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Exploiting the Irish Border to Estimate Minimum Wage Impacts in Northern Ireland

Abstract

This paper examines the impacts of the introduction of the UK National Minimum Wage (NMW) in 1999 and the introduction of the UK National Living Wage (NLW) in 2016 in Northern Ireland (NI) on employment and hours. NI is the only part of the UK with a land border where the NMW and NLW cover those working on one side of the border but not those working on the other side of the border (i.e., Republic of Ireland). This discontinuity in minimum wage coverage enables a research design that estimates the impacts of the NMW and NLW on employment and hours worked using difference-in-differences estimation. We find a small decrease in the employment rate of 22–59/64-year-olds in NI, of up to 2% points, in the year following the introduction of the NMW, but no impact on hours worked. We find no clear evidence that the introduction of the NLW impacted either employment or hours worked in NI.

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1 Introduction

The question of whether minimum wages, and minimum wage increases, lead to falls in employment and/or hours worked continues to attract significant interest among both policy makers and researchers. It is particularly pertinent not only in the US where some cities have substantially increased minimum wages over recent years (e.g., for evidence on the impacts of recent minimum wage increases in Seattle, see Jardim et al., 2017), in Germany where a relatively high minimum wage was introduced in 2015 (for evidence of its early impacts, see Caliendo et al., 2018), but also in the UK given the recent introduction of the National Living Wage (NLW) for those aged 25 years and older and its planned uprating to reach 60% of national median wages over the next few years. The introduction of the NLW in April 2016 was a big change, corresponding to an overnight increase of 7.5% in the minimum wage rate for the age group of 25+ years, or an increase in the bite of the UK minimum wage for the relevant age group from 52.5% of the UK median wage in April 2015 to an estimated 55.8% by October 2016 (Low Pay Commission, 2016).

There is an extensive international body of evidence on the effects of minimum wages on employment and hours, employing a range of methods in a range of contexts and coming to a variety of conclusions. Even reviews of this literature have drawn mixed conclusions (e.g., contrast Neumark and Wascher (2006) with Schmitt (2013)). These disagreements continue, e.g., consider the evidence presented by recent studies (e.g., Dube et al., 2010) generalizing the cross-border case study approach of Card and Krueger (1994) and others, and the subsequent critique by Neumark et al. (2014). Nonetheless, inasmuch as there is a consensus in the international literature, it is that the effects of modest minimum wage increases on employment and hours are typically small and possibly zero.

The UK evidence points to a similar lack of employment responsiveness to minimum wage increases overall, although there is some evidence of employment impacts for some particular groups and sectors (see Dickens et al. (2015) on part-time women, Machin et al. (2003) on the residential care sector, and the reviews of de Linde Leonard et al. (2014) and Low Pay Commission (2016)). There is also evidence of small effects on hours (Stewart and Swaffield, 2008). Because the UK minimum wage was introduced at the same time across the whole country and has subsequently been uprated across the whole country at the same point in time, the UK researchers have had to be creative to generate plausible counterfactuals by which to identify the effects on employment and hours. Among the more credible methods employed are difference-in-differences estimation comparing low-wage workers with those higher up the wage distribution (e.g., Stewart, 2002), exploiting geographical differences in the bite of the minimum wage (e.g., Stewart, 2002; more recently Dolton et al., 2015) and regression discontinuity comparing outcomes either side of age thresholds (e.g., Dickens et al., 2014).

This paper examines the impacts of two key UK minimum wage policy changes on employment and hours, specifically for Northern Ireland (NI): (1) the original introduction of the National Minimum Wage (NMW) in April 1999 and (2) the introduction of the NLW for 25-year-olds and older in April 2016. Our motivation for focusing on NI is threefold. First, NI is a relatively low-wage region where minimum wages have more bite. For example, the bite of the NLW in NI in the mid-2016 was already estimated to be well over 60%, and the second highest of all the UK regions (Low Pay Commission, 2016). Second, NI is the only part of the

UK where there is a jurisdictional land border reflected in a substantial discontinuity in minimum wage rates but (arguably) a reasonable degree of labor market comparability otherwise, at least in terms of changes over the periods of interest, i.e., the border with the Republic of Ireland (RoI). This enables a simple quasi-experimental approach to estimating NMW and NLW impacts on employment and hours which, for the first time, exploits the RoI as a comparison group. Third, despite the potential for minimum wage impacts on employment and hours in NI, there is no existing study that seeks to estimate such effects against a defined counterfactual. In all three respects, this paper makes a contribution to the wider empirical literature on UK minimum wages and, potentially, also to contemporary UK policy advice regarding minimum wage impacts.

Specifically, we conduct a simple difference-in-differences analysis of the impacts on employment and hours of both the NMW and NLW introductions, with the RoI as the comparison group, exploiting comparable cross-sectional unit record data available quarterly in both jurisdictions from the Quarterly Labor Force Survey (QLFS; NI) and the Quarterly National Household Survey (QNHS; which became the Irish Labor Force Survey as of 2017Q3 [Central Statistics Office, 2018]; RoI). The RoI did not introduce an NMW until April 2000, and more recently, the introduction of the NLW in NI in April 2016 was not echoed by any contemporaneous increase in the RoI minimum wage, although the RoI increased its own NMW on January 1, 2016. Before and after periods for this quasi-experimental approach, which given data availability and other issues (discussed in the following section) are shorter than would be ideal, are therefore defined (Table 1).

2 Institutional details, data, and methods

The UK NMW was set initially at £3.60 for all employees aged 22 years and older (not self-employed, not armed forces), with a lower rate (£3.20) for 18–21-year-olds. It has subsequently been uprated on an annual basis, with both the level of the initial rates and the size of the increases recommended to government by an independent commission known as the Low Pay Commission (LPC). The recommended initial rate and subsequent recommended increases were constrained by what the LPC assessed businesses were able to absorb without harming employment.

