as a dependent variable and then weekly earnings.

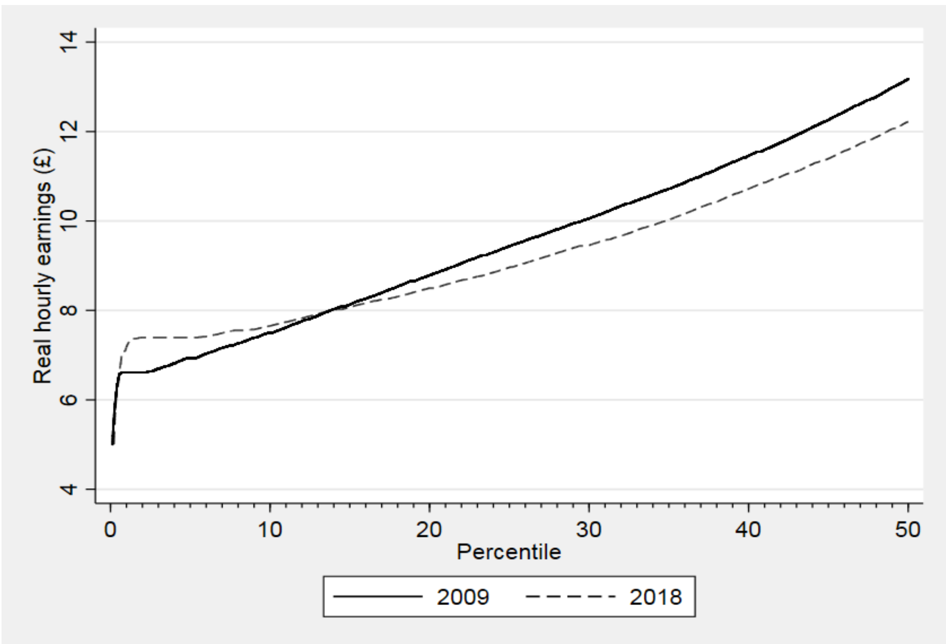
3 Descriptive Results

3.1 Hourly and weekly wage growth at different along the wage distribution

We start by presenting descriptive evidence on the evolution of real wages between 2009 and 2018. Figure 1 shows the level of real hourly wages across the bottom half (1st to 50th percentile) of the distribution in 2009 and 2018. Real hourly wages growth was positive up to the 15th percentile but negative at higher percentiles. The relatively high growth of hourly earnings at the bottom of the distribution between 2009 and 2018 suggests that wage inequality fell among those in the bottom half of the hourly wage distribution over this period.

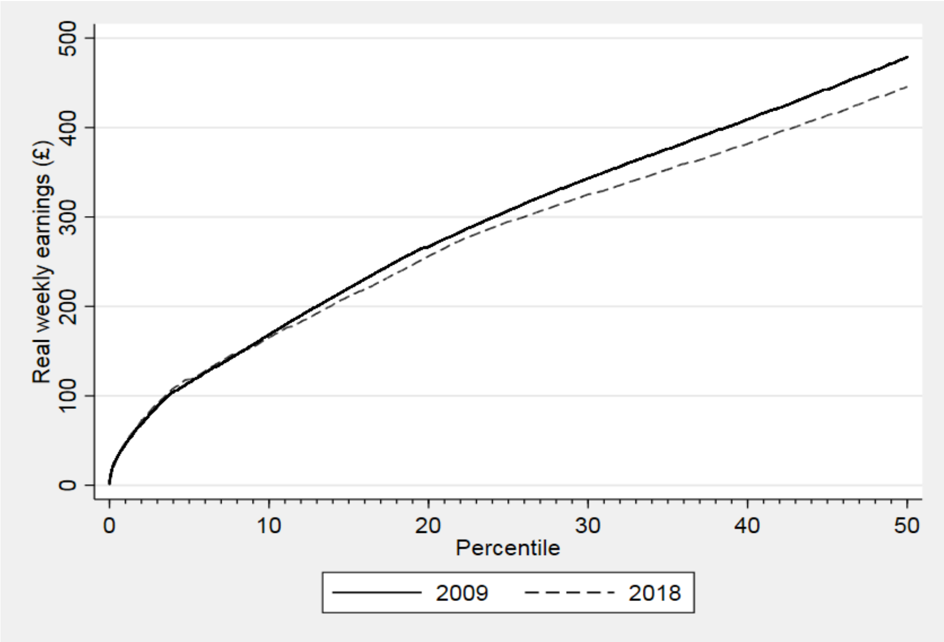
The same picture is shown for real weekly earnings in Figure 2. Over the same period, real weekly earnings were stagnant at the bottom decile and showed a small fall further up the distribution. This led to a smaller reduction in inequality in weekly earning than that for hourly wages between 2009 and 2018 as there was no positive growth in real weekly earnings at the bottom of the distribution while losses in earnings further up the distribution were much smaller. This suggests that changes in real hourly wages were partly compensated for by changes in working hours, working patterns and/or overtime pay.

Figure 1: Real hourly earnings in the bottom half of the distribution, 2009 and 2018



Notes: Earnings are in 2015 prices.
Source: ASHE 2009-2018

Figure 2 Real weekly earnings in the bottom half of the distribution, 2009 and 2018



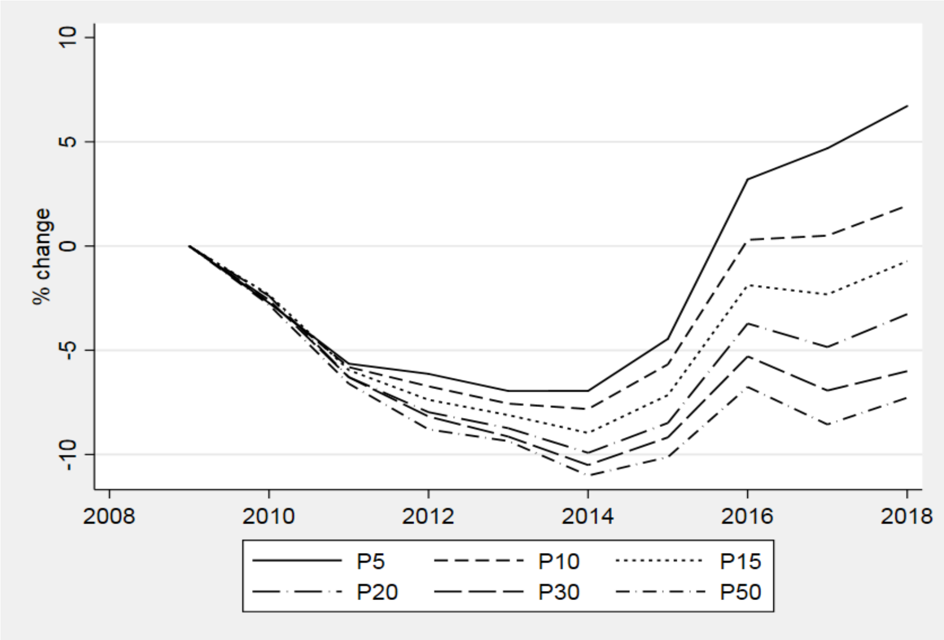
Notes: Earnings are in 2015 prices.
Source: ASHE 2009-2018

Figure 3 plots the change in real hourly wages between 2009 and 2016, relative to 2009 wages, at selected quantiles of the wage distribution. Relative to 2009, wage growth was negative for each of the quantiles we examine in every year between 2009 and 2015. Between 2009 and 2011 hourly wages declined by approximately 5% for all quantiles. After 2011, growth patterns began to diverge. By 2014 the real hourly wages of workers earning at the 5th percentile had fallen by approximately 7% whereas the median fell by around 11%. From 2014 wage growth resumed across the distribution but growth was more vigorous at the bottom end of the wage distribution than at middle quantiles. Overall, real hourly wages at the 5th percentile were 6% higher in 2018 compared to 2009 while those at the 50th percentile were approximately 7% lower.

Changes in real weekly earnings, shown in Figure 4, display a similar pattern. Wages fell by similar amounts across the distribution between 2009 and 2011. From 2011 to 2014, weekly earnings fell by less at the bottom of the distribution than in the middle: real weekly earnings at the 5th percentile fell by around 10% between 2009 and 2014 whereas the median fell by around 13%. The subsequent recovery was also stronger at the bottom than the middle. In 2018 weekly wages at the 5th percentile were 3% higher in real terms than in 2009, whereas the median was 8% lower.

