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DISCUSSION PAPER SERIES

IZA DP No. 16031

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ABSTRACT

The Impact of a Minimum Wage Increase on Hours Worked: Heterogeneous Effects by Gender and Sector

A minimum wage increase could lead to adverse employment effects for certain sub-groups of minimum wage workers, while leaving others unaffected. This heterogeneity could be overlooked in studies that examine the overall population of minimum wage workers. In this paper, we test for heterogeneous effects of a minimum wage increase on the hours worked of minimum wage employees in Ireland. For all minimum wage workers, we find that a ten percent increase in the minimum wage leads to a one-hour reduction in weekly hours worked, equating to an hours elasticity of approximately -0.3. However, for industry workers and those in the accommodation and food sector, the impact is larger, with an elasticity of -0.8. We also find a negative impact on the hours worked among men on minimum wage, with no significant effect for women. In line with suggestions from the recent literature, our study uses administrative wage data to accurately identify those in receipt of minimum wage, while also studying the dynamic impact on hours worked over multiple time periods using a fully flexible difference-in-differences estimator.

JEL Classification: E24, J22, J23, J31, J42

Keywords: minimum wages, heterogeneous effects, flexible difference-in-difference

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1. Introduction

The impact of a minimum wage change on employment outcomes has been studied extensively over the last several decades. Despite the accumulated evidence, it remains difficult to definitively state whether a minimum wage increase negatively affects employment outcomes (see e.g. Allegretto et al., 2011; 2017; Neumark et al., 2014; Neumark and Wascher, 2017). Several attempts have been made to synthesise the existing evidence to assess what the 'weight of evidence' has to say. One recent example is Dube (2019), who concludes that the international evidence points to 'muted' effects of minimum wages on employment but cautions that the evidence on high minimum wage rates is still developing. In a recent meta-analysis of minimum wage research in the US, Wolfson and Belman (2019) find a small, but statistically significant, negative effect of minimum wages on employment.[1] However, they note that this finding differs from their earlier meta-analyses (Belman and Wolfson, 2014), as well as the meta-analysis of Doucouliagos and Stanley (2009), both of which did not find statistically significant effects. Motivated by the lack of consensus among minimum wage researchers, Neumark and Shirley (2021) examine the minimum wage literature for the US since the early 1990s. They directly ask authors of papers about their 'preferred estimate'. This has advantages over including all estimates, as the authors themselves may think some of the estimates are not credible. Neumark and Shirley (2021) find a clear preponderance of negative employment effects in the literature, particularly among studies of directly affected workers.

When considering the recent international literature, several important considerations emerge for future minimum wage research, some of which may help explain inconsistencies in findings across studies. The first consideration relates to how minimum wage workers are identified. Neumark and Shirley (2021) argue that studies using wage data to accurately identify minimum wage workers are likely to better capture the true effect compared to studies of broad groups of workers (i.e. workers in low-wage industries). The reason is that when broad groups of workers are studied, many may be earning above the minimum wage and therefore will not be directly affected by the policy. The second consideration relates to examining different types of minimum wage workers. The finding of small, or zero, employment effects when looking at the full population of minimum wage workers could hide the fact that certain types of workers experience negative outcomes. For example, recent work has highlighted that certain groups may be particularly susceptible to negative outcomes, including part-time women in the UK (Dickens et al., 2015), low-skilled manufacturing workers in automatable jobs in the US (Lordan and Neumark, 2018), and teens in the US (Neumark and Yen, 2022).[2] The third consideration is the potential dynamic impacts of minimum wage changes. Meer and West (2016) find that the minimum wage reduces employment over a longer period of time than is usually studied. Therefore, they caution against drawing strong conclusions when no immediate effect is observed, as

[1] Specifically, Wolfson and Belman find a minimum wage elasticity of employment in the range [-0.13, -0.07].

[2] In related work, Vom Berge and Frings (2020) find regional variation in employment effects associated with the minimum wage in Germany. Godoey and Reich (2021) test for heterogeneity across high and low-wage areas in the US, but find no adverse impacts in either area. Okudaira et al. (2019) and Azar et al. (2019) link heterogeneous employment effects to the type of labour market, indicating that negative employment effects tend not to appear in settings where there is a high degree of monopsony power.

it can take time to materialise.

Motivated by the issues outlined above, in this paper we test for the presence of heterogeneous employment effects across different types of minimum wage workers over time. We use administrative wage data to directly identify affected workers, an approach that Neumark and Shirley (2021) suggest is more suited to capturing minimum wage effects than studying broad groups of workers. Having distinguished workers who are directly impacted by the minimum wage from slightly higher-paid workers, we investigate whether minimum increases lead to a reduction in hours worked. We do this for minimum wage workers generally, as well as for minimum wage workers in different sectors of work and of different genders. We are the first to examine such a wide range of potential heterogeneous effects relating to the intensive margin.

In addition to having access to administrative wage data, the Irish data that we use have the advantage of containing several years during which no minimum wage change occurred, followed by several years of minimum wage increases. Using a fully flexible difference-in-differences estimator, we use the pre-treatment years to test for the presence of common pre-treatment dynamics, while using the post-treatment years to evaluate the cumulative effect of three years of consecutive minimum wage increases. Therefore, our approach combines a methodology that directly identifies minimum wage workers and applies it to different groups to study the dynamic effects of several consecutive minimum wage increases.

Note that the main outcome of interest in our study is hours worked. When discussing employment effects, a binding minimum wage has the potential to impact workers in one of two ways (a) at the extensive margin, whereby there is a reduction in the total number of low paid workers employed, or (b) at the intensive margin, through a reduction in the number of hours worked by low paid employees (Brown 1999). While much of the existing literature focuses on the employment effect measured in terms of the number of jobs (see e.g. Harasztosi and Lindner, 2019; Azar et al., 2019; Stewart, 2004), recent work highlights the importance of the intensive margin (hours worked) as a channel of adjustment. In oral evidence submitted to the UK Low Pay Commission, British retailers indicated that managers look closely at hours adjustments to offset rising labour costs following a minimum wage increase (Metcalf, 2008). There is empirical evidence to support this. Stewart and Swaffield (2008) find that the introduction of the UK minimum wage led to a reduction of between one and two hours per week for low-paid workers. This has also been the focus of several recent studies for Germany, following the introduction of a minimum wage in 2015. In a review of this literature, Caliendo et al. (2019), find broad consensus that the introduction of the German minimum wage was associated with a reduction in hours worked (see Caliendo et al., 2017; Pusch and Rehm, 2017). There is also evidence of an hours reduction related to the minimum wage in the US (Neumark et al., 2004; Couch and Wittenburg, 2001). However, Hirsch et al. (2015) find little evidence of hours reductions by restaurants in the US in response to a minimum wage increase. Therefore, further developing the evidence base on hours worked as an adjustment channel is important in order to fully understand the employment impacts of a minimum wage change.

Our results show that after three consecutive yearly increases, from 2016 to 2018, during which time the minimum wage increased from €8.65 per hour to €9.55 per hour (a 10 percent increase), the hours worked of minimum wage workers declined by approximately one hour per week, relative to workers who are paid just above the minimum wage. This equates to an elasticity of approximately -0.3. We identify heterogeneous impacts on hours worked among different groups of workers. Minimum wage workers in the industry sector and accommodation and food sector saw their hours reduce by approximately three hours per week and 2.5 hours per week, respectively.[3] With regard to gender, we detected larger impacts for men than women. It is also notable that men make up a disproportionate amount of workers in the industry / manufacturing sector, which is the sector that shows the greatest negative impact on hours. Therefore, our results are consistent with Lordan and Neumark (2018) for the US, who find that minimum wage workers in manufacturing industries appear to be particularly susceptible to adverse employment effects following a minimum wage increase.