Table 1 Introduction of NMW and NLW as natural experiments

	Before	After
NMW introduction, 22+ years	1998Q2–1999Q1	1999Q2–2000Q1
NI minimum hourly wage	N/A	£3.60
RoI minimum hourly wage	N/A	N/A
NLW introduction, 25+ years	2015Q4–2016Q1	2016Q2–2016Q3
NI minimum hourly wage	£6.70	£7.20
RoI minimum hourly wage	€8.65 (2015Q4) €9.15 (2016Q1)	€9.15

Note: In sensitivity analysis, we also explore the exclusion of 2015Q4 in the "before" period for the introduction of the NLW.

NI, Northern Ireland; NLW, National Living Wage; NMW, National Minimum Wage; RoI, Republic of Ireland.

The introduction of the NLW in 2016 (initially set at £7.20 but only for those aged 25+ years, with the lower NMW and youth rates still applying to under 25-year-olds) and its planned increases to reach 60% of median wages by 2020 represents a subtle change in this remit.

An NMW was first introduced in the RoI in 2000, at a rate of €5.58 per hour. The rate was increased in subsequent years and stood at €8.65 per hour by 2007. As a consequence of the economic downturn from 2008 onward, no further increases were announced and the minimum wage still remained at its 2007 level of €8.65 per hour in 2015. However, in 2015, against the backdrop of an economic recovery, the Irish LPC was established with the remit of providing yearly recommendations to the Irish government regarding changes in the minimum wage. Following recommendations in 2015, the minimum wage was increased to €9.15 per hour in January 2016, further increases followed in January 2017 and 2018 to €9.25 and €9.55 per hour, respectively. Subminimum wage rates exist for certain categories of workers in the RoI. Expressed as a percentage of the full rate, the subminimum rate is 70% for employees under 18 years of age, 80% for employees in their first year of employment, 90% for employees in their second year of employment, and 75–90% for employees in structured training during working hours, depending on the level of progression.

In terms of other labor market institutions, from 1987 onward, wage bargaining in Ireland was centralized through a process called social partnership whereby the government, trade unions, and employer bodies would come together to determine a national wage agreement which recommended a level of pay increase for the subsequent year. McGuinness et al (2010) estimate that just 30% of Irish employees were covered by the national wage agreement in 2003. The social partnership model broke down in 2010 following disagreements among the partners on the issue of cuts to public sector pay that were imposed by government as a consequence of the recession. Since 2010, it is likely that the majority of pay claims are resolved through individual bargaining, although this has yet to be fully established.[1] No social partnership model has ever been operational in NI. With regard to employment protection, while no standardized measures of employment protection legislation (EPL) are available for NI, data do exist at a UK level. The Organization for Economic Cooperation and Developments (OECD's) strictness of employment protection index runs from 0 to 6, where 6 is the strictest level; Ireland's EPL level in 2013 using this metric was 1.4 compared to the UK's of 1.1, suggesting that levels of employment protection in NI and the RoI are likely to be broadly similar.

Over this period, the RoI labor market has been subject to much higher levels of economic volatility, due principally to the highly open nature of the Irish economy, compared to the NI labor market, which is generally perceived as being less subject to national and international shocks, in part due to its heavier reliance on public sector employment. Public sector jobs are estimated to account for over 30% of total employment in NI, compared to a UK average of 17% (McFlynn, 2015) and a figure of 18% for RoI (OECD Government at a Glance 2013). Although a high reliance on the public sector has helped insulate the NI labor market to some degree against external shocks, the RoI economy has experienced some remarkable shifts in fortune that have resulted in large movements in unemployment, employment, and migration, in particular comparing the period through the late 1990s and early 2000s with the years following 2008 and the global downturn.

1 McGuinness et al (2003) estimate that in 2003 just, prior to the collapse of social partnership, under 50 per cent of workers were covered by individual level pay agreements.

Such differences, of course, suggest that the RoI does not provide an *ideal* counterfactual for NI. Nevertheless, labor market conditions in both regions were relatively stable and, at least in terms of indicators such as unemployment and net migration (an important "safety valve" for labor markets in both north and south), quite similar during the time points of key importance to our study, i.e., 1999 and 2016.[2] This relative stability, coupled with the evidence of parallel trends presented in Section 3, suggests that NI and RoI are *sufficiently* comparable with these periods to support the research design adopted here. We return to this question in Section 3.3.

This paper exploits the unit record data drawn from two national, representative, quarterly household surveys – the QLFS and the QNHS – which are treated as repeated cross-sections. Both surveys provide detailed information for large samples of individuals in identified households quarterly from 1998Q2 onward, with the QLFS sample size large enough to make quarterly analysis specifically for NI just about feasible, at least overall if not for narrowly defined subgroups. Once we restrict samples to working-age individuals – aged 22–59/64 years for the introduction of the NMW and 25–59/64 years for the introduction of the NLW – we are left with quarterly sample sizes of around 2,700 for NI around the introduction of the NMW and around 1,700 for NI around the introduction of the NLW. The equivalent QNHS sample sizes for the RoI are approximately 55,000 per quarter at the time of the introduction of the NMW and approximately 21,000 per quarter at the time of the introduction of the NLW.

To analyze the introduction of the NMW in April 1999, there are four quarters of data available both pre treatment (from 1998Q2 to 1999Q1) and post treatment (from 1999Q2 to 2000Q1), from both surveys, where no other minimum wage changes took place in either NI or RoI (2000Q2 saw the introduction of the RoI's own minimum wage – a point we return to below).[3] This is our window of observation for the NMW analysis described in the following sections. The usable window of observation around the introduction of the NLW in April 2016 is narrower (essentially the bare minimum) for two reasons. First, the UK (including NI) uprated the NMW in October 2015 and again in October 2016, although the latter change did not directly affect those aged 25+ years given the NMW rate still fell below the NLW rate. Second, there was an increase in the RoI minimum wage from January 1, 2016 (from €8.65 to €9.15). In what follows, we restrict our analysis to data drawn from the two quarters prior to the NLW introduction and the two quarters following its introduction, i.e., from 2015Q4 to 2016Q3, although we test sensitivity to further restrictions given the potentially confounding other minimum wage changes in this case. We have to make additional assumptions concerning the impact of the RoI 2016Q1 uprating to estimate NLW impacts for NI.

