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The Changing Nature of Irish Wage Inequality from Boom to Bust*

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Abstract: The dramatic change in economic conditions in Ireland over the last ten years provides an opportunity to examine the impact of large macroeconomic shocks on inequality. We analyse wage inequality in Ireland, from the height of an economic boom, through a very deep recession, to the start of a recovery. In keeping with previous work we find that the dispersion in wages increased towards the height of the boom, driven largely by rising returns to skill. However the economic crisis of 2008-2013 was accompanied by a significant reduction in wage dispersion. Although the improving characteristics of the workforce increased wages for all workers over this period, this was offset by falling returns to these skills. Only workers in the lowest decile were unaffected by declining returns, resulting in a reduction in wage inequality during the recession. Our analysis highlights the important role played by the National Minimum Wage in this process.

I INTRODUCTION

A number of studies have examined the impact of the macroeconomic environment of a country on its level of inequality, looking in particular at whether inequality increases or declines during recessions (Heathcote *et al.*, 2010, Bonhomme and Hospido 2012, Jenkins *et al*., 2013). The recent experience of the Irish economy provides a very useful setting for further examination of this issue.

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After a period of exceptional growth from 1994 to 2007, the Irish economy collapsed, with negative output growth from 2008 to 2010 and only very modest growth during the weak recovery of 2011 to 2013. The contrasting experience of the Irish economy over this period provides researchers with an ideal opportunity to track and examine the evolution of inequality as an economy moves from a boom to a severe recession, through to a subsequent recovery.

Any attempt to understand the changing nature of inequality during the Great Recession must account for the dramatic changes in the composition of the workforce that occurred during this period. To do this we use a decomposition technique developed by Machado and Mata (2005) to identify the separate contributions of changes in the composition of the workforce and changes in the returns to these characteristics to changes in wage inequality over the period from 2004 to 2013. Our work builds on earlier work by Voitchovsky *et al*. (2012) who adopted a similar approach when examining wage inequality in Ireland from 1994 to 2007. Extending the period of analysis to cover the time period from 2007 to 2013 allows us to assess the impact of the Great Recession on wage inequality in Ireland. Consistent with Voitchovsky *et al*. (2012) we show that wage inequality increased substantially during the boom, driven almost entirely by rising returns to skill. However, the pattern changed dramatically with the onset of the recession. Between 2007 and 2012 wage inequality fell significantly, so that by 2012 inequality had almost returned to its 2004 level. This fall in inequality reflects stagnant or declining wages at all points in the distribution above the 10th percentile. The failure of wages to grow for these workers, despite substantial improvements in the skills of the workforce, reflects a significant decline in the returns to these skills during the recession.

The contrasting roles of returns and characteristics in explaining the evolution of wages in Ireland during the recession highlights the importance of controlling for compositional changes when examining wage trends (Solon *et al*., 1994; Doris *et al*., 2015). We find that the changing composition likely reflects a combination of factors including cohort effects, job loss and emigration. Furthermore, we find that the relative wage gains observed for the lowest paid reflects the force exerted on the bottom of the earnings distribution by the National Minimum Wage; the provision of a binding wage floor preventing large wage reductions for the lowest paid workers during the Great Recession.

Section II outlines the key features of the Irish macroeconomic environment over the period examined in our study and briefly reviews earlier work on wage inequality. Section III discusses the data used in our analysis and establishes the overall evolution of wage dispersion throughout the period of our analysis. Section IV briefly describes the decomposition we use, along with the main findings of our analysis. Section V discusses our findings in more detail and Section VI concludes.

II THE GREAT RECESSION

The past decade saw the major world economies experience deep recessions, alongside a worldwide financial crisis. Ireland was one of the countries most affected by the economic downturn. Table 1 shows that prior to 2008 the Irish economy was thriving, with growth rates close to 6 per cent and unemployment rates of only 4 per cent (see also Whelan, 2013).

Table 1: GDP Growth Rate and Total Unemployment Rate: Ireland 2004-2013

Year	*GDP Growth (Annual %)*	*Unemployment Rate Quarter 1 Each Year*
2004	4.4	4.6
2005	6.3	4.2
2006	6.3	4.5
2007	5.5	4.6
2008	–2.2	5.0
2009	–5.6	10.3
2010	0.4	13.1
2011	2.6	14.4
2012	0.2	15.0
2013	1.4	13.7

Source: GDP Growth (OECD), Unemployment Rate (CSO).

