

# **Employment and Hours Impacts of the National Minimum Wage and National Living Wage in Northern Ireland**

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## **Non-technical Summary**

This report examines the employment and hours impacts of the 1999 introduction of the UK National Minimum Wage (NMW) and the 2016 introduction of the UK National Living Wage (NLW) in Northern Ireland (NI) using Labour Force Survey data. Because NI is a relatively low-wage region of the UK we might expect minimum wages to have more impact on employment and hours in NI than in other parts of the UK. NI is also the only part of the UK with a land border – the border between NI and the Republic of Ireland (RoI) – 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. This discontinuity in minimum wage coverage enables a research design that estimates the impacts of the NMW and NLW by comparing changes in employment and hours north and south of the border around the time of the NMW and NLW introductions. In practice we estimate a number of alternative models using this approach. Although no existing study of minimum wage impacts has previously exploited this particular border, there is a long tradition of estimating minimum wage impacts in this way, particularly within the US where the minimum wage varies across states and even within states.

We find a small decrease in the employment rate of 22-59/64 year olds in NI, of up to two percentage points, in the year following the introduction of the NMW. The estimates at the upper end of this range are statistically significant at conventional levels and are consistent with a non-trivial, negative employment effect of the NMW, although other potential explanations (e.g. employment impacts of the appreciation of sterling relative to the euro during 1999 or of faster economic growth in the RoI relative to NI during 1999), for at least part of this effect, cannot be entirely ruled out. Estimates at the lower end of this range, from models which make more conservative assumptions at the risk of potentially underestimating the impact of the NMW, are typically not statistically significant, i.e. we cannot be confident they do not show zero impact.

We find no evidence of an impact of the introduction of the NLW on employment in NI, and no evidence of impacts of either the NMW or NLW introductions on weekly hours worked in NI, regardless of the particular model estimated; estimates tend to be very small in magnitude and everywhere statistically insignificant.

In presenting new (albeit tentative) evidence of a possible negative employment effect of the introduction of the NMW in 1999 in a low-wage region, this report adds to the small group of existing UK studies to have found 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 evidence of zero employment and hours impacts of the 2016 introduction of the NLW in NI, however, this report shows that the possible negative employment impact of the introduction of the original NMW in NI was not repeated in 2016, despite NI's continuing position as a relatively low-wage UK region. The report thus also makes a timely additional contribution to the body of research on which the Low Pay Commission can draw in making recommendations regarding the NLW going forward.

## 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 in the UK, and especially at the current time, given the recent introduction of the National Living Wage (NLW) for those aged 25 and over and its planned uprating to reach 60% of national median wages over the next few years. The April 2016 introduction of the NLW was itself a big change, corresponding to an overnight increase of 7.5% in the minimum wage rate for the 25+ age group, or an increase in the bite of the UK minimum wage for the relevant age group from 52.5% of the UK median wage at the April 2015 NMW mid-year point to an estimated 55.8% by the October 2016 NLW mid-year point (Low Pay Commission, 2016).

There is an extensive international body of evidence on the employment and hours effects of minimum wages, 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 & Wascher (2006) with Schmitt (2013)). Nonetheless, inasmuch as there is a consensus in the international literature it is probably that the employment and hours effects of modest minimum wage increases are typically small. UK evidence points to a similar lack of employment and hours responsiveness to minimum wage increases overall, although there is some evidence of impacts for some particular groups and sectors (e.g. see the reviews of de Linde Leonard et al., 2014; Low Pay Commission, 2016).

This report examines the employment and hours impacts of two key UK minimum wage policy changes, specifically for Northern Ireland (NI): (i) the original introduction of the NMW in April 1999 and (ii) the introduction of the NLW for 25s and over 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 mid-year 2016 was already estimated to be well over 60%, and the second highest of all the UK regions (Low Pay Commission, 2016). If, as seems to be the case from the existing body of research in the UK and internationally, employment and/or hours effects of minimum wages are partly dependent on the extent to which such minimum wages bite, then such effects may be more likely in NI than in higher-wage regions of the UK. Second, NI is the only part of the UK where there is a jurisdictional border reflected in a substantial discontinuity in minimum wage rates but (arguably) a reasonable degree of labour market comparability otherwise, at least in terms of changes over the periods of interest, i.e. the land border with the Republic of Ireland (RoI). This enables a quasi-experimental approach to estimating NMW and NLW impacts on employment and hours which 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 report makes a contribution to the wider empirical literature on minimum wages and, potentially, also to contemporary UK policy advice regarding minimum wage impacts.

Specifically, for both the NMW and NLW introductions we conduct a difference-in-differences analysis of the employment and hours impacts of the NMW and NLW

introductions, with the RoI as the main comparison group, exploiting comparable cross-sectional unit record data available quarterly in both jurisdictions from the Quarterly Labour Force Survey (QLFS) (NI) and the Quarterly National Household Survey (QNHS) (RoI). The RoI did not introduce a national minimum wage 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 national minimum wage on 1<sup>st</sup> January 2016. Before and after periods for this quasi-experimental approach are therefore defined as in Table 1.

*Table 1: The Introduction of the NMW and NLW as Natural Experiments*

	<b>Before</b>	<b>After</b>
NMW Introduction, 22+	1998Q2-1999Q1	1999Q2-2000Q1
NI Minimum Hourly Wage	n/a	£3.60
RoI Minimum Hourly Wage	n/a	n/a
NLW Introduction, 25+	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 exclusion of 2015Q4 – see Sections 3.1 and 3.2 for further discussion – in the ‘before’ period for the introduction of the NMW.

We find a small decrease in the employment rate of 22-59/64 year olds in NI, of up to two percentage points, in the year following the introduction of the NMW. The estimates at the upper end of this range are statistically significant at conventional levels and are consistent with a non-trivial, negative employment effect of the NMW, although other potential explanations (e.g. employment impacts of the appreciation of sterling relative to the euro during 1999 or of faster economic growth in the RoI relative to NI during 1999), for at least part of this effect, cannot be entirely ruled out. Estimates at the lower end of this range, from models which make more conservative assumptions at the risk of potentially underestimating the impact of the NMW, are typically not statistically significant, i.e. we cannot be confident they do not show zero impact. Further, we find no statistically significant impacts of the introduction of the NLW on employment in NI, and no clear impacts of either the NMW or NLW introductions on weekly hours worked in NI.

In presenting new (albeit tentative) evidence of possible negative employment effects of the NMW this report adds to the small group of existing UK studies to have found similar employment effects among particular low-wage groups of workers or in particular low-wage sectors (Machin et al., 2003; Dickens et al., 2015). In presenting evidence of zero employment and hours impacts of the introduction of the NLW in NI, despite the relatively

high bite of the NLW in the region, this report also makes a timely addition to the body of research on which the Low Pay Commission can draw in making recommendations regarding the NLW going forward.

The remainder of this report is set out as follows. The following section presents a brief review of relevant empirical literature on the employment and hours impacts of minimum wages in particular for the UK. We also discuss studies of RoI minimum wage effects and the very limited existing literature on minimum wage impacts in NI. **Section 3** presents a brief comparative discussion of labour markets north and south of the border, discusses the data used in the analysis, and the approach to estimation of the minimum wage impacts adopted. **Section 4** presents a preliminary descriptive analysis of hourly wages, employment rates and hours in NI over the time periods either side of both reforms, comparing informally to similar outcomes over the same period in GB (wages) and RoI (employment and hours). **Section 5** presents and discusses the formal difference-in-differences analyses, including an exploration of heterogeneous treatment effects by gender, age and education level, and sensitivity analyses for the main estimates. **Section 6** concludes. An Appendix provides further data details and additional estimates.

## 2. Existing Research

Economic theory is ambiguous about the employment and hours impacts of minimum wages because predicted effects depend on the market context in which they are introduced. As pointed out by Butcher (2012), in a perfectly competitive labour market theory suggests that firms would reduce the amount of labour employed through reductions in employment (the extensive margin) or hours (the intensive margin) or both in response to a minimum wage set above the market-clearing wage. In contrast, in a monopsonistic labour market, or a labour market where higher wages induce greater productivity through efficiency wage effects, theory suggests that minimum wages may even have a positive impact on employment or hours.

This theoretical ambiguity is one of the factors that have led to a vast international empirical literature on the employment and hours effects of minimum wages, employing a range of methods in a range of contexts – although much of it focussed on the US – and coming to a variety of conclusions (the latter being another factor in the literature’s longevity). Some early studies found negative employment effects (e.g. Brown et al., 1982; Neumark et al., 2004), while others (notably Card and Krueger, 1994; also Card et al., 1994) found positive employment effects. Even reviews of this literature have drawn mixed conclusions (e.g. contrast Neumark & Wascher (2006) with Schmitt (2013)). Inasmuch as there is a consensus in the international literature, however, it is probably that employment effects of modest minimum wage increases are typically small. Although fewer studies examine hours, there is perhaps slightly more weight of evidence of negative hours effects among low-paid workers in the US (e.g. see Couch & Witttenburg, 2001; Belman et al., 2015), but again there are counter-examples (e.g. Zavodny, 2000).

UK evidence points to a similar lack of employment responsiveness to minimum wage increases overall, although there is some evidence of impacts for some particular groups (see Dickens et al. (2015) on part-time women), particular sectors (see Machin et al. (2003) on the residential care sector) and again on hours (see Stewart & Swaffield, 2008). Reviews of this literature are provided by de Linde Leonard et al. (2014) and various Low Pay Commission reports (e.g. Low Pay Commission, 2016). 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 points in time, UK researchers have had to be creative to generate plausible counterfactuals by which to identify employment and hours effects. Among the more credible methods employed are difference-in-differences comparing low-wage workers with those higher up the wage distribution (e.g. Stewart, 2002) and regression discontinuity comparing outcomes either side of age thresholds (e.g. Dickens et al., 2014).