As both the QLFS and QNHS are aligned to the European Labor Force Survey, here is a high degree of compatibility between the two data sources, both of which use similar sampling frames and contain information on economic activity, hours worked and other job characteristics, as well as some demographic and household characteristics. Note, however, that the QNHS has very limited information on pay – household income bands only – so hourly pay/wage data cannot be derived for the RoI from this source. Neither are the wage data in the QLFS ideal

2 Unemployment rates in NI were within 2 percentage points of those in the RoI in both periods, and were falling at a similar rate both sides of the border in both periods. Net migration was close to zero both north and south in both periods.

3 QNHS data are only available from 1998Q2 onwards.

given poor coverage for one measure (HRRATE) and serious measurement error for the other (HOURPAY; see Ormerod and Ritchie, 2007). As a consequence, we do not present a first-stage analysis of the impact of the NMW or NLW on wages in this paper. Having said that, we know from existing studies (exploiting the New Earnings Survey and more recently the Annual Survey of Hours and Earnings) that the first-stage impacts were likely in both cases. In the case of the NMW introduction, Low Pay Commission (2000) reports that 7–8% of eligible workers in NI were paid below the NMW in April 1998 (the joint highest of all UK regions) but only 2–3% were paid below the NMW in April 1999. For the NLW, Department for the Economy (2016) estimates that around 5% of eligible workers were likely to be directly affected in 2016 by the introduction of the NLW.

Instead, the key outcome variables used in the descriptive and/or econometric analysis are as follows:

Employment: The standard ILO definition as in the QLFS variable ILODEFR and the QNHS variable ILO is used to measure whether an individual is employed during the reference period. Note that, because they cannot be reliably separately identified in the QNHS, the self-employed – not covered by the NMW or NLW – are included along with employees here.

Weekly hours worked: The paper focuses primarily on total usual weekly hours in the main job, including overtime. The relevant variable in the QLFS (QNHS) is TTUSHR (HWUSUAL). Estimates are also provided for total actual hours worked in the last week (TTACHR/HWACTUAL), although this measure is complicated by zeroes for those on holidays or off work for other reasons in the previous week.

These variables, along with all the controls used in the econometric analysis, are listed and defined in Table A1.

Tables 2 and 3 present the descriptive statistics for the respondents, north and south of the border, before and after both reforms. In most respects, the composition of the NI and RoI samples appears very similar. Where there are differences (e.g., in qualification levels), and to the extent that they reflect genuine differences rather than differences in the precise definition of variables or categorization of responses between the two surveys, they are time-invariant over the periods under consideration, and therefore will not confound estimated NMW/NLW impacts. Having said that, even time-invariant differences could imply asymmetric responses to shocks other than minimum wage shocks. In terms of outcomes, note the 3% point increase in the employment rate in the RoI between the pre-NMW and post-NMW periods which is not reflected in an increased employment rate in NI. One potential explanation for this divergence, which we explore in the following section, is that it is picking up a negative employment impact of the NMW in NI against a counterfactual increasing trend. There is no such divergence in employment rates at the time of the introduction of the NLW.

In common with many previous studies of minimum wage effects internationally, including the seminal study of Card and Krueger (1994), differences across space are exploited here to identify impacts on employment and hours. In particular, differences in the timing of the introduction and uprating of the NMW and NLW in NI and their counterpart in the RoI are exploited. The introductions of NMW and NLW in north of the border are, in effect, treated as natural experiments – individuals in NI are the treatment group and individuals in RoI are the control group – and their impacts are estimated using a standard difference-in-differences

approach (see Blundell and Costa Dias, 2009). Specifically, linear regressions of the following form are estimated as follows:

$$y_{ict} = \alpha \mathrm{NI}_i + \lambda_t + \delta (\mathrm{NI}_i \cdot \mathrm{Post}_t) + \beta X_{ict} + \varepsilon_{ict} \quad (1)$$

where y_{ict} is the outcome variable of interest (employment or log hours) for individual i in country c at time t; NI_i is a dummy for individuals living in a household within NI; λ_t is the quarterly fixed effects common to both NI and RoI; δ is the average treatment effect on the treated (ATT), averaged over all post-reform periods; Post_t is a dummy variable for whether the quarter is in the post-reform period (i.e., post-NMW or post-NLW); X_{ict} contains individual and household observed characteristics; and ε_{ict} is a stochastic error term capturing other influences.

For (log) hours, we estimate the model by ordinary least squares (OLS) and δ gives the percentage change in average hours among the NI sample driven by the NMW or NLW

Table 2 Sample means/proportions (standard deviations) for outcomes and other observable characteristics, NI and RoI, pre and post the introduction of NMW

	NI		RoI	
	1998Q2–1999Q1	1999Q2–2000Q1	1998Q2–1999Q1	1999Q2–2000Q1
Employment rate, 22–59/64 years	0.70	0.70	0.69	0.72
Total actual weekly hours in main job	34.6 (18.0)	35.0 (17.9)	40.4 (14.8)	40.1 (14.5)
Total usual weekly hours in main job	39.6 (13.5)	39.5 (13.9)	39.1 (12.7)	38.7 (12.0)
Proportion of employed in minimum wage sector	0.31	0.30	0.26	0.26
Male	0.51	0.51	0.52	0.52
Age, years	40.0 (11.3)	40.2 (11.2)	39.7 (11.3)	39.8 (11.3)
Single	0.27	0.27	0.32	0.33
Married/cohabiting	0.63	0.63	0.62	0.61
Widowed/divorced	0.05	0.05	0.06	0.06
Number of children <18 years in household	1.07 (1.27)	1.04 (1.26)	1.09 (1.32)	1.05 (1.29)
Nobs	11,366	11,552	220,795	219,934

Notes: Estimates are weighted for nonresponse using pwt07 (QLFS) and gf (QNHS) and based on the full set of information available for each variable. Variables are defined in Table A1. Qualifications data for the RoI sample are not available over this period.