The paper proceeds as follows. Chapter 2 provides an overview of minimum wage policy in Ireland. Chapter 3 describes the data and presents some descriptive statistics. Chapter 4 describes the difference-in-differences methodology in detail. Chapter 5 presents our results and Chapter 6 concludes.

2. Minimum wage policy in Ireland

A minimum wage was first introduced in Ireland in 2000 at a rate of €5.58 per hour. Following this, the minimum wage rate was increased regularly in subsequent years, reaching €8.65 per hour by 2007. Following the onset of the global financial crisis in 2008, Ireland experienced a severe and prolonged economic downturn, with the unemployment rate reaching a high of 15 per cent in 2012. Coinciding with this economic downturn, there were no increases in the minimum wage for a period of almost nine years, such that the minimum wage in 2015 was the same as it had been in 2007 (€8.65 per hour).[4]

As the economy recovered, a Low Pay Commission was established in Ireland in 2015. Their role is to make yearly recommendations to the Irish government on a minimum wage that is 'fair and sustainable' and will 'assist as many low-paid workers as possible without harming overall employment and competitiveness'. Following recommendations from the Low Pay Commission, the minimum wage was increased in January 2016 from €8.65 to €9.15 per hour. The 2016 minimum wage change was the first increase in the minimum wage since 2007. Based on recommendations from the Low Pay Commission, further increases to the minimum wage were implemented in 2017 (to €9.25 per hour), 2018 (to €9.55 per hour), 2019 (to €9.80 per hour), 2020 (to €10.10 per hour), 2021 (€10.20 per hour), 2022 (€10.50 per hour) and 2023 (€11.30 per hour).

Minimum wages are a common feature of advanced western democracies. Currently, 21 of the 27 EU Member States, along with the United Kingdom and the United States, have a statutory minimum wage. A recent comparative study by Redmond et al. (2021) benchmarked Irish minimum wage policy within an EU context.[5] In nominal terms, Ireland has the second highest minimum wage in the EU. When measured in purchasing power standard terms, the Irish minimum wage is the sixth highest in the EU, behind Luxembourg, Germany, the Netherlands, Belgium and France. Using data for 2017 and 2018, Redmond et al. (2021) estimate that 9.6 per cent of employees in Ireland were paid the

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[3] The elasticities for the industry and accommodation and food sectors are both approximately equal to -0.8.

[4] There was a short-lived reduction in the minimum wage in January 2011, from €8.65 to €7.65 per hour, which was reversed six months later (Redmond, 2020).

[5] Redmond et al. (2021) analysed 14 countries: Ireland, Portugal, Germany, Poland, Hungary, Spain, United Kingdom, Luxembourg, Estonia, France, Latvia, Greece, Netherlands and Belgium.

minimum wage. This compared to an average incidence of minimum wage employment across all countries studied of 10.5 per cent.

3. Data and descriptive statistics

We use a dataset called the *Earnings Analysis using Administrative Data Sources* (EAADS), which links earnings from administrative sources to the Irish Labour Force Survey data. The data are administered by the Central Statistics Office (CSO) in Ireland. Earnings data are taken from official P35 tax records. The administrative earnings data are then linked to data from the Irish Labour Force Survey (LFS), which capture a range of employee characteristics including age, gender, education, marital status and sector of work. Importantly, for our analysis, it also captures the usual hours worked of the employee. Some restrictions are made on the sample of respondents included in EAADS. Respondents with missing information for any of the linked LFS variables are omitted. The data also exclude employees earning less than €500 per annum, employments with a duration of less than two weeks in a year and employment activity in agriculture (NACE code A), activities of households as employers (NACE code T) and activities of extraterritorial organisations and bodies (NACE code U). Earnings outliers with extremely high or low earnings are removed from the data.[6] Finally, the EAADS focuses on the employee's principal employment. In the case of employees with multiple jobs, the principal employment, defined as the employment with the highest annual earnings, is included in the dataset.

We use seven years of repeated cross-sectional data, from 2012 to 2018. From 2012 to 2015 the minimum wage in Ireland was unchanged, at €8.65 per hour. As such, we have four pre-treatment years of data. In 2016, the minimum wage was increased by approximately 6 per cent, from €8.65 per hour to €9.15 per hour. There was a further increase in 2017, from €9.15 to €9.25 per hour, and a further increase in 2018 to €9.55 per hour. As we describe in more detail in the next section, we use a difference-in-differences estimator to evaluate the impact of a minimum wage change on hours worked. This is based on comparing a treatment group of low-paid workers, who were directly affected by minimum wage changes, to a control group consisting of relatively low-paid workers earning in excess of the minimum wage that were, therefore, not directly impacted by the minimum wage changes.

We calculate a worker's hourly wage rate by dividing their gross monthly income (from administrative sources) by their self-reported usual hours of work. We define our treatment group, the minimum wage workers, as those earning above €6 and less than €10.03 per hour. The €10.03 cut-off equates to the 2018 minimum wage, of €9.55 per hour, plus 5 per cent. The *plus 5 per cent* is to add a degree of flexibility as the hourly wage is estimated using self-reported hours. We implement a lower bound of €6 per hour as it approximately equals the lowest legally permitted sub-minimum wage rate that was operational over the time period covered in the analysis.[7] We chose this cut-off to limit the possibility of capturing low-paid employees who are working for non-compliant employers and are therefore being illegally paid a very low wage rate. When analysing the impact of a minimum wage change, it would not be appropriate to include such employees in the analysis given that their employers may be non-compliant to begin with. The €6 lower bound also excludes individuals whose calculated wage is implausibly low, suggesting that for these individuals there may be issues with either the gross monthly earnings or reported hours of work data. There are individuals in the dataset

[6] The cut-off used by the CSO to define outliers is Q3+3*IQR for high earners or Q1-3*IQR for low earners. Therefore, these outliers are so extreme that they would be excluded from our analysis even if they were included in the dataset.

[7] From 2012 to 2015, when the full minimum wage rate was €9.15 per hour, the sub-minimum wage rate for those under 18 years of age was €6.06 per hour.

that report very high weekly hours of work. We exclude the top one percentile of the hours worked distribution, leaving us with employees working on or below 60 hours per week. We define our control group as employees earning above €10.03 but below €15 per hour.[8]

As noted by Stewart (2012), choosing a control group for minimum wage studies involves a trade-off. Choosing a control group higher up the wage distribution reduces the risk of the control group being affected by spillover effects associated with a minimum wage change. However, the higher up the distribution, the less similar the control group will be to the treatment group. Our identification strategy seeks to balance these two issues by ensuring that individuals in our control group should not be directly impacted by the minimum wage change, but are still relatively low-paid and therefore likely to be similar to the treatment group based on characteristics such as education, age and experience.

In Table 1 we present descriptive statistics for our treatment and control groups. To help with exposition, we will refer to the treatment group as minimum wage employees, as this is the low-paid group that is likely to be directly impacted by minimum wage increases. We show the averages for both groups in two time periods, the years where no minimum wage change occurred (2012 to 2015) and the years where the minimum wage was increased (2016 to 2018). Comparing the treatment and control groups, we see that the minimum wage employees are slightly younger, less likely to have a tertiary education, less likely to be married, and more likely to be working in a services sector job (defined as retail, accommodation or food).

Table 1: Descriptive statistics of minimum wage and higher paid (non-MW) employees

	MW Employees		Non-MW Employees	
	2012-2015	2016-2018	2012-2015	2016-2018
Hours worked	32.0	32.2	33.0	33.5
Age	34.5	35.2	37.6	38.4
Male (%)	38.7	41.2	44.7	45.4
Tertiary Education (%)	28.3	25.3	34.4	32.5
Married (%)	36.4	34.0	45.9	43.6
Services sector (%)	46.5	45.0	34.8	34.2
Observations	8,299	4,723	17,575	11,328

Source: EAADS. Authors' own calculations.