Very little is known about the impact of the NMW or NLW on employment and hours specifically in NI. We know from UK-wide analysis that the bite of the NMW and NLW is higher in NI than most other regions of the UK (e.g. Low Pay Commission, 2016), a fact that has been exploited for identification of its impacts by a number of the studies cited above, starting with Stewart (2002). There is also a descriptive statistical report by the relevant NI government department, published in autumn 2016 following the introduction of the NLW, which estimates the number of workers likely to be affected by the NLW introduction and how this varies across groups and sectors (Department for the Economy, 2016). It uses Annual Survey of Hours and Earnings (ASHE) data from 2014/15 to estimate that around 8% of employees in NI were likely to be directly affected by the introduction of the NLW, with disproportionate impacts on female workers, part-time workers, young workers (aged 25-34) and those in certain sectors, reflecting the wider variations in bite at the national level. This report, however, does not consider impacts on employment or hours.

It is also the case that very little is known with regard to the impact of the minimum wage in RoI on outcome variables such as hours worked or employment. Nolan et al. (2002), which collected longitudinal data on a sample of firms in Ireland in 1998 and 2001 to assess the impact of the 2000 introduction of the RoI minimum wage on employment, found no impact with respect to employment growth at a general level, but a lower rate of employment growth among the very small percentage of firms employing high proportions of workers covered by the new minimum wage. Forthcoming research by McGuinness and Redmond adopts a difference in difference framework to analyse the impact of the NMW increase from €8.65 to €9.15 in January 2016. They find that while the rate rise had no detectable impact on employment, it did result in a reduction of 1 hour per week in the number of hours worked. The fall in hours worked was particularly pronounced, at -3.5 hours, among minimum wage workers on temporary contracts.

### 3. Methodology

#### 3.1 Comparison of Labour Markets North and South of the Border

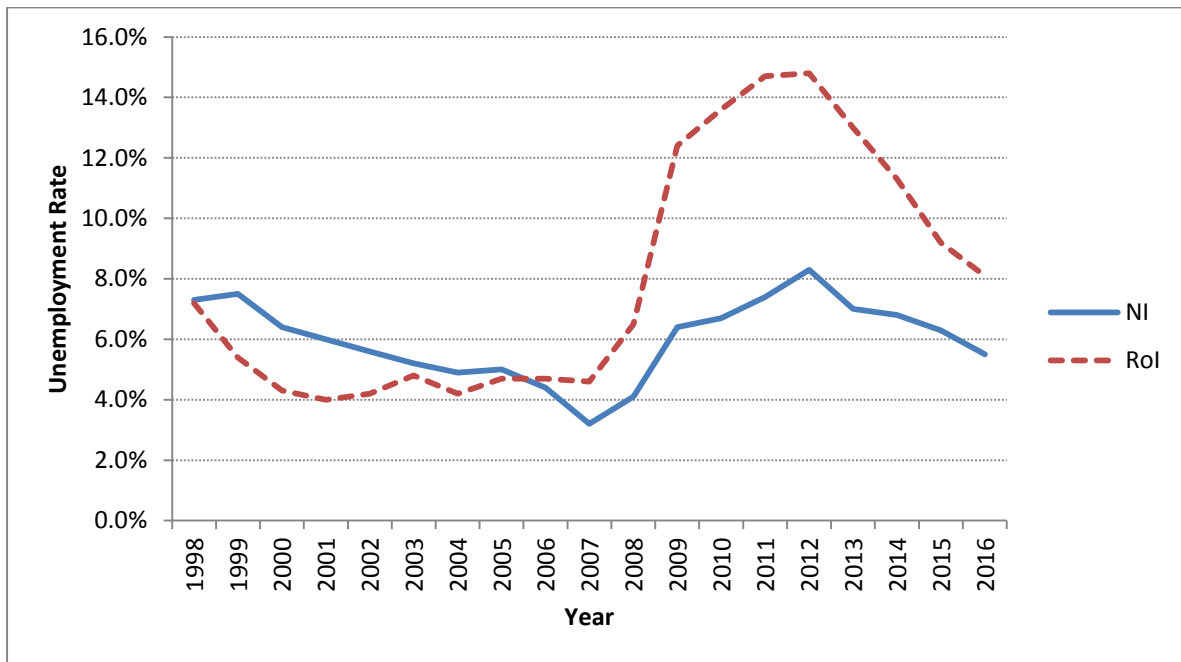
Despite their geographical proximity, the labour markets on both sides of the Irish border are quite distinct in terms of some of their core characteristics. The RoI labour market has been subject to much higher levels of economic volatility, due principally to the highly open nature of the Irish economy; in contrast the NI labour market is generally perceived as being less subject to national and international shocks, due to its heavier reliance on public sector employment. Public sector jobs are estimated to account for over 30 per cent of total employment in NI, compared to a UK average of 17 per cent (Flynn, 2015) and a figure of 18 per cent for RoI (OECD)<sup>1</sup>. The NI labour market is also a relatively poor regional performer within a UK context; while NI unemployment rates follow the UK trend, they typically lie above the UK average irrespective of the business cycle position. Whilst a high reliance on the public sector has helped insulate the NI labour market against external shocks, the RoI economy has experienced some remarkable shifts in fortune that have resulted in large movements in unemployment, employment and migration following the very high growth rates during the late 1990s and early 2000s and, again, during the global downturn period of 2008 to 2012<sup>2</sup>. The more open nature of the RoI labour market is apparent from the more pronounced swings in both unemployment and net migration, relative to NI, over the 1998 to 2016 period (Figures 1 and 2). Migration represents an important safety valve for the Irish labour market (Bergin & Kelly, forthcoming) helping to dampen wage inflation during periods of growth and unemployment during recessions. Nevertheless, it is important to note that labour market conditions in both regions were relatively stable and similar, in terms of both unemployment and net migration, during the time points of key importance to our study i.e. 1999 and 2016. We will demonstrate this further in the next section through more detailed comparisons of key labour market trends over in the periods immediately preceding the introductions of the UK NMW and NLW.

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<sup>1</sup> OECD Government at a Glance (2013).

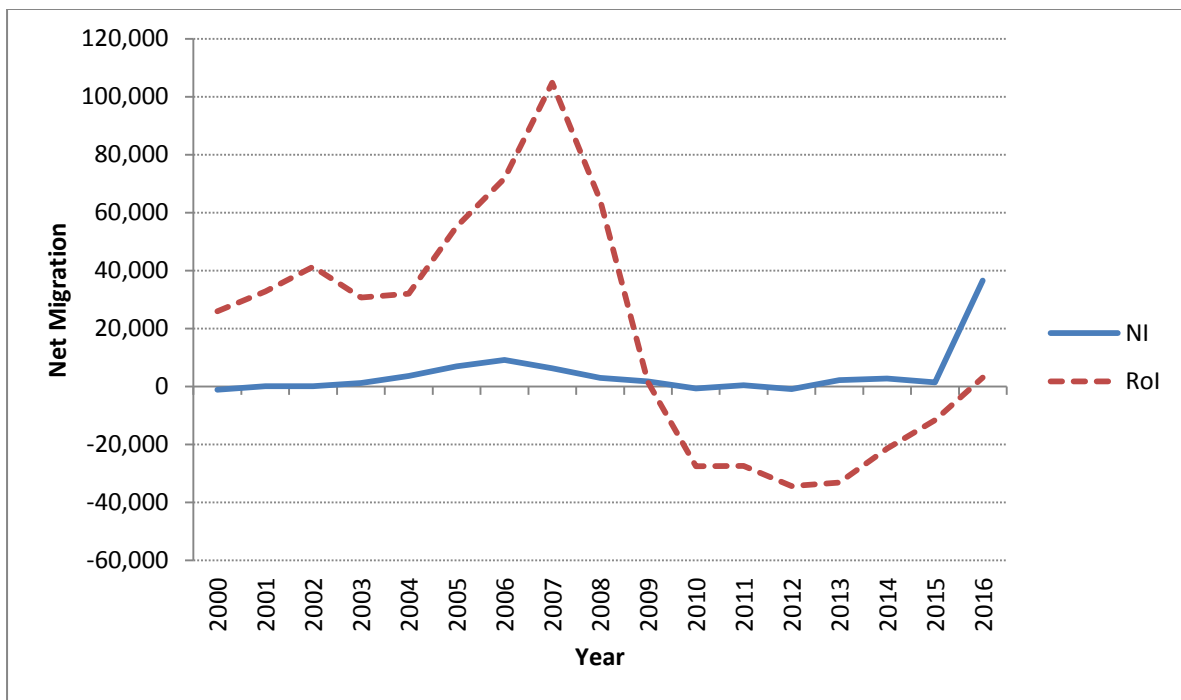
<sup>2</sup> Growth rates in real GDP averaged nine per cent between 1997 and 2000 before moderating to five per cent between 2001 and 2007 (Barret & McGuinness (2012)).

Figure 1: Unemployment Rates for Northern Ireland and Republic of Ireland



Source: CSO(RoI) and NISRA (NI). Notes: ROI figures relate to July. NI figures relate to May-July averages.

Figure 2: Net Migration for Northern Ireland and Republic of Ireland



Source: CSO(RoI) and NISRA (NI).



## 3.2 Data

We exploit unit record data drawn from two national, representative, quarterly household surveys – the QLFS and the QNHS – which we treat as repeated cross-sections. Both surveys provide detailed information for large samples of individuals in identified households quarterly from 1998Q2 through to the latest available quarter, with the QLFS sample size large enough to make quarterly analysis specifically for NI feasible, at least overall if not for narrowly-defined sub-groups. Once we restrict samples to working age individuals – age 22-25/64 for the introduction of the NMW and 25-59/64 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 around 55,000 per quarter around the introduction of the UK NMW and around 21,000 per quarter around the introduction of the UK NLW.

To analyse the introduction of the NMW in April 1999 there are four quarters of data available both pre-treatment (from 1998Q2-1999Q1) and post-treatment (from 1999Q2-2000Q1), from both surveys, where no other minimum wage changes took place either in NI or RoI (2000Q2 saw the introduction of the Republic of Ireland’s own minimum wage.) 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 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+ given the NMW rate still fell below the NLW rate. Second, there was a large increase in the RoI minimum wage from 1<sup>st</sup> January 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.