NI, Northern Ireland; NMW, National Minimum Wage; QLFS, Quarterly Labor Force Survey; QNHS, Quarterly National Household Survey; RoI, Republic of Ireland.

introduction. For employment, where the outcome is binary, for ease of interpretation, we also estimate by OLS, with δ interpreted as the impact of the NMW or NLW introduction on the probability of employment among the NI sample. We also explore the sensitivity of the key employment estimates to adopting a logit specification, in which case we present marginal effects of the NMW or NLW introduction on the probability of employment which are interpretable in the same way.

Table 3 Sample means (standard deviations) for outcomes and other observable characteristics, NI and RoI, pre and post the introduction of NLW

	NI		RoI	
	2015Q4–2016Q1	2016Q2–2016Q3	2015Q4–2016Q1	2016Q2–2016Q3
Employment rate, 25–59/64 years	0.76	0.76	0.73	0.73
Total actual weekly hours in main job	32.5 (16.6)	33.6 (16.7)	35.6 (13.0)	36.8 (12.8)
Total usual weekly hours in main job	37.5 (12.1)	37.6 (12.6)	36.5 (11.6)	36.8 (11.4)
Proportion of employed in minimum wage sector	0.31	0.30	0.32	0.32
Male	0.52	0.50	0.51	0.52
Age, years	43.0 (10.7)	43.1 (10.7)	42.5 (10.4)	42.5 (10.4)
Single	0.30	0.30	0.34	0.35
Married/cohabiting	0.59	0.58	0.60	0.58
Widowed/divorced	0.07	0.06	0.06	0.07
Number of children <18 years in household	0.91 (1.12)	0.90 (1.13)	0.97 (1.20)	0.96 (1.20)
ISCED1	0.22	0.22	0.06	0.06
ISCED2	0.22	0.20	0.11	0.12
ISCED3–4	0.22	0.21	0.15	0.15
ISCED5	0.08	0.09	0.13	0.12
ISCED6	0.24	0.26	0.30	0.30
Nobs	3,430	3,832	42,170	41,961

Notes: Estimates are weighted for nonresponse using pwt16 (QLFS) and gf (QNHS) and based on the full set of information available for each variable. Variables are defined in Table A1.

ISCED, International Standard Classification of Education; NI, Northern Ireland; NLW, National Living Wage; QLFS, Quarterly Labor Force Survey; QNHS, Quarterly National Household Survey; RoI, Republic of Ireland.

Because minimum wage impacts on employment or hours may not be instantaneous and may vary over the post-reform period, we also estimate an extended version of (1) which allows for dynamic treatment effects as follows:

$$y_{ict} = \alpha \mathrm{NI}_i + \lambda_t + \sum_{p=1}^{Q} \delta_p \left(\mathrm{NI}_i \cdot p \right) + \beta X_{ict} + \varepsilon_{ict} \tag{2}$$

where p is a series of quarter dummy indicators for each quarter. With at most four quarters post treatment, however, we can only hope to identify short-term impacts.

A crucial identifying assumption using difference-in-differences estimation is that the treatment and control groups are following parallel paths, also known as common trends, which in this case means that in the absence of the introduction of the NMW or NLW in NI, outcomes would have followed a path that is parallel to that observed in RoI. Although this assumption is unstable, the standard procedure in the literature is to check the plausibility of the assumption by testing whether the treatment and control group outcomes at least follow parallel paths prior to the reform. One potential driver of diverging prior trends is anticipation effects in NI following the announcement of – June 1998 and July 2015, respectively – but ahead of the implementation of the NMW/NLW. Other potential confounding factors that might drive diverging prior trends include the faster growth rate of the RoI economy relative to the NI economy in each of the years 1998, 1999, 2015, and 2016, changes in the £/€ exchange rate around both the NMW and NLW introductions, and anticipation effects surrounding the Brexit referendum in the run up to the introduction of the NLW (we return to these potential confounders later).

Diverging prior trends are explored here by extending the dynamic model (equation (2)) over the pre-reform period to give estimates of any divergence in outcomes for quarters prior to the introduction of the NMW and NLW. This is straightforward for the introduction of the NMW – both jurisdictions had no minimum wage in the four quarters (or before) prior to 1999Q2, and RoI did not introduce its minimum wage until 2000Q2. It is less so for the introduction of the NLW in 2016Q2 because the RoI minimum wage was uprated from €8.65 to €9.15 in 2016Q1. Even without the RoI uprating, having only two data points pre NLW limits what we can learn about prior trends in this case, and estimates should be interpreted in this light. Nevertheless, we examine the two quarters prior to 2016Q2 on the assumption that the changes in employment and hours in the RoI induced by the uprating of the RoI minimum wage in 2016Q1 were negligible. McGuinness and Redmond (2018) provide support for this assumption in the case of employment, although they cannot rule out a small hours impact of the January 2016 uprating of the RoI minimum wage.

3 Results

3.1 Baseline estimates

Table 4 presents our baseline difference-in-differences estimates of the impacts of the introduction of the NMW in NI on employment and hours using the RoI as the comparison group. Only the key estimated parameters are reported here; full results are given in Appendix

(see Tables A2 and A3).[4] First consider employment. The first row of column 1 gives the estimated impact of the NMW introduction on employment, averaged over the first four quarters following its introduction, under the assumption of parallel trends. The estimate suggests that the NMW was associated with a fall in employment in NI, with employment in the year following its introduction almost 2% points lower than we estimate would otherwise have been the case. This is broadly similar in magnitude to the negative impact of the NMW introduction on employment retention of part-time women (3% points) reported by Dickens et al. (2015) and corresponds to around 20,000 individuals (out of a working-age population of approximately one million) who might otherwise have been in employment.