The Irish economy underwent a dramatic reversal with the onset of the Great Recession in 2008, with GDP contracting by 14 per cent and unemployment rates rising to 14 per cent by 2011. The effects of the global recession felt elsewhere were compounded in Ireland by the collapse of the construction sector following the bursting of a property bubble and a subsequent financial crisis in the banking sector. Few sectors of the economy were spared, although the construction sector experienced the largest declines, with employment in this sector falling by 60 per cent between 2007 and 2011. By 2013 the Irish economy had bottomed out and was beginning to show signs of a weak recovery, though unemployment remained very high.

The Irish government responded to the crisis with a series of fiscal measures. These included the introduction of a new income levy, increases in the employee health levy and the abolition of the ceiling on pay related social insurance contributions. In addition there was a substantial cut in pay for public sector workers. Initially these pay cuts took the form of a new Pension Levy introduced in 2009 but were followed in 2010 by direct pay cuts of between 5 per cent and 10 per cent. An additional round of public sector pay cuts was implemented in 2013

affecting higher paid public sector workers; those earning more than €65,000 had their pay cut by between 5.5 per cent and 10 per cent, with the biggest cuts applying to those on higher pay.

A number of recent international studies have examined the impact of the macroeconomic environment on inequality. However, the evidence in this respect is quite mixed. Jenkins *et al.* (2013) examined the impact of the Great Recession on household incomes. They provided a general overview for 21 countries, with detailed analysis for a subset of six of these countries. Between 2007 and 2009 the changes in the distribution of household income in Germany, Sweden and the UK were generally modest, whether measured in terms of real income levels, income inequality, or relative poverty rates. Italy and the US were the two case study countries where increases in inequality were most apparent. In keeping with this, Meyer and Sullivan (2013) found that income inequality increased in the US during the Great Recession, however in contrast, consumption inequality fell.

Wage inequality increased in Germany following the economic downturn that accompanied the reunification of Germany in 1992/93 (Fuchs-Schündeln *et al*., 2010). However, wage inequality decreased in Germany during the Great Recession, driven predominantly by a decline in the exporter wage premium (Dauth *et al*., 2015).

Bonhomme and Hospido (2012) found a strong countercyclical pattern to male earnings inequality in Spain, with inequality increasing at the time of the 1993 recession, decreasing substantially during the 1997-2007 expansion, and increasing again during the recent recession. Likewise Newell and Socha (2007) reported that wage inequality increased in Poland following the economic downturn in the late 1990s. Looking over a longer period, Heathcote *et al*. (2010) found that those in the bottom of the earnings distribution tended to suffer the biggest losses during recessions in the United States.

Turning to Ireland, Callan *et al*. (2011) and Keane *et al*. (2012) documented the progressivity of the fiscal changes introduced in response to the crisis. Incomes for households in the lowest income groups fell by 4 per cent to 5 per cent, compared to a fall of almost 13 per cent for those households with the highest incomes. Callan *et al*. (2014) examined income inequality from 2008-2013 and found that the largest falls in market income occurred in the bottom half of the income distribution. Much of this reflects the loss of earnings resulting from job losses which were most pronounced among the lower paid (Nolan and Voitchovsky, 2016). Callan *et al*. (2014) focused their analysis on the distribution of total household income and on the impact of changes in the tax benefit system on this distribution. They found that the relatively larger declines in market income for low income households were moderated by changes in taxes and transfers, with the effect of transfers being especially important.

There have been fewer papers examining wage inequality, per se, in Ireland. Nolan *et al*. (2000) analysed the distribution of earnings for employees between 1987 and 1994. They found that the level of earnings inequality in Ireland at the time was high by OECD standards. Furthermore they reported a substantial increase in earnings inequality between 1987 and 1994, an increase they attribute to rising returns to skill. Voitchovsky *et al*. (2012) examined inequality in gross hourly wages for Irish workers from 1994 to 2007. They found that dispersion in hourly wages fell sharply to 2000 before increasing somewhat to 2007. However, their analysis did not extend to the Great Recession.