With regard to changes over time in the characteristics of employees, we first look at hours worked which is the outcome of interest in this study. There was an increase of 0.2 hours per week among the minimum wage workers compared to an increase of 0.5 hours per week among the non-minimum wage workers. Note that one could construct a basic difference-in-differences estimate which would simply compare the average hours change in both groups, pre- and post-minimum wage change. This would give an estimate of -0.3 hours (0.2-0.5), indicating the hours worked of the minimum wage workers increased by less than the hours worked of the control group. However, this type of basic estimate is problematic, as it fails to allow for the possibility of divergent pre-treatment dynamics, does not allow for the flexible identification of results in post-treatment years, does not control for

8 €15 per hour approximately equals the 40th percentile of the wage distribution across all years.

the possibility of differences in the composition of treatment and control groups over time and does not indicate statistical significance. We formally address these issues later in the paper by using a fully flexible difference-in-differences estimator which includes a range of control variables. The other characteristics reported in Table 1 were relatively stable over time. There was a slight increase in the average age and the percentage of males in both groups over time, while there was a decrease in the percentage with tertiary education, the percentage that were married and the percentage in services occupations. The direction of these changes was the same in both the treatment and control groups.

4. Methodology

We implement a difference-in-differences estimator. This involves comparing the change in hours worked of the treated group (minimum wage workers) pre- and post-minimum wage increase, to the change in hours worked among the control group over the same period. The control group are low-paid workers earning in excess of the minimum wage, and therefore should not be directly impacted by the minimum wage change. The control group, therefore, serve as a counterfactual for what may have happened to the treated group in the absence of a minimum wage change. For example, if we observe a fall in hours worked among the treated group, pre- and post-minimum wage change, and observe a similar fall in hours worked among the control group over the same period, then we cannot attribute the change in hours worked among the treated group to the minimum wage change. However, if we were to observe a fall in hours worked among the treated group, while observing no fall in hours (or an increase in hours) among the control group, then this suggests that we can attribute the fall in hours worked among the treated group to the minimum wage change. The validity of the estimator is based on parallel pre-treatment trends. For the control group to be a valid counterfactual, we should observe similar pre-treatment trends among both groups, i.e., the change in average hours worked among the control group should not be diverging significantly from the treatment group in the pre-treatment (pre-minimum wage increase) years.

We use a fully flexible difference-in-differences estimator, proposed by Mora and Reggio (2015), to examine the impact of recent changes to the Irish minimum wage on hours worked. Unlike other basic difference-in-differences estimators, the fully flexible estimator does not impose parallel pre-treatment trends. Instead, the slope and intercept are free to vary for all pre-treatment and post-treatment time periods. Mora and Reggio (2015) propose a test for common trends, which essentially tests whether the treatment and control groups, which are free to take on different pre-treatment trends, actually display common pre-treatment dynamics. The post-treatment periods are also fully flexible, allowing us to examine the post-treatment dynamics relating to three years of minimum wage changes.

More formally, the fully flexible difference-in-differences estimator is implemented with the following regression,

$$E(Y_{it}|D_i, X_i) = \delta + X_{it}'\beta + \sum_{\tau=t_2}^{T} \delta_\tau I_t^\tau + \gamma^D D_i + \sum_{\tau=t_2}^{T} \alpha_\tau . I_t^\tau . D_i + \varepsilon_{it} \quad (1)$$

where the outcome variable, Y_{it}, is the usual weekly hours worked by individual i in year t. D_i is the treatment dummy variable which equals one for low-paid workers likely to be directly impacted by the minimum wage increase (the treatment group) and zero for other low-paid workers earning above the minimum wage (the control group).[9] The variable I_t^τ is a dummy variable for year τ and X_{it}' is a vector of additional control variables including age, education, gender, marital status, time with current employer, firm size, region, nationality (Irish or non-Irish) and sector of employment. The interaction term on the right-hand side of Equation (1) is what makes the model fully flexible; each year dummy is interacted with the treatment dummy. This may include multiple pre-treatment and multiple post-treatment years. In addition to examining each year separately, we can use the model to estimate the overall, cumulative effect of three consecutive minimum wage increases that occurred from 2016 to 2018.

The estimates of interest involve linear combinations of the interaction terms, and this needs to be taken into account when calculating standard errors. Mora and Reggio (2015) also provide a test for common pre-treatment trends, which involves comparing pre-treatment interaction terms. We provide a detailed discussion of the estimator in the accompanying appendix, where we provide an algebraic derivation of the estimates of interest and relate them back to the parameters in equation (1). We then show how this relates to the test of pre-treatment dynamics. To help convey the intuition, we also provide an illustrative example to accompany the derivations in the Appendix.

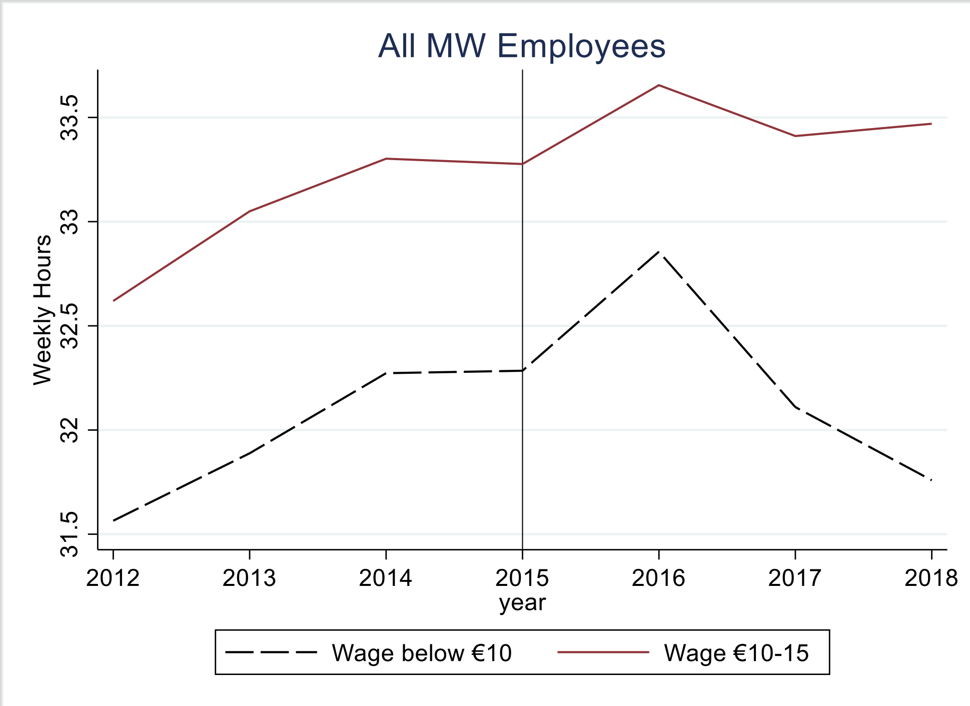
5. Results

Before discussing the results from our difference-in-differences estimator, it is useful to graphically display the average outcomes among the treatment and control groups over time, as this directly relates to the difference-in-differences coefficients of interest. We begin by showing the outcomes for all minimum wage workers (Figure 1). From 2012 to 2015, the minimum wage was unchanged. During this period, we see that the average hours worked for both the treatment and control group followed a very similar trend. This provides descriptive evidence of parallel pre-treatment dynamics and hence supports the validity of the estimator. The minimum wage was increased in 2016, and again in 2017 and 2018. The vertical line distinguishes the pre-treatment period from the post-treatment period. While there is no apparent immediate impact in 2016, we see that by 2018, a gap has opened up between the hours worked of minimum wage workers and those paid just above the minimum wage. This suggests that the cumulative minimum wage increases from 2016 to 2018 may have led to a fall in the hours worked of minimum wage workers, relative to workers paid just above the minimum wage. Specifically, the average hours worked of minimum wage workers in 2015 (pre-minimum wage increase) was 32.3 hours per week. Following three consecutive minimum wage increases, average hours worked for this group in 2018 was 31.8 hours per week, representing an overall decline of 0.5 hours per week. Over the same period, the control group of low-paid, non-minimum wage workers saw an increase in their hours from 33.3 hours per week in 2015 to 33.5 hours per week in 2018 (an increase of 0.2 hours). Therefore, this descriptive evidence indicates that, following three consecutive minimum wage increases, the hours worked of minimum wage workers declined by a total of 0.7 hours per week relative to the control group.[10]

[9] As defined earlier, the treatment group consist of workers earning less than €10.03 per hour and the control group consists of those earning between €10.03 and €15 per hour.