The remaining rows of column 1 in Table 4 present quarter-specific employment estimates for both pre- and post-NMW quarters. First, consider the pre-NMW period and the question of whether we can reject the assumption of parallel trends. None of the estimated coefficients on the NI × quarter interactions pre NMW are statistically significant, whether individually or jointly. In other words, there is insufficient evidence to reject the assumption of parallel trends for employment here. Similarly, if we replace the quarter-specific NI dummies with pre-NMW and post-NMW NI dummies (with the former defined as =1 for 1998Q3–1999Q1 and =0 otherwise), we reject the hypothesis that the estimated coefficients on the pre × NI and post × NI dummies are equal at the 99% level of statistical significance. The pre-NMW estimates can also be interpreted as null estimates for placebo tests in each of the quarters prior to the actual introduction of the NMW. Note that although we cannot rule out that the standard errors reported in Table 4 are underestimated – they are robust but not clustered, and we return to this point in Section 3.3 – this would likely lead us to over-reject rather than under-reject the null of no parallel trends.

Table 4 Difference-in-differences estimates of impacts of the NMW introduction on employment and hours in NI, coefficients (robust standard errors)

	Employment	Weekly hours
Constant treatment effect (1999Q2–2000Q1)	−0.019*** (0.006)	0.001 (0.007)
Quarter-by-quarter estimates		
1998Q2 (pre-NMW)	Ref. case	Ref. case
1998Q3 (pre-NMW)	−0.014 (0.012)	0.001 (0.014)
1998Q4 (pre-NMW)	−0.003 (0.012)	0.007 (0.014)
1999Q1 (pre-NMW)	−0.016 (0.012)	0.020 (0.014)
1999Q2 (post-NMW)	−0.025** (0.012)	0.020 (0.013)
1999Q3 (post-NMW)	−0.023* (0.012)	0.010 (0.014)
1999Q4 (post-NMW)	−0.028** (0.012)	0.011 (0.014)
2000Q1 (post-NMW)	−0.033*** (0.012)	−0.009 (0.013)
Nobs	463,647	282,435

Notes: ***Significant at 1%; **significant at 5%; *significant at 10%. Standard errors are robust. Covariates listed in Table A1 are included in the model, and full estimates for the constant treatment effects models are presented in Table A2.

NI, Northern Ireland; NMW, National Minimum Wage.

4 We do not separately discuss estimated correlations between employment/hours and control variables here, which are consistent with what we would expect in all cases.

Turning to the quarter-specific post-NMW employment estimates, all are statistically significant and the magnitudes of these estimates are reasonably stable, with at most a slight trend increase in the estimated NMW impact on employment over the year, consistent with the NMW impacting in part via employment *growth* (see Meer and West, 2016). Also, recall that the RoI introduced its own minimum wage in 2000Q2. If there were large anticipatory employment effects in the RoI in the one or two quarters before this introduction, we would expect to see the evidence of this here in the estimated coefficients for 2001Q1 and perhaps 1999Q4. We do not.[5]

Turning to estimated impacts of the NMW on hours (column 2 of Table 5), we see no clear evidence of any impact within the first year of the NMW introduction. The estimated impact averaged over this period is very close to zero in magnitude and is nowhere near statistical significance. Again, we cannot reject the assumption of parallel trends – all pre-NMW NI coefficients are statistically insignificant individually and jointly. So too are the post-NMW quarter-specific estimates, and we cannot reject that the estimated coefficients on pre- and post-NMW NI dummies are equal.

Table 5 repeats the exercise for the introduction of the NLW in 2016Q2. In this case, under the assumption of parallel trends, there is very little evidence of any NLW impact on employment in NI, with the two-quarter point estimate very close to zero and nowhere near statistical significance. As for the introduction of the NMW, there is no evidence of diverging prior trends here, although with only two data points pre NLW, this can only be tentative. Neither is there any evidence of an employment effect that accumulates – via employment growth – over time following the NLW introduction, although again the caveat here is that we have data for only two post-NLW quarters. We cannot reject that pre = post.

For hours, again there is no clear evidence here of any impact from the introduction of the NLW within 6 months of its introduction. The point estimate in the first row is small (the magnitude suggests a decrease of less than half an hour) and not statistically significant at

Table 5 Difference-in-differences estimates of impacts of the NLW introduction on employment and hours in NI, coefficients (robust standard errors)

	Employment	Weekly hours
Constant treatment effect (2016Q2–2016Q3)	−0.001 (0.010)	−0.011 (0.011)
Quarter-by-quarter estimates		
2015Q4 (pre-NLW)	Ref. case	Ref. case
2016Q1 (pre-NLW)	−0.002 (0.014)	−0.009 (0.016)
2016Q2 (post-NLW)	−0.005 (0.014)	−0.009 (0.015)
2016Q3 (post-NLW)	0.0004 (0.014)	−0.023 (0.015)
Nobs	91,393	61,551

Notes: ***Significant at 1%; **significant at 5%; *significant at 10%. Standard errors are robust. Covariates listed in Table A1 are included in the model, and full estimates for the constant treatment effects models are presented in Table A3.

NI, Northern Ireland; NLW, National Living Wage.

5 More generally, Nolan et al. (2002) find no evidence of employment effects from the introduction of the RoI minimum wage.

conventional levels. We cannot reject that pre = post. The quarter-specific estimates are also statistically insignificant individually and jointly, although the estimate for 2016Q3 is larger in magnitude and is approaching the margin of conventional levels of statistical significance, at least given the standard errors reported here.

3.2 Heterogeneous minimum wage effects

Table 6 presents the key parameters from reestimating (1) on subsamples split by gender, age, and education level (the latter only for the introduction of the NLW given unavailability of data for the earlier period in the QNHS). There is no evidence of heterogeneity in the employment effect of the introduction of the NMW; the estimated 2% point decline in the employment rate is common in men and women and in the younger and older age groups. Similarly, the estimated zero impacts of the NLW on employment, and of both the NMW and NLW on hours, are common to men and women, older and younger workers, and lower- and higher-qualified workers; all estimates, for all groups, are statistically insignificant. In terms of magnitudes of estimated NLW impacts, however, there are some tentative signs of possible heterogeneous effects, albeit imprecisely estimated, e.g., with an apparent gender contrast where any negative employment response appears limited to men and any negative hours response appears limited to women.

