



Minimum Wage Effects on Reservation Wages

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Abstract

Reservation wages are part of the transmission mechanism between minimum wages and unemployment via the labour force participation decision. The limited available empirical evidence on the relationship between reservation wages and legal minimum wages suggest that individuals use minimum wages as benchmarks against which their reservation wages are set. This has a profound behavioural effect that may encourage individuals to either enter the labour force or price themselves out of potential employment. We employ a fuzzy regression discontinuity design to explore the influence of minimum wages on reservation wages. Our findings suggest that the behavioural response is too small to be extracted from the variability of the reservation wage data. For policy makers this finding is important. While minimum wages raise earnings and living standards, they can push some workers out of the labour force by increasing their reservation wage beyond the minimum. We do not find any evidence of such a response of the reservation wage of jobseekers to the minimum wage in the UK.

Keywords Minimum wages · Reservation wages · Fuzzy regression discontinuity · Participation rate · Unemployment · Employment

JEL classification: J21 · J23 · J31 · J38

Introduction

The effect of operating minimum wage laws on individuals' labour supply decisions is an under-researched area despite the extensive, theoretical and empirical, literature on the role of legal wage floors on labour demand (Belman and Wolfson

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2014; Neumark and Wascher 2008). Economic theory predicts that in competitive markets, minimum wages lead to employment losses, higher equilibrium wages and higher unemployment. In imperfect markets, employment gains can be observed provided firms have enough monopsony (oligopsony) power, the minimum wage is set above what the firm (monopsonist) would pay in its absence, and the minimum wage remains below the competitive wage level. Even if labour markets are broadly competitive, firms can still benefit from some monopsony power if search frictions are present, for example if worker relocation costs are large enough or if hiring costs are substantial (Manning 2003). Under such conditions, setting a minimum wage can lead to increases in employment, particularly if individuals' participation to the labour market is sensitive enough to the wage offered (Boeri and van Ours 2008).

In the presence of frictions, higher minimum wages induce some workers (back) into the labour force (supply effect) if the minimum wage is set above their reservation wage. Given that the reservation wage determines the participation rate, it is effectively part of a transmission channel on the supply side, that links minimum wages to employment. It is the interaction of this supply-side mechanism with the, better understood, demand-side transmission mechanism of the minimum wage to employment which determines the overall effect of the minimum wage on unemployment¹. A higher reservation wage contributes to non participation in less direct ways. For example in an environment where individuals search for work, it results in longer spells devoted to job seeking. This would contribute further to higher (voluntary) unemployment.

The impact of minimum wages on reservation wages has been largely overlooked in the labour supply literature mainly due to the lack of appropriate data. This gap is partially filled by Falk et al. (2006) and more recently (Fedorets et al. 2018). Using laboratory experiments, (Falk et al. 2006), show that minimum wages have a strong and positive influence on reservation wages. The authors argue that a government mandated wage is not only a legal minimum but acts as a benchmark for what workers come to perceive as a “fair” wage, giving rise to so called entitlement effects. Reservation wages are subsequently adjusted in tandem with the legal minimum. (Fedorets et al. 2018) use the German Socio-Economic Panel and present evidence that minimum wages have significant effects on both the observed and reservation wage distributions. The authors estimate an around 4% increase in reservation wages in the lower percentiles of the reservation wage distribution following the introduction of a minimum wage.

Koenig et al. (2021) consider minimum wages as a “reference” point in the determination of reservation wages in the context of their model explaining the “wage flexibility puzzle” - the disproportionate volatility of unemployment and wages over the business cycle. The direct impact of minimum wages on reservation wages is consistent with the authors' “backward-looking” individuals' decision making proposition. The interpretations of (Koenig et al. 2021) and (Falk et al. 2006) of minimum wages are similar despite arising from different vantage points. Both studies

¹ See Brown and Taylor 2011 and/or Gavrel et al. 2010 for some recent examples of the effect of minimum wages and legislative labour market conditions on unemployment.

view the minimum wage as a behaviour-changing external influence – whether the minimum is understood as an entitlement or a threshold wage value. In either case, the empirical questions concern the existence of an effect on the reservation wage of an increase to the minimum wage and the magnitude of that effect. Falk et al. (2006) suggest that labour market behaviour ought to confirm experimental findings. The present study follows in (Falk et al. 2006) line of enquiry using, however, observational field data to explore the role of minimum wages on individuals' reservation wage formation.

We use individual-level data drawn from the British Household Panel Survey (BHPS) from 1998 to 2008 and we focus our analysis on workers who are looking for work in a low-pay occupation. The BHPS data contains information which allows us to construct a credible measure of the reservation wage for these workers similarly to (Brown and Taylor 2013). We can then describe the association between the reservation wage and the regular up-rating of the UK National Minimum Wage. Formally we use a regression discontinuity (RD) design where the difference between last period's reservation wage and the current period minimum wage act as the scoring variable and the current reservation wage is the outcome of interest. We then exploit the premise that individuals in the neighbourhood of the threshold are otherwise comparable in terms of observed and unobserved characteristics so any differences in the reservation wage in the current period can be attributed to the effect of the National Minimum Wage. We find a positive and significant effect of the National Minimum Wage on reservation wages in the lower part of the skills distribution. In particular, individuals with reservation wages below the minimum increase their reservation wages by approximately 6%, compared to individuals whose reservation wages are above.

The contribution of our study is twofold. First, it confirms the theoretical insights which describe the effect of minimum wages on reservation wages and it explores the validity of existing laboratory results using observational data. Secondly, it contributes to the limited literature on the effects of minimum wages on reservation wages, and the determinants of the latter, by presenting empirical estimates of the relationship between the national minimum wage and reservation wages in the UK. Recent studies by (Krueger et al. 2011), (Krueger and Mueller 2012, 2014) and (Barbanchon et al. 2017) explore the effect of institutional factors on reservation wages but do not explicitly consider the effect of minimum wages. The effect of minimum wage laws on labour supply via the reservation wage matters both at the macro and micro levels. While minimum wages seek to raise living standards of those in low-pay employment, they should ensure that jobseekers do not price themselves out of employment at the same time.

The paper is organised as follows. The next two sections describe the data used and our modelling strategy, respectively. The following section presents a graphical analysis and our estimates of the main effects of interest with a discussion of the latter. The final section concludes.

Table 1 National minimum wage rates and monthly FT income, Y , (£)

Year Month	18–21 rate	% Δ	Y	ΔY	22+ rate	% Δ	Y	ΔY
1999 Apr	3.00		472.50		3.60		567.00	
2000 Oct	3.20	6.67%	504.00	31.50	3.70	2.78%	582.75	15.75
2001 Oct	3.50	9.37%	551.25	47.25	4.10	10.8%	645.75	63.00
2002 Oct	3.50	0.00%	551.25	0.000	4.20	2.44%	661.50	15.75
2003 Oct	3.80	8.57%	598.50	47.25	4.50	7.14%	708.75	47.25
2004 Oct	4.10	7.89%	645.75	47.25	4.85	7.78%	763.88	55.13
2005 Oct	4.25	3.66%	669.38	23.63	5.05	4.12%	795.38	31.50
2006 Oct	4.45	4.71%	700.88	31.50	5.35	5.94%	842.63	47.25
2007 Oct	4.60	3.37%	724.50	23.63	5.52	3.18%	869.40	26.78
2008 Oct	4.70	2.17%	740.25	15.75	5.73	3.80%	902.48	33.08
2009 Oct	4.83	2.77%	760.73	20.48	5.80	1.22%	913.50	11.03

Notes: Monthly income figures for Full Time (FT) employees are calculated as 37.5 hours \times 4.2 weeks \times the applicable NMW rate. Source: UK Low Pay Commission data

Data

The National Minimum Wage (NMW) was formally introduced in 1999, however, the adjustment process is likely to have started a year earlier following the announcement of the impending policy reform, hence we use 1998 as the beginning of the period when the NMW is in effect. The level and changes to the National Minimum Wage, since its introduction by the Labour government in 1999, is the decision of the UK government, in consultation with the Low Pay Commission. The Low Pay Commission is an independent body that submits a report to the government in October each year, making recommendations on the future level of the National Minimum Wage rates, and related matters². Table 1 below, summarises the UK National Minimum Wage rates for the sample period. The yearly percentage changes may be small in magnitude, especially in later years, however, we believe they are significant enough to induce a response change among survey participants. Arguably, it is the announcement of the uprating rather than the absolute NMW change that entices a revision of one's reservation wage. In that respect, even seemingly small increases generate significant responses.