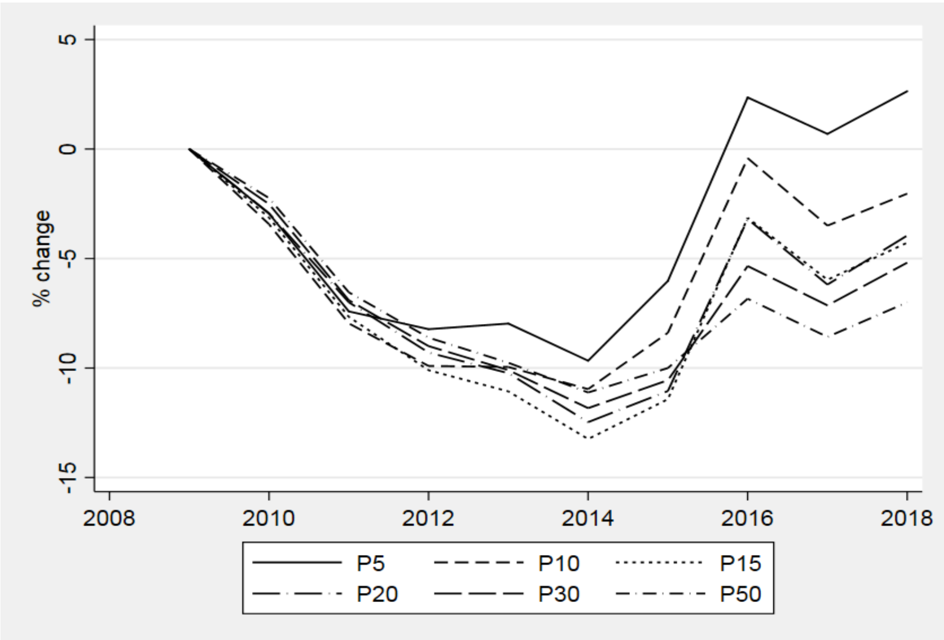
The change in weekly earnings was more uniform across quantiles than changes in hourly pay. Moreover, the fact that at all quantiles examined weekly earnings fell more than hourly wages suggests that workers lost out not only from the erosion of real hourly wages but also from other changes in working hours, bonuses and/or overtime pay.

Figure 3 Change in real hourly earnings relative to 2009, selected quantiles



Source: ASHE 2009-2018

Figure 4 Change in real weekly earnings relative to 2009, selected quantiles



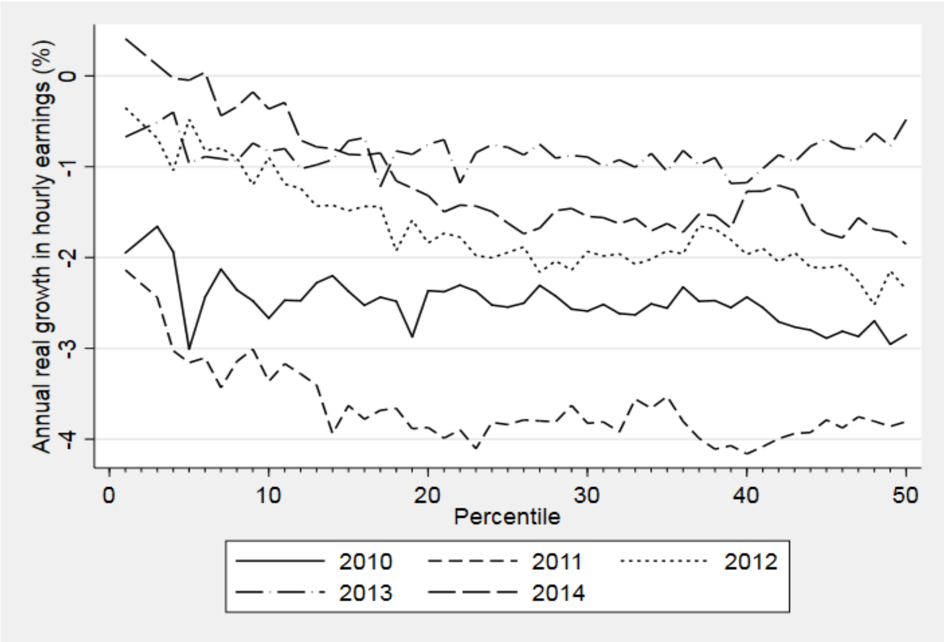
Source: ASHE 2009-2018

To gain a better understanding of the timing of these different patterns of wage growth, **Error! Not a valid bookmark self-reference.** plots the annual growth in real hourly wages for each year between 2009 and 2014 (**Error! Not a valid bookmark self-reference.**a), the period over which real wages declined, and 2015 to 2018 (**Error! Not a valid bookmark self-reference.**b), when real wages rose. It shows that, with the exception of 2010 and 2013, wages at the very bottom of the distribution fell by less than those in the middle. Similarly, between 2014 and 2015, wages grew more in the bottom compared to the middle. This is especially true for 2016, when the introduction of the NLW increased wages in the bottom decile substantially.

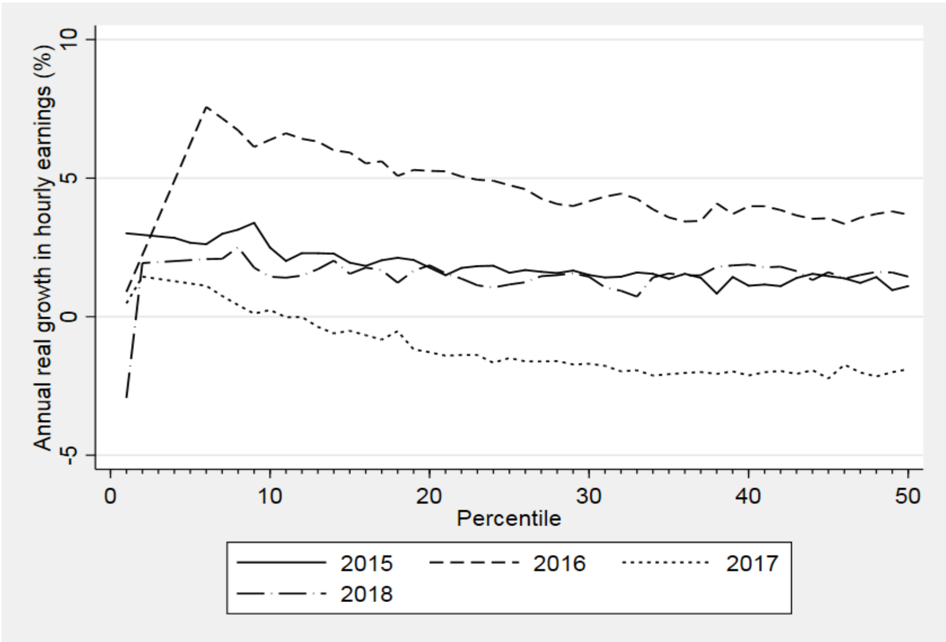
The picture is more nuanced for weekly earnings. As shown in Figure 6, annual growth rates for weekly earnings vary much less across the distribution than those for hourly wages in all years except 2016, when the NLW was introduced. In 2016, weekly earnings grew significantly faster in the first two deciles compared to the rest of the distribution (although 2016 was a year of relatively high weekly wage growth across all percentiles in the bottom half of the distribution).

Figure 5: Annual growth in real hourly earnings (%) in the bottom half of the wage distribution, 2010-2018