Next (in the absence of good-quality wage data), we examine whether the NMW or NLW impacted disproportionately on three sectors with high concentrations of minimum wage workers in both NI and RoI (wholesale and retail trade, accommodation and food, and human health and social work).[6] First, we estimate the impact of the NMW and NLW on the employment share in these sectors, i.e., whether the NMW/NLW led to any reallocation of employment across sectors. For both the NMW and NLW, the resulting estimates are negative, but small and statistically insignificant, suggesting in the case of the NMW that the reduction in employment was spread evenly between these and other sectors, and in the case of the NLW that there was no substantial reallocation of employment obscured by the overall zero employment effect. Second, we restrict the sample to those employed in these sectors and reestimate the NMW/NLW impacts on hours. Again, both estimates are small in magnitude and statistically insignificant, suggesting no impacts on hours even in these sectors.

3.3 Sensitivity analysis and potential threats to identification and inference

Table 7 presents the key parameter estimates from a number of sensitivity analyses.

1. We reestimate the employment models as logit models rather than linear probability models (LPMs), given the binary nature of the outcome variable.
2. We reestimate the baseline model excluding the quarter prior to the NMW and NLW introductions in each case to test sensitivity to possible anticipation effects.

6 Research from Maitre et al. (2017) compares the sectoral distribution of minimum wage workers in RoI and the UK in 2014 using EU-SILC data, finding that the proportions of minimum wage workers employed in the three identified sectors in RoI and the UK stood at 58 and 55 per cent respectively. NI-specific analysis also shows these sectors to have high concentrations of minimum wage workers (Department for the Economy, 2016).

Table 6 Difference-in-differences estimates of impacts of the NMW and NLW introductions on employment and hours in NI, heterogeneous effects, constant treatment effects, coefficients (robust standard errors; number of observations)

	NMW introduction		NLW introduction	
	Employment	Weekly hours	Employment	Weekly hours
Baseline	−0.019*** (0.006) [463,647]	0.001 (0.007) [282,435]	−0.001 (0.010) [91,393]	−0.012 (0.011) [61,551]
Men	−0.020** (0.008) [238,402]	0.005 (0.007) [161,121]	−0.020 (0.013) [46,661]	0.005 (0.012) [32,430]
Women	−0.019** (0.009) [225,245]	−0.006 (0.012) [121,314]	0.018 (0.015) [44,732]	−0.027 (0.018) [29,121]
Age 22–34/ 25–34 years	−0.022** (0.010) [161,846]	0.013 (0.010) [115,105]	−0.005 (0.019) [21,976]	−0.020 (0.019) [15,716]
Age 35–59/ 64 years	−0.019*** (0.008) [301,801]	−0.008 (0.009) [167,330]	−0.002 (0.012) [69,417]	−0.009 (0.013) [48,835]
Higher qualification level	–	–	−0.005 (0.012) [51,531]	−0.02 (0.012) [39,319]
Lower qualification level	–	–	−0.001 (0.018) [19,055]	0.002 (0.023) [9,168]
(Share of those employed who are) employed in minimum wage sector	−0.008 (0.007) [322,021]	−0.011 (0.013) [75,607]	−0.018 (0.013) [66,462]	0.011 (0.021) [19,439]

Notes: ***Significant at 1%; **significant at 5%; *significant at 10%. Standard errors are robust. Covariates listed in Table A1 – with the exception of the relevant dummy on which the sample is restricted – are also included in each model. The models are estimated under the parallel path assumption in each case.

NI, Northern Ireland; NLW, National Living Wage; NMW, National Minimum Wage.

3. We reestimate the baseline model excluding 2015Q4 in the NLW case to test sensitivity to potential effects of the RoI uprating of its own minimum wage on January 1, 2016, under the assumption that any impacts of the 2016Q1 uprating in the RoI were constant over the period from 2016Q1 to 2016Q3.
4. We reestimate the effects on hours using the total actual hours in the reference week rather than the total usual hours.
5. We reestimate the baseline model restricting the control group to the NUTS3 border region of the RoI in an effort to minimize potential asymmetric shocks. (The trade-off is less precise estimates and more potential for spillover effects, e.g., via cross-border commuting.)
6. We reestimate the baseline models allowing standard errors to be clustered at the NUTS3 level using a wild cluster bootstrap approach (with 1,000 draws) as suggested by Cameron and Miller (2015).[7]

Table 7 shows that the coefficient estimates presented in Table 5 for the effects of the introduction of the NLW on employment and hours are generally robust; for each outcome,

7 The wild bootstrap approach is warranted because of the potential downward bias of standard cluster-robust error estimates when the number of groups is small. In this case the number of groups is nine.

Table 7 Sensitivity analysis, constant treatment effects, coefficients (robust standard errors)

	NMW introduction		NLW introduction	
	Employment	Weekly hours	Employment	Weekly hours
Baseline	−0.019*** (0.006)	0.001 (0.007)	−0.001 (0.010)	−0.011 (0.011)
Baseline as logit (marginal effects)	−0.020*** (0.006)	–	−0.0002 (0.011)	–
Exclude 1999Q1	−0.022*** (0.007)	0.006 (0.007)	–	–
Exclude 2015Q4	–	–	−0.00001 (0.012)	−0.007 (0.014)
Exclude 2016Q1	–	–	−0.002 (0.012)	−0.015 (0.013)
Total actual hours	–	−0.005 (0.008)	–	−0.018 (0.012)
Border region only	−0.010 (0.007)	0.006 (0.008)	0.014 (0.013)	−0.011 (0.015)
Estimated with wild bootstrap clustered standard errors (*p*-value)	−0.019*** (0.002)	0.001 (0.656)	−0.001 (0.600)	−0.011*** (0.002)

Notes: ***Significant at 1%; **significant at 5%; *significant at 10%. Covariates listed in Table A1 are included in each model. Wild bootstrap standard errors are clustered at the NUTS 3 regional level.