Because the QNHS evolved from the RoI’s own LFS there 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.

The key outcome variables we use in the descriptive and/or econometric analysis are as follows:

*Hourly wage (QLFS only):* We use two measures of hourly pay: HOURPAY and HRRATE. The former is derived by ONS from hours and earnings data recorded elsewhere in the QLFS survey, has good coverage for those in employment, and is available for analysis of both the introduction of the NMW and the introduction of the NLW. The trade-off for its good coverage is noise. As a result studies specifically of the wage effects of UK minimum wage upratings have tended to use data from the ASHE (see Low Pay Commission, 2016). An

alternative variable available in the QLFS since spring 1999 – so available for analysis of the wage effects of the introduction of the NLW but not the NMW – is HRRATE, which refers to the basic hourly rate of respondents whose last pay period was less than monthly. This restriction, and the fact that it is asked in all quarters but only for respondents who are in the first or last wave of their five-quarter rotation in the QLFS sample, means coverage is far less complete than in the case of HOURPAY. The trade-off for lower coverage is an hourly wage measure that is perceived by some to be more accurate than HOURPAY (e.g. Ormerod and Ritchie, 2007).

*Employment:* To measure whether an individual is employed during the reference period we use the standard ILO definition as in the QLFS variable ILODEFR and the QNHS variable ILO. 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:* We focus primarily on total usual weekly hours in the main job, including overtime. The relevant variable in the QLFS (QNHS) is TTUSHR (HWUSUAL). We also provide estimates for total actual hours worked in the last week (TTACHR / HWACTUAL), although this measure is complicated by zeroes for those on holiday or off work for other reasons in the previous week.

*Employment in a minimum wage sector:* The absence of wage data in the QNHS means we are limited in our ability to restrict analysis to those most likely to be affected by the minimum wage, i.e. the low paid. Instead we define an additional outcome variable over those employed that seeks to exploit the concentration of minimum wage workers in certain sectors. Specifically, we define ‘employed in a minimum wage sector’ as being employed in wholesale and retail, food and accommodation, and health and social care. We also separately examine hours impacts of the NMW and NLW among those employed in these sectors.

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

Tables 2 and 3 present descriptive statistics – sample means and proportions and standard deviations for continuous variables – 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 – whether reflecting genuine differences in outcomes or characteristics, or differences in the precise definition of variables or categorisation of responses between the two surveys – e.g. in average actual weekly hours around the introduction of the NMW or in education levels around the introduction of the NLW, they are time-invariant over the period under consideration, and therefore will not confound estimated NMW/NLW impacts. Note the three percentage point increase in the employment rate in the RoI between the pre-NMW and post-NMW periods, however, which is not reflected in an increased employment rate in NI. Also note the large increases in employment rates for 18-21 (18-24) year olds in the RoI over the period of the introduction of the NMW (NLW), again not reflected in NI. We return to these points below.

*Table 2: Sample Means / Proportions (Standard Deviations) for Outcomes and Other Observable Characteristics, NI and RoI, Pre and Post Introduction of NMW*

	NI		RoI	
	1998Q2- 1999Q1	1999Q2- 2000Q1	1998Q2- 1999Q1	1999Q2- 2000Q1
Hourly wage (£, HOURPAY)	7.14 (4.07)	7.45 (4.17)	-	-
Employment rate 22-59/64	0.70	0.70	0.69	0.72
Proportion of employed in minimum wage sector	0.31	0.30	0.19	0.19
Employment rate 18-21	0.60	0.59	0.52	0.56
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
Employment rate 18-21	0.60	0.59	0.52	0.56
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
No. children <18 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

Note: Estimates are weighted for non-response using pwt07 (QLFS) and gf (QNHS) and based on the full set of information available for each variable. Variables are defined in Table A1.

*Table 3: Sample Means (standard deviations) for Outcomes and Other Observable Characteristics, NI and RoI, Pre and Post Introduction of NLW*

	NI		RoI	
	2015Q4- 2016Q1	2016Q2- 2016Q3	2015Q4- 2016Q1	2016Q2- 2016Q3
Hourly wage (£, HOURPAY)	12.82 (7.03)	12.35 (5.92)	-	-
Hourly wage (£, HRRATE)	9.23 (3.27)	9.71 (3.65)	-	-
Employment rate 25-59/64	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
Employment rate 18-24	0.58	0.59	0.44	0.49
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
No. children <18 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

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

### 3.3 Approach to Estimation

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, NLW in NI and their counterpart in the RoI are exploited here. The NMW and NLW introductions 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 estimated using a standard difference-in-differences approach (see Blundell and Costa Dias, 2009). Specifically, linear regressions of the following form are estimated:

$$y_{ict} = \alpha NI_i + \lambda_t + \delta(NI_i \cdot Post_t) + \beta X_{ict} + \varepsilon_{ict} \quad (1)$$

where,

$y_{ict}$  is the outcome variable of interest (employment or hours) for individual  $i$  in country  $c$  at time  $t$ ;

$NI_i$  is a dummy for individuals living in a household within Northern Ireland;

$\lambda_t$  are quarterly fixed effects common to both NI and RoI;

$\delta$  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);

$X_{it}$  contains individual and household observed characteristics;

and  $\varepsilon_{ict}$  is a stochastic error term capturing other influences, which we allow to be clustered at the NUTS 3 regional level in a sensitivity analysis.

For (log) hours we estimate the model by ordinary least squares (OLS) and  $\delta$  gives the percentage change in average hours among the NI sample driven by the NMW or NLW introduction. For employment, where the outcome is binary, for ease of interpretation we also estimate by OLS (in this case as a linear probability model (LPM)). In this case  $\delta$  is interpreted as the impact of the NMW or NLW introduction on the probability of employment among the NI sample. We also explore 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.

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:

$$y_{ict} = \alpha NI_i + \lambda_t + \sum_{p=1}^q \delta_p(NI_i \cdot p) + \beta X_{ict} + \varepsilon_{ict} \quad (2)$$

where  $p$  is a series of quarter dummy indicators for each of the post-reform quarters.

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. While this assumption is untestable, 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. There are also other potential drivers which we discuss below.

An informal sense of whether the outcomes of interest here – employment and hours – were diverging prior to the introductions of the NMW and NLW is given by Figures 6-9 in the following section. Diverging trends can be more formally tested, however, by estimating the dynamic model over the pre-reform period, similar to equation (2), except  $p$  is a series of quarterly dummy indicators for each of the pre-reform periods. 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 didn't 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. 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 (forthcoming) provide support for this assumption in the case of employment, although they cannot rule out an hours impact of the January 2016 uprating of the RoI minimum wage.

Estimated coefficients and standard errors for NI-quarter interactions in each case (i.e.  $\delta_p$ ) and p-values for the corresponding tests of their joint significance are presented in Table 4. In neither case – the introduction of the NMW and the introduction of the NLW – is there evidence of statistically significant diverging prior trends for employment or for hours. We therefore proceed, at least initially, on the basis that the assumption of common trends holds in all cases here. The estimates in Table 4 can also be interpreted as null estimates for placebo tests in each of the quarters prior to the actual introduction of the NMW and NLW.

Table 4: Testing for Parallel Prior Trends – Difference-in-difference Estimates for the Pre-treatment Periods, Coefficients (Robust Standard Errors)

$\delta_p$	Employment	Weekly hours
<i>Introduction of the NMW</i>		
1998Q2	ref. case	ref. case
1998Q3	-0.014 (0.012)	0.002 (0.014)
1998Q4	-0.003 (0.012)	0.007 (0.014)
1999Q1	-0.016 (0.012)	0.021 (0.013)
$F_{\delta_{1998Q3}=\delta_{1998Q4}=\delta_{1999Q1}=0}$ [p-value]	0.83 [0.48]	0.97 [0.41]
Nobs	232,161	139,351
<i>Introduction of the NLW</i>		
2015Q4	ref. case	ref. case
2016Q1	-0.003 (0.018)	-0.009 (0.016)
Nobs	45,600	30,703

\*\*\*Significant at 1%, \*\*significant at 5% and \*significant at 10%. These represent coefficients on interaction terms between the dummy variable for NI and individual quarter dummies. All models are estimated with a full set of controls (as listed and defined in Table A1).

Having said that, Table 4 does suggest *some* prior divergence in employment (possibly growing faster in the RoI than NI prior to the NMW) and hours (possibly growing faster in NI than RoI prior to the NMW with the opposite being the case just prior to the NLW, despite the possible hours effect of the RoI minimum wage uprating in 2016Q1) although too small and imprecisely estimated to be statistically significant at conventional levels. To explore sensitivity to the common trends assumption we therefore also report estimates based on an alternative assumption of parallel growth, i.e. estimates that allow for diverging linear trends

(see Mora and Reggio, 2012). In practice this entails inclusion of a NI-specific linear time trend in (1) as an additional control variable. That estimated minimum wage effects can be sensitive to the inclusion of such trends has been demonstrated in previous studies (e.g. Allegretto et al., 2011), although some question how to interpret such sensitivity (e.g. Neumark, 2017).