Analyses of the behaviour of wages in Ireland during the Great Recession have tended to focus either on aggregate changes or on year-on-year wage changes. The Central Statistics Office (2010) used aggregate data from the Earnings Hours and Employment Costs Survey to study the change in the wage bill paid by employers in Ireland during the early part of the Great Recession. Between the third quarter of 2008 and the third quarter of 2009 the total wage bill of all employers fell by 7 per cent. The majority of this reduction resulted from a decrease in employment levels in firms, with a smaller proportion due to a reduction in hours worked by employees. Walsh (2012) extended this analysis to cover the years from 2009 to 2011. He reported a 6 per cent reduction in the wage bill of employers between 2009 and 2010 and a further reduction of 1 per cent between 2010 and 2011. Once again, the majority of the reduction in the wage bill between 2009 and 2010 was as a result of a decrease in the number of employees.

Since the analysis in Walsh (2012) is based on the aggregate wage bill of employers it suffers from potential composition bias. Doris *et al*. (2015) used administrative longitudinal data to follow individual earnings for the entire employee population in Ireland between the years of 2005 and 2013. They found a significant degree of downward wage flexibility in the pre-crisis period. They also observed a significant response in wage change behaviour with the onset of the crisis; the proportion of workers receiving earnings cuts more than trebled during the crisis. In addition these wage cuts were progressive, particularly in the public sector, where highest wage earners recorded cuts to earnings of 12 per cent. However, their analysis is limited by the lack of control variables for individual characteristics over time. While the use of longitudinal data allowed them to look at individual wage changes over time, the absence of detailed information on the characteristics of these individuals made it more difficult to analyse changes in inequality.

In this paper we extend the earlier analysis of wage inequality in Ireland by examining hourly wage dispersion from 2004 to 2013, a period covering the peak of the boom, the worst of the recession and the subsequent seeds of a recovery. We decompose changes in wage inequality into a component due to changes in the price of skill and a component due to changing characteristics of the workforce. In

this way we assess the impact of the Great Recession on inequality in Ireland, taking into account any compositional changes that may have occurred during this period.

III DATA AND DESCRIPTIVE STATISTICS

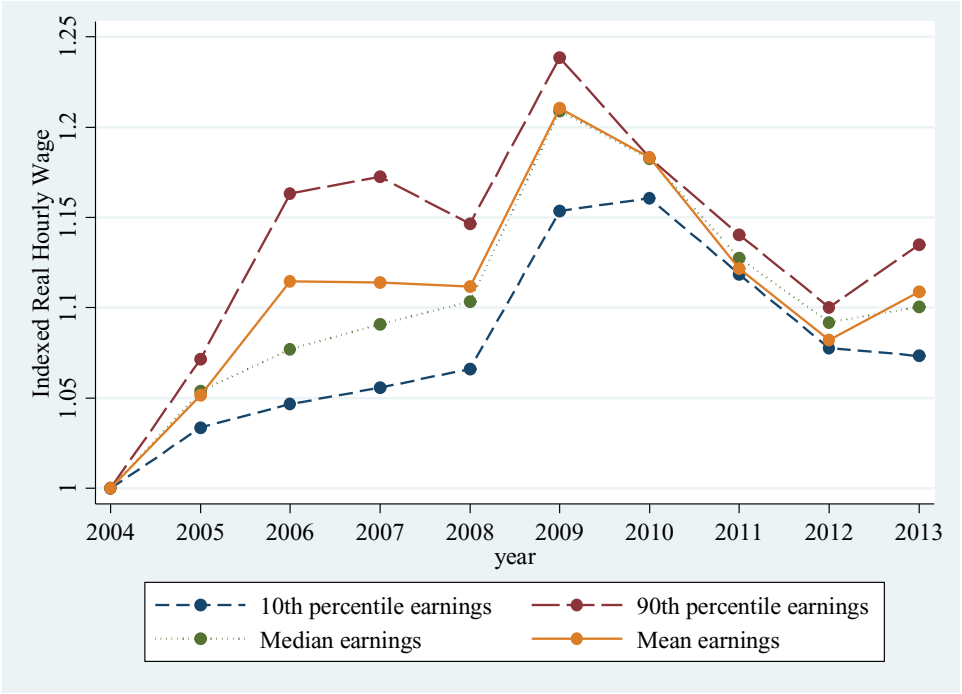
To carry out our analysis we use data from the Irish component of the EU Statistics on Income and Living Conditions (EU-SILC). The EU-SILC is an annual EU-wide household survey, which is conducted in Ireland by the Central Statistics Office. The EU-SILC is a cross-sectional dataset that provides information on the income and living conditions for a sample of households. The survey is conducted annually and the sizes of the Irish samples range from 5,000 to 6,000 households and from 11,000 to 14,000 individuals. The sampling frame and weighting procedures are designed to ensure the EU-SILC sample is representative of the population. The EU-SILC commenced in Ireland in 2003. However in our analysis we make use of the RMF version of the data available from the CSO. These data contain a cleaned measure of hourly wages constructed by the CSO. These data are only available from 2004 onwards and the latest year for which we have access to the RMF data is 2013. Although we do not have data for the most recent years, the time period available to us nevertheless allows us to examine both the end of the boom period in Ireland, and almost all of the Recession period.