(a) 2010-2014



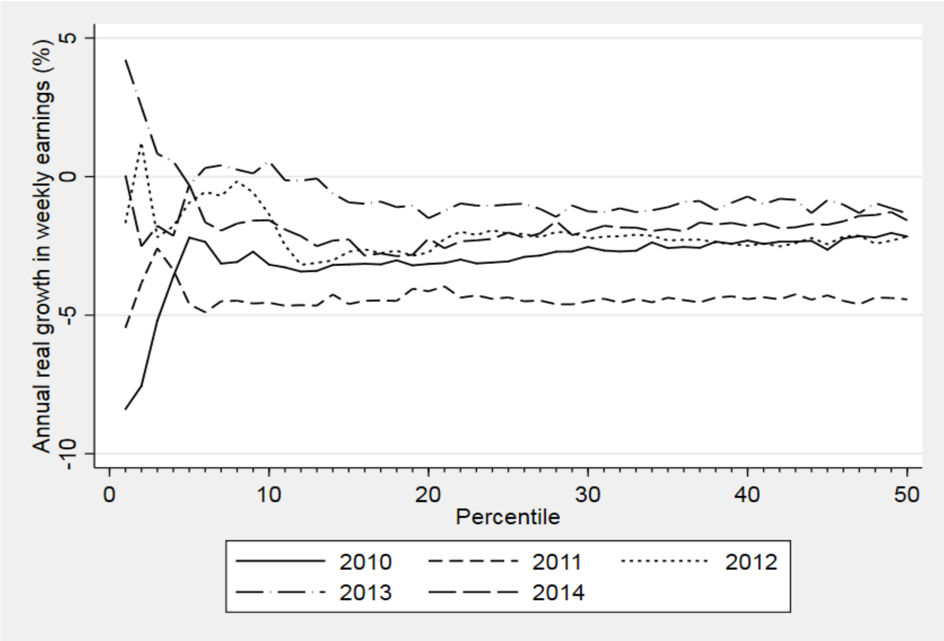
(b) 2015-2018



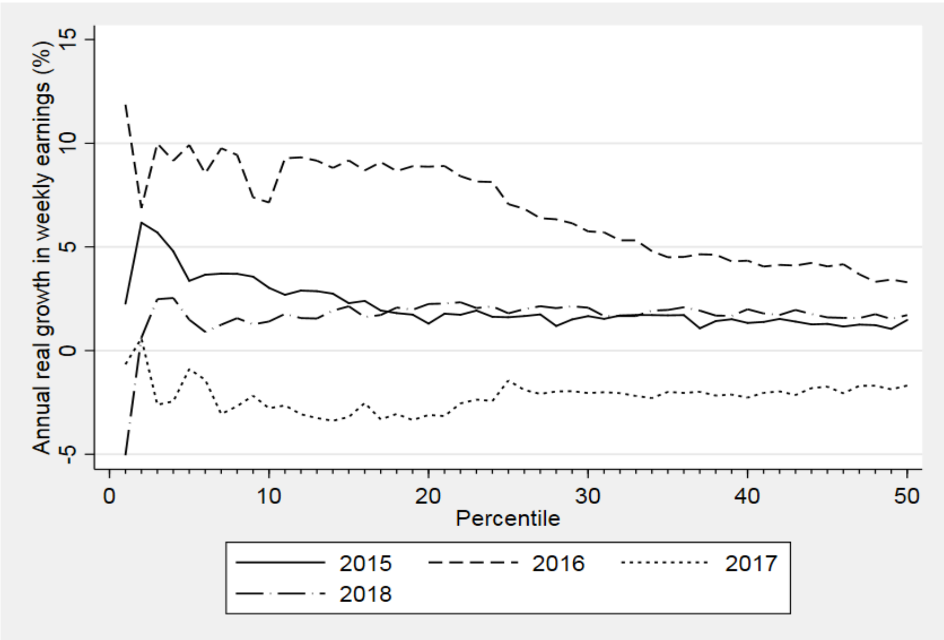
Source: ASHE 2009-2018

Figure 6: Annual growth in real weekly earnings (%) in the bottom half of the wage distribution, 2010-2018

(a) 2010-2014



(b) 2015-2018

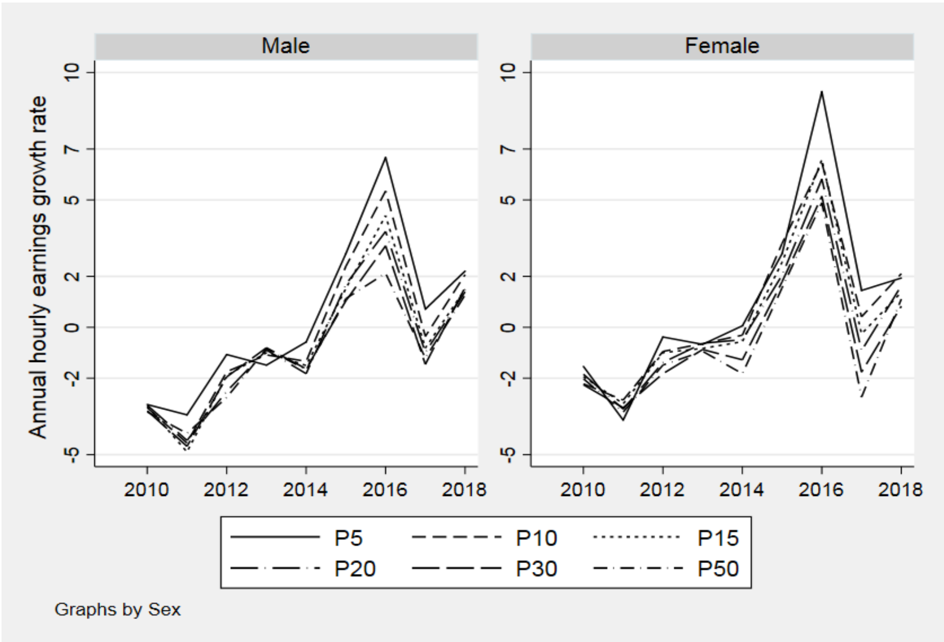


Source: ASHE 2009-2018

3.2 Wage growth at selected quantiles by gender, region and industry

We next examine wage growth patterns by gender, region and industry. Figure 7 depicts annual growth rates for male and female hourly earnings along the wage distribution. Wage growth patterns for men and women are very similar: wages fell before 2014 and rose subsequently. Wage losses were slightly larger for men, and wage gains slightly larger for women. This is consistent with stronger wage growth at the bottom of the distribution where women are disproportionately concentrated. We also see a spike in wage growth following the NLW's introduction in 2016, with larger spikes for women, at all reported percentiles, compared to men. This is consistent with higher coverage of the minimum wage among females. It is notable, too, while wages at the 5th percentile grew by 7% for men and 9% for women, the spike in earnings growth in 2016 extended up the median, with male median male hourly earnings growing 2% and female median hourly earnings by 5% (the largest annual increase we observe over the period).

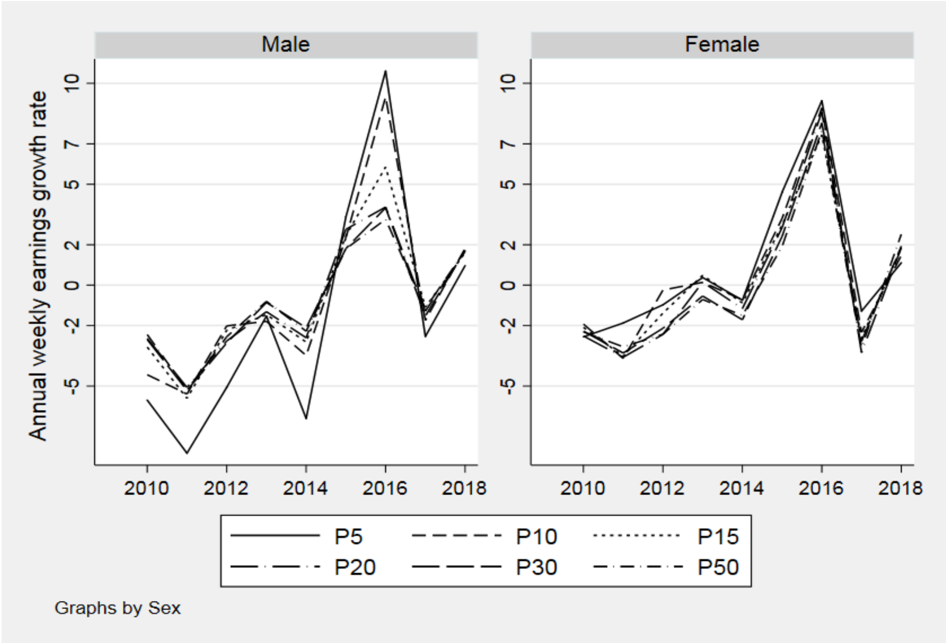
Figure 7: Annual growth in real hourly earnings by sex, selected quantiles



Source: ASHE 2009-2018

Annual growth rates in real weekly earnings by sex are shown in Figure 8. The most striking difference is that, for the female distributions, lines depicting the various quantiles are packed tightly together, whereas there is much more variation in wage growth across the male distribution. The greatest volatility is seen at the 5th percentile in the male distribution, which experienced the largest falls prior to 2014, and the greatest increases in 2016. In 2016, the 5th and 10th percentiles of the male weekly earnings distribution grew by more than their female counterparts. Percentiles higher up in the distribution saw smaller rises. Clearly, weekly earnings growth patterns differ from hourly wages, especially at the very bottom of the distribution. It should be noted though workers in the bottom of one distribution may be different from workers at the bottom of the other.

Figure 8: Annual growth in real weekly earnings by sex, selected quantiles



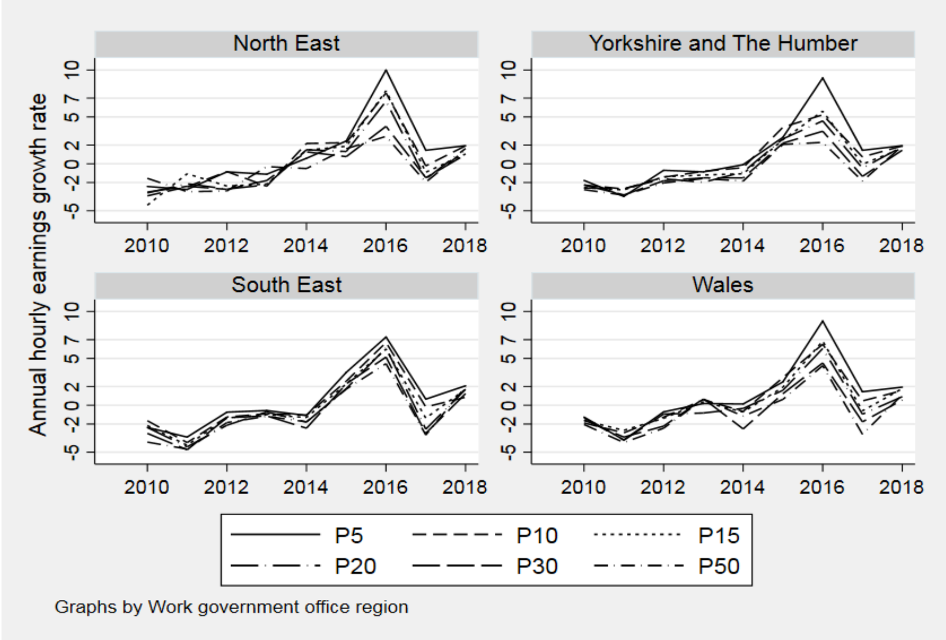
Source: ASHE 2009-2018

Figure 9 shows real hourly wages growth at the 5th, 10th, 15th, 20th, 30th and 50th percentile by region. Three poorer regions (North-East, Yorkshire and Humber and Wales) are shown alongside a richer one (the South East). The 2016 spike in wage growth is higher in the North East, Yorkshire and Wales than the South East, consistent with the introduction of NLW inducing faster wage growth at the bottom of the distribution. Changes at the median are more similar across regions. Note also that, in 2016, variation across quantiles was greater in the poorer regions that in the South-East, again consistent with minimum wage increases being more likely to be binding in these regions.