We also estimate alternative models comparing outcomes in NI with those in Great Britain (GB) in place of the RoI, comparing outcomes within NI for 22/25-59/64 year olds with those for 18-21/24 year olds, and exploiting the three-way difference between the younger and older age groups north and south of the border. None of these robustness tests are ideal, however, given the NMW was introduced simultaneously in GB and NI, given that the NMW also covered 18-21 year olds albeit at a lower rate, and given the rapid growth in youth employment in the RoI around the introduction of both the NMW and NLW (see Tables 2 and 3), likely reflecting the particular sensitivity of youth employment to the rapid growth south of the border at the time of the introduction of the UK NMW and to the recovery from the Great Recession at the time of the introduction of the NLW. Specifically, all are likely to underestimate any negative minimum wage impacts on employment or hours. Finally, we also estimate models for NMW and NLW impacts on employment and hours in the three one-digit industries likely to have the highest concentrations of minimum wage workers both north and south of the border (wholesale & retail trade, accommodation & food, and human health & social work), for which we can also reject diverging prior trends.<sup>3</sup>

Even with parallel prior trends, parallel assumptions may still be violated if there are confounding sources of divergence in the quarters coinciding with or immediately following the NMW/NLW introductions. There are potential candidates for such confounders. The NI and RoI economies were growing at very different rates around the time of the introduction of the NMW, with real GDP and GNP growth rates of between 8% and 10% in RoI in 1998 and 1999 (in part reflecting expansionary monetary policy associated with the launch of the Euro, e.g. with a 50 basis point cut in April 1999) compared to growth in NI GVA of only 0.1% in 1998 and 4.3% in 1999, with the more rapid NI growth in 1999 in part reflecting the peace dividend following the signing of the Good Friday Agreement. The rapid growth in the RoI at this time may be partly reflected in the increased employment rate between the pre and post-NMW periods shown in Table 2. On the other hand this growth disparity was at its widest in 1998 where we find no evidence of diverging trends in employment or hours. Nevertheless, because we cannot entirely rule out that employment rates would have diverged north and south of the border over the year following the introduction of the NMW even in the absence of its introduction, we must remain cautious about interpreting any estimated negative employment effect from our main model as causal; such an estimate is more likely to be an upper bound on the absolute magnitude of any negative NMW effect. There was also a steady appreciation of Sterling relative to the Euro over the course of 1999 (of around 10%), which may have led to changes in cross-border shopping and tourism, or changes in employment in export industries either side of the border. If these currency-related potential confounding effects impart a bias on our main NMW employment estimate it is also likely to

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<sup>3</sup> Results for testing divergence of prior trends in these cases are available from the authors on request.



take a negative sign, reinforcing the likely interpretation of this main estimate as an upper bound on the absolute magnitude of any negative NMW effect on employment. It is less clear how these potential confounders would bias estimated hours impacts of the NMW. For both outcomes this provides further motivation for the battery of sensitivity analyses set out in Section 5.3.

The RoI and NI were also growing at different rates in the period around the NLW introduction, with faster growth in the RoI compared to steady growth of around 2% in GVA for NI.<sup>4</sup> The introduction of the NLW also broadly coincided with the Brexit referendum in the UK, with the surprise ‘leave’ result declared at the end of 2016Q2 quickly followed by a dip in business and consumer confidence – although these subsequently recovered and GDP growth in the UK (and to a lesser extent NI) remained strong throughout 2016 – and a large depreciation of the £/€ exchange rate (by over 10% during the fortnight from 23<sup>rd</sup> June to 7<sup>th</sup> July 2016, with further falls over the course of 2016Q3). The Brexit vote is also likely to have impacted on RoI over the second half of 2016, in part but not only through the changes in the £/€ exchange rate, although GDP growth remained strong over the second half of the year. Given the mixed nature of these potential confounders, however, it is less straightforward to sign any potential bias on the estimated NLW impact on employment, and again on hours<sup>5</sup>, in this case. Again we rely in part on the sensitivity analysis set out in Section 5.3 to draw conclusions on the extent to which these issues may be biasing our main estimates of NLW impacts.

Another necessary condition to correctly identify the impacts of the NMW/NLW introduction using this kind of regression approach is that there are no large, relevant, asymmetric, unobserved changes in the composition of the working age population or, for hours, in the composition of those in employment. We know from Tables 2 and 3, however, that *observable* characteristics of the treatment and control groups are stable between the pre and post-reform periods in each case. It is not unreasonable to therefore assume the absence of large compositional changes in *unobservables*.

Finally, although substantial changes in cross-border migration as a result of the introductions of the NMW and NLW seem unlikely and there is no documented evidence of such, we cannot entirely rule out the potential for spillover effects associated with cross-border commuting ex ante. For example substantial commuting from RoI to NI could potentially lead to estimated employment / hours effects of the NMW/NLW introduction that are biased towards zero (e.g. consider an extreme example where half of those employed in NI commute in from the RoI and therefore are recorded not in the QLFS but in the QNHS). It is also possible that commuting patterns may have been directly affected by the introduction of the NMW/NLW – although the larger exchange rate movements are likely more salient – which could lead to biases of uncertain sign. Unfortunately there is insufficient information on

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<sup>4</sup> For RoI 2015 growth in total consumption of 4.5% is probably a better reflection of the situation than estimated GDP growth of 26%. RoI GDP growth in 2016 was estimated at 5.2%.

<sup>5</sup> An exception is that the hours impact of the January 2016 uprating of the RoI minimum wage reported by McGuinness and Redmond (forthcoming) would bias the estimated hours impact of the NLW towards zero.

cross-border commuting in the QLFS and QNHS for a detailed analysis of such impacts.<sup>6</sup> In none of the quarters analysed here, however, does reported cross-border commuting ever exceed one percent of the relevant age group.

#### 4. Descriptive Analysis

Before turning to the formal difference-in-differences analysis comparing NI and RoI described above, we take a preliminary look at the QLFS and QNHS data to see if there is any evidence of changes in employment rates or average hours in NI that are potentially consistent with NMW or NLW effects.

First however, given that the primary mechanism for minimum wages to impact on employment or hours is through their impacts on actual wages paid to workers, we explore whether the QLFS suggests any change in the *hourly wage* distribution in NI that coincides with the introduction of the NMW or NLW. In other words we look for changes consistent with ‘first stage’ effects of the NMW or NLW. For the introduction of the NMW we are limited to using the HOURPAY variable in the QLFS which ONS derives from data on reported hours and earnings (see Section 3.2). For the introduction of the NLW we use both HOURPAY and the alternative HRRATE, which although reported for far fewer survey respondents, is likely to be more accurate for those that do report it (again see Section 3.2). Because the QNHS does not report wage data for RoI, in this case we compare NI and GB.

Figures 3-4 show the proportion of workers paid below the NMW according to the HOURPAY measure (Figure 3) and the proportion of workers paid below the NLW according to the HOURPAY and HRRATE measures (Figures 4 and 5 respectively), for both NI and GB, over the relevant periods. For both charts using the HOURPAY variable there is no clear change in either NI or GB coinciding with the introduction of the NMW or NLW.<sup>7</sup> Instead, around the introduction of the NMW the proportion of workers recorded as being paid below the NMW follows a reasonably steady downward trend in both GB and NI with no apparent acceleration in its rate of decline in the run up to 1999Q2. Similarly, there appears to be a falling proportion paid below the NLW in both GB and NI in the two quarters preceding its introduction in 2016Q2, which then levels off for GB from 2016Q2 but continues to decline for NI through 2016Q3. (The series for NI appears particularly noisy over this period.) In contrast, Figure 5 shows a clear drop in the proportion of workers paid below the NLW in both GB and NI in 2016Q2 when using the HRRATE measure, of a

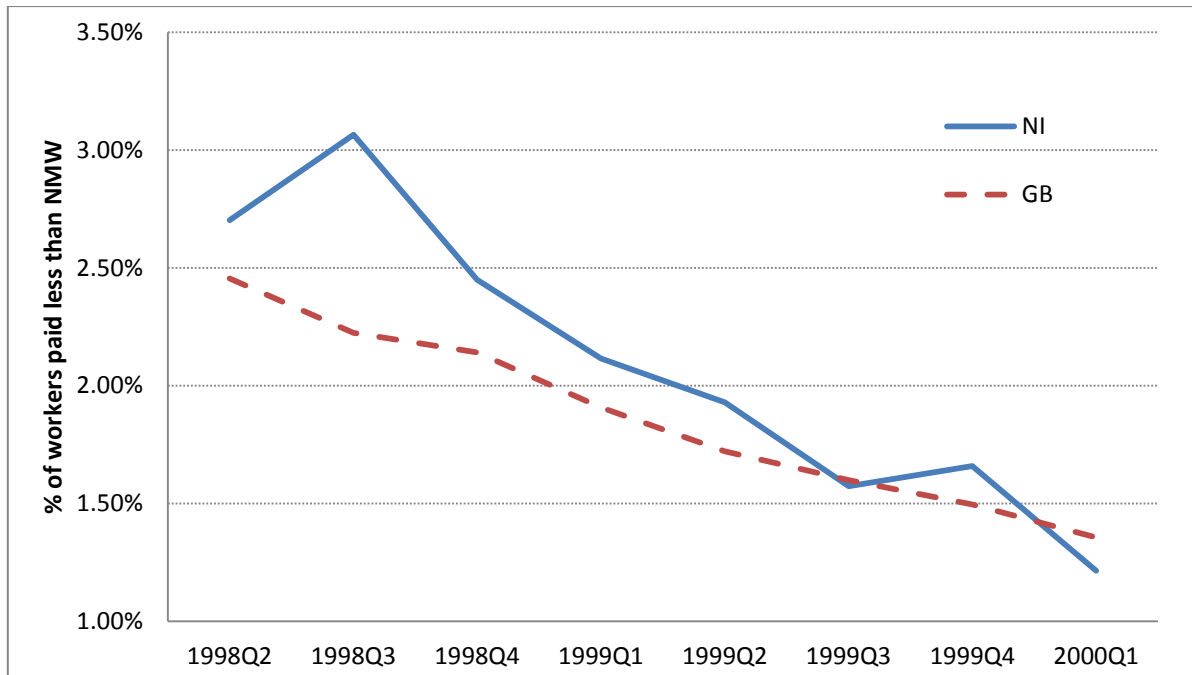
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<sup>6</sup> Data on cross-border commuting is very limited in both the QLFS and QNHS. In the QLFS there is a question on whether the individual’s usual place of work is outside the UK (REGWKR) but if so there is no information on the country of work. Even if we proceed under the assumption that anyone living in NI whose usual place of work is outside NI is working in RoI, very few respondents ever report that they work outside of NI in any of the quarters analysed here, which raises both reliability and potential disclosure issues. The QNHS data is similarly sparse, although commutes to NI are identified separately from commutes to other parts of the UK (the relevant variable is UKCOUNTRYW).