NLW, National Living Wage; NMW, National Minimum Wage.

the estimates from the range of variants of the model are of similar magnitude. They are also statistically indistinguishable from zero in all cases except where we bootstrap clustered standard errors for the hours effect, which in this case appears to exacerbate any underestimation of standard errors (we return to this point below). The same holds – in this case with no exceptions – for the estimated impact of the introduction of the NMW on hours, which is robustly small and nowhere statistically significant. Similarly, the estimated negative impact on employment of the NMW is robust, although in one case is smaller in magnitude and no longer statistically significant.

Although our estimates are generally robust and we find no evidence of diverging prior trends, parallel assumptions may still be violated, and our estimates potentially subject to bias, if there are confounding sources of divergence in the quarters coinciding with or immediately following the NMW/NLW introductions. (This is, after all, a simple "two-by-two" difference-in-differences approach, and a cross-country one at that.) Although we cannot test for this, we can at least consider the most likely sign of any potential bias. The two most obvious potential culprits in 1999 – higher economic growth rates in RoI than NI and a 10% appreciation of sterling relative to the Euro over the year – would most likely bias our estimated NMW employment effect in a negative direction, implying that the 2% point estimated employment effect may be an upper bound on the absolute magnitude of any negative NMW effect. It is less clear how these potential confounders might bias estimated impacts of the NMW on hours, if at all, but neither provides a strong case for overturning the zero hours effect conclusion. This lack of a strong case for overturning zero estimates also holds for the estimated impacts of the NLW on employment and hours. In this more recent case, the RoI was also growing faster than NI in 2016 and there was a dip in business and consumer confidence in 2016Q3 (although subsequently reversed) following the Brexit referendum result in

the UK, both of which might suggest that any possible bias to estimated employment effects would be negative. On the other hand, the exchange rate was moving in the opposite direction (most notably in the fortnight following the Brexit referendum), potentially offsetting any such bias at least in part.

We cannot entirely rule out the potential for spillover effects associated with cross-border commuting, which could lead to biases of uncertain sign. Although there is insufficient information on cross-border commuting in the QLFS and QNHS for a detailed analysis of such impacts, cross-border commuting never exceeds 1% of the relevant age group in any of the quarters analysed here. Similarly, any potential biases due to general equilibrium effects on the NMW or NLW on cross-border shopping seem likely to be dwarfed by the exchange rate movements discussed above.

In addition to these remaining concerns about the unbiasedness of the point estimates, we cannot rule out that standard errors are underestimated here, in both the baseline estimates (with robust but not clustered standard errors) and the alternative set of estimates where we allow standard errors to be clustered at the NUTS3 level using a wild cluster bootstrap approach. The reason we relegate the estimates with clustered standard errors to the sensitivity analysis is that there is no ideal clustering in this case – again, this is a "two-by-two" difference-in-differences analysis – and the fact that the estimated clustered standard errors are smaller than the robust standard errors suggests that the NUTS3-level clustering exacerbates rather than mitigates any underestimation problems. On the other hand, there is no additional reason to question the conclusion of zero NMW impact on hours and zero (or at least no convincing evidence of) NLW impacts on hours and employment.

4 Conclusions

This paper presents the estimates of the impacts on employment and hours in NI of the introductions of the UK NMW and NLW, using the RoI – where minimum wages were not introduced until 2000Q2 and were constant at the time of the introduction of the NLW – to generate the relevant counterfactuals in each case. It is the first study to exploit the UK's only land border to identify minimum wage effects and the first study to estimate the minimum wage impacts on employment and hours in NI – one of the lowest wage regions of the UK – against a defined counterfactual.

We find that the NMW is associated with a decrease in the employment rate of 22–59/64-year-olds in NI, of up to 2% points, in the year following its introduction. The magnitude of this effect is small but nontrivial, corresponding to a loss of up to 20,000 jobs in NI, and is generally robust to a series of sensitivity checks. We (again robustly) find no clear evidence of an impact of the introduction of the NLW on employment in NI in the 6 months following its introduction and no clear evidence of impacts of either the NMW or NLW introductions on weekly hours worked in NI.

In presenting new, albeit tentative, evidence of a negative employment effect of the introduction of the NMW in 1999 in a low-wage region, this paper adds to the small group of existing UK studies to find similar employment effects among particular low-wage groups of workers or in particular low-wage sectors. The conclusion of the UK literature to date – that there has been

no overall negative employment effect of the NMW at the national level – should be tempered by these low-wage group, sectoral and regional exceptions. In presenting new, albeit tentative again, evidence of zero impacts of the introduction of the NLW in 2016 on employment and hours in NI, however, this paper shows that any negative employment impact of the introduction of the original NMW in NI appears not to have been repeated in 2016, despite NI's continuing position as a relatively low-wage UK region. These latter estimates are more in line with the bulk of the literature on the UK minimum wage providing estimates at the national level, although readers should bear in mind the shortness of the period pre and post the introduction of the NLW for which we analyze data here.

What can explain this contrast between the estimated NMW and NLW employment impacts? There are essentially two possible explanations. First, it could reflect the relative difficulty in identifying the NLW impacts given, among other things, that we only have two periods pre and two periods post NLW. It may also be that the balance of potential biases we discuss in Section 3.3 works in favor of "finding" an NMW effect but against finding an NLW effect. More interesting, however, is the argument that there really were different employment responses to the NMW and NLW introductions in NI. This could reflect stronger first-stage effects of the NMW than the NLW, which seems plausible given existing estimates of the proportion of NI workers paid below the NMW relative to those paid below the NLW prior to their introductions. It could also be that what (short term) response there was to the introduction of the NLW in NI may have come in hours – we estimate a small, albeit statistically insignificant, negative hours effect for the NLW but not for the NMW – rather than employment.

Declarations

Availability of data and materials

The data that support the findings of this study are subject to restrictions but potentially available under license from the UK Data Archive and the Irish Central Statistics Office. Analysis code is available from the authors on request.

Competing interests

The authors declare that they have no competing interests.

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Author contributions

AP and SM contributed to the data preparation and estimation and made major contributions to writing the manuscript. DM contributed to writing the manuscript. All the authors contributed to the interpretation of results and read and approved the final manuscript.