Patterns of real weekly earnings growth by region are shown in Figure 10. Contrary to the patterns in

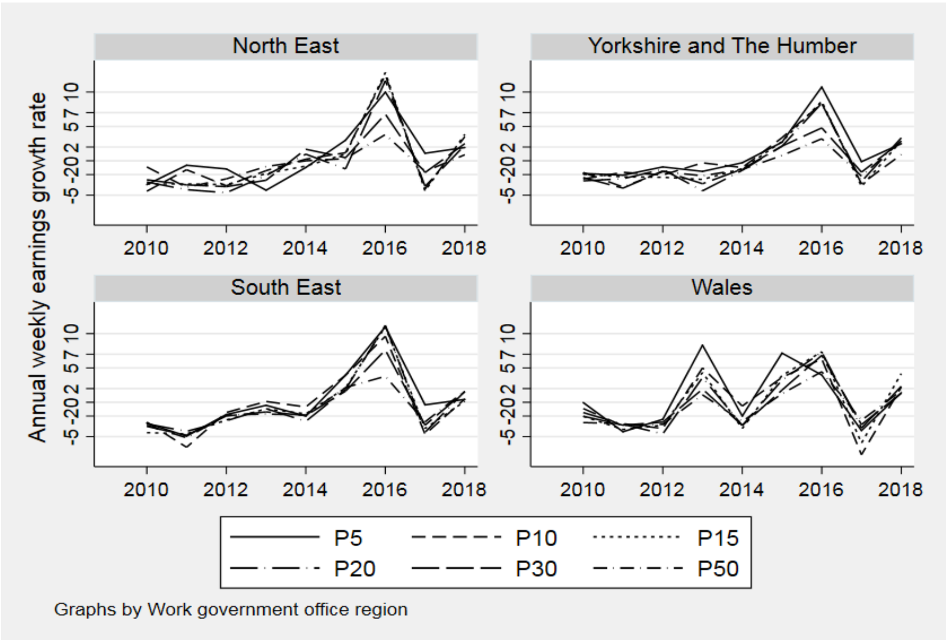
Figure 9, weekly earnings growth was relatively similar in the three poorer regions and in the South East. Within regions earnings growth is also much more similar across quantiles. For Wales we also see that, compared to hourly wages growth, the pattern of weekly earnings growth differs with spikes in 2013 and 2015/2016.

Figure 9: Annual growth in real hourly earnings by region, selected quantiles



Source: ASHE 2009-2014

Figure 10: Annual growth in real weekly earnings by region, selected quantiles



Source: ASHE 2009-2018

Our last set of figures in this section,

Figure 11 and

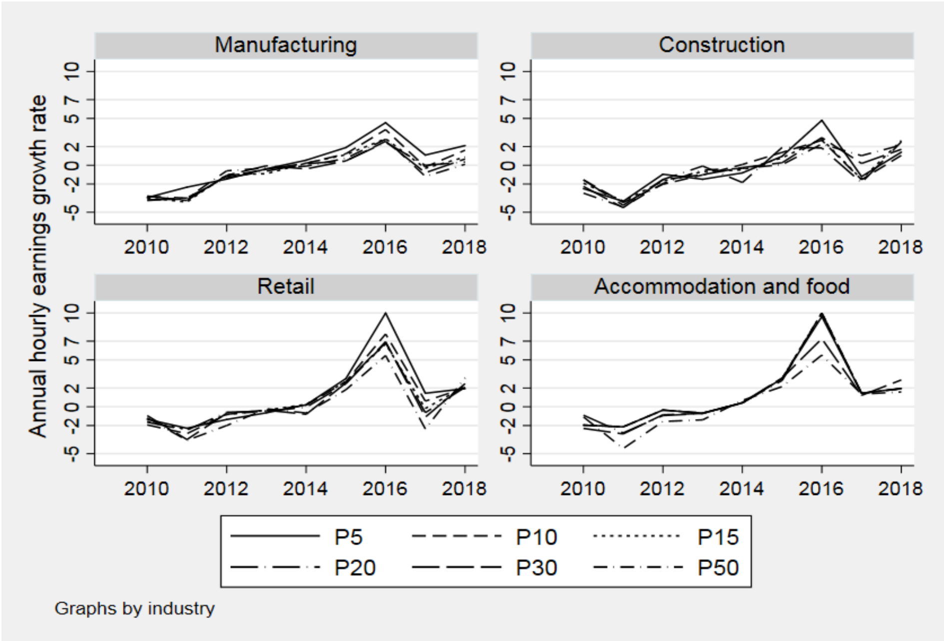
Figure 12, illustrate growth in real hourly and weekly earnings by industry. Two relatively well-paid industries (manufacturing and construction), and two relatively low paid ones (retail and hospitality) are included.

Figure 11 shows that, as expected, real hourly wage growth has been higher in the lower paying industries, particularly in 2016 when the NLW was introduced.

Patterns shown in

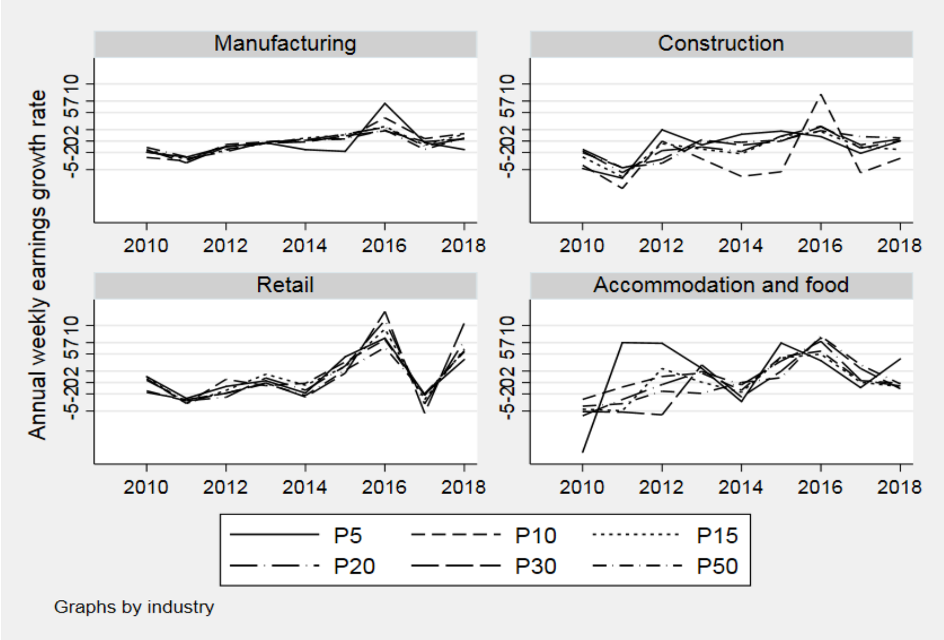
Figure 12 are less straightforward to interpret. The clear 2016 spike is only present in manufacturing and retail. In construction, weekly earnings at the 30th percentile increased more than at lower levels. As with previous graphs, we also find that the growth in weekly earnings varies much less across the distribution than it does for hourly pay.

Figure 11: Annual growth in real hourly earnings by industry, selected quantiles



Source: ASHE 2009-2018

Figure 12: Annual growth in real weekly earnings by industry, selected quantiles



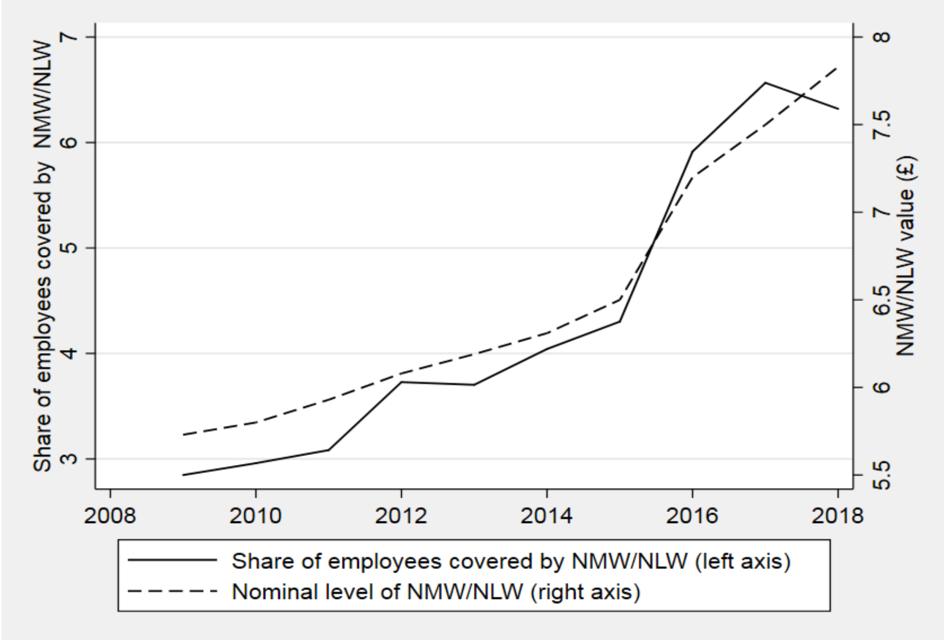
Source: ASHE 2009-2018

In summary, in this section we have shown that changes in hourly earnings growth conform to expectations: growth is higher for groups where wages are lower, lower quantiles grow more than higher ones and there is a distinctive spike in 2016 when the NLW was introduced. Patterns for weekly earnings growth are somewhat different and less consistent with wage growth being strongest for those on low weekly pay. Generally, growth rates are much more uniform across quantiles than for hourly earnings. This suggests that changes in other elements that affect weekly pay, such as hours worked, bonuses and overtime pay, have offset the progressivity of hourly pay growth.