We draw individual-level data from the British Household Panel Survey (BHPS), from 1998 to 2008³. Individual respondents (job seekers) are asked, firstly, what is the lowest net payment they would consider for taking up a job, and secondly, how many hours per week they would expect to work for that payment. From these two responses we construct a simple measure of individuals' reservation wage. We divide the lowest net payment required by the expected number of hours for that payment and convert the data to a 40-hour working week following Blackaby et al. (2007).

² There are 9 Low Pay Commissioners drawn from a range of employee, employer and academic backgrounds Low Pay Commission (2019)

³ In 2009 the BHPS sample was absorbed into the UK Household Longitudinal Study and the questions relevant to our study were discontinued.

Table 2 Table caption

Current economic activity	Does not report reservation wage	Reports reservation wage	Total
Unemployed	9,687 80.30%	2,377 19.70%	12,064
Inactive	51,775 93.82%	3,413 6.18%	55,188
Total	61,462 91.39%	5,790 8.61%	67,252

Source: BHPS, 1998-2008

Our sample consist of 18-65 year old individuals who are looking for work in a low-pay occupation (personal and protective services, sales, plant and machine operatives and other occupations), and who further satisfy the Lancaster and Chesher (1983) rationality restriction, which requires that reservation wages are greater than or equal to unemployment benefit payments and less than or equal to expected wages. We exclude individuals who report wages or reservation wages less than £1 (0.04% of the sample) on the basis that such a low figure ought to be erroneous. We also exclude those who are in work (either employed or self-employed) yet their records show a reservation wage (0.25% of the sample). Only individual respondents who do not have a job, and are actively looking for one, were asked the relevant questions and hence this information must be recorded in error. A measure of the respondents' expected wage is constructed using responses to two questions on the expected weekly net pay and hours committed for the job sought.

Following Brown and Taylor (2013), we include economically inactive individuals who report a reservation wage. Table 2 below reports the response rates to the relevant questions in our sample. In line with similar surveys (e.g. NLSY79), there is a low response rate raising concerns over sample selection issues. In Table 7 we report summary descriptive statistics for the response and non-response samples. The two groups are comparable in all key characteristics such as age, gender composition, educational attainment, and non-labour income among others.

Figures 1 and 2 present the distributions of the wage and reservation wage over the sample period⁴ for 22+ and 18-21 year old adults, respectively.

From Fig. 1 we see that the reservation wage distribution follows the wage distribution closely in all years suggesting that people are mindful of average wages in the economy. After 1998, while the two distributions never deviate greatly, the reservation wage distribution is clearly anchored to the NMW rate. Flinn (2006) makes the interesting theoretical prediction that “a binding minimum wage results

⁴ We go back to 1993 until 1997 for a comparison sample solely for descriptive purposes. For the comparison sample (when the NMW was not in effect), we could set the period to coincide with the start of the BHPS survey sample in 1991; however, we choose 1993 as the start following Butcher (2005) who argues for using 1993 as the start of the comparison period since Wage Councils were still in operation in 1992 and that year marks the end of the early 1990s recession.

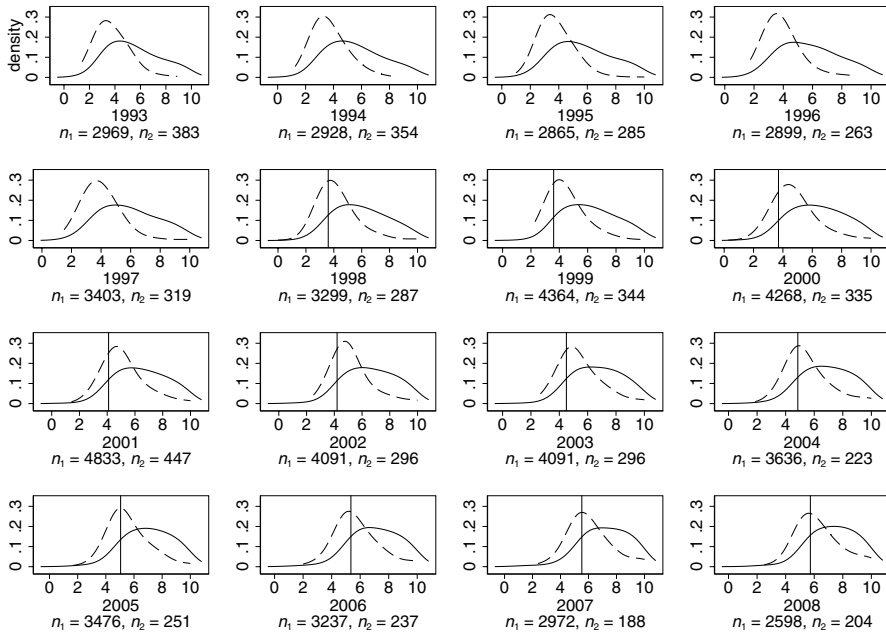


Fig. 1 Parametric estimates of the distributions of hourly wage (solid line, n_1) and reservation wage (dashed line, n_2) over time for 22+ year old adults in low wage occupations. Vertical lines mark the level of the National Minimum Wage

in a (positive-valued) wedge between the minimal acceptable wage imposed by the policy maker and the wage offer that a searcher would be willing to take” (Flinn 2006 p. 1021). The evidence appears to support this prediction. This is clearly seen for years 1999 to 2003 in Fig. 1 and for years 1999 to 2008 in Fig. 2. For years 2004 to 2008 in Fig. 1, we could interpret the observed reservation wage distribution as an indication that reservation wages either do not adjust upwards with each uprating or they are slow to do so. If we understand an individual’s reservation wage as a function of the discounted future stream of earnings (from employment), as in the context of a standard search model, then it becomes an implicit function of the wage offer distribution and the job offer arrival rate. The minimum wage affects the reservation wage positively through a right shift in the wage distribution and/or negatively through a reduction in the job offer arrival rate – the overall effect is *a priori* indeterminate and thus an empirical question.

Figure 2 shows a similar picture for the 18-21 year old jobseekers in so far as the alignment of the wage and reservation wage distributions is concerned. However, the reservation wage distribution is consistently centered to the right of the sub-minimum rate in line with the theoretical proposition of Flinn (2006) model. It may reflect the older jobseekers’ greater need for labour income and/or young jobseekers’ greater valuation of non-labour time – younger people will value non-labour time higher if it can be devoted to education and/or training (the opportunity cost of which is lower to them).