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Appendix: Additional Data Details and Results

Table A1 Variable definitions and descriptions

Variable	Definition	Description
Outcome variables		
Employment	Employed in the reference week	Employed in the reference week = 1, 0 otherwise
Employment in minimum wage sector	Those employed in the reference week in sectors with high concentrations of minimum wage workers	Employed in the following sectors: UK SIC07 G, I, and Q = 1, 0 if employed in other sectors*
Total actual weekly hours in main job	Total actual hours worked in main job in the reference week including overtime	This variable is constructed from TTACHR from the QLFS and HWACTUAL from the QNHS
Total usual weekly hours in main job	Total usual hours worked in main job including overtime	This variable is constructed from TTUSHR from the QLFS and HWUSUAL from QNHS
Controls		
Male	Sex of respondent	Male = 1, female = 0
Age, years	Age of respondent in years	Age of respondent in years
Age squared	Age of respondent in years, squared	Age of respondent in years, squared
Single	Respondent's marital status is single	Respondent's marital status is single = 1, 0 otherwise
Married/cohabiting	Respondent's marital status is married/cohabiting	Respondent's marital status is married/cohabiting = 1, 0 otherwise
Widowed	Respondent's marital status is widowed	Respondent's marital status is widowed = 1, 0 otherwise
Divorced	Respondent's marital status is divorced	Respondent's marital status is divorced = 1, 0 otherwise
Number of Children under the age of 18 years in household	Number of children resident in the household	Number of children under the ages of 17 (RoI) and 19 (NI) years, resident in the household
Number of children under the age of 18 years in household missing	Dummy for missing data on the number of children <18 years	Missing =1, 0 otherwise
ISCED 1	Respondent reports highest level of qualification as "no qualifications" or equivalent	ISCED 1 = 1, 0 otherwise.
ISCED 2	Respondent reports highest level of qualification as General Secondary Certificate of Educations (GCSEs) (NI)/ Junior Certificate (RoI) or equivalent	ISCED 2 = 1, 0 otherwise
ISCED 3–4	Respondent reports highest level of qualification as A-level (NI)/leaving certificate (RoI) or equivalent	ISCED 3/4 = 1, 0 otherwise
ISCED 5	Respondent reports highest level of qualification as sub-degree level higher or further education	ISCED 5 = 1, 0 otherwise
ISCED 6	Respondent reports highest level of qualification as degree level or higher	ISCED 6 = 1, 0 otherwise
ISCED missing	Dummy for missing data on highest qualification level	Missing =1, 0 otherwise

Note: *SIC codes: G = wholesale and retail trade; repair of motor vehicles and motorcycles; I = accommodation and food services activities and human health and social work activities.

ISCED, International Standard Classification of Education; NI, Northern Ireland; QLFS, Quarterly Labor Force Survey; RoI, Republic of Ireland.

Table A2 Full difference-in-differences estimates of impacts of the NMW introduction on employment and hours in NI, coefficients (standard errors)

	Employment	Weekly hours
NI × post	−0.019*** (0.006)	−0.006 (0.007)
NI	0.009** (0.004)	−0.024*** (0.005)
1998Q3	0.005* (0.003)	0.015*** (0.003)
1998Q4	0.011*** (0.003)	−0.014*** (0.003)
1999Q1	0.018*** (0.003)	−0.014*** (0.003)
1999Q2	0.024*** (0.003)	−0.009*** (0.003)
1999Q3	0.030*** (0.003)	0.013*** (0.003)
1999Q4	0.035*** (0.003)	−0.008*** (0.003)
2000Q1	0.038*** (0.003)	−0.023*** (0.003)
Age	0.029*** (0.001)	0.003*** (0.001)
Age^2	−0.0005*** (0.00001)	−0.00006*** (0.00001)
Male	0.263*** (0.001)	0.350*** (0.002)
Number of children <18 years in household	−0.044*** (0.001)	−0.019*** (0.001)
Married	0.044*** (0.002)	−0.037*** (0.002)
Divorced	−0.018*** (0.004)	−0.096*** (0.005)
Widowed	−0.028*** (0.006)	−0.102*** (0.009)
Constant	0.226*** (0.010)	3.42*** (0.011)
R^2	0.135	0.146
Nobs	463,647	298,473

Notes: ***Significant at 1%; **significant at 5%; *significant at 10%. Standard errors are robust.

NI, Northern Ireland; NMW, National Minimum Wage.

Table A3 Full difference-in-differences estimates of impacts of the NLW introduction on employment and hours in NI, coefficients (standard errors)

	Employment	Weekly hours
NI × post	−0.001 (0.010)	−0.019 (0.012)
NI	0.040*** (0.007)	0.055*** (0.009)
2016Q1	−0.001 (0.004)	0.035*** (0.006)
2016Q2	0.001 (0.004)	0.059*** (0.006)
2016Q3	0.007* (0.004)	0.061*** (0.006)
Age	0.032*** (0.001)	0.014*** (0.002)
Age^2	−0.0004*** (0.00002)	−0.0002*** (0.00002)
Male	0.129*** (0.003)	0.299*** (0.004)
Number of children <18 years in household	−0.038*** (0.001)	−0.029*** (0.002)
Married	0.119*** (0.004)	0.020*** (0.005)
Divorced	−0.006 (0.007)	−0.005 (0.011)
Widowed	−0.021 (0.014)	−0.049** (0.025)
ISCED 6	0.213*** (0.004)	0.079*** (0.005)
ISCED 5	0.161*** (0.005)	0.039*** (0.007)
ISCED 3–4	0.094*** (0.005)	0.019*** (0.006)
ISCED 2	−0.028*** (0.005)	−0.036*** (0.007)
Constant	−0.004 (0.028)	3.02*** (0.038)
R^2	0.099	0.085
Nobs	91,393	61,329

Notes: ***Significant at 1%; **significant at 5%; *significant at 10%. Standard errors are robust.

ISCED, International Standard Classification of Education; NI, Northern Ireland; NLW, National Living Wage.