3.3 The NMW/NLW in the local wage distribution

We consider a worker to be receiving the minimum wage if their hourly earnings, as reported in ASHE, are within 5p of the minimum wage level applicable in the year of the survey. As we exclude very young workers, the share of workers receiving the minimum wage is lower than levels normally reported in official statistics (Smith, 2018). Figure 13 reports the share of workers receiving the minimum wage, in our data and its nominal level between 2009 and 2018. The share of minimum wage workers clearly mirrors nominal increases in the level of the minimum wage, increasing throughout the period from around 3% in 2009 to 6.5% in 2018. In line with expectations, there is a large jump in 2016 from around 4.2% to around 6% of our sample.

Figure 13: Share of employees receiving the NMW/NLW, 2009-2018



Notes: Employees aged 25-70 with an hourly wage within 5 p of the NMW/NLW
Source: ASHE 2009-2018

The proportion of minimum wage workers varies substantially across TTWAs and this variation increases over time. In 2009, there were TTWAs where no worker in our sample was on a minimum wage while the highest share of minimum wage workers in any TTWA was nearly 9%. In contrast, in 2018 the share of minimum wage workers varied between 2% and 18%. Table 1 reports the mean, minimum and maximum proportions by TTWA, as well as the standard deviation, by year.

Table 1: Proportion of minimum wage workers at the TTWA level by year

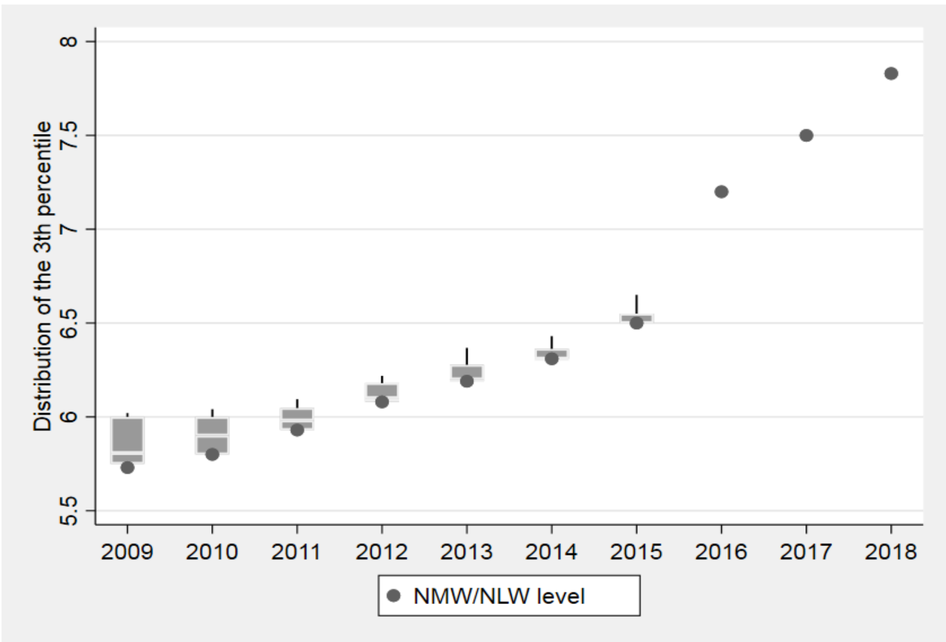
Year	Mean	Minimum	Maximum	SD	N TTWAs
2009	2.82	0	8.93	1.26	195
2010	2.95	0	13.24	1.34	195
2011	3.07	0	13.51	1.21	195
2012	3.72	0	13.43	1.40	195
2013	3.68	0	18.40	1.49	196
2014	4.03	0	12.5	1.52	184
2015	4.29	0	12.5	1.64	184
2016	5.90	1.36	17.91	2.05	179
2017	6.54	1.92	20.97	2.16	185
2018	6.30	1.67	18.06	2.16	178

Source: ASHE 2009-2018

To estimate the effect of minimum wage upratings on the wage distribution we rely on comparing wage growth at different quantiles within TTWAs. However, which quantiles should be most affected by the uprating of the minimum wage? Depending on the TTWA wage distribution, the minimum wage level will sit at different points of the distribution. We calculate the value of 3rd, 5th, and 10th percentile of the hourly wage distribution in each of nearly 200 TTWAs and plot their distribution by year in **Error! Not a valid bookmark self-reference.**, Figure 15 and Figure 16 respectively. The boxplots show the wages at each of these percentiles for the lowest to highest wage TTWAs. The boxplots are drawn for the 25th (bottom), 50th (middle) and 75th (top) TTWA percentiles, while the whiskers show the values of the 10th and 90th percentiles.

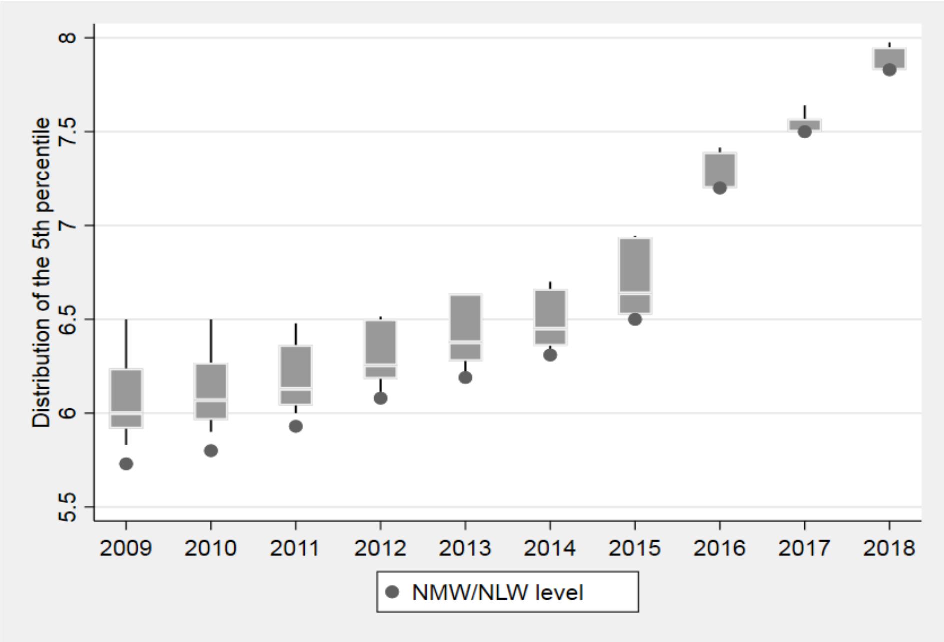
As expected, the distribution becomes more compressed over time as the coverage of the minimum wage increases. In 2009, over half of the TTWAs had wages at the 3rd percentile that were above the NMW level. It was also the case that in 2009 in almost all TTWAs the 5th percentile of the wage distribution was higher than the corresponding value of the NMW. We can conclude, therefore, that in 2009 the minimum wage was non-binding for workers earning at the 5th percentile of local hourly earnings. This contrasts sharply with the situation in 2016 when there was no TTWA which had wages at the 3rd percentile which were higher than the minimum wage level (and as a result there is no variation in wages across areas at the 3rd percentile in 2016 to 2018). In 2017, the minimum wage stood above the 5th percentile of local wages in three-quarters of TTWAs. Figure 16 shows that the 10th percentile in all TTWAs is well above the minimum wage level in all years. The median observed 10th percentile also increases more slowly over time compared to the 3rd and 5th percentiles. The three figures therefore suggest that the minimum wage uprating was likely to *directly* affect wage growth at the 3rd and 5th percentiles but not at the 10th percentile.