[10] Calculation is -0.2-0.5=-0.7 hours per week.

Figure 1: Average weekly hours worked (2012 to 2018)



Source: Authors' analysis based on Irish EAADS (Earnings Analysis Using Administrative Data Sources) data.

To formally estimate the impact of the minimum wage increases, we estimate Equation (1) for all minimum wage employees. The results are shown in Table 2. The estimate for 2018 indicates that, compared to the time period before the minimum wage increase (2015), minimum wage workers in 2018 saw a one-hour (approximately) reduction in their weekly hours worked relative to the control group. The estimate for 2017, while negative, is not statistically significant, and the estimate for 2016 is close to zero and not significant. Our difference-in-differences estimates are consistent with the graphical evidence shown in Figure 1. With regard to the other control variables, being male, having high education and being married are associated with working longer hours, as is increased job tenure and living in the Dublin region. Working in the services sector, being an Irish national and working in a firm with less than 100 employees is associated with working fewer hours.

While Figure 1 shows graphical evidence of parallel pre-treatment trends, we report the p-value from the Mora and Reggio (2015) test for common pre-treatment dynamics.[11] The null hypothesis is the existence of common pre-treatment dynamics. Therefore, a 'low' p-value below 0.10 would lead us to reject the null hypothesis of common pre-treatment dynamics at the 10 per cent level. In Table 5.1, the p-value is 0.48. As such, we conclude that common pre-treatment dynamics exist, which is consistent with Figure 1 and supports the validity of our estimator.

[11] The test statistic on common dynamics is a Wald test of the joint significance of all pre-treatment α_τ in Equation (1). Further details are given in the supplementary Appendix. The associated p-value is reported in the tables of results.

Table 2: Estimates of the impact of a minimum wage increase on hours worked

Variables	Hours
DiD Estimates	
DiD - 2018	-0.95** (0.46)
DiD - 2017	-0.59 (0.42)
DiD - 2016	0.04 (0.08)
Control Variables	
Male	7.05*** (0.10)
High education	5.16*** (0.16)
Medium education	2.21*** (0.15)
Married	0.41*** (0.11)
Services sector	-2.45*** (0.10)
Irish national	-1.76*** (0.05)
Experience (log years)	1.41*** (0.05)
Firm size (<100 employees)	-3.28*** (0.11)
Dublin region	0.20*** (0.01)
Age	-0.08*** (0.01)
Year dummies	Yes
Pre-dynamics: p-value	0.92
Observations	38,599

Source: Authors' analysis based on LFS-Earnings Analysis Using Administrative Data Sources (EAADS) data. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

It is possible that certain groups of minimum wage workers experience more pronounced employment effects while other groups experience little to no effects. As such, we investigate heterogeneous effects by sector and gender. For the sectoral analysis, we examine six NACE sectors: industry; accommodation and food; wholesale and retail; administrative and support; health and social activities; and arts, entertainment and recreation.

In Table 3 we show the difference-in-differences estimates for the different subgroups of minimum wage employees. In addition to showing the difference-in-differences estimates, we also show the p-value associated with the Mora and Reggio (2015) test of common pre-treatment dynamics.

Table 3: Difference-in-differences estimates (2016 to 2018)

	2018	2017	2016	Pre-dynamics: p-value
Sectors				
Industry N=4,572	-3.02*** (1.18)	-1.64 (1.10)	-2.09** (1.07)	0.99
Accommodation & food N=5,014	-2.56** (1.15)	-1.17 (1.14)	-0.18 (1.22)	0.74
Wholesale & retail N=10,483	0.50 (0.83)	-0.47 (0.81)	0.67 (0.84)	0.47
Admin & support N=2,729	2.31 (1.67)	1.30 (1.64)	1.05 (1.74)	0.19
Health & social activities N=4,293	-1.66 (1.33)	-1.96 (1.23)	-0.11 (1.28)	0.79
Arts, entertainment & recreation N=2,145	-1.56 (1.89)	1.06 (1.74)	0.31 (1.94)	0.19
Gender				
Males N=18,160	-1.52** (0.65)	-0.27 (0.63)	0.16 (0.65)	0.80
Females N=23,765	-0.70 (0.58)	-0.91 (0.56)	-0.09 (0.60)	0.92

Notes: Authors' analysis based on LFS Earnings Analysis Using Administrative Data Sources (EAADS) data. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. We test for common pre-treatment dynamics using the Mora-Reggio test. All specifications display common pre-treatment dynamics.

The results in Table 3 indicate that minimum wage employees in the industry sector and in the accommodation and food sector experienced a decline in their hours worked following a minimum wage change. In 2018, minimum wage workers in the industry sector were working three hours less per week compared to their higher paid counterparts. Negative coefficients, of 2.09 and 1.64 hours respectively, were also observed in 2016 and 2017, however the 2017 coefficient is not statistically significant at conventional levels.[12] For minimum wage workers in accommodation and food, we see a series of year-on-year reductions in hours worked from 2016 to 2018. While the coefficients in 2016 and 2017 of -0.18 and -1.17 are not statistically significant, by 2018 the effect is statistically significant, indicating that minimum wage workers in the accommodation and food sector were working 2.5 fewer hours than their higher paid counterparts. These results show the value of our methodology. By utilising several post-treatment years, and by allowing for fully flexible post-treatment dynamics, we can see the hours effects gradually becoming more and more pronounced as the minimum wage rises over three consecutive time periods. The p-values shown in Table 3 are consistent with common pre-treatment dynamics for each sector.