<sup>7</sup> Note that Figure 3 appears to underestimate the proportion of workers paid below the minimum wage as of April 1999 compared to an ASHE-based figure cited in LPC (2016) that suggests 3.4% of UK workers were directly affected by the NMW at the time of its introduction.

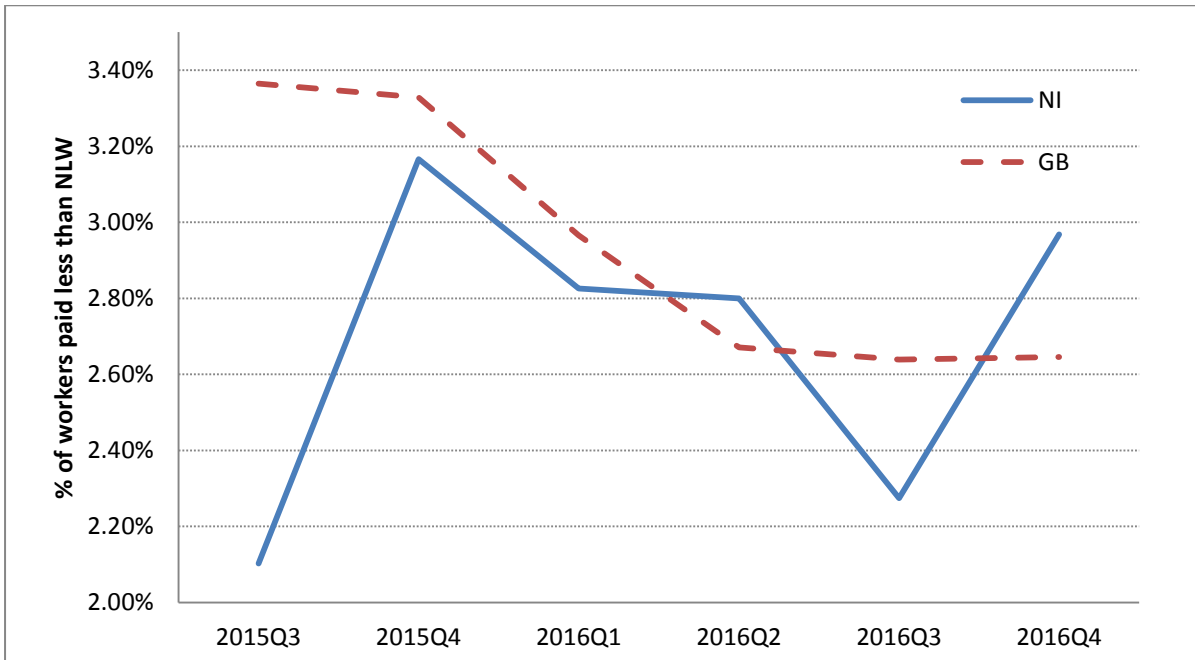
similar magnitude in both GB and NI, although from a slightly higher starting point in NI. From 2016Q2 onwards the proportion in both GB and NI is, as we would expect if there is almost complete compliance, very close to zero (less than 0.2%). In other words, the HRRATE measure if not the HOURPAY measure suggests clear first stage effects of the introduction of the NLW in both GB and NI. We are left uncertain as to the first stage effects of the original introduction of the NMW.

Figure 3: Proportion of Workers Paid Below £3.60, NI and GB, HOURPAY Wage Measure



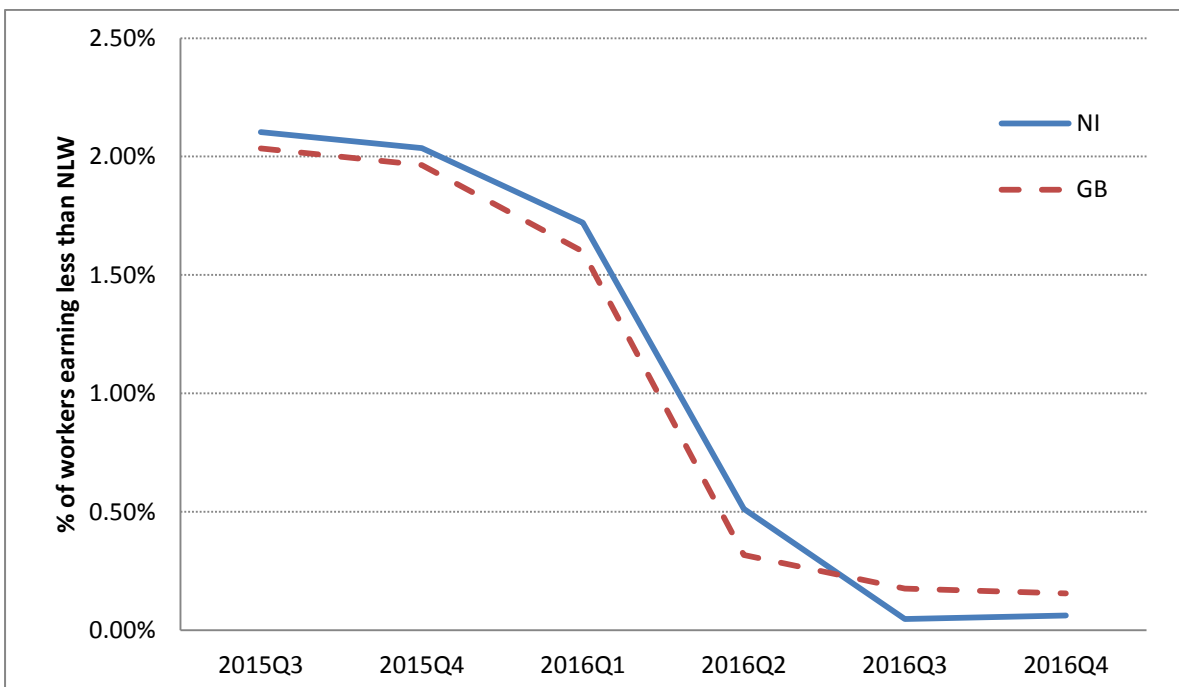
Source: QLFS 1998Q2-2000Q1. Notes: Weighted; age 22-59 (women) and 22-64 (men).

Figure 4: Proportion of Workers Paid Below £7.20, NI and GB, HOURPAY Wage Measure



Source: QLFS 2015Q3-2016Q4. Notes: Weighted; age 25-59 (women) and 25-64 (men).

Figure 5: Proportion of Workers Paid Below £7.20, NI and GB, HRRATE Wage Measure

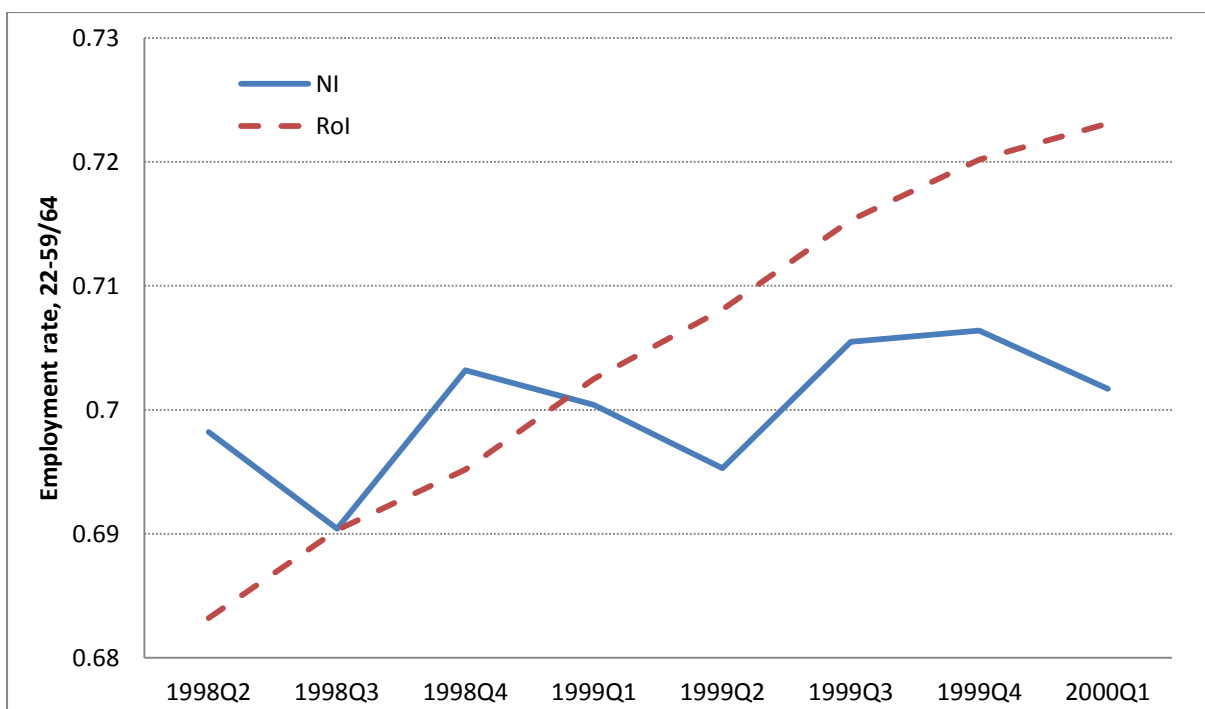


Source: QLFS 2015Q3-2016Q4. Notes: Weighted; age 25-59 (women) and 25-64 (men).

Figures 6-7 show trends in the employment rates for both NI and RoI over the relevant periods. Figure 6 shows a clear, steady upward trend in employment in the RoI over the period 1998Q2-2000Q1. The NI data are noisier, as we would expect given the smaller sample size, but approximately track the upward trend for the RoI over the period prior to the introduction of the NMW, consistent with Table 4. As of 1999Q2, however, the two series clearly diverge, with the NI employment rate growing only slowly through to 2000Q1 compared to rapid ongoing growth in the RoI. From an essentially zero gap on average over the period prior to the NMW, a gap of around two percentage points emerges by 2001Q1. This is consistent with an employment effect of the NMW, although as already discussed there may be other explanations.