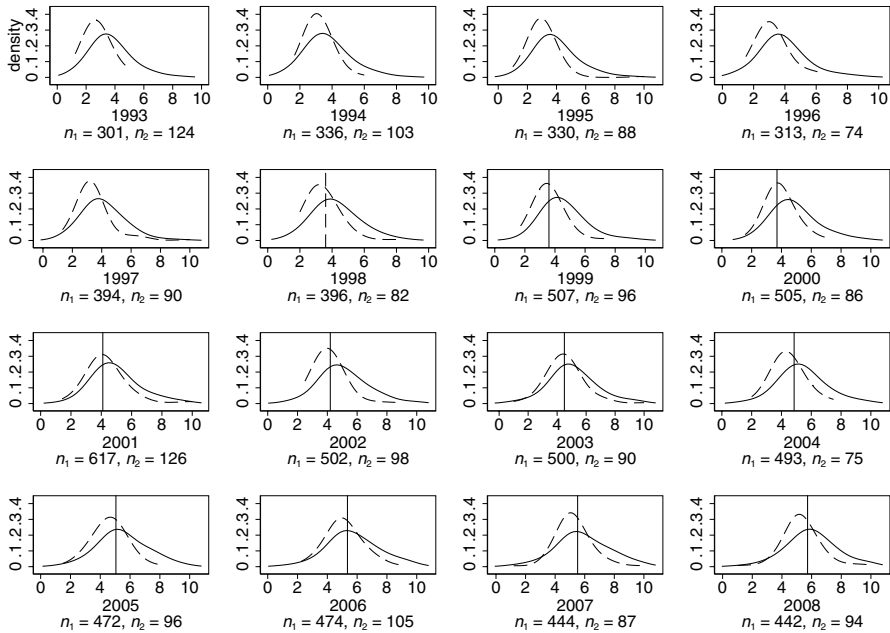


Fig. 2 Parametric estimates of the distributions of hourly wage (solid line, n_1) and reservation wage (dashed line, n_2) over time for 18-21 year old adults in low wage occupations. Vertical lines mark the level of the National Minimum Wage

Overall, the empirical distributions of the reservation and actual wages are aligned. Since the introduction of the legal minimum, the reservation wage distribution is centered to the left of the wage distribution and closer to the minimum wage value. The NMW rates appear to act as an anchor or reference point (also in line with Koenig et al. (2021) proposition) for the determination of the reservation wage. To reinforce the proposition that minimum wages act as a benchmark for reservation wages, Fig. 3 plots the median reservation wage against the minimum wage over time. The former clearly converges to the legal minimum for both the 18-21 and 22+ year old jobseekers.

Empirical Strategy

If jobseekers use the NMW as a reference point or as an anchor for their reservation wage formation, then the NMW matters. However, it will matter only (or more) for those individuals whose reservation wage in period $t - 1$, w'_{t-1} , is below the NMW in period t , i.e., whenever $w'_{t-1} < \underline{w}_t$, where w' and \underline{w} denote the reservation and minimum wage, respectively. If we understand $x_{t-1} \equiv \underline{w}_t - w'_{t-1}$ as a non-random “scoring” variable and define a threshold value (in this context 0), we could assign individuals into two groups, a first group where the binary variable T is $T = 1$ whenever $x_{t-1} = \underline{w}_t - w'_{t-1} \geq 0$ and a second group such that $T = 0$ whenever $x_{t-1} = \underline{w}_t - w'_{t-1} < 0$, and in period t , we would expect the reservation wage of individuals in the first group to be different from

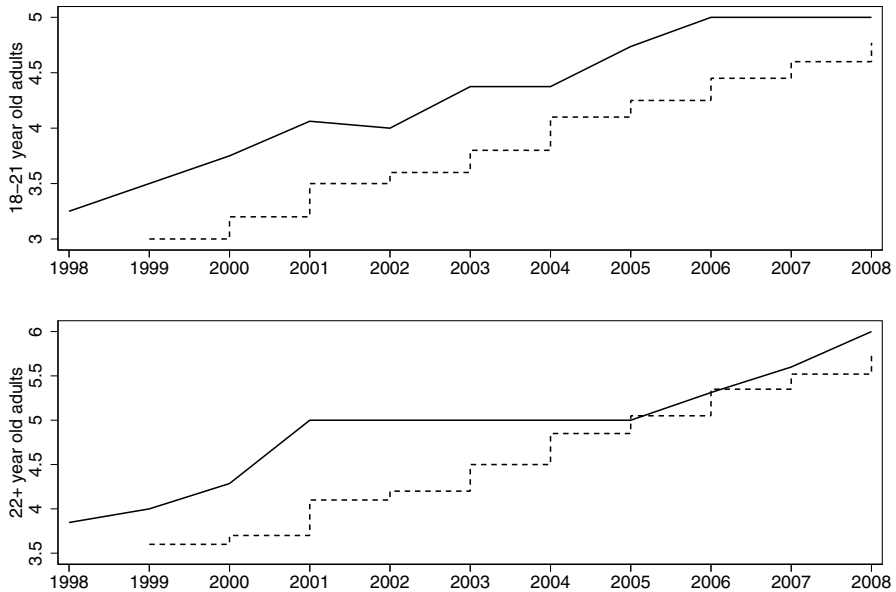


Fig. 3 Median hourly reservation wage (solid line) and National Minimum Wage (short dash line) over time for 18-21 (upper), and 22+ (lower) year old adults

the reservation wage of individuals in the second group. Because the scoring variable is predetermined and can not be manipulated, around the threshold value of 0 the difference in reservation wage between the two groups measures the reservation wage increase in the current period in response to an increase of the national minimum wage such that x_{t-1} takes its values close to 0.

This is the essence of the Regression Discontinuity (RD) design, which works similarly to a randomised experiment but where the assignment to the control or treatment groups is now based on a non-random variable. In the RD case, assignment is exogenous conditional on the scoring (other common names are *forcing* or *running*) variable. RD exploits the premise that individuals in the neighborhood of the threshold are otherwise comparable in terms of observed and unobserved characteristics so any differences in outcomes can be attributed to the effect of the “treatment” Dunning (2012).

There are several factors that affect the reservation wage⁵ and that are not captured by the NMW rate. If a job-seeker’s reservation wage is below next period’s minimum, she is likely to (but not compelled to) increase her/his reservation wage to or above the minimum – the reservation wage question asks for the lowest acceptable wage rather than the lowest expected wage⁶. Similarly, workers with a reservation wage at time $t - 1$ greater than the minimum wage in period t , are likely

⁵ The reservation wage can be understood as the marginal rate of substitution between consumption and labour supply at the non participation corner solution to an individual’s utility maximisation problem.

⁶ This line of reasoning appears at odds with Flinn (2006) theoretical prediction, however, his model does not allow for compensation other than the wage, which could arguably affect individuals’ reservation wage.

to respond less, if at all, to the NMW increase⁷. To capture this possibility we consider that the group of interest, the treated group, is the group of individuals with a reservation wage above the NMW. This defines the binary variable D_t which is such that $D_t = 1$ if $\underline{w}(t) > w^r(t)$, and 0 otherwise. Our interest is then to measure the reservation wage increase among those who set their reservation value below the current minimum wage.

Unlike in situations where “treatment” can be effectively monitored (and implemented), in this context some individuals with reservation wages below next period’s NMW may not subsequently adjust their wage demands and/or individuals with reservation wages above next period’s NMW may do⁸. When the probability of being in the “affected” or “treated” group⁹ does not deterministically change from 1 to 0 at the threshold, $x_{t-1} = 0$ where $w^r_{t-1} = \underline{w}_t$, the discontinuity is referred to as *fuzzy* and the design is called fuzzy RD. In a fuzzy RD design, the exogeneity of assignment created by the running (or scoring) variable and its threshold, is maintained.