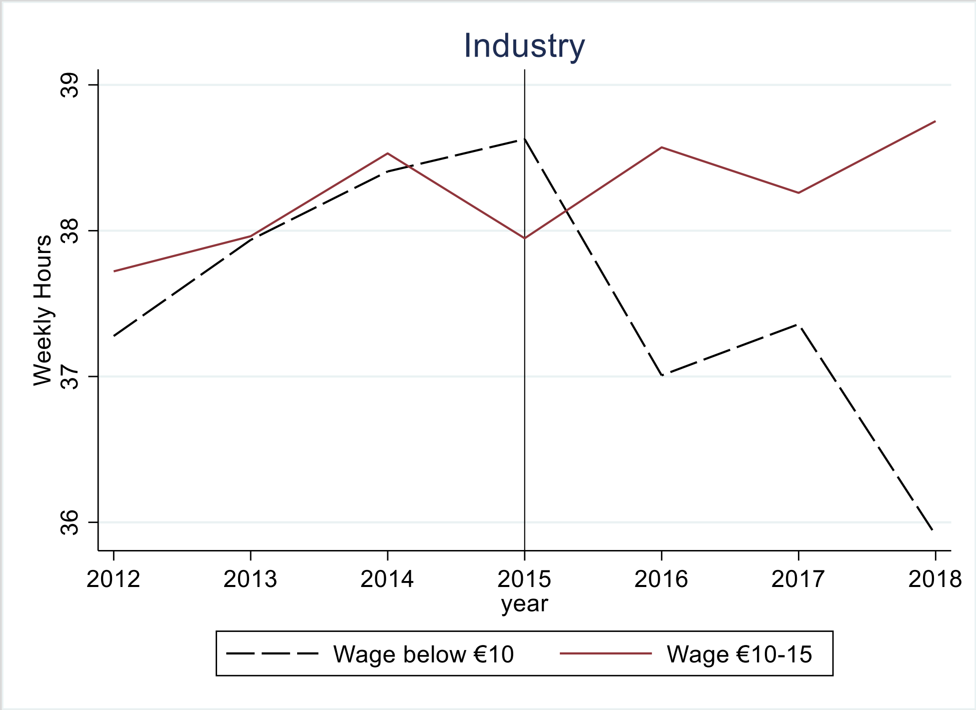
In Figures 2 and 3, we present the corresponding descriptive graphs for the two sectoral groups that display statistically significant effects, by plotting average hours worked for the treated and control groups over time in both the industry and accommodation and food sectors. The descriptive evidence from the graphs correspond to our difference-in-differences estimates. We see that, before the minimum wage increases (pre-2016), the average hours worked for the treatment and control groups displayed similar patterns. The graph for the industry sector (Figure 2) shows a substantial and immediate effect following the first minimum wage increase in 2016. A gap appeared between the treatment and control group, and by 2018, minimum wage workers in the industry sector were working approximately three hours less per week compared to their higher paid counterparts. This is consistent with the coefficients and the test for pre-treatment dynamics in Table 3. For the accommodation and food sector, while no immediate effect appeared in 2016, it is apparent that by 2018, the average hours worked of minimum wage workers in this sector had fallen relative to their higher paid counterparts.

With respect to gender, the results in Table 3 show that, following three consecutive minimum wage increases (from €8.65 to €9.55 per hour), men on the minimum wage were working 1.5 fewer hours per week than their higher paid counterparts. However, for women we detect no statistically significant effect. In Figures 4 and 5, we present the corresponding descriptive graphs showing average hours worked for the treated and control groups over time for both genders. There are several possible explanations behind the heterogeneous gender impacts that we detect in this paper. Many workers in the industry sector are in jobs that are automatable, such as assembly line workers, and therefore may be easily substituted with machines, robots or new technologies. As such, these workers in automatable jobs may be particularly susceptible to adverse employment effects associated with a minimum wage change, as found by Lordan and Neumark (2018) for the US. Our results for the industry sector are consistent with this hypothesis.[13] With regard to heterogeneity by gender, it is notable that most workers in the industry sector are men. In Ireland, nearly three quarters of employees in industry are male. Therefore, the negative finding for men may partially reflect their higher concentration in this sector.

[12] T-statistic of 1.50.

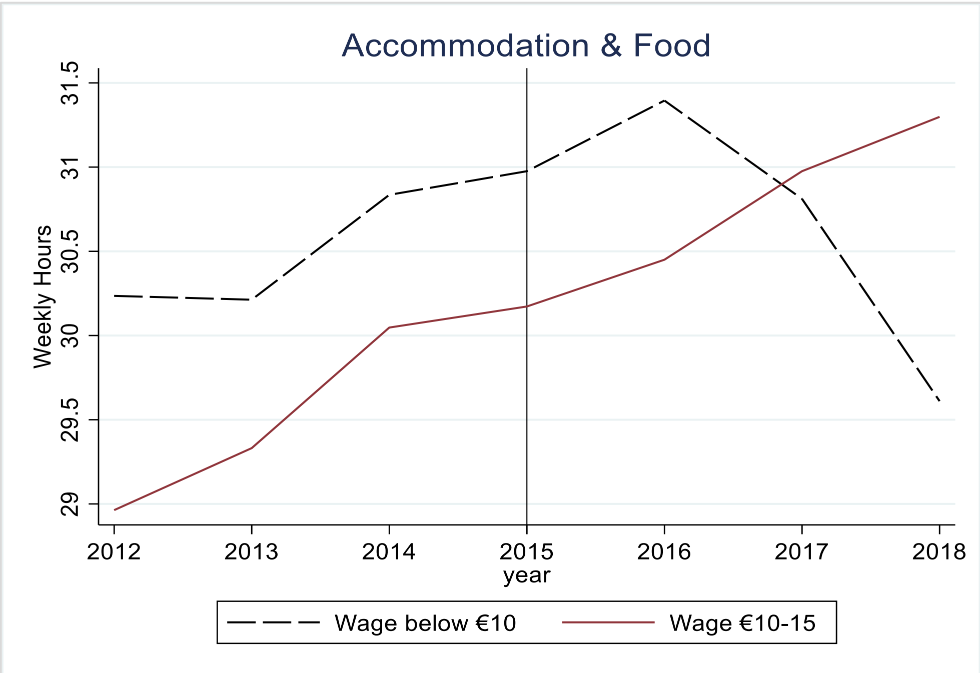
[13] The “industry” sector referred to in this paper relates primarily to manufacturing workers.

Figure 2: Average weekly hours worked for industry sector employees (2012 to 2018)



Notes: Authors' analysis based on LFS Earnings Analysis Using Administrative Data Sources (EAADS) data

Figure 3: Average weekly hours worked for accommodation & food sector employees (2012 to 2018)



Notes: Authors' analysis based on LFS Earnings Analysis Using Administrative Data Sources (EAADS) data

Figure 4: Average weekly hours worked for men on the minimum wage (2012 to 2018)