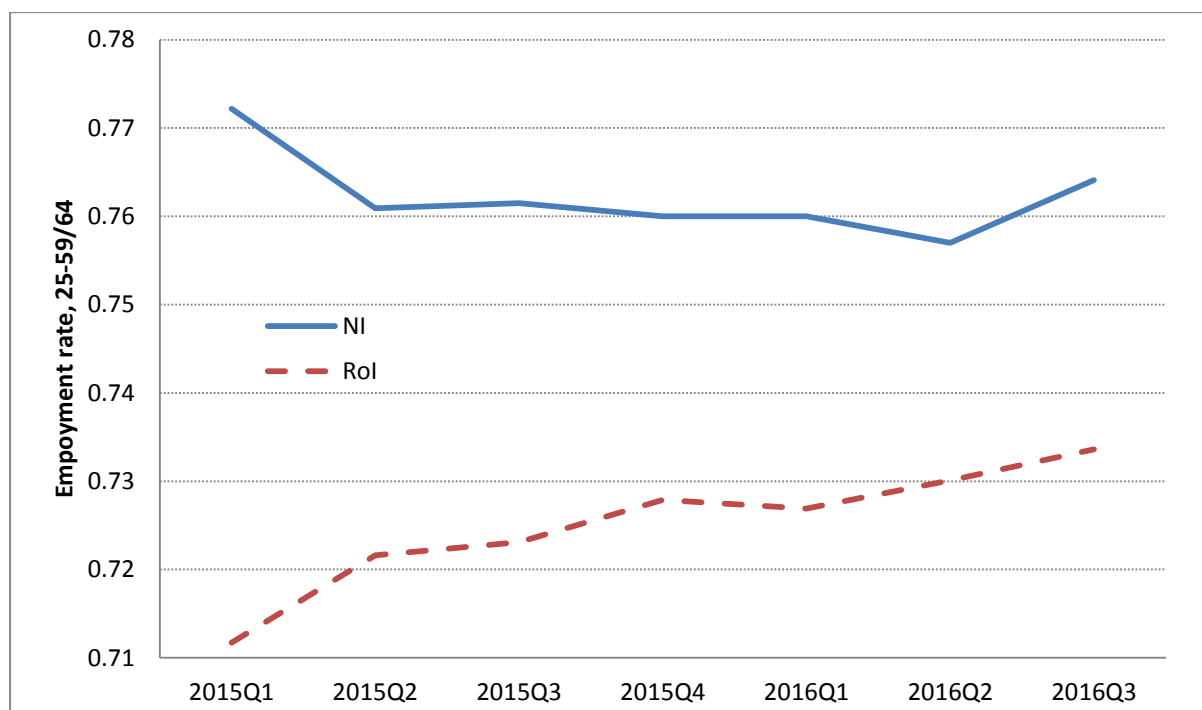
Figure 7 suggests that there is no such apparent impact on the NI employment around the time of the NLW introduction; the NI employment rate remains essentially flat throughout the period leading up to and following the introduction of the NLW whereas the RoI employment rate grows steadily over the period.

Figure 6: Employment Rate, NI and RoI, 1998Q2-2000Q1



Source: QLFS and QNHS 1998Q2-2001Q1. Notes: Weighted; age 22-59 (women) and 22-64 (men).

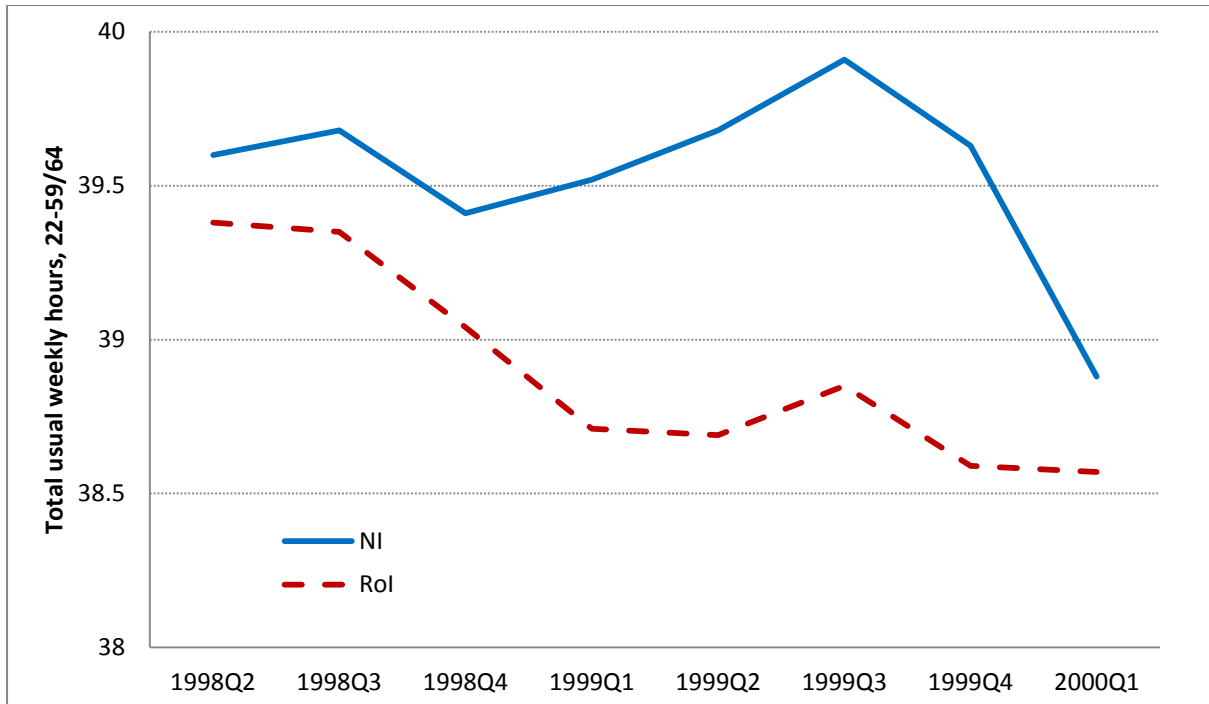
Figure 7: Employment Rate, NI and RoI, 2015Q1-2016Q3



Source: QLFS and QNHS 2015Q1-2016Q3. Notes: Weighted; age 25-59 (women) and 25-64 (men).

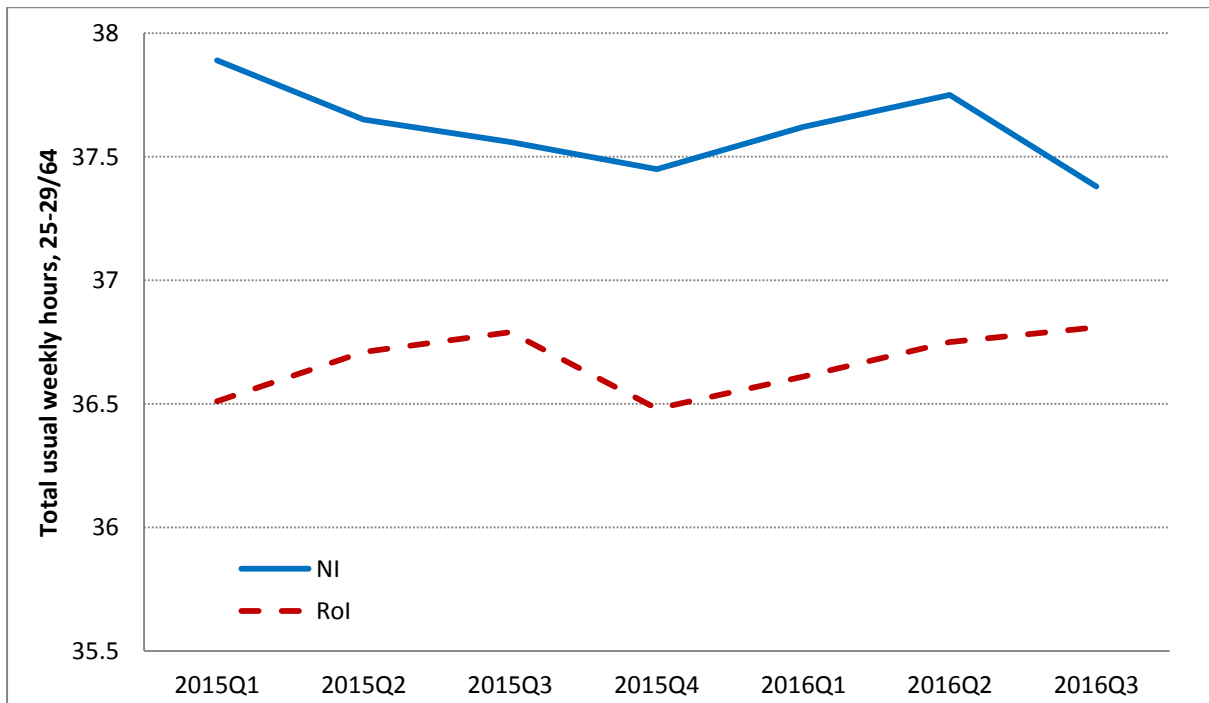
Figures 8-9 show trends in average weekly total usual hours worked in both NI and RoI over the relevant periods. The data are noisy (and seasonal), but in the earlier period (Figure 8) average hours in NI are shown to be higher than those in the RoI by around half an hour per week. They were also flatter prior to the NMW introduction than in RoI where average hours were falling. Following the introduction of the NMW average hours initially rise in NI before falling from their peak in 1999Q3, and continue to fall, albeit slowly, in the RoI. In short, there is little evidence here of a clear NMW effect on hours. Figure 9 shows that average hours in NI were also higher than those in the RoI in the period around the introduction of the NLW, and in this case neither NI nor the RoI show any clear trend either before or after its introduction. Again there is little evidence here of any NLW impact on hours.

Figure 8: Average Total Usual Weekly Hours, NI and RoI, 1998Q2-2000Q1



Source: QLFS and QNHS 1998Q2-2001Q1. Notes: Weighted; age 22-59 (women) and 22-64 (men).

