I Z A Institute
of Labor Economics
Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 11585

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

Duncan McVicar
Andrew Park
Seamus McGuinness

JUNE 2018

I Z A Institute
of Labor Economics

Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 11585

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

Duncan McVicar
Queen's University Belfast and IZA

Andrew Park
University of Ulster Economic Policy Centre

Seamus McGuinness
Economic and Social Research Institute and IZA

JUNE 2018

IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

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

This paper examines 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). 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 (NI) but not those working on the other side of the border (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. 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, but no impact on hours worked. We find no evidence that the introduction of the NLW impacted either employment or hours worked in NI.

JEL Classification: E24, J31, J38

Keywords: minimum wages, Northern Ireland, employment, hours

Corresponding author:
Duncan McVicar
Queen's Management School
Queen's University Belfast
185 Stranmillis Road
BT9 5EE Belfast
Northern Ireland
E-mail: d.mcvicar@qub.ac.uk

* This paper is based on research funded under the UK Low Pay Commission's (LPC) Open Call for Other Research on the Impact of the National Living Wage contract number BLOJEU-CR17028LPC. We thank the Office for National Statistics Social Survey Division and Northern Ireland Statistics and Research Agency for making UK Quarterly Labour Force Survey data available via the UK Data Archive. We thank the Irish Central Statistics Office for making Quarterly National Household Survey data available. Thanks also to Tim Butcher, Kevin Wrake, Peter Dolton, Jonathan Wadsworth and participants at the 2017 LPC Spring Workshop, 2017 LPC Annual Research Symposium and 2018 Irish Economic Association Annual Conference for helpful comments and suggestions on earlier drafts. The views expressed are those of the authors alone and do not represent the views of the LPC, ONS, NISRA, CSO, QMS, UUEPC or ESRI.

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, but also in the UK 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 and possibly zero. 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 (e.g. see the reviews of de Linde Leonard et al., 2014; Low Pay Commission, 2016) and of small effects on hours (Stewart and Swaffield, 2008).

This paper 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). Given that international evidence suggests that the 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, for the first time, 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 paper makes a contribution to the wider empirical literature on minimum wages and, potentially, also to contemporary UK policy advice regarding minimum wage impacts.

Specifically, we conduct a difference-in-differences analysis of the employment and hours impacts 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 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 1st 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

	Before	**After**
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 in the 'before' period for the introduction of the NLW.

I. 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. 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 or possibly zero. 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 in 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 existing 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. A more recent study by McGuinness and Redmond (2018) 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 one 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.

II. DATA AND APPROACH TO ESTIMATION

This paper exploits 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 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 22-59/64 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 1st 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. In contrast, two measures of hourly pay are potentially available for NI from the QLFS, although neither is ideal: 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). The lack of wage data for the RoI and the less than ideal wage data for NI, however, means we do not present a first-stage analysis of the impact of the NMW or NLW on wages in this paper.

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 holiday 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 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 periods 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. 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.

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
Employment rate 22-59/64	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 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
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
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 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.

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. 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:

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

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 are 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 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 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:

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

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. 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 trends can be tested 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 (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.

Estimated coefficients and robust standard errors for NI-quarter interactions in each case (i.e. δ_p) and p-values for the corresponding tests of their joint significance are presented in Table 4. In both cases – the introduction of the NMW and the introduction of the NLW – there is insufficient evidence to reject the null of parallel trends for employment or for hours. We therefore proceed on the basis that the assumption of common trends holds in all cases here, although we return to this point in Section III. 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. [i] Note that although we cannot rule out that the standard errors reported in Table 4 are under-estimated – they are robust but not clustered, and we return to this point in Section III – this would likely lead us to over-reject rather than under-reject the null of no parallel trends.

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

δ_p	Employment	Weekly hours
Introduction of the NMW		
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
Introduction of the NLW		
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).

III. DIFFERENCE-IN-DIFFERENCES ANALYSIS

Baseline Estimates

Table 5 presents our baseline 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.[ii] 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.

The next four rows of Table 5 present quarter-specific estimates of NMW impacts on employment. 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).

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 very close to 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 very small, ranging in magnitude from +0.013 to -0.015 (i.e. approximately +/- half an hour).

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
Constant treatment effect (1999Q2-2000Q1)	-0.019***	0.001
	(0.006)	(0.007)
Time-varying treatment effect		
1999Q2	-0.017*	0.013
	(0.010)	(0.010)
1999Q3	-0.014	0.004
	(0.010)	(0.011)
1999Q4	-0.020**	0.004
	(0.010)	(0.011)
2000Q1	-0.025***	-0.015
	(0.009)	(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.

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 two-quarter 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 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 is small and 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% (although this still only corresponds to around two thirds of one hour), and is approaching the margin of conventional levels of statistical significance, at least given the standard errors reported here.

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
Constant treatment effect (2016Q2-2016Q3)	-0.001	-0.011
	(0.010)	(0.011)
Time-varying treatment effect		
2016Q2	-0.004	-0.004
	(0.012)	(0.013)
2016Q3	0.002	-0.019
	(0.012)	(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.