Angrist and Pischke (2008) formalise this idea and present the general fuzzy RD set up, which we adapt here. Considering that the assignment to “treatment” or control group is no longer clear cut – in the fuzzy RD design, it is not receipt of treatment that changes at the threshold but rather the probability of receiving the treatment – we can define a potential “treatment” receipt indicator as (note that we drop the implied i subscript to index individuals throughout):

$$P(D_t = 1|x_{t-1}) = \begin{cases} f_1(x_{t-1}), & \text{if } x_{t-1} < 0; \\ f_0(x_{t-1}), & \text{if } x_{t-1} \geq 0; \end{cases} \tag{1}$$

where $x_{t-1} = w^r_{t-1} - \underline{w}_t$. The relationship between receiving the “treatment” and the scoring (running) variable, x_{t-1} , can be described by:

$$E[D_t|x_{t-1}] = P(D_t = 1|x_{t-1}) = f_0(x_{t-1}) + [f_1(x_{t-1}) - f_0(x_{t-1})]T_t, \tag{2}$$

where T_t is the binary variable which indicates the location of the individual relative to the threshold, $T_t = 1(x_{t-1} > 0)$. T_t can be understood as an “intent-to-treat” indicator.

If we further define potential outcomes as

$$E[w^r_{0t}|x_{t-1}] = \beta_0 + g_0(x_{t-1}), \tag{3}$$

$$w^r_{1t} = w^r_{0t} + \delta, \tag{4}$$

where g_0 is a continuous function, we can specify a regression model such as

⁷ We could expect that some effects ripple up the reservation wage distribution mainly in response to employers maintaining a differential in the actual wages.

⁸ This can also be understood as “imperfect compliance” Lee and Lemieux (2009).

⁹ By “treatment” or being in the “treated” group we mean reporting a reservation wage at period t , greater than that reported in period $t - 1$.

$$w_t^r = \beta_0 + g_0(x_{t-1}) + \delta D_t + \varepsilon_t \quad (5)$$

where δ is the causal effect of interest, which cannot, however, be directly uncovered by Eq. 5 since D_t is a deterministic function of x_{t-1} . Angrist and Pischke (2008) show that T_t can be used as an instrumental variable for D_t to obtain consistent and unbiased estimates of δ , using a Two Stage Least Squares (2SLS) Instrumental Variable (IV) estimator.

Assuming that $f_i(x_{t-1})$ can be adequately described by polynomials of some order¹⁰ (to be determined empirically), we can describe Eq. 2 with a series of polynomial terms and their interactions with T_t , which can all be used as instruments for D_t in a regression model such as Eq. 5 Angrist and Pischke (2008).

The RDD estimator will be unbiased as long as the functional form of the relationship between the outcome and the scoring variables is correctly specified. In the current set up, we expect the relationship between the reservation wage and the scoring variable to vary systematically with scores (values of x_{t-1}). Individuals with higher scores i.e. jobseekers with reservation wages 'far' (to the left) from the current minimum, are expected to adjust their reservation wages more or be more likely to respond to the NMW uprating. Accordingly, we expect those with reservation wages close (to the left or right) to the minimum i.e. low scores, not to adjust their reservation wages much, if at all¹¹. This gives rise to a nonlinear relationship between w_t^r and x_{t-1} .

In the absence of any theoretical justification for such a relationship or guidance as to the true shape of the relationship, the choice of functional form is an empirical question. Gelman and Imbens (2018) recommend that local linear or quadratic polynomials are used for the functional form of $f_i(x_{t-1})$. We test the appropriate form of function $f_i(x_{t-1})$ following Lee and Lemieux (2009). We conduct F-tests for a series of model specifications to determine which best fits the data. We conclude that a second-order polynomial specification that includes interaction terms with the treatment variable is adequately describing the relationship between the outcome and scoring variables¹².

The model we therefore estimate is given by the first-stage equation:

$$D_t = \zeta_0 + \zeta_1 x_{t-1} + \zeta_2 x_{t-1}^2 + \tau_0 T_t + \tau_1 x_{t-1} T_t + \tau_2 x_{t-1}^2 T_t + u_{1t} \quad (6)$$

and the fuzzy RD reduced-form, which we get by substituting Eqs. 6 into Eqs. 5:

$$w_t^r = \gamma_0 + \gamma_1 x_{t-1} + \gamma_2 x_{t-1}^2 + \theta_0 T_t + \theta_1 x_{t-1} T_t + \theta_2 x_{t-1}^2 T_t + \varepsilon_t \quad (7)$$

¹⁰ Angrist and Pischke (2008) show the general case of a p -th order polynomial.

¹¹ If the NMW acts as a benchmark, individuals (closely) above the threshold may increase their reservation wage in order to maintain their relative distance from it. Table 9, in the appendix, provides descriptive statistics for those respondents ± 0.5 from the cutoff value of the scoring variable. These summary measures reassure us that respondents on either side of the threshold are similar in most key characteristics

¹² We don't report details of the tests here for brevity but these are available from the authors upon request.

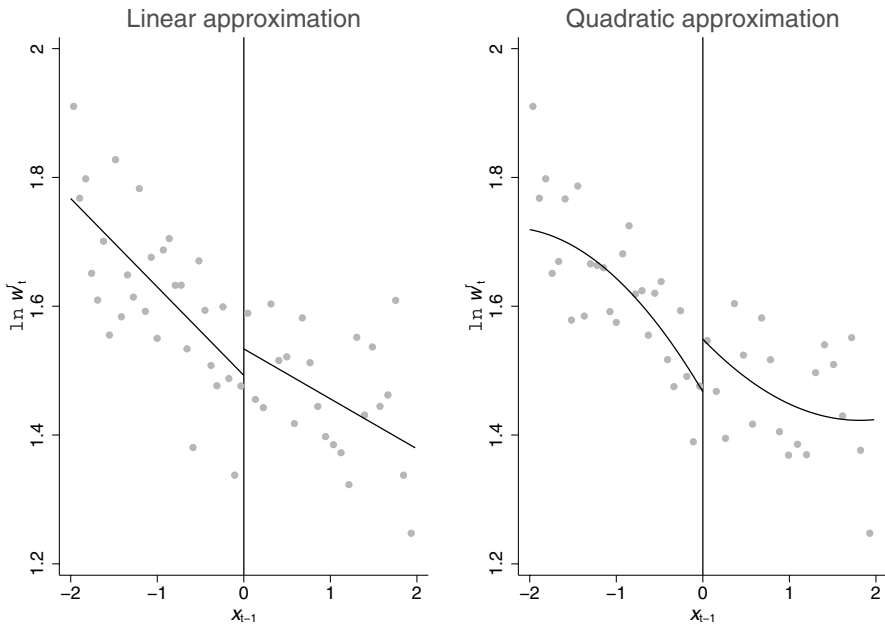


Fig. 4 Conditional expectation of the outcome variable, the natural logarithm of w_t^r , given the scoring variable $x_{t-1} = w_t - w_{t-1}^r$ for the control (to the right of the cut-off, $n_+ = 612$) and treatment (to the left of the cut-off, $n_- = 540$) groups. The support of x_{t-1} is restricted to $[-2, 2]$ for clarity. The solid grey circles (dots) represent means of sub-samples of variable sizes, defined by the optimal bin widths 0.082 (to the left of the cut-off point) and 0.067 (to the right of the cut-off point). The data comes from the estimation sample (1998–2008), which consists of 18–65 year old individuals who are looking for work in a low-pay occupation and who further satisfy the Lancaster and Chesher (1983) rationality restriction

where $\gamma_i = \beta_i + \delta\zeta_i$, and $\theta_i = \delta\tau_i$. Identification rests in the ability to distinguish between the (continuous) trend relationship described by the polynomial approximation and the discontinuous $T_t = 1(x_{t-1} > 0)$ step function.

Estimation is carried out using the 1998–2008 sample accounting for within-individual correlation of the errors over time using clustered standard errors following Lee and Lemieux (2009). Whenever additional controls are included in the specification, we follow (Koenig et al. 2021 p. 21) and include available variables pertinent to reservation wage determination. Table 8, in the Appendix, provides summary measures of the estimation sample.