Figure 14: Box-plot of TTWA 3rd percentile relative to the NMW/NLW level, by year



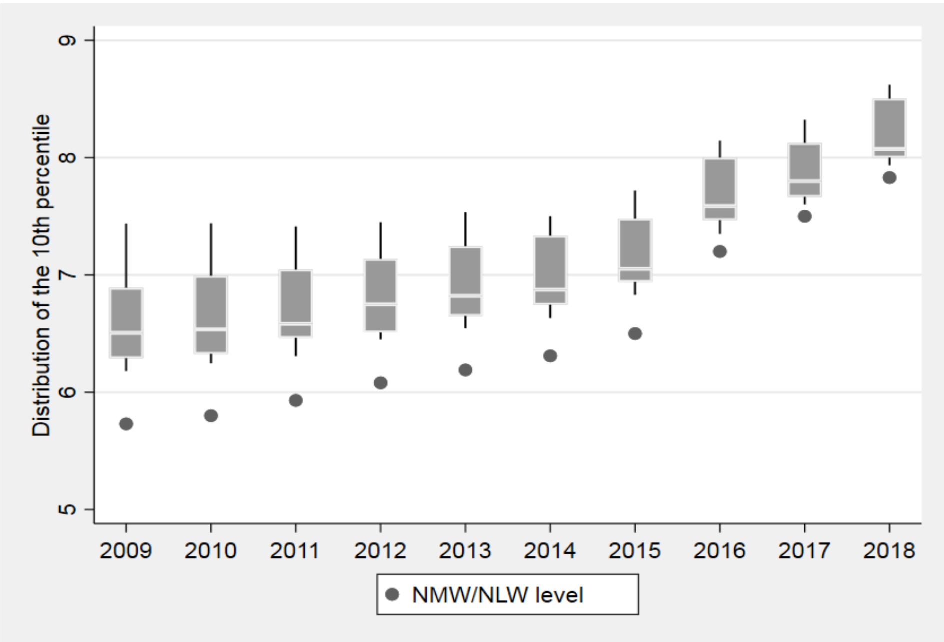
Source: ASHE 2009-2018

Figure 15: Box-plot of TTWA 5th percentile relative to the NMW/NLW level, by year



Source: ASHE 2009-2018

Figure 16: Box-plot of TTWA 10th percentile relative to the NMW/NLW level, by year



Source: ASHE 2009-2018

4 Results from quantile regressions

We next present results from unconditional quantile regressions of wage growth at the 5th, 10th, 15th, 20th, 30th and 30th percentiles. For each, we estimate simple models with only year and area (TTWA) fixed effects and full models with controls for gender, age, occupation, industry, firm size, sector, working part-time and working on a temporary contract. The coefficients of interest are those attached to the share of minimum wage workers in the TTWA in 2009, which captures the additional wage growth resulting, at any given quantile, from having a higher share of employees earning the minimum wage.

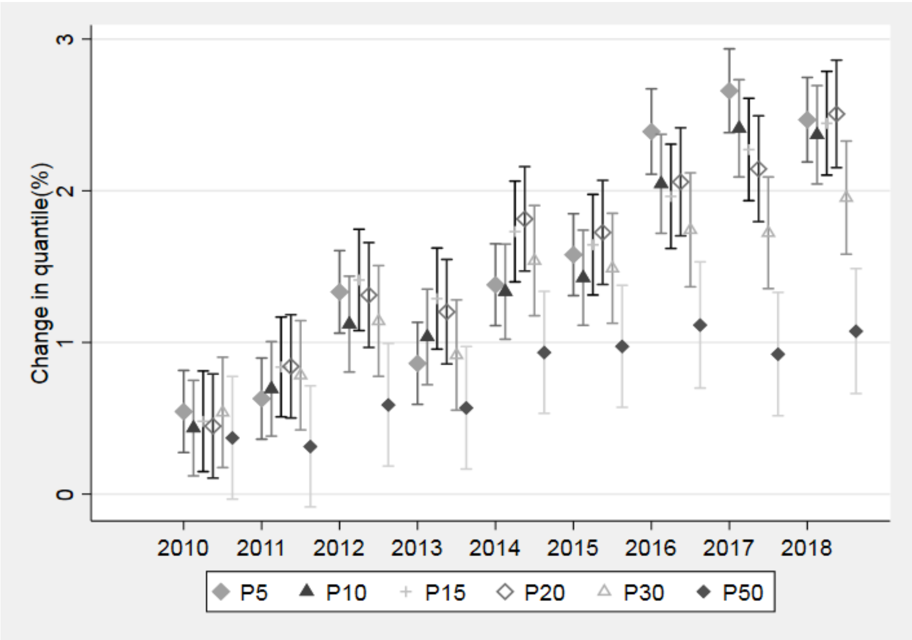
i) A basic model including only year and area (TTWA) fixed effects.
ii) A full model where in addition to year and area fixed effects, we control for gender, age, occupation, industry, firm size, sector, working part-time and working on a temporary contract

As discussed in Section 2.6, we wish to estimate the effect of minimum wage upratings at different points in the wage distribution to capture both the direct effects generated by the need to comply with minimum wage legislation, and indirect or spillover effects where minimum wage hikes induce employers to raise wages above the minimum wage. We estimate quantile regressions at the 5th, 10th, 15th, 20th, 30th and 50th percentile. Based on Figures 14-16, we expect the direct effect of the minimum wage to be greatest at the 5th percentile. Effects at higher percentiles reflect the presence of spillover effects. We carry out estimations using both real hourly wages (logged) and real weekly earnings (logged).

4.1 Hourly earnings

Figure 17 plots the estimated γ_t^p, our coefficients of interest, from the basic unconditional quantile regressions (UQR) model expressed as percentage change. They express the increased wage growth at a given quantile associated with a one percentage point increase in the area's share of employees covered by the minimum wage in 2009. Wage growth is estimated relative to 2009. As expected, we find a positive effect, implying that wage growth is faster in areas which had a higher share of minimum wage workers in 2009. More surprisingly, however, with the exception of 2010 and 2011, we find that this positive effect extends all the way up to the 50th percentile. However, the extra wage growth associated with having a higher share of minimum wage workers is clearly lower at the median compared to the other quantiles. Differences in wage growth at the other quantiles are small up to an including 2015. From 2016, there is a clear discontinuity: wage growth at the 5th percentile – and, to a slightly lesser extent, at the 10th, 15th and 20th percentile - jumped significantly in areas with larger shares of minimum wage workers. Wages at the 30th centile also saw strong growth, while estimates for the effects on changes in the median levelled off. Moreover, after 2016, we observe, as expected, that the estimated effect of the area share of minimum wage workers on wage growth is greater at lower wage quantiles. At the 5th percentile, wage growth has been approximately 2-2.5% higher for every percentage point in the area's share of minimum wage workers (measured in 2009). At the 30th percentile, wage growth has increased by 1.5-2% and at the median by around 1%.

Figure 17: Estimated marginal effects of the area share of minimum wage workers on real hourly wage growth at selected quantiles (Basic model; UQR)

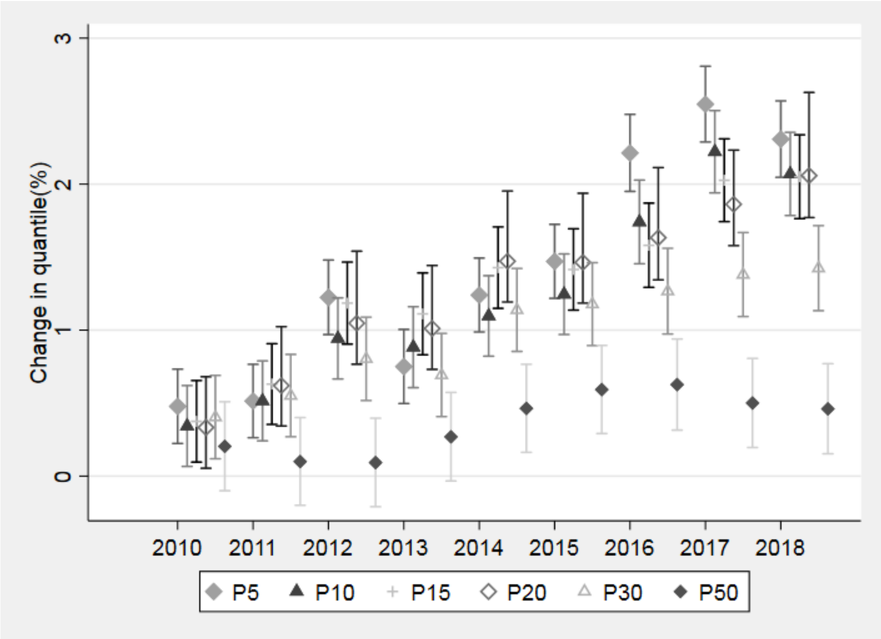


Source: ASHE 2009-2018

Results in Figure 17 do not account for the fact that areas with higher shares of minimum wage workers may be different in other ways and this can influence wage growth. Figure 18 shows estimated effects after controlling for individual and job-related characteristics. The pattern is similar to the basic models, although effect sizes are smaller and pattern described above become clearer. Estimated effects of area share of minimum wage workers on wage growth at the median are now much smaller and statistically insignificant before 2015. The differences between the 5th, and in some cases the 10th, percentile and the median become larger. Finally, after 2016, differences in wage growth at the 5th percentile are clearly larger compared to those at quantiles higher up in the distribution. After the introduction of the NLW in 2016, real hourly wages at the 5th percentile grew 2% faster for each percentage point increase in the area's (2009) share of minimum wage workers. In contrast, at the 30th percentile wages grew approximately 1.2% faster.