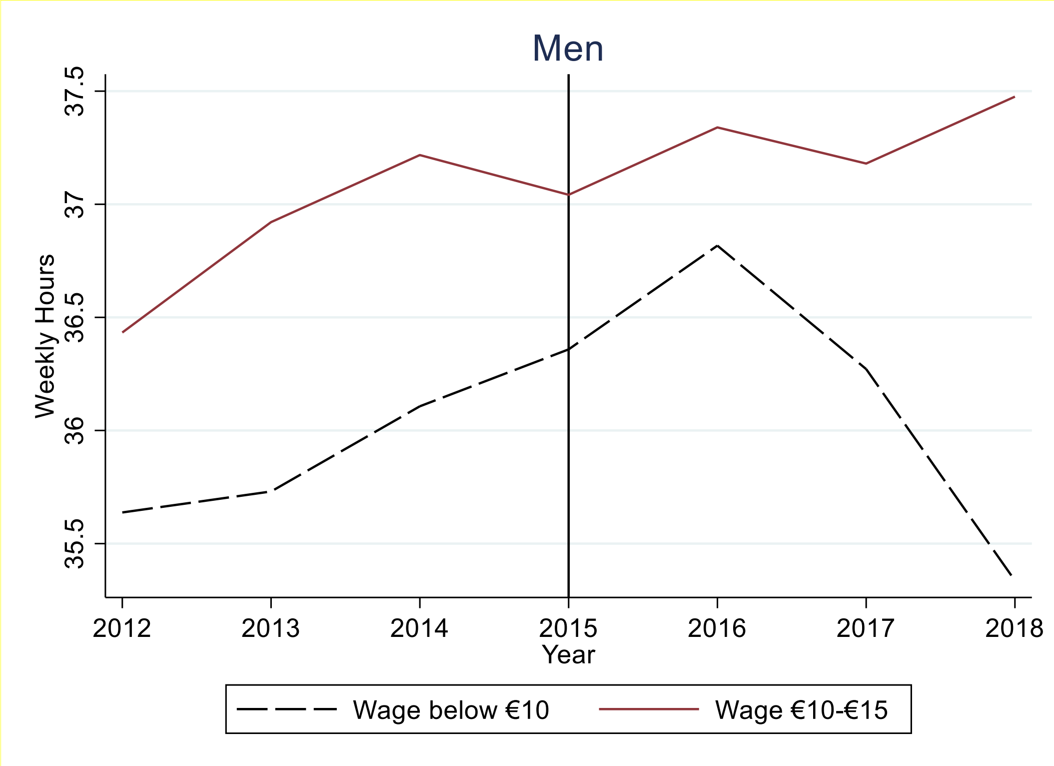
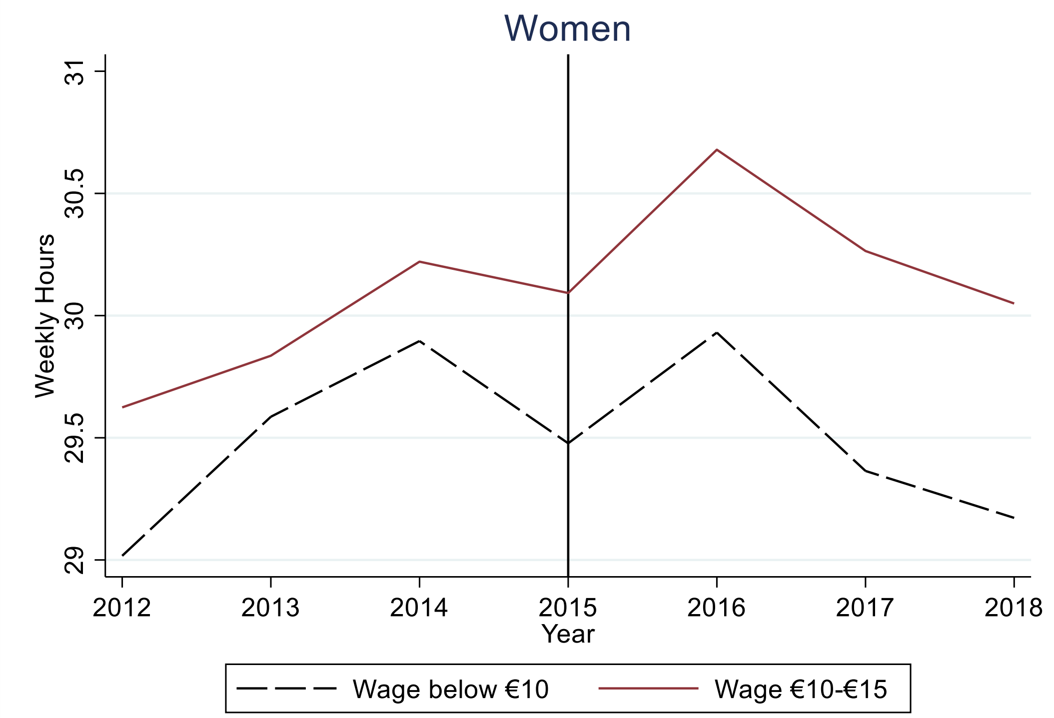


Figure 5: Average weekly hours worked for women on the minimum wage (2012 to 2018)



Another potential explanation as to why men experience more significant adverse impacts than women could relate to gender differences in education levels combined with compensating differentials. Ireland has the second highest educational attainment in the EU, with over 60 percent of individuals aged 25-34 with tertiary educational attainment. Moreover, there is a significant gap in educational attainment by gender; 66 percent of women aged 25-34 are educated to tertiary level compared to just 57 percent of men.[14] However, despite being highly educated, women in Ireland often face labour market constraints as Ireland has some of the highest childcare costs in the EU (OECD, 2022). Highly educated women that could command higher wages, may therefore trade off potentially higher pay for lower paid jobs that offer greater flexibility for combining work and family life. This can be seen with reference to a question in the 2014 European Skill and Jobs Survey, that askes respondents to rank the importance of various factors in their decision to accept their current job. Respondents rank factors on a scale of 0 to 10, with 10 being the most important. When it comes to benefits and pay, the average score for men in Ireland is 7, compared to 6.54 for women. However, when asked about the importance of the job being “close to home”, the average score for women is 6.36, compared to 6.05 for men.

If highly educated women seeking job flexibility due to prohibitively high childcare costs are working in low-paid jobs, then in response to a minimum wage increase employers may seek to retain such employees by preserving their hours of work while reducing the hours of other less-qualified employees. The less-qualified employees are disproportionately made up of men, which may explain why men are more susceptible to negative employment effects. In Ireland, just 24 percent of male minimum wage employees are educated to tertiary level, compared to 30 percent of women on the minimum wage. However, while these statistics are consistent with the theory of compensating differentials playing a role in the estimated gender differences, more work is needed to establish a causal effect and to develop a formal theoretical framework to frame the channels of adjustment. This may present an important area for future minimum wage research.

The tables above showed the estimated impact of minimum wage changes on the *number* of hours worked. We can also represent these changes as elasticities, as this tends to facilitate comparisons with existing studies. For the overall sample of minimum wage employees, as well as the separate subgroups, we represent the estimated decline in hours in 2018 as a percentage of the average hours worked before the minimum wage increase (in 2015).[15] We then divide this by 10 per cent, which is the percentage increase in the minimum wage from 2015 to 2018 (€8.65 per hour in 2015 to €9.55 per hour in 2018). For the full sample of minimum wage employees, the elasticity of hours worked with respect to the minimum wage is -0.30. This closely matches the hours elasticities found by Couch and Wittenburg (2001), Neumark et al. (2004) and McGuinness and Redmond (2019), of -0.5, -0.3 and -0.3 respectively. The calculated elasticity of hours with respect to the minimum wage for the subgroups that show a statistically significant result are higher: -0.77 for industry minimum wage workers; -0.83 for accommodation and food minimum wage workers; -0.42 for male minimum wage workers.

[14] See https://ec.europa.eu/eurostat/databrowser/view/sdg_04_20/default/table?lang=en

[15] The average hours worked among all minimum wage workers in 2015 was 32 hours per week. For minimum wage workers in the industry and accommodation and food sectors it was 39 and 31 hours per week, respectively. For non-Irish nationals on the minimum wage, it was 36 hours per week.

Previous work by McGuinness et al. (2019) showed that, compared to other sectors, minimum wage workers in the industry sector in Ireland are more likely to be older, male, married, working full-time and have longer job tenure. As such, they resemble 'career minimum wage workers', as opposed to transient minimum wage workers, such as young people working part-time while also in education, who may work temporarily on minimum wage before progressing to higher pay. This distinction is important as, given their reliance on full-time, minimum wage work, career minimum wage workers may be hit harder by adverse employment effects as a result of minimum wage increases. Our data confirm that minimum wage workers in the industry sector are more likely to resemble career minimum wage workers. While just 14 per cent of minimum wage workers in the industry sector work part-time, the corresponding figure for all other minimum wage workers is 38 per cent. In this paper, we have shown a substantial hours effect for minimum wage workers in the industry sector. Our results are consistent with work by Lordan and Neumark (2018), who find that minimum wage workers in manufacturing industries in the US appear to be particularly susceptible to adverse employment effects following a minimum wage increase. Many workers in these sectors are in jobs that are automatable, such as assembly line workers, and therefore may be relatively easily substituted with machinery or new technology. Therefore, this appears to be a sector that requires careful monitoring and consideration relating to further impacts of future minimum wage changes.

In light of our findings, it is important to note that different possibilities exist that could potentially explain the results. The decline in hours worked could be due to employers reducing hours due to the higher minimum wage. However, it could also be due to the income effect, that is, employees reducing hours in order to consume more leisure time in response to a wage rise. However, economic theory generally indicates that income effects are more likely to occur for higher paid workers.