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. 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 small and 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)
(Share of those employed who are) 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%. 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.

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 the RoI (wholesale & retail trade, accommodation & food, and human health & social work)[iii]. 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 re-estimate the NMW/NLW impacts on hours. Again both estimates are small in magnitude and statistically insignificant, suggesting no hours impacts even in these sectors.

Sensitivity Analysis and Potential Threats to Identification and Inference

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

1. We re-estimate the employment models as logit models rather than LPMs, given the binary nature of the outcome variable.
2. We re-estimate the baseline model excluding the quarter prior to the NMW and NLW introductions in each case to test sensitivity to possible anticipation effects.
3. We re-estimate the baseline model excluding 2015Q4 in the NLW case to test sensitivity to potential effects of the RoI uprating of its own minimum wage on1st January 2016.
4. We re-estimate hours effects using total actual hours in the reference week rather than total usual hours.
5. We re-estimate the baseline 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).[iv]

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)	-
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)
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]

***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.

Table 8 shows that the coefficient 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 range of variants of the model are small. 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 under-estimation of standard errors (we return to this point below). The same holds – in this case with no exceptions – for the estimated hours impact of the introduction of the NMW, which is robustly very small and nowhere statistically

significant. Similarly, the estimated 2 percentage point impact on employment of the NMW is robust.

Although our estimates are 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.) 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 two percentage point estimated employment effect may be an upper bound on the absolute magnitude of any negative NMW effect. We therefore moderate our conclusion to the following: that the introduction of the NMW led to a small decrease in the employment rate of 22-59/64 year olds in NI of *up to* two percentage points. It is less clear how these potential confounders might bias estimated hours impacts of the NMW, 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 NLW employment and hours impacts. 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 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.

In addition to these remaining concerns about the unbiasedness of the point estimates, we cannot rule out that standard errors are under-estimated here, both in the baseline estimates (with robust but not clustered standard errors) and in 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 – and the fact that the estimated clustered standard errors are smaller than the robust standard errors suggests the NUTS3 level clustering exacerbates rather than mitigates any under-estimation problems. The bottom line is that this threat to inference again leads us to moderate our conclusion of the NMW impact on employment from a decrease of two percentage points to a decrease of *up to* two percentage points. On the other hand it gives no additional reason to question the conclusion of zero NMW impact on hours and zero NLW impacts on hours and employment.

IV. CONCLUSIONS

This paper 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 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 magnitude

of this effect is small but non-trivial, corresponding to a loss of up to 20,000 jobs in NI. We describe this effect as 'up to' two percentage points rather than two percentage points unequivocally because we cannot entirely rule out asymmetric shocks in the period following the introduction of the NMW that could have biased the estimated effect downwards and because we cannot rule out that the standard errors are under-estimated leading to potential over-rejection of the null hypothesis of no effect. The estimated employment coefficient, however, is robust to a series of sensitivity checks. We (again 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. Threats to inference from correlated standard errors are less relevant in these cases since we already fail to reject the null.

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 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 paper 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.

REFERENCES

BELMAN, D. WOLFSON, P. and NAWAKITPHAITOON, K. (2015). Who is affected by the minimum wage? *Industrial Relations: A Journal of Economy and Society* 54(4): 582-621.

BLUNDELL, R. AND COSTA DIAS, M. (2009). Alternative approaches to evaluation in empirical microeconomics. *Journal of Human Resources* 44, 3, 565-640.

BROWN, C., GILROY, C. and KOHEN, A. (1982). The effect of the minimum wage on employment and unemployment. *Journal of Economic Literature* 20(2): 487-528.

BUTCHER, T. (2012). Still evidence-based? The role of policy evaluation in recession and beyond: The case of the National Minimum Wage. *National Institute Economic Review* 219: R26-R40.

CAMERON, A.C. and MILLER, D.L., (2015). A practitioner's guide to cluster-robust inference. *Journal of Human Resources* 50(2): 317-372.

CARD D. and KRUEGER, A.B. (1994) Minimum wage and employment: a case study of the fast food industry in New Jersey and Pennsylvania. *The American Economic Review* 84(4): 772-793.

CARD, D., KATZ, L.F. and KRUEGER, A.B. (1994). Comment on David Neumark and William Wascher, "Employment effects of minimum and subminimum wages: Panel data on state minimum wage laws". *Industrial & Labor Relations Review* 47(3): 487-497.

COUCH, K.A. and WITTENBURG, D.C. (2001). The response of hours of work to increases in the minimum wage. *Southern Economic Journal* 68(1): 171-177.

DICKENS, R., RILEY, R. and WILKINSON, D. (2014). The UK minimum wage at 22 years of age: a regression discontinuity approach. *Journal of the Royal Statistical Society A* 177 (1): 95-114.

DICKENS, R., RILEY, R. and WILKINSON, D. (2015). A re-examination of the impact of the UK National Minimum Wage on employment. *Economica* 82: 841-865.