To sum up, results from the unconditional quantile regressions indicate that the uprating of the minimum wage, and especially the introduction of the NLW, induced higher hourly wage growth at the bottom of the distribution. We find considerable direct and spillover effects up to around the 30th percentile of the wage distribution. Wages at the 5th percentile of the local wage distribution grew by around 2-2.5% more in TTWA's with a 1 percentage point higher share of minimum wage workers. The 10th percentile grow by an additional 1.5-2%, and the 30th percentile by around 1-1.5%, for each additional percentage point increase in minimum wage workers. In contrast, the median grow by just an extra 0.5%. The fact that we do find effects at the median (albeit small ones) suggests that there are area specific wage shocks that are confounded with minimum wage upratings. Finally, note that the coefficients express the *extra* wage growth occurring in areas with higher shares of minimum wage workers. If the introduction of the NLW did affect wage growth in all TTWAs, this common effect would not be captured by our coefficients.

Figure 18: Estimated marginal effects of the area share of minimum wage workers on real hourly wage growth at selected quantiles (Full model; UQR)



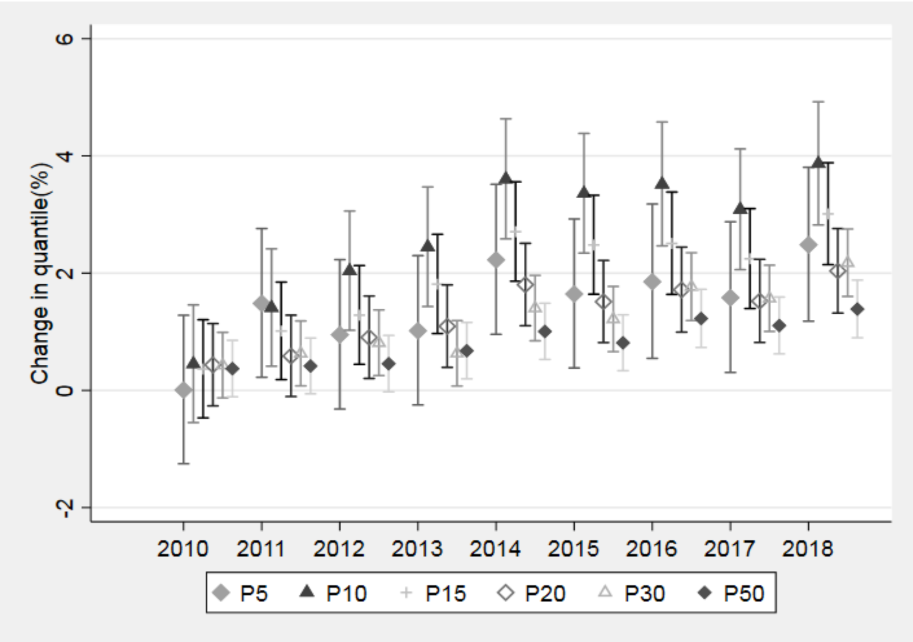
Source: ASHE 2009-2018

4.2 Weekly earnings

We next examine effects on weekly earnings using the same specifications. Descriptive results in section 3.2 suggest that weekly earnings growth has been less progressive than hourly wage growth. As the minimum wage is set at the hourly level employers may have more discretion in setting weekly wage levels.

Error! Not a valid bookmark self-reference. displays estimated effects of the area share of minimum wage workers on weekly earnings growth using the unconditional quantiles basic model specification. Estimates are somewhat imprecise, especially in the case of the 5th percentile. In 2010 and 2011, there is little evidence that wage growth varied across areas with lower and higher shares of minimum wage workers. After 2014, wage growth at the 10th percentile appears to be most strongly correlated with the area share of minimum wage workers. Effects at the median are positive after 2014, albeit small. Unlike the results for hourly earnings, there does not appear to be a jump in 2016 when the NLW was introduced.

Figure 19: Estimated marginal effects of the area share of minimum wage workers on real weekly earnings growth at selected quantiles (Basic model; CQR)

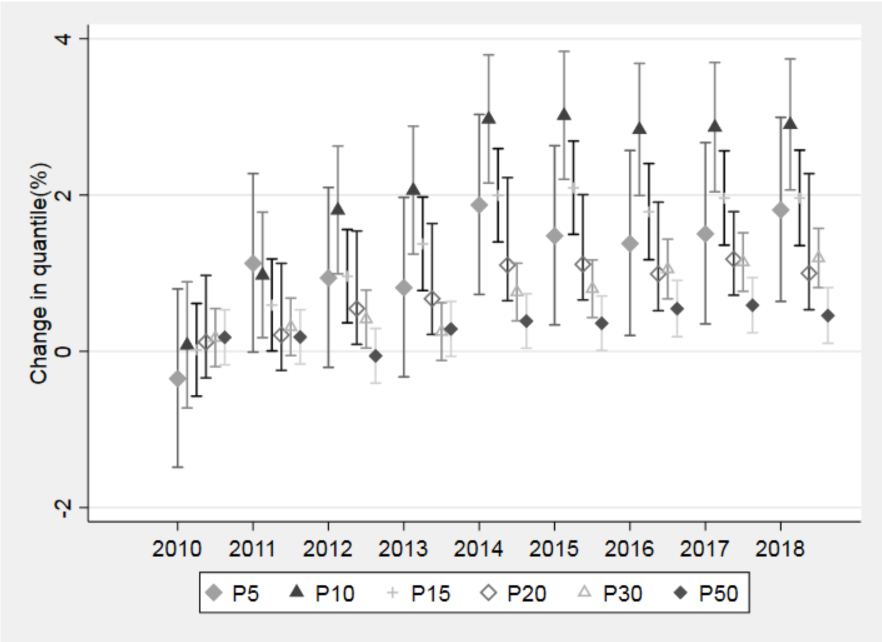


Source: ASHE 2009-2018

Figure 20 shows estimated coefficients from the full unconditional quantile regression models. The overall pattern is similar to the basic model but the size of the estimated effects is somewhat smaller. After 2014, the effect of the area share of minimum wage workers on wage growth at the 10^{th} percentile is about 3%. This is considerably higher than the 1.5% effect found at the 5^{th} percentile. In fact, differences in wage growth at the 10^{th} and 15^{th} percentile across areas with high and low shares of minimum wage workers are higher than differences at the 5^{th} percentile.

Both the basic and the full model suggest that weekly earnings growth has been higher in areas with a higher share of minimum wage workers. In contrast to hourly wages, the biggest extra growth occurred at 10^{th} and 15^{th} percentile rather than at the 5^{th} percentile although we cannot reject the hypothesis that growth rates are in fact the same. Weekly earnings growth also does not discontinuously increase in 2016, the year of the NLW introduction.

Figure 20: Estimated marginal effects of the area share of minimum wage workers on real weekly earnings growth at selected quantiles (Full model; conditional quantiles)



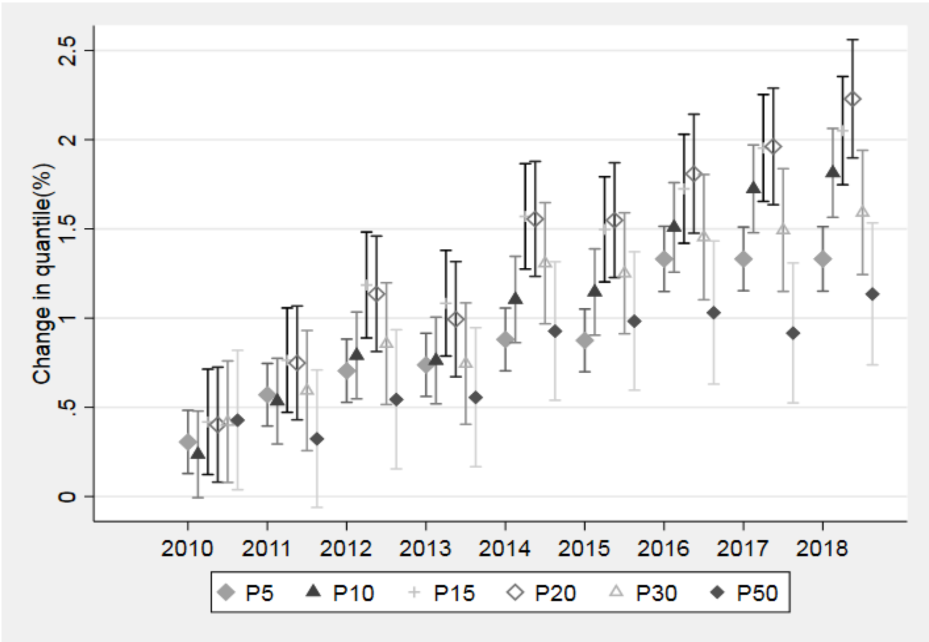
Source: ASHE 2009-2018

5 Robustness checks: Conditional quantile regressions

As discussed in section 2.6, interpreting the meaning of coefficients from conditional quantile regressions is more complicated as the actual level of the quantiles changes once controls are introduced. We nevertheless show estimates for comparison with the previous literature that has tended to use conditional quantile regressions and as a robustness check. We expect result from CQR models to be noisier but qualitatively similar to our UQR estimates.