Figure 9: Average Total Usual Weekly Hours, NI and RoI, 2015Q1-2016Q3



Source: QLFS and QNHS 2015Q1-2016Q3. Notes: Weighted; age 25-59 (women) and 25-64 (men).

## 5. Difference-in-differences Analysis

### 5.1 Main Estimates

Table 5 presents our main difference-in-difference estimates of the employment and hours impacts of the introduction of the NMW in NI using the RoI as the comparison group. Only the key estimated parameters are reported here; full results are given in the appendix.<sup>8</sup> First consider employment. The first row gives the estimated impact of the NMW introduction on employment, averaged over the first four quarters following its introduction. The estimate suggests that the NMW was associated with a fall in employment in NI, with employment in the year following its introduction almost two percentage 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 (three percentage 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.

*Table 5: Difference-in-Differences Estimates of Impacts of the NMW Introduction on Employment and Hours in NI, Coefficients (Robust Standard Errors)*

	Employment	Weekly hours
<i>Constant treatment effect (1999Q2-2000Q1)</i>	-0.019*** (0.006)	0.001 (0.007)
<i>Time-varying treatment effect</i>		
1999Q2	-0.017* (0.010)	0.013 (0.010)
1999Q3	-0.014 (0.010)	0.004 (0.011)
1999Q4	-0.020** (0.010)	0.004 (0.011)
2000Q1	-0.025*** (0.009)	-0.015 (0.011)
Nobs	463,647	298,473

\*\*\*Significant at 1%, \*\*significant at 5% and \*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.

<sup>8</sup> We do not separately discuss estimated correlations between employment and control variables here, which are consistent with what we would expect in all cases.



Given the earlier discussion about possible confounding trends, how do we interpret this estimate? We know from Table 4 that we can reject diverging *prior* trends, which strengthens the case for interpreting this as a causal effect of the NMW introduction.<sup>9</sup> But we also know that we cannot entirely rule out confounders in the year *following* the introduction of the NMW, which on balance suggest this estimate may be an upper bound on any ‘true’ causal impact of the NMW on employment. We investigate this further by subjecting the model to a range of sensitivity analyses, as discussed in Section 5.3.

The next four rows of Table 5 present quarter-specific estimates of NMW impacts on employment. Three out of four are statistically significant at conventional levels, and the magnitudes of these estimates are reasonably stable around the -1.9 percentage point average, 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).<sup>10</sup>

Turning to estimated impacts of the NMW on hours (column 2 of Table 5) we see no clear evidence of any impact. The estimated impact averaged over the first year following the NMW introduction is essentially zero in magnitude and is nowhere near statistical significance. Neither is there any clear estimated impact in the quarter-specific estimates, all of which are statistically insignificant and range in magnitude from +0.013 to -0.015.

How sure can we be that these estimates are showing a zero impact of the NMW on hours? Again we know from Table 4 that we can reject diverging prior trends, although if anything in this case there appears to be a slight (although statistically insignificant) *growth* in hours in NI relative to the RoI over the period prior to the introduction of the NMW that could, if continued into the post-NMW period, bias any estimated negative hours effect towards zero.<sup>11</sup> We also cannot entirely rule out confounders in the year following the introduction of the NMW, although in this case it is less straightforward to sign any potential bias (faster growth in the RoI could lead to increased hours among those already in work but could also draw previously non-employed workers into the labour market, some of whom may work part-time). As for employment, to increase confidence in this zero estimate we subject the model to a range of sensitivity analyses as discussed in Section 5.3.

Table 6 repeats the exercise for the introduction of the NLW in 2016Q2. In this case there is very little evidence of any NLW impact on employment in NI, with the point estimate very close to zero and nowhere near statistical significance. As shown by rows 2 and 3, neither is there any evidence of an employment effect that accumulates – via employment growth – over time following the NLW introduction, although the caveat here is that we have data for only two post-NLW quarters. Again, how sure can we be that these estimates are showing a

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<sup>9</sup> A more exacting test on prior trends is to estimate the model over the whole sample period with both pre and post NI-specific dummies (with the former defined as =1 for 1998Q3-1999Q1 and =0 otherwise) and to test whether the estimated coefficients on the pre\*NI and post\*NI dummies are equal. We reject the null hypotheses (of equal coefficients) at the 99% level of statistical significance.

<sup>10</sup> An alternative explanation for larger point estimates in later quarters is ongoing diverging trends.

<sup>11</sup> In this case, however, we cannot reject that the estimated coefficients on the pre\*NI and post\*NI dummies are equal when we repeat the test described in footnote 9 (p-value of 0.85).

zero impact of the NLW on employment? We know from Table 4 that we can once again reject diverging prior trends.<sup>12</sup> We cannot entirely rule out confounders in the two quarters following the introduction of the NLW, although in this case, as for hours following the introduction of the NMW, it is less straightforward to sign any potential bias (for example, any confounding effect of currency movements over this period seem likely to work in the opposite direction to any confounding effect of more rapid growth in the RoI). Again, to increase confidence in this zero estimate we subject the model to a range of sensitivity analyses as discussed in Section 5.3.

Similarly, for hours, there is no clear evidence here of any impact from the introduction of the NLW. The point estimate in the first row suggests a decrease of around one percent in average usual weekly hours in the six months following the introduction of the NLW but the estimate is not precise and is not statistically significant at conventional levels. The quarter-specific estimates are also statistically insignificant, although the estimate for 2016Q3 is larger in magnitude at -1.9%, and is approaching the margin of conventional levels of statistical significance. This raises the question of whether NLW impacts on hours might emerge in subsequent quarters as more data become available. In terms of confidence in this zero estimate, as before we can rule out statistically significant prior diverging trends<sup>13</sup> but not potential confounding effects in the period immediately following the introduction of the NLW, biases from which are difficult to sign. Again our approach is to subject the estimate to sensitivity analysis, as set out in Section 5.3.

*Table 6: Difference-in-Differences Estimates of Impacts of the NLW Introduction on Employment and Hours in NI, Coefficients (Robust Standard Errors)*

	Employment	Weekly hours
<i>Constant treatment effect (2016Q2-2016Q3)</i>	-0.001 (0.010)	-0.011 (0.011)
<i>Time-varying treatment effect</i>		
2016Q2	-0.004 (0.012)	-0.004 (0.013)
2016Q3	0.002 (0.012)	-0.019 (0.013)
Nobs	91,393	61,550

\*\*\*Significant at 1%, \*\*significant at 5% and \*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.

<sup>12</sup> Further, we cannot reject that the estimated coefficients on the pre\*NI and post\*NI dummies are equal when we repeat the test described in footnote 9 (p-value of 0.83).

<sup>13</sup> Again we cannot reject that the estimated coefficients on the pre\*NI and post\*NI dummies are equal when we repeat the test described in footnote 9 (p-value of 0.97).

## 5.2 Heterogeneous Minimum Wage Effects?

Table 7 presents the key parameters from re-estimating (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 two percentage point decline in the employment rate is common to men and women and to the younger and older age groups (although the latter is a very broad grouping). 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.

*Table 7: 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)*

	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)
Men	-0.020** (.008)	0.005 (0.008)	-0.020 (0.013)	0.006 (0.012)
Women	-0.019** (0.009)	-0.006 (0.012)	0.018 (0.015)	-0.027 (0.018)
Age 22-34 / 25-34	-0.022** (0.010)	0.011 (0.010)	-0.005 (0.019)	-0.020 (0.019)
Age 35-59/64	-0.019*** (0.008)	-0.007 (0.009)	-0.002 (0.012)	-0.009 (0.013)
Higher qualification level	-	-	-0.005 (0.012)	-0.019 (0.012)
Lower qualification level	-	-	-0.001 (0.018)	0.002 (0.023)

\*\*\*Significant at 1%, \*\*significant at 5% and \*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 paths assumption in each case.

### 5.3 Sensitivity Analysis

Table 8 presents the key parameter estimates from a number of sensitivity analyses.

First we re-estimate the employment models as logit models rather than LPMs, given the binary nature of the outcome variable.

Second, we include a linear trend term for NI to control for diverging trends that do not reach the threshold for statistical significance. To the extent that this is over-controlling, these estimates are likely to be on the conservative side.

Third, we re-estimate the main model excluding the quarter prior to the NMW and NLW introductions in each case to test sensitivity to possible anticipation effects.

Fourth, we re-estimate the main model excluding 2015Q4 in the NLW case to test sensitivity to potential effects of the RoI uprating of its own minimum wage on 1st January 2016.

Fifth, we re-estimate hours effects using total actual hours in the reference week rather than total usual hours.

Sixth, we restrict the QNHS sample to those in the NUTS3 border region in an effort to minimise potential asymmetric shocks.

Seventh, we exclude the RoI border region in an attempt to minimise the scope for biases from cross-border spillovers.

Eighth, we replace the RoI as the control group with a control group drawn from the QLFS for GB. Although GB and NI both introduced the NMW, and later the NLW, at the same time, this approach aims to exploit the contrast in bite in both the NMW and NLW between NI and GB to identify its impacts. But, as for the estimates including a linear trend for NI, these are likely to be conservative estimates because we cannot rule out minimum wage impacts in the control group too.

Ninth, we replace the RoI as the control group with a control group drawn from within NI but for a younger age group (18-21s in the case of the NMW and 18-24s in the case of the NLW). Again these are likely to be (very) conservative estimates because the younger age groups are also covered by the NMW, albeit at lower rates, and we cannot rule out that employment and/or hours for these younger age groups react more strongly to minimum wages than those for the older age groups. This is likely to be a bigger issue for the introduction of the NMW than the NLW because the adult and youth rates were introduced simultaneously for the former whereas the NMW rate for under-25s was constant over the period of analysis around the introduction of the NLW.

We then estimate a triple differences version of the model which exploits both the age dimension and the NI/RoI dimension for identification of NMW and NLW impacts. In other

words it is the difference in relative employment and hours changes between the older and younger age groups north and south of the border that are exploited for identification. Again this is likely to lead to (very) conservative estimates of any negative NMW/NLW impacts on employment – it is less clear in the case of hours – given the rapid growth in youth employment in the RoI around the introduction of both the NMW and NLW, which because it most likely reflects the particular sensitivity of youth employment to wider economic conditions in RoI, would be unlikely to carry over to NI under the counterfactual.