DE LINDE LEONARD, M., STANLEY, TD. and DOUCOULIAGOS, H. (2014). Does the UK Minimum Wage reduce employment? A meta-regression analysis. *British Journal of Industrial Relations* 52(3): 499-520.

DEPARTMENT FOR THE ECONOMY (2016). The potential direct impact of the National Living Wage in Northern Ireland. Department for the Economy NI.

LOW PAY COMMISSION (2016). The National Minimum Wage: Low Pay Commission Report Autumn 2016.

MAITRE, B., MCGUINNESS, S. and REDMOND, P. (2017). A Study of Minimum Wage Employment in Ireland: The Role of Worker, Household and Job Characteristics. Low Pay Commission (Ireland).

MACHIN, S., MANNING, A. and RAHMAN, L. (2003). Where the minimum wage bites hard: introduction of minimum wages to a low wage sector. *Journal of the European Economic Association* 1: 154–80.

MCGUINNESS, S. and REDMOND, P. (2018). "Estimating the effect of an increase in the minimum wage on hours worked and employment in Ireland", Joint ESRI / Low Pay Commission Report.

MEER, J. and WEST, J. (2016). Effects of the minimum wage on employment dynamics. *Journal of Human Resources* 51, 2: 500-522.

NEUMARK, D. and WASCHER, W. (2006) Minimum Wages and Employment: A Review of Evidence from the New Minimum Wage Research. National Bureau of Economic Research WP 12663.

NEUMARK, D., SCHWEITZER, M. and WASCHER, W. (2004). Minimum wage effects throughout the wage distribution. *Journal of Human Resources* 39(2): 425-450.

NOLAN, B., O'NEIL, D. and WILLIAMS, J. (2002). The Impact of the Minimum Wage on Irish Firms. *ESRI Policy Research Series No. 44*.

ORMEROD, C. and RITCHIE, F. (2007). Issues in the measurement of low pay. *Economic and Labour Market Review* 1, 6: 37-45.

SCHMITT, J. (2013) Why Does the Minimum Wage have No Discernible Effect on Employment? Centre for Economic and Policy Research.

STEWART, M. (2002). Estimating the impact of the minimum wage using geographical wage variation. *Oxford Bulletin of Economics and Statistics* 64**:** 583–605.

STEWART, M.B. and SWAFFIELD, J.K. (2008). The other margin: do minimum wages cause working hours adjustments for low-wage workers? *Economica* 75: 148-167.

ZAVODNY, M. (2000). The effect of the minimum wage on employment and hours. *Labour Economics* 7(6): 729-750.

Appendix: Further Data Details and Additional 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 & 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
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
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

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**	-0.024***
	(0.004)	(0.005)
1998Q3	0.005*	0.015***
	(0.003)	(0.003)
1998Q4	0.011***	-0.014***
	(0.003)	(0.003)
1991Q1	0.018***	-0.014***
	(0.003)	(0.003)
1999Q2	0.024***	-0.009***
	(0.003)	(0.003)
1999Q3	0.030***	0.013***
	(0.003)	(0.003)
1999Q4	0.035***	-0.008***
	(0.003)	(0.003)
2000Q1	0.038***	-0.023***
	(0.003)	(0.003)
Age	0.029***	0.003***
	(0.001)	(0.001)
Age^2	-0.0005***	-0.00006***
	(0.00001)	(0.00001)
Male	0.263***	0.350***
	(0.001)	(0.002)
No. children <18 in household	-0.044***	-0.019***
	(0.001)	(0.001)
Married	0.044***	-0.037***
	(0.002)	(0.002)
Divorced	-0.018***	-0.096***
	(0.004)	(0.005)
Widowed	-0.028***	-0.102***
	(0.006)	(0.009)
Constant	0.226***	3.42***
	(0.010)	(0.011)
R^2	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	-0.019
	(0.010)	(0.012)
NI	0.040***	0.055***
	(0.007)	(0.009)
2016Q1	-0.001	0.035***
	(0.004)	(0.006)
2016Q2	0.001	0.059***
	(0.004)	(0.006)
2016Q3	0.007*	0.061***
	(0.004)	(0.006)
Age	0.032***	0.014***
	(0.001)	(0.002)
Age^2	-0.0004***	-0.0002***
	(0.00002)	(0.00002)
Male	0.129***	0.299***
	(0.003)	(0.004)
No. children <18 in household	-0.038***	-0.029***
	(0.001)	(0.002)
Married	0.119***	0.020***
	(0.004)	(0.005)
Divorced	-0.006	-0.005
	(0.007)	(0.011)
Widowed	-0.021	-0.049**
	(0.014)	(0.025)
ISCED6	0.213***	0.079***
	(0.004)	(0.005)
ISCED5	0.161***	0.039***
	(0.005)	(0.007)
ISCED3-4	0.094***	0.019***
	(0.005)	(0.006)
ISCED2	-0.028***	-0.036***
	(0.005)	(0.007)
Constant	-0.004	3.02***
	(0.028)	(0.038)
R^2	0.099	0.085
Nobs	91,393	61,329

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

[i] An alternative 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 in all four cases.

[ii] 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.

[iii] 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).

[iv] 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.