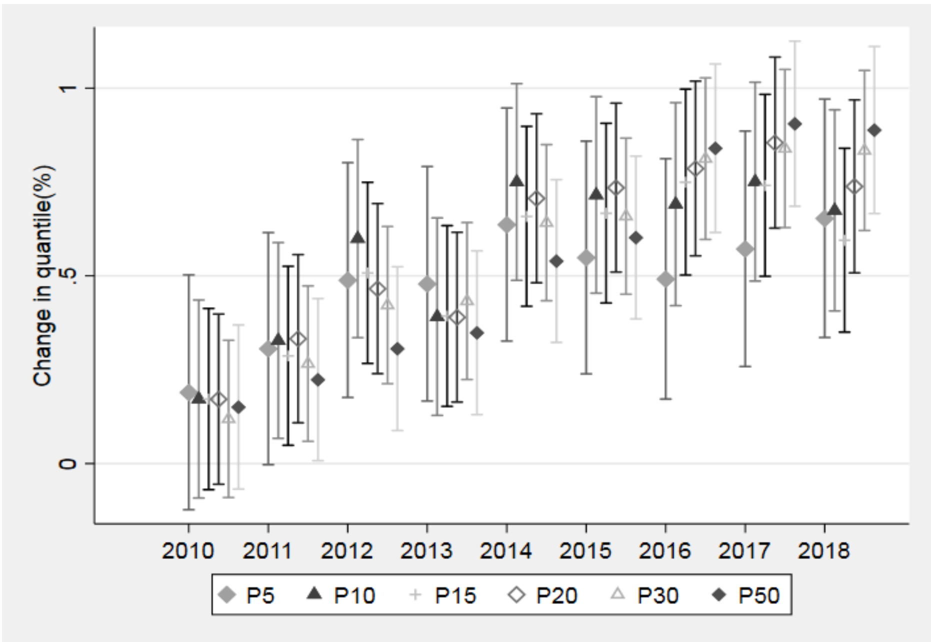
Figure 21 and Figure 22 show estimated effects from the basic and full models in the case of hourly wages. Overall, the estimated effects of the area share of minimum wage workers are positive and significant but patterns are less clear than those emerging from the UQR. In the basic model, the largest effects are found at the 15th and at the 20th percentiles while in the full model wage growth appears to be very similar at all six quantiles included in our analysis. Effect sizes are also noticeably smaller, between 0.5% and 2% depending on the quantile and the specification. There is also no noticeable jump in wage growth rates in 2016 when the NLW was introduced. Overall, results from conditional quantile regressions still point to positive effects on wage growth from the minimum wage increases, but estimates are smaller, noisier and more difficult to interpret.

Figure 21: Estimated marginal effects of the area share of minimum wage workers on real weekly earnings growth at selected quantiles (Basic model; conditional quantiles)



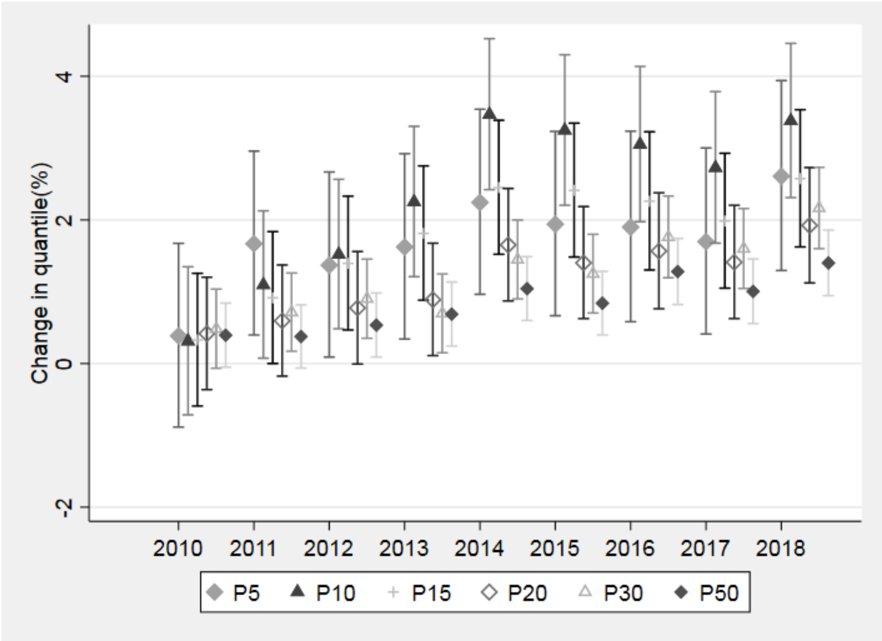
Source: ASHE 2009-2018

Figure 22: Estimated marginal effects of the area share of minimum wage workers on real weekly earnings growth at selected quantiles (Full model; unconditional quantiles)



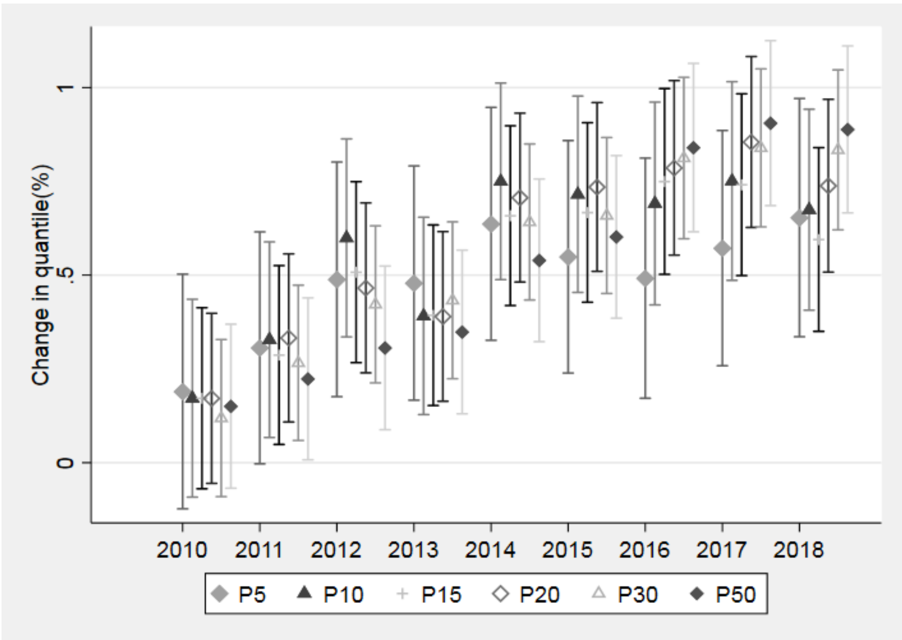
Source: ASHE 2009-2018

Figure 23: Estimated marginal effects of the area share of minimum wage workers on real hourly wage growth at selected quantiles (Basic model; unconditional quantiles)



Source: ASHE 2009-2018

Figure 24: Estimated marginal effects of the area share of minimum wage workers on real hourly wage growth at selected quantiles (Full model; UQR)



Source: ASHE 2009-2018

Figure 23 and Figure 24 plot the estimated effects on weekly earnings growth from the basic and full model respectively. Results of the basic model are very similar to those obtained from UQR. Wage growth is higher in areas with a higher share of minimum wage workers at all quantiles, but especially at the 10th and 15th percentile. Adding controls for individual and employer characteristics reduces the size of the coefficients substantially. There is also no evidence now that the impact of the area share of minimum wage workers on wage growth varies for different quantiles of the weekly earnings distribution. In fact, contrary to expectation, after 2016 the effects appear to be largest at the median. However, these puzzling findings might be the result of quantile levels changing with the addition of control variables.

6 Conclusions

We use geographic variation in the wage levels and time variation in the level of the minimum wage to study the impact of minimum wage uprating on wage differentials between 2009 and 2018. We find that NMW uprating after 2014, and especially the introduction of the NLW in 2016, had a sizeable effect in boosting hourly wage growth for the lowest paid workers. We find a large direct effect at the 5th percentile but also significant effects going up to the 30th percentile. In our preferred specification, we find that a 1 percentage point increase in the area share of minimum wage workers is associated with a 2-2.5% higher growth at the 5th percentile (in that area), 1.5-2% higher growth at the 10th percentile and 1-1.5% higher growth at the 30th percentile. Overall, the effect of minimum wage increases has been to compress hourly wage inequality in the bottom half of the distribution, with stronger effects in areas with more minimum wage workers. Our results confirm the previous findings of a significant negative effect of minimum wage increases on wage inequality. In contrast to the literature focusing on the introduction of the NMW, we also find significant spillover effects going up to the 30th percentile of the hourly wage distribution.

During the period we study, differences in weekly earnings growth across the distribution have shown less progressive change than hourly wage growth. This is consistent with employers adjusting hours, bonuses and/or overtime pay in reaction to strong hourly wage growth at the bottom. We find that area share of minimum wage workers is most strongly correlated with wage growth at the 10th percentile of the weekly earnings distribution with smaller (but still positive) effects at the 5th percentile. Our results are in line with previous research that has shown that minimum wage increases may adversely affect the hours worked by low paid workers (Stewart & Swaffield, 2008). Future research should examine which elements of weekly earnings are most affected by the increase of the minimum wage.

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