It is also worth noting the potential role of labour-labour substitution. If higher paid workers are more productive than lower paid (minimum wage) workers, then firms may substitute away from the lower paid workers towards higher paid workers in response to a minimum wage increase (Fairris and Bujanda, 2008; Redmond and McGuinness, 2021). The slightly higher-paid control group may be, to a certain extent, substitutes for the treatment group, in which case a reduction in hours among the treatment group would correspond to an increase in hours among the control group. This type of substitutability could amplify the hours reduction experienced by minimum wage workers. If, on the other hand, the treatment group were complements to the control group, this could serve to limit the hours reduction among the treatment group. From Figures 2 to 5 we can see that, in some cases, the sharp decline in hours worked among the treatment group coincided with continuing increases in the hours worked of the control group, indicating that some labour-labour substitution may be occurring between the two groups.

An important consideration is whether, following the minimum wage increases, the average worker was better off, even after taking hours reductions into account. More specifically, were the minimum wage increases from 2016 to 2018 large enough to offset any wage loss, for the average worker, due to hours reductions? Again, we carry this analysis out for minimum wage workers in general, as well as for each of the subgroups that showed a statistically significant hours reduction. In Table 4 we show the average weekly wage of minimum wage workers in 2015, before the minimum wage was increased. This is shown in the first column, entitled 'Weekly Wage 2015'. This is calculated as the average hours worked in 2015, for each group, multiplied by the prevailing minimum wage in 2015, of €8.65 per hour. We then take the hours reductions into consideration by subtracting the cumulative estimated hours effects from 2016 to 2018 from the 2015 average hours. The adjusted hours are then multiplied by the 2018 minimum wage (€9.55 per hour) and the average weekly wage in 2018 is shown in the second column ('Hours Adjusted Weekly Wage 2018'). If we assume that hours would have been unchanged in the absence of a minimum wage increase, we can compare the 2015 weekly wage to the hours adjusted weekly wage in 2018 to see if minimum wage workers are better off, in nominal terms, in 2018 compared to 2015. Essentially, we are investigating whether the increases in the minimum wage were sufficiently large to offset average hours reductions. The results indicate that all groups, on average, are better off in nominal terms in 2018 despite the hours reductions. For example, for all minimum wage employees, despite the one-hour reduction in hours in 2018 compared to 2015, the minimum wage increasing from €8.65 to €9.55 per hour was sufficient to see a nominal increase in average weekly wages of €20, or 7 per cent. The results for industry, accommodation and food and men are 2 per cent, 1 per cent and 6 per cent respectively. The figures in Table 4 represent nominal wage changes. The rate of inflation, as measured by the CPI, from December 2015 to December 2018 was 1.1 per cent. Therefore, after taking inflation into account, the average weekly wage of minimum wage workers in accommodation and food is relatively unchanged, while the other groups are still better off.

Table 4: Actual 2015 and adjusted 2018 weekly wages

Group	Weekly Wage 2015	Hours Adjusted Weekly Wage 2018	Difference
All MW workers	€277	€297	+€20 (7%)
Industry MW workers	€337	€344	+ €6 (2%)
Accommodation and food MW workers	€268	€272	+ €3 (1%)
Male MW workers	€315	€333	+ €18 (6%)

Notes: Authors' calculations based on LFS Earnings Analysis Using Administrative Data Sources (EAADS) data

6. Conclusion

Drawing definitive conclusions from the minimum wage literature is difficult due to conflicting findings across different studies. While some find negative employment effects associated with a minimum wage increase, others find little to no effect. The recent literature in this area highlights several key areas for consideration, some of which may account for inconsistencies in results across studies. While some studies find little to no effects for all minimum wage workers, it is possible that certain subgroups of minimum wage employee may experience adverse effects while others do not, highlighting the importance of accounting for potentially heterogeneous impacts. The type of data also matters. Using administrative wage data that allows for a more precise identification of minimum wage workers may be preferable to identifying minimum wage workers by focusing on broad groups, such as those in certain sectors. Any adverse impacts, should they be present, may also take time to manifest and therefore looking at post-treatment dynamics is important. We attempt to address these points by studying three successive minimum wage increases in Ireland using administrative wage data. We examine heterogenous impacts across groups of workers, while using a fully flexible difference-in-differences estimator to trace out pre- and post-treatment dynamics.

Our results indicate that following three successive yearly minimum wage increases, during which time the minimum wage increased from €8.65 to €9.55 per hour (a ten percent increase), minimum wage employees, overall, experienced a decline in hours of approximately one hour per week. This equates to an elasticity of approximately -0.3. However, certain subgroups of minimum wage worker experienced more pronounced declines in hours worked. Those in the industry and accommodation and food sectors saw their hours reduce by three and 2.5 hours per week, respectively.

Our analysis also highlights differences by gender. Men on the minimum wage experienced a decline of 1.5 hours per week, while for women, there was no statistically significant impact. The gender differences may be explained by a disproportionate number of men in the industry sector. However, it may also relate to compensating differentials. Women in Ireland, including those on the minimum wage, have significantly higher educational qualifications than men. However, women are also more likely to choose a job for reasons of flexibility, such as being close to home. In the presence of some of the highest childcare costs in Europe, highly educated Irish women may trade-off higher pay for lower paid jobs that offer greater flexibility. Therefore, in the presence of a minimum wage increase, when it comes to reducing hours, employers may target the less educated male workers while maintaining the hours of the highly educated women. While we present descriptive evidence that is consistent with this hypothesis, more research is required in this area.

Finally, we showed that despite the reductions in hours worked, minimum wage workers were better off following the minimum wage increase. This is because the scale of the minimum wage increase was sufficient to offset any negative financial effects due to a reduction in hours worked.

Appendix: Detailed Explanation of Fully Flexible Difference-in-Differences Estimator

For ease of exposition, we accompany our explanation of the fully flexible difference-in-differences estimator shown in Equation (1) with a hypothetical illustrative example (Figure A1). We begin by assuming that there are three pre-treatment periods and one post-treatment period.[16] Let us assume that time periods 1-3 are the pre-treatment years and time period 4 is the post-treatment year. The quantity of interest that we wish to capture with our difference-in-differences estimator is the difference in average outcomes among the treated group, pre- and post-treatment, minus the difference in outcomes among the control group over the same period. Given the last pre-treatment year is period 3 and the post-treatment year is period 4, from Equation (1) we get,

$$[E(Y|D=1,\tau=4)-E(Y|D=1,\tau=3)]-[E(Y|D=0,\tau=4)-E(Y|D=0,\tau=3)]=\alpha_4-\alpha_3 \quad (2)$$

The estimate in Equation (2), which is a linear combination of the interaction parameters in Equation (1), corresponds to the standard difference-in-differences approach, whereby one examines changes in outcomes from the last pre-treatment year (year 3) to the post-treatment year (year 4). Graphically, it would correspond to (A-B)-(E-F) in our illustrative example in Figure A1.[17] As the estimated treatment effect is a linear combination of the interaction coefficients, computation of the standard errors of the treatment effect needs to take this into account.[18]

Note, however, that we have not yet mentioned pre-treatment dynamics. It may be that the outcomes of the treated and control group were diverging before the treatment, for example from period 2 to period 3. In the context of a difference-in-differences setup, this is important, because if the outcomes of the treated and control group were diverging before the treatment occurred, then we cannot be confident that the difference in outcomes post-treatment is attributable to the treatment itself. Referring to the illustrative example (Figure A1), we could incorporate possible pre-treatment divergence into our estimate, by estimating [(A-B)-(E-F)]-[(B-C)-(F-G)]. In our hypothetical example, we can see that the outcome for the treated group increased by more than the control group in the pre-treatment periods 2 to 3, captured by (B-C)-(F-G), and this is subtracted from the original estimate of (A-B)-(E-F). Therefore, accounting for this leads to a lower estimated treatment effect (compared to the first estimate of (A-B)-(E-F)). The analogous estimate using Equation (1) is,