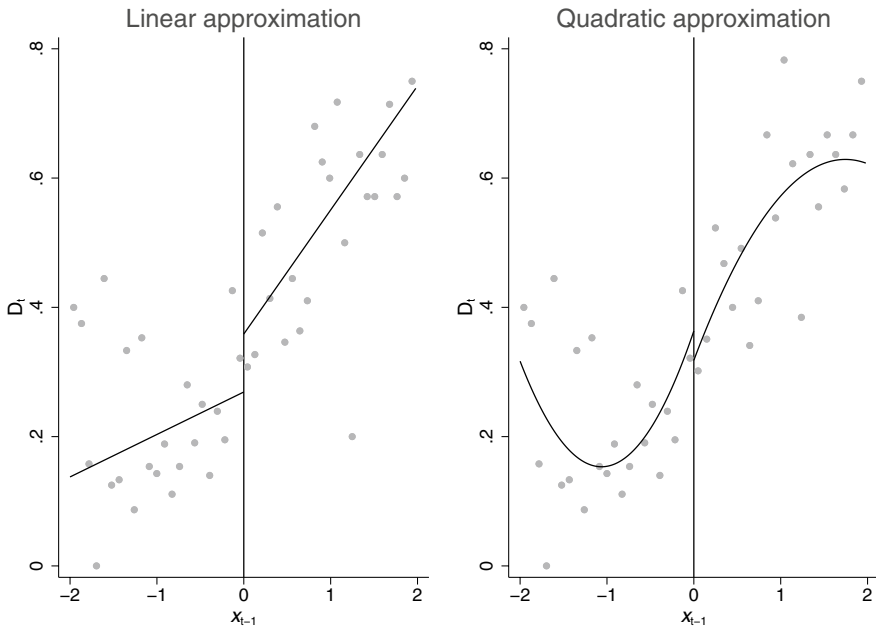


Fig. 5 Conditional expectation of the treatment indicator variable, D_t , given the scoring variable $x_{t-1} = w_t - w_{t-1}^r$ for the control (to the right of the cut-off, $n_+ = 616$) and treatment (to the left of the cut-off, $n_- = 547$) groups. The support of x_{t-1} is restricted to $[-2, 2]$ for clarity. The solid grey circles (dots) represent means of sub-samples of variable sizes, defined by the optimal bin widths 0.082 (to the left of the cut-off point) and 0.091 (to the right of the cut-off point). The data comes from the estimation sample (1998–2008), which consists of 18–65 year old individuals who are looking for work in a low-pay occupation and who further satisfy the Lancaster and Chesher (1983) rationality restriction

Results and Discussion

Graphical Analysis

Lee and Lemieux (2009) argue for the importance of graphical exploration and representation of RD designs and (Calonico et al. 2015 p. 1754) suggest appropriate RD plots to be used. In particular, a graph can (a) reveal discontinuities away from the cut-off point, which would invalidate the RD design and (b) describe the data variability. Such data features could be concealed by a simple scatterplot of raw data. Figure 4 is a typical RD plot and has two elements. The first depicts a smooth approximation of the conditional expectation of the outcome variable (the natural logarithm of w_t^r) given the scoring variable, $x_{t-1} = w_t - w_{t-1}^r$, for the control and 'treatment' groups separately. The second element is a set of means of sub-samples, defined by a specified bin width. Calonico et al. (2015, 2014) describe in detail different approaches in the construction of these bins and suggest optimal data-driven

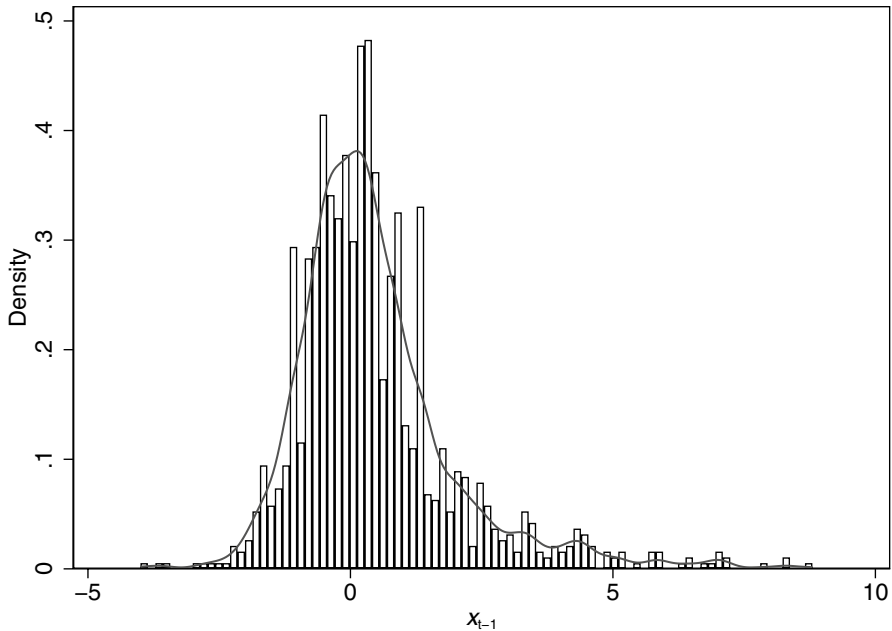


Fig. 6 Density of the scoring variable, x_{t-1} , using data from the estimation sample (1998–2008), which consists of 18–65 year old individuals who are looking for work in a low-pay occupation and who further satisfy the Lancaster and Chesher (1983) rationality restriction. A Gaussian kernel function is used for the kernel density estimate. The number of bins is set to 90

procedures, which we follow here¹³. What we are looking for is clear evidence of a discontinuity (jump) in the conditional mean of the outcome variable around the cut-off point. Figure 4 shows a (relatively) small yet clear discontinuity at the threshold and confirms that there are no other jumps in the conditional expectation of $w_t^r | x_{t-1}$, which implies that the discontinuity can be understood as the causal effect of the “intended treatment.”

Figure 5 illustrates the observed association between the scoring variable x_{t-1} and D_t . The discontinuity (jump) of the conditional mean of the binary variable D_t around the cut-off point is clearly visible. This indicates that in the Fuzzy discontinuity design, T_t will have substantial explanatory power for D_t , i.e. it is not a weak instrument. Finally, from Fig. 6 we see that there is no discontinuity in the distribution of the scoring variable at the threshold value. McCrary (2008) suggests that in some instances, individuals may “manipulate” the forcing variable, if the threshold is known, which would invalidate the RDD. In the current setting this is highly unlikely since we do not expect individuals to report reservation wages this period below next period’s NMW rate on purpose. As expected, Fig. 6 confirms our belief.

¹³ Figure 7, in the appendix, plots the outcome against the scoring variable for different bin sizes.

Table 3 Sharp RD estimates of the effect of the NMW on reservation wages (1998–2008)

	Discontinuity Samples										
	±2					±5					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
δ	-0.011 (0.025)	0.078 (0.087)	0.005 (0.050)	-0.012 (0.024)	-0.004 (0.022)	-0.048 (0.048)	-0.024 (0.047)	0.033 (0.041)	0.002 (0.029)	0.002 (0.028)	-0.005 (0.026)
x_{t-1}	0.070*** (0.013)	0.262 (0.360)	0.023 (0.092)	0.064*** (0.012)	0.083*** (0.011)	0.065* (0.030)	0.057 (0.029)	0.084*** (0.025)	0.074*** (0.014)	0.070*** (0.014)	0.085*** (0.013)
x^2_{t-1}	0.006 (0.003)	1.354 (1.777)	0.258 (0.187)	0.004 (0.003)	-0.003 (0.003)	-0.011 (0.009)	-0.009 (0.009)	-0.015 (0.008)	0.007 (0.004)	0.005 (0.003)	-0.001 (0.003)
Additional controls				✓	✓		✓	✓		✓	✓
Time Fixed Effects					✓			✓			✓
Observations	1287	204	467	1285	1285	268	268	268	1019	1017	1017