Next, we re-estimate the main models allowing standard errors to be clustered at the NUTS3 level using a wild cluster bootstrap approach (with 1000 draws) as suggested by Cameron and Miller (2015).<sup>14</sup>

Finally, we also re-estimate the main models specifically for NMW and NLW impacts on employment and hours in the three one-digit industries likely to have the highest concentrations of minimum wage workers both north and south of the border (wholesale & retail trade, accommodation & food, and human health & social work).<sup>15</sup> These are the sectors arguably most likely to experience minimum wage employment and/or hours effects. Forthcoming research from Maitre et al. compares the sectoral distribution of minimum wage workers in RoI and the UK in 2014 using EU-SILC data. Maitre et al. (forthcoming) found 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 8 shows that the estimates presented in Table 6 for the employment and hours effects of the introduction of the NLW are highly robust; for each outcome the estimates from the wide range of variants of the model and/or sample are statistically indistinguishable from zero in all but one case. The exception for employment is the triple differences model exploiting variation by age group and either side of the Irish border, with the positive employment estimate likely explained by the confounding effect of rapid growth in young adult employment in the RoI as the economy continued to recover from the deep recession following the financial crisis. For hours the exception is the estimate with clustered standard errors, which although identical in magnitude to the baseline estimate with robust standard errors, is now estimated to be statistically significant at conventional levels given the bootstrapped clustered standard errors are smaller than in the baseline case. In neither case is this evidence convincing enough to overturn the baseline estimate of zero NLW impacts on employment and hours. The same holds – in this case with no exceptions – for the estimated hours impact of the introduction of the NMW, which is robustly zero.

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<sup>14</sup> The wild bootstrap approach is warranted because of the potential downward bias of standard cluster-robust error estimates when the group size is small. In this case the number of groups is nine.

<sup>15</sup> Recall that wage data are not available in the QNHS so we cannot restrict our analysis to low-paid workers explicitly; instead we attempt to proxy concentration of low-pay workers using sectoral variation in wages.

Table 8: Sensitivity Analysis, Constant Treatment Effects, Coefficients (Robust St. 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 (m. effects)	-0.020*** (0.006)	-	-0.0002 (0.011)	-
Including linear trend for NI	-0.006 (0.013)	0.005 (0.014)	-0.005 (0.022)	0.013 (0.025)
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 regions only	-0.010 (0.007)	0.006 (0.008)	0.014 (0.013)	-0.011 (0.015)
Exclude border regions	-0.020*** (0.006)	0.001 (0.007)	-0.003 (0.010)	-0.011 (0.011)
GB as control group	-0.004 (0.006)	-0.006 (0.007)	0.005 (0.010)	-0.001 (0.011)
18-21 / 18-24 as control group, NI only	0.032 (0.021)	-0.002 (0.033)	0.006 (0.028)	0.015 (0.042)
Triple difference by age and country	0.038* (0.021)	-0.019 (0.033)	0.056* (0.030)	0.038 (0.045)
Estimated with wild-bootstrap clustered st. errors [p-value]	-0.019*** [0.002]	0.001 [0.656]	-0.001 [0.600]	-0.011*** [0.002]
Employed in minimum wage sector	-0.008 (0.007)	-0.012 (0.013)	-0.018 (0.013)	0.011 (0.021)

\*\*\*Significant at 1%, \*\*significant at 5% and \*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.

In contrast, the estimated employment effect of the introduction of the NMW is more sensitive to variations in sample and model specification, as we might expect from the earlier discussion of potential confounders. The baseline estimate of a two percent decline in employment is robust to estimating as a logit model rather than an LPM, to exclusion of 1999Q1, to exclusion of the RoI border region, and, in terms of statistical significance (the coefficient estimate is identical), to re-estimating with wild cluster bootstrapped standard errors. It is robust in sign (i.e. negative), but smaller in magnitude and statistically insignificant, in most other cases. In particular, for three important sensitivity analyses – the model including a linear trend for NI, the model with GB as the comparison group in place of the RoI, and the model estimating impacts on the employment share in minimum wage sectors – the introduction of the NMW is estimated to reduce the employment rate in NI by less than one percentage point, with none of these estimates statistically significant. We have already argued that the first two of these estimates are likely to be on the conservative side, so arguably by themselves do not provide convincing evidence of a zero employment of the NMW in NI. The third estimate, however, more strongly suggests that at least part of the baseline estimated NMW impact on employment – a part that is substantial enough to make the difference between statistical significance and statistical insignificance – may be driven by confounding trends post-treatment rather than the NMW itself. On the other hand this can only be interpreted as a rough proxy for low-wage employment, and we also estimate larger and statistically significant impacts on this particular outcome measure for two important subgroups: males and 22-34s.<sup>16</sup> The positive estimated employment effects for the model comparing age groups within NI and the triple differences model – statistically insignificant in the first case but not the second case – likely reflect NMW impacts on the younger age group in NI and the confounding trend increase in youth employment in the RoI discussed above. Neither estimate provides convincing evidence to either reject or further support the baseline estimate.

## 6. Conclusions

This report presents estimates of employment and hours impacts 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 in order to identify minimum wage effects and the first study to estimate 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 small decrease in the employment rate of 22-59/64 year olds in NI, of up to two percentage points, in the year following its introduction. The estimates at the upper end of this range are statistically significant at conventional levels

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<sup>16</sup> The relevant estimates (robust standard errors) are -0.024\*\*\* (0.009) and -0.033\*\*\* (0.013), respectively.

and are consistent with a non-trivial, negative employment effect of the NMW, although other potential explanations, for at least part of this effect, cannot be entirely ruled out. Estimates at the lower end of this range, from models which make more conservative assumptions at the risk of potentially underestimating the impact of the NMW, are typically not statistically significant, i.e. we cannot be confident they do not show zero impact of the NMW on employment.

We (robustly) find no evidence of an impact of the introduction of the NLW on employment in NI in the six months following its introduction, and no evidence of impacts of either the NMW or NLW introductions on weekly hours worked in NI.

In presenting new (albeit tentative) evidence of a possible negative employment effect of the introduction of the NMW in 1999 in a low-wage region, this report adds to the small group of existing UK studies to have found 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 now possibly regional exceptions. In presenting new evidence of zero employment and hours impacts of the 2016 introduction of the NLW in NI, however, this report shows that any negative employment impact of the introduction of the original NMW in NI was not 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.

We conclude with two potential takeaways for the Low Pay Commission in its deliberations on the NMW and NLW going forward, albeit takeaways that are subject to the various caveats concerning internal validity discussed throughout this report, as well as the usual caveats concerning external validity. First, because neither the introduction of the NMW nor the introduction of the NLW impacted on average hours worked in NI, this report provides no additional reasons to expect that a further modest increase in the NLW would reduce average hours in NI. Second, because the evidence of overall employment impacts of the NMW and NLW in NI is more mixed – no impact of the introduction of the NLW but a possible negative impact of the introduction of the NMW – this report provides no unambiguous message on whether a further modest increase in the NLW would reduce employment in NI.

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## Appendix: Further Data Details and Additional Results

Table A1: Variable Definitions and Descriptions

Variable	Definition	Description
<i>Outcome Variables</i>		
Hourly wage (£, HOURPAY)	Average gross hourly pay	Pay in pounds per hour of work, derived from earnings and hours data
Hourly wage (£, HRRATE)	Basic hourly rate	Basic reported pay in pounds per hour of work for those on hourly rate or paid more frequently than monthly. Only asked for wave 1 and 5 respondents.
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 & 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 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
<i>Controls</i>		
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

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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
No. of Children under age of 18 in household	Number of children resident in the household	Number of children under the ages of 17 (RoI) and 19 (NI) resident in the household
No. of children under age 18 in household missing	Dummy for missing data on number of children <18	Missing =1, 0 otherwise
ISCED 1	Respondent reports highest level of qualification as No Qualifications or equivalent	ISCED1 = 1, 0 otherwise.
ISCED 2	Respondent reports highest level of qualification as GCSEs (NI) / Junior Certificate (RoI) or equivalent	ISCED2 = 1, 0 otherwise
ISCED 3-4	Respondent reports highest level of qualification as A-Level (NI) / Leaving Certificate (RoI) or equivalent	ISCED3/4 = 1, 0 otherwise
ISCED 5	Respondent reports highest level of qualification as sub-Degree level Higher or Further Education	ISCED5 = 1, 0 otherwise
ISCED 6	Respondent reports highest level of qualification as Degree level or higher	ISCED6 = 1, 0 otherwise
ISCED missing	Dummy for missing data on highest qualification level	Missing =1, 0 otherwise

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Note: \* SIC Codes: G=Wholesale & retail trade; repair of motor vehicles & motorcycles; I=Accommodation & food services activities and Human Health & social work activities.

*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)
1991Q1	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 <sup>2</sup>	-0.0005*** (0.00001)	-0.00006*** (0.00001)
Male	0.263*** (0.001)	0.350*** (0.002)
No. children <18 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 <sup>2</sup>	0.135	0.146
Nobs	463,647	298,473

\*\*\*Significant at 1%, \*\*significant at 5% and \*significant at 10%. Standard errors are robust.

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 <sup>2</sup>	-0.0004*** (0.00002)	-0.0002*** (0.00002)
Male	0.129*** (0.003)	0.299*** (0.004)
No. children <18 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)
ISCED6	0.213*** (0.004)	0.079*** (0.005)
ISCED5	0.161*** (0.005)	0.039*** (0.007)
ISCED3-4	0.094*** (0.005)	0.019*** (0.006)
ISCED2	-0.028*** (0.005)	-0.036*** (0.007)
Constant	-0.004 (0.028)	3.02*** (0.038)
R <sup>2</sup>	0.099	0.085
Nobs	91,393	61,329

\*\*\*Significant at 1%, \*\*significant at 5% and \*significant at 10%. Standard errors are robust.