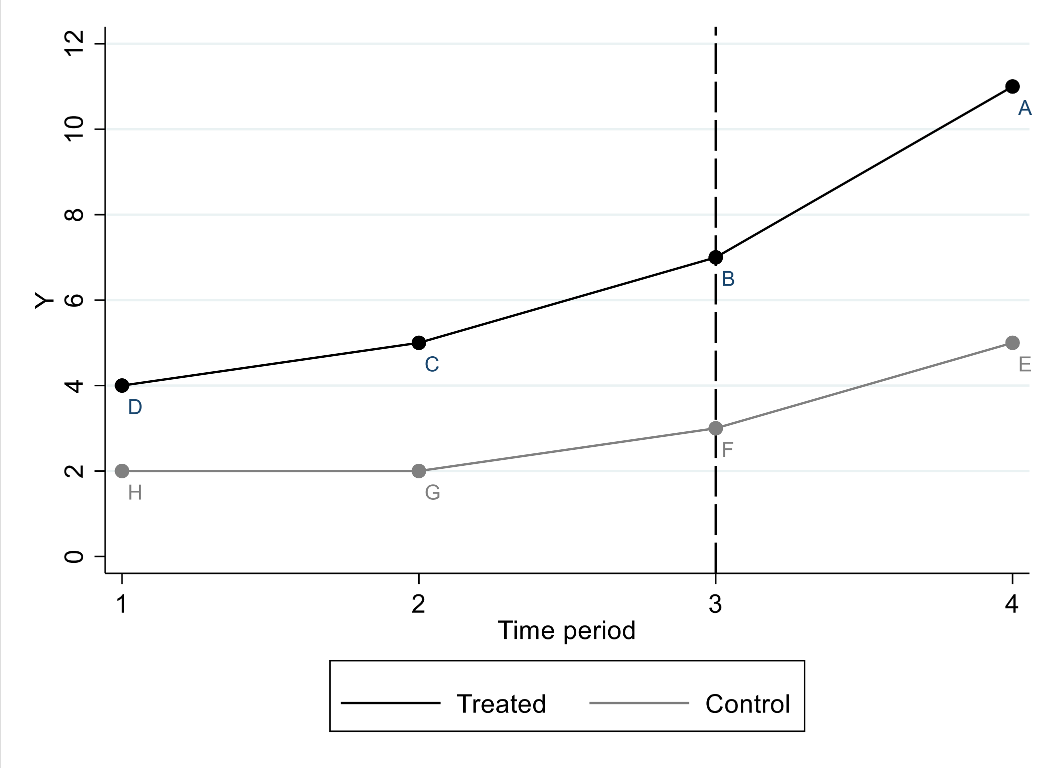
$$\{[E(Y|D=1,\tau=4)-E(Y|D=1,\tau=3)]-[E(Y|D=0,\tau=4)-E(Y|D=0,\tau=3)]\}-\{[E(Y|D=1,\tau=3)-E(Y|D=1,\tau=2)]-[E(Y|D=0,\tau=3)-E(Y|D=0,\tau=2)]\}=\alpha_4-2\alpha_3-\alpha_2 \quad (3)$$

16 Note that Equation (1) allows for multiple post-treatment periods, which we will discuss later in the context of our application of the method.

17 To see why (A-B)-(E-F) are equivalent, note that (A-B)-(E-F) = [(A-D)-(E-H)]-[(B-D)-(F-H)] = $\alpha_4-\alpha_3$.

18 The Mora and Reggio (2015) *didq* command for Stata computes the adjusted standard errors.

FIGURE A1 ILLUSTRATIVE EXAMPLE OF FULLY-FLEXIBLE DIFFERENCE-IN-DIFFERENCES ESTIMATOR



Source: Authors' analysis.

Finally, in the discussion of pre-treatment dynamics, it is important to take account of potentially different acceleration between the treated and control group outcomes. For example, if the treated group outcomes are accelerating faster than the control group outcomes (pre-treatment), as appears to be the case in the illustrative example (Figure A1), then in the absence of treatment, assuming that the treated group would have continued the trajectory observed from periods 2 to 3 may not be accurate; with different acceleration in the treatment and control groups, then in the absence of treatment, the increase from period 3 to 4 may be greater than the increase from period 2 to 3, and therefore, the estimate in Equation (3) would be an overestimate. With reference to the illustrative example (Figure A1), different acceleration between the groups can be taken into account by estimating, [(A-B)-(E-F)]-[(B-C)-(F-G)] and then subtracting [(B-C)-(F-G)]-[(C-D)-(G-H)]. The analogous estimate using Equation (1) is,

$$\{[E(Y|D=1,\tau=4)-E(Y|D=1,\tau=3)]-[E(Y|D=0,\tau=4)-E(Y|D=0,\tau=3)]\}-\{[E(Y|D=1,\tau=3)-E(Y|D=1,\tau=2)]-[E(Y|D=0,\tau=3)-E(Y|D=0,\tau=2)]\}-\{[E(Y|D=1,\tau=3)-E(Y|D=1,\tau=2)]-[E(Y|D=0,\tau=3)-E(Y|D=0,\tau=2)]\}-\{[E(Y|D=1,\tau=2)-E(Y|D=1,\tau=1)]-[E(Y|D=0,\tau=2)-E(Y|D=0,\tau=1)]\}=\alpha_4-3\alpha_3+3\alpha_2 \quad (4)$$

Note that in the presence of common pre-treatment dynamics, the estimates shown in Equations (2) to (4) would be the same. More formally, equal pre-treatment dynamics between the treated and control groups implies that $\alpha_\tau = 0$ for all $\tau \leq 3$. As noted by Mora and Reggio (2015), the test of the null hypothesis of common pre-treatment dynamics, i.e. that $\alpha_\tau = 0$ for all $\tau \leq 3$, is a test for the simultaneous equivalence of all of the estimates shown in Equations (2) to (4). In our tables of results, we report the relevant p-values for each difference-in-differences specification to indicate whether common pre-treatment dynamics exist.[19]

In our application of this estimator, in addition to multiple pre-treatment years, we have multiple post-treatment years. In our data there was no minimum wage increase from 2012 to 2015 (pre-treatment years). However, the minimum wage was increased in 2016, with further incremental increases in 2017 and 2018. Therefore 2016-2018 are post-treatment years. It is important to discuss the post-treatment years in the context of our estimator, in order to get a clear understanding on how we interpret the results. To illustrate how post-treatment years are incorporated into the estimator, consider again the illustrative graph (Figure A1). Suppose there were two post-treatment years (3 and 4), so that the vertical line was now positioned at period 2 on the x-axis. The estimate for the first post-treatment time point, period 3, is (B-C)-(F-G). The estimate for the second post-treatment time point, period 4, is (A-C)-(E-G). In the context of successive minimum wage increases, as in our application, this can be viewed as a cumulative impact of the minimum wage increases across both post-treatment years. It is important that we view our results in this way. For example, consider a scenario where the treatment and control groups experience common pre-treatment dynamics. When treatment occurs (i.e. the minimum wage starts to increase in 2016), the outcomes may begin to diverge, however not to the extent that we observe a statistically significant effect in 2016. Likewise, if the additional small incremental change in 2017 leads to a further small effect on the outcome, then comparing 2017 to 2016 alone may not indicate a statistically significant result. Finally, the same could happen with the additional incremental change in 2018, and again, simply comparing 2018 to 2017 may show a relatively small and perhaps not significant result. Meanwhile, the incremental divergence between the treatment and control groups over the three years may cumulate to a substantial impact, which potentially could be missed if all we examine are the changes associated with each year pairing.

[19] While we use three pre-treatment periods for the purpose of exposition, there can be any number of pre-treatment periods.

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