^a The dependent variable is the natural logarithm of the reservation wage
^b Additional controls: gender (male = 1), age at interview and its square term, marital status (married = 1), 2+ children in household, whether receiving housing benefit, the natural logarithm of the 16+ national unemployment rate, unemployment duration (weeks), five educational qualifications dummies (excluded category is Still at school/No QI) and eleven government office region dummies (excluded category is Northern Ireland)
^c Standard errors are clustered at the individual level
^d Data source: University of Essex. Institute for Social and Economic Research. (2018). British Household Panel Survey: Waves 1-18, 1991-2009. [data collection]. 8th Edition. UK Data Service. SN:5151, <http://doi.org/10.5255/UKDA-SN-5151-2>
^e All estimations are carried out for $0.7 \leq \ln w^i_t \leq 2.8$ and $|x_{t-1}| < 5$ to deal with outliers
^f * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Estimates

In this section we present the estimates of the ‘sharp’ regression discontinuity design and the estimates of the ‘fuzzy’ regression discontinuity design we describe in the previous section. In Table 3, column (1), we present the sharp RD estimation results for the whole sample in the absence of any additional controls. We then proceed and present the results for the data near the threshold value for x_{t-1} in columns (2) and (3), within a distance of 0.2, resp. 0.5, from 0. Next we focus on the whole data controlling for individual characteristics, column (4), adding time fixed effects, column (5). In principle the absence of control variables does not affect the ability of the sharp design to identify the effect of the treatment at the threshold. Adding controls however can improve the precision of the RD estimator if the controls contribute to increasing the signal to noise ratio.

The last six columns present the estimation results, without or with some or all controls, for the sub-sample of individuals covered by the national minimum wage rules for those aged less than 21 and for the sub-sample of individuals older than 22. The point estimates are systematically small (in absolute value they are always less than 0.08) and given the estimated standard error they are not precise enough to distinguish them from the value of 0. Adding controls has the expected effect of reducing the estimated standard errors. This is not sufficient for us to modify the conclusion that according to the sharp RD design an increase to the NMW does not have a measurable effect on the individual reservation wage.

The estimates based on local-polynomial regressions, see Table 4, provide a similar picture. The estimates are in general too imprecise to conclude for a noticeable effect of the NMW on the reservation wage except if we restrict our attention to observations within 0.5 of the threshold or if we focus on the younger sub-sample. In the former case the effect increases from 15% to 34% with the use of bias correction. The use of a robust version of the estimator based on local-polynomial regressions does not change the conclusion. The estimates based on the younger sub-sample show large effects of the NMW on the reservation wage, around 30%, in the absence of controls. Adding demographic controls reduces the estimated effect to about 19%, and increases the estimated standard errors. Controlling both for demographic and time specific effects reduces the estimated value further and suggests that the estimated effect is not measured precisely enough to draw a clear cut conclusion about its value or its sign.

Given our definition of D_t , i.e. $D_t = 1$ if $\underline{w}_t \geq w^r(t)$, we estimate model Eqs. 5 using 2SLS as discussed in the previous section. Table 5 presents our findings in the same manner we presented the results for the sharp RD design. Hence we present estimates with or without controls, as well as estimates obtained on the sub-sample of observation such that the scoring variables are close to the threshold (resp. within 0.2 or 0.5 of the threshold), or the sub-sample of individuals younger than 21 or older than 22. Overall, the estimated values for δ are too imprecisely estimated to be able to draw any sharp conclusion concerning the absolute magnitude or sign. Table 6 presents estimates of δ based on local polynomial regressions. Again these estimates are characterised by large standard errors (in some cases extremely so) which suggest that the effect of the NMW on the reservation wage is close to zero. We further estimate

Table 4 Sharp RD Estimates of δ (local-polynomial regression), 1998–2008

	Discontinuity Samples										
	± 2					± 5					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Conventional	-0.072 (0.053)	-0.287 (0.157)	-0.151* (0.077)	-0.044 (0.049)	0.004 (0.046)	-0.109 (0.074)	-0.067 (0.074)	-0.001 (0.068)	-0.057 (0.066)	-0.036 (0.061)	0.015 (0.057)
Bias-corrected	-0.130* (0.053)	-0.126 (0.157)	-0.338*** (0.077)	-0.124* (0.049)	-0.035 (0.046)	-0.298*** (0.074)	-0.199** (0.074)	-0.062 (0.068)	-0.078 (0.066)	-0.113 (0.061)	-0.033 (0.057)
Robust	-0.130 (0.073)	-0.126 (0.243)	-0.338** (0.122)	-0.124 (0.068)	-0.035 (0.065)	-0.298*** (0.091)	-0.199* (0.094)	-0.062 (0.093)	-0.078 (0.091)	-0.113 (0.084)	-0.033 (0.077)
Additional controls		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time Fixed Effects			✓		✓		✓		✓		✓
Observations	1287	204	467	1285	1285	268	268	268	1019	1017	1017
Order Loc. Pol.	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
Kernel Type	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform

^a The dependent variable is the natural logarithm of the reservation wage

^b Additional controls: gender (male = 1), age at interview and its square term, marital status (married = 1), 2+ children in household, whether receiving housing benefit, the natural logarithm of the 16+ national unemployment rate, unemployment duration (weeks), five educational qualifications dummies (excluded category is Still at school/No Qf) and eleven government office region dummies (excluded category is Northern Ireland)

^c Standard errors are clustered at the individual level

^d Data source: University of Essex. Institute for Social and Economic Research. (2018). British Household Panel Survey: Waves 1-18, 1991-2009. [data collection]. 8th Edition. UK Data Service. SN:5151, <http://doi.org/10.5255/UKDA-SN-5151-2>

^e All estimations are carried out for $0.7 \leq \ln w_i^r \leq 2.8$ and $|x_{i-1}| < 5$ to deal with outliers

$t^*p < 0.05$, $**p < 0.01$, $***p < 0.001$

Table 5 Fuzzy RD estimates of the effect of the NMW on reservation wages (1998–2008)

	Discontinuity Samples										
	±2					±.5					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
δ	0.091 (0.161)	-0.275 (0.726)	0.054 (0.199)	0.108 (0.156)	0.140 (0.145)	-0.462 (0.500)	-0.457 (0.511)	-0.104 (0.305)	0.119 (0.164)	0.083 (0.176)	0.197 (0.168)
x_{t-1}	0.060* (0.027)	-0.023 (0.219)	-0.004 (0.082)	0.052* (0.025)	0.064** (0.022)	0.155* (0.079)	0.122 (0.068)	0.081* (0.040)	0.055* (0.027)	0.057* (0.027)	0.060* (0.024)
x^2_{t-1}	0.008 (0.005)	-0.096 (3.270)	0.238 (0.187)	0.006 (0.004)	0.000 (0.004)	-0.028 (0.018)	-0.022 (0.017)	-0.014 (0.010)	0.009* (0.005)	0.007 (0.005)	0.002 (0.004)
Additional controls				✓	✓		✓	✓		✓	✓
Time Fixed Effects					✓			✓			✓
Observations	1287	204	467	1285	1285	268	268	268	1019	1017	1017

^a The dependent variable is the natural logarithm of the reservation wage

^b Additional controls: gender (male = 1), age at interview and its square term, marital status (married = 1), 2+ children in household, whether receiving housing benefit, the natural logarithm of the 16+ national unemployment rate, unemployment duration (weeks), five educational qualifications dummies (excluded category is Still at school/No QF) and eleven government office region dummies (excluded category is Northern Ireland)

^c Standard errors are clustered at the individual level

^d Data source: University of Essex. Institute for Social and Economic Research. (2018). British Household Panel Survey: Waves 1-18, 1991-2009. [data collection]. 8th Edition. UK Data Service. SN:5151, <http://doi.org/10.5255/UKDA-SN-5151-2>

^e All estimations are carried out for $0.7 \leq \ln w^*_t \leq 2.8$ and $|x_{t-1}| < 5$ to deal with outliers

^f * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6 Fuzzy RD Estimates of δ (local-polynomial regression), 1998–2008

	Discontinuity Samples										
	± 2					± 5					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Conventional	-0.635 (0.869)	-1.004 (1.106)	22.066 (383.664)	-0.345 (0.573)	0.064 (0.641)	-6.376 (55.191)	-2.454 (14.878)	-0.012 (1.049)	-0.457 (0.839)	-0.233 (0.503)	0.345 (1.035)
Bias-corrected	-1.644 (0.869)	-0.600 (1.106)	972.084* (383.664)	-1.224* (0.573)	-0.462 (0.641)	-98.278 (55.191)	-22.262 (14.878)	-0.969 (1.049)	-0.871 (0.839)	-0.831 (0.503)	-0.249 (1.035)
Robust	-1.644 (1.129)	-0.600 (1.663)	972.084 (528.340)	-1.224 (0.771)	-0.462 (0.909)	-98.278 (67.645)	-22.262 (19.344)	-0.969 (1.427)	-0.871 (1.123)	-0.831 (0.684)	-0.249 (1.435)
Additional controls				✓	✓		✓	✓		✓	✓
Time Fixed Effects					✓			✓			✓
Observations	1287	204	467	1285	1285	268	268	268	1019	1017	1017
Order Loc. Pol.	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
Kernel Type	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform

^a The dependent variable is the natural logarithm of the reservation wage

^b Additional controls: gender (male = 1), age at interview and its square term, marital status (married = 1), 2+ children in household, whether receiving housing benefit, the natural logarithm of the 16+ national unemployment rate, unemployment duration (weeks), five educational qualifications dummies (excluded category is Still at school/No Qf.) and eleven government office region dummies (excluded category is Northern Ireland)

^c Standard errors are clustered at the individual level

^d Data source: University of Essex. Institute for Social and Economic Research. (2018). British Household Panel Survey: Waves 1-18, 1991-2009. [data collection]. 8th Edition. UK Data Service. SN:5151, <http://doi.org/10.5255/UKDA-SN-5151-2>

^e All estimations are carried out for $0.7 \leq \ln w_t^i \leq 2.8$ and $|x_{t-1}| < 5$ to deal with outliers

^f * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

all specification with an alternative (placebo) discontinuity threshold set arbitrarily at the NMW level + £2. With the exception of the ∓ 0.5 sample in the restricted (no additional controls) specification using 2SLS, all other estimates of δ are statistically insignificant as expected. These estimates confirm the validity of the discontinuity threshold defined by the actual NMW level. We do not include the full set of results at the placebo threshold, but these are available from the authors upon request.

Because of their lack of precision and despite not being directly comparable, our findings do not contradict the very limited available empirical evidence in the literature. Experimental findings reported by Falk et al. (2006) support the proposition that the introduction of minimum wages leads to an upward revision of reservation wages. Fedorets et al. (2018) find that minimum wages cause a 4% increase in reservation wages in the lower end of the distribution. Falk et al. (2006) interpret their estimates as evidence of a behavioural effect of economic policy. Our findings suggest that the behavioural response is too small to be extracted from the variability of the reservation wage data. For policy makers this finding is important. While minimum wages intend to raise earnings and living standards, they can push some workers out of the labour force by increasing their reservation wage beyond the minimum. We do not find any evidence of such a response of the reservation wage of jobseekers to the minimum wage in the UK.

Conclusion

Although the effect of operating minimum wage laws on labour demand has been extensively researched in the literature, their influence on the decision to enter the labour market has remained largely unexplored due to the unavailability of direct data on reservation wages. Our study tests inferences from theory about the effect of minimum wages on reservation wages and explores the validity of existing laboratory results using observational data. It also contributes to the very scant literature of the influence of minimum wages on job seekers' reservation wages. Our results suggest that minimum wages and their periodic increases do not have a positive effect on reservation wages. We motivate this result by the work of Falk et al. (2006) who through experiments, support the proposition that the introduction of minimum wages leads to an upward revision of significant effect on reservation wages. Our estimates suggest that a positive and statistically significant effect can be identified only near the discontinuity threshold.

Despite statistically insignificant, the estimated effect is greater in magnitude for 18–21 year old job seekers suggesting that younger job seekers align their reservation wage with the NMW more than older ones do. This is not surprising if we consider that younger people would have less labour market experience and thus use the NMW as a “reference” point. Older adults while influenced by the NMW are more likely to take into account a variety of factors when deciding on their reservation wage. For policy makers this means that job seekers may well use the NMW as a way of obtaining labour market and wage information (particularly younger ones), hence the NMW becomes/is an expectation forming “reference” point.

Appendix

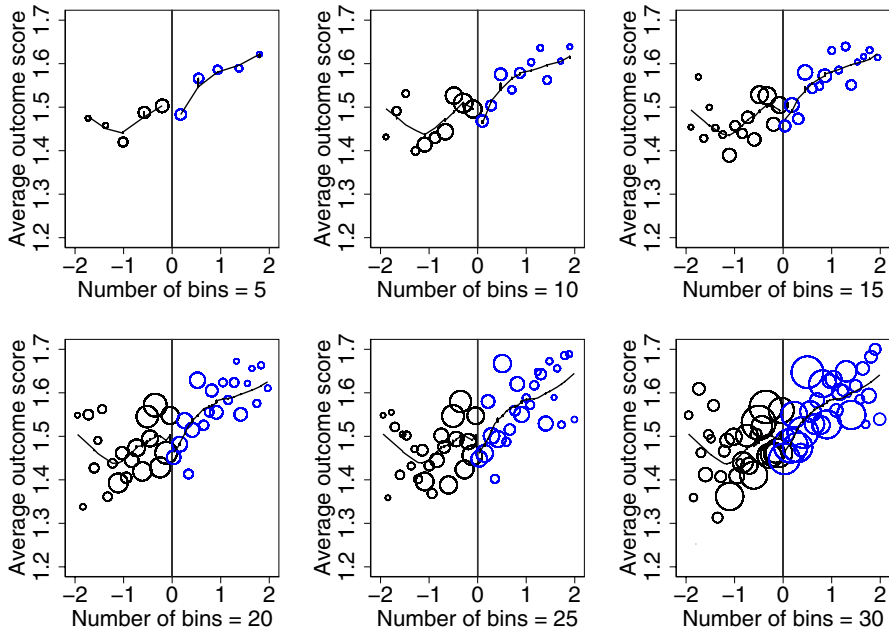


Fig. 7 Smoothed plots of decreasing bin width. The x -axis is the average of the scoring variable, x_{t-1} based on the respective bin size. Each circle represents the mean of each bin, which is weighted by the number of observations in the bin, so the size of the circle represents the number of observations in that bin. A lowess line is superimposed as a visualisation aid. The number of bins to the left and to the right of the cutoff point is indicated at the bottom of each panel. The average bin length is 0.4 when $J=5$ bins are used, 0.2 for $J=10$, 0.13 for $J=15$, 0.1 for $J=20$, 0.08 for $J=25$, and 0.067 for $J=30$

Table 7 Summary statistics according to the reported status of the reservation wage, 1998–2008

Variable	Reported w_t^r			Not reported w_t^r		
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Age at interview	5790	34.259	12.413	61462	36.162	13.643
Male	5790	0.4212	0.4938	61018	0.3825	0.486
Female	5790	0.5788	0.4938	61018	0.6175	0.486
Single	5790	0.6623	0.4729	61462	0.8339	0.3722
Married or Cohabiting	5790	0.3377	0.4729	61462	0.1661	0.3722
No Children in Household	5790	0.475	0.4994	22424	0.549	0.4976
One Child in Household	5790	0.2104	0.4076	22424	0.1894	0.3918
Two or more Children in Household	5790	0.3147	0.4644	22424	0.2616	0.4395
Housing benefit (Yes = 1)	5790	0.2824	0.4502	21378	0.1972	0.3979
Weeks in current spell (unemployed)	5774	37.951	20.664	20726	45.580	15.858
Non-labour income: last month	5790	385.95	378.17	21378	427.35	548.23
16+ unemployment rate	5790	5.3434	0.4251	61462	5.3438	0.4292
Expected hourly wage (jobseekers)	5033	5.6938	3.2562	162	5.9552	5.1093
Reservation wage (jobseekers)	5663	5.1821	2.5002			
Higher Degree	5790	0.0062	0.0786	22424	0.0121	0.1093
First Degree	5790	0.0352	0.1844	22424	0.0536	0.2252
Teaching Qf	5790	0.0043	0.0656	22424	0.0105	0.1018
Other Higher Qf	5790	0.1568	0.3637	22424	0.1361	0.343
Nursing Qf	5790	0.0059	0.0764	22424	0.0116	0.1073
Gce A Levels	5790	0.1637	0.3701	22424	0.1844	0.3879
Gce O Levels Or Equiv	5790	0.2225	0.4159	22424	0.1584	0.3651
Commercial Qf, No O Levels	5790	0.0192	0.1371	22424	0.0223	0.1478
Cse Grade 2-5, Scot Grade 4-5	5790	0.0648	0.2461	22424	0.0376	0.1903
Apprenticeship	5790	0.0116	0.1070	22424	0.0108	0.1035
Other Qf	5790	0.0161	0.1257	22424	0.01	0.0997
Missing Or Wild	5790	0.0055	0.0741	22424	0.0065	0.0802
North East	5790	0.0418	0.2001	22424	0.0288	0.1673
North West	5790	0.0689	0.2533	22424	0.072	0.2585
Yorkshire & Humber	5790	0.0534	0.2248	22424	0.0589	0.2354
East Midlands	5790	0.0727	0.2597	22424	0.0523	0.2227
West Midlands	5790	0.0601	0.2377	22424	0.0486	0.2151
East Of England	5790	0.0318	0.1754	22424	0.0507	0.2193
London	5790	0.034	0.1813	22424	0.0469	0.2115
South East	5790	0.0651	0.2467	22424	0.0602	0.238
South West	5790	0.038	0.1912	22424	0.0467	0.2111
Wales	5790	0.163	0.3694	22424	0.1768	0.3815
Scotland	5790	0.1798	0.3840	22424	0.1767	0.3814

Table 8 Summary Statistics, 1998–2008

Variable	Obs	Mean	Std. Dev.
Age at interview	67252	35.999	13.552
Male	66808	0.3859	0.4868
Female	66808	0.6141	0.4868
Single	67252	0.8191	0.3849
Married or Cohabiting	67252	0.1809	0.3849
No Children in Household	28214	0.5338	0.4989
One Child in Household	28214	0.1937	0.3952
Two or more Children in Household	28214	0.2725	0.4453
Housing benefit (Yes = 1)	27168	0.2153	0.4111
Weeks in current spell (unemployed)	26500	43.918	17.310
Non-labour income: last month	27168	418.53	516.97
16+ unemployment rate	67252	5.3438	0.4289
Expected hourly wage (jobseekers)	5195	5.7019	3.3291
Reservation wage (jobseekers)	24728	4.6254	2.4690
Higher Degree	28214	0.0109	0.1037
First Degree	28214	0.0498	0.2176
Teaching Qf	28214	0.0092	0.0956
Other Higher Qf	28214	0.1404	0.3474
Nursing Qf	28214	0.0105	0.1017
Gce A Levels	28214	0.1802	0.3844
Gce O Levels Or Equiv	28214	0.1715	0.3770
Commercial Qf, No O Levels	28214	0.0217	0.1457
Cse Grade 2-5, Scot Grade 4-5	28214	0.0432	0.2033
Apprenticeship	28214	0.0110	0.1042
Other Qf	28214	0.0113	0.1056
North East	28214	0.0315	0.1746
North West	28214	0.0713	0.2574
Yorkshire & Humber	28214	0.0577	0.2333
East Midlands	28214	0.0565	0.2309
West Midlands	28214	0.051	0.2199
East Of England	28214	0.0468	0.2112
London	28214	0.0443	0.2057
South East	28214	0.0612	0.2398
South West	28214	0.0449	0.2072
Wales	28214	0.1740	0.3791
Scotland	28214	0.1773	0.3819

Table 9 Summary statistics for samples to the left and right of the discontinuity, 1998–2008

Variable	Sample at $-0.5 \leq x_{r-1} \leq 0$			Sample at $0 < x_{r-1} \leq 0.5$			H_a : diff. $\neq 0$ <i>p</i> -value
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	
Age at interview	271	33.94	13.04	261	33.42	13.11	0.649
Male	271	0.524	0.500	261	0.547	0.498	0.581
Female	271	0.476	0.500	261	0.452	0.498	0.581
Single	271	0.682	0.466	261	0.693	0.461	0.788
Married or Cohabiting	271	0.317	0.466	261	0.306	0.461	0.788
No Children in Household	271	0.616	0.487	261	0.601	0.490	0.728
One Child in Household	271	0.158	0.366	261	0.191	0.394	0.318
Two or more Children in Household	271	0.225	0.418	261	0.206	0.405	0.611
Housing benefit (Yes = 1)	271	0.166	0.372	261	0.187	0.391	0.512
Weeks in current spell (unemployed)	270	41.28	18.71	261	41.39	18.98	0.946
Non-labour income: last month	271	229.9	217.5	261	238.0	246.8	0.688
16+ unemployment rate	271	5.367	0.437	261	5.378	0.432	0.762
Expected hourly wage (jobseekers)	251	5.417	4.318	237	5.292	1.977	0.685
Reservation wage (jobseekers)	268	4.789	2.150	260	4.762	1.308	0.858
First Degree	271	0.022	0.147	261	0.007	0.087	0.170
Other Higher Qf	271	0.110	0.314	261	0.145	0.353	0.228
Gce A Levels	271	0.191	0.394	261	0.218	0.413	0.449
Gce O Levels Or Equiv	271	0.206	0.405	261	0.241	0.428	0.337
Commercial Qf, No O Levels	271	0.025	0.158	261	0.023	0.150	0.832
Cse Grade 2–5, Scot Grade 4–5	271	0.055	0.229	261	0.065	0.247	0.635
Other Qf	271	0.022	0.147	261	0.015	0.123	0.563
North East	271	0.036	0.188	261	0.061	0.240	0.192
North West	271	0.081	0.273	261	0.088	0.284	0.774
Yorkshire & Humber	271	0.048	0.214	261	0.057	0.233	0.624
East Midlands	271	0.084	0.279	261	0.095	0.294	0.661
West Midlands	271	0.066	0.249	261	0.038	0.192	0.147
East of England	271	0.033	0.179	261	0.011	0.106	0.092
London	271	0.025	0.158	261	0.049	0.218	0.146
South East	271	0.084	0.279	261	0.057	0.233	0.220
South West	271	0.036	0.188	261	0.065	0.247	0.138
Wales	271	0.140	0.347	261	0.126	0.333	0.640
Scotland	271	0.180	0.385	261	0.191	0.394	0.750

Notes: Variables with less than two (2) available observations have been excluded

Author Contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Panos Sousounis and Gauthier Lanot. The first draft of the manuscript was written by Panos Sousounis and Gauthier Lanot and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Declarations

Conflicts of Interest All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

Ethical Approval Not applicable.

Informed Consent Not applicable.

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