We follow Voitchovsky *et al*. (2012) and restrict our sample to all employees aged between 16 and 65 years of age, who work more than one hour and less than 100 hours a week, and who report a gross wage above €1 an hour and below €100 an hour (in 2010 prices).[1] The analysis excludes those in full-time education at the time of the survey. In keeping with Voitchovsky *et al*. (2012) we focus on gross hourly earnings. This allows us to abstract from government induced changes in inequality arising from tax changes and instead focus on the labour market forces affecting inequality. Data on hourly wages are provided directly by the CSO in the RMF version of the data and are based on earnings received in the last pay cheque combined with hours worked. These data are subject to careful cleaning by the CSO, using administrative and other sources, prior to release of the RMF data.

The evolution of wage inequality from 2004 to 2013 is presented in Figure 1 and in more detail in Table 2. Two clear patterns emerge from the data. From 2004 to 2007 inequality increased, with the ratio of the top wage decile to the bottom

[1] These restrictions are the same as those used by Voitchovsky *et al*. (2012) and allow us to directly compare our findings with this earlier work. However as a robustness check we repeated our analysis looking at workers aged 25-55 and working at least 15 hours a week. We also looked at workers working at most 39 hours a week to remove the effects of overtime. Our results, which are available from the authors upon request, are robust to all these changes in sample selection.

Figure 1: Indexed Real Hourly Wages by Percentile, 2004-2013



Source: Authors' analysis.

Table 2: Hourly Earnings, 2004-2013 (2010 Prices)

Year	*Bottom Decile*	*Bottom Quartile*	*Median*	*Top Quartile*	*Top Decile*	*Mean*	*TopDecile/ Bottom Decile*
2004	8.26	10.64	14.48	21.04	30.08	17.37	3.64
2005	8.54	11.00	15.26	22.36	32.23	18.27	3.78
2006	8.65	11.24	15.60	23.55	34.99	19.37	4.05
2007	8.72	11.16	15.80	23.65	35.27	19.35	4.04
2008	8.81	11.14	15.98	23.79	34.48	19.32	3.92
2009	9.53	12.18	17.51	26.12	37.25	21.03	3.91
2010	9.59	12.12	17.12	25.38	35.59	20.56	3.71
2011	9.24	11.30	16.33	24.11	34.30	19.49	3.71
2012	8.90	10.76	15.81	23.18	33.10	18.80	3.72
2013	8.87	11.03	15.93	23.51	34.13	19.27	3.85

Source: Authors' analysis.

decile rising from 3.62 to 4.04. Although wages at the bottom of the distribution increased by 5.6 per cent over this period, this was much smaller than the 12.4 per cent increase in wages experienced by those at the top of the distribution.

The trend in inequality changed dramatically with the onset of the crisis in 2008. Between 2008 and 2012 earnings at the bottom of the distribution rose, albeit at a very modest 1 per cent over this entire period. In contrast, earnings at the top of the distribution fell by 4 per cent over the same period. As a result, by 2012 inequality had almost returned to its 2004 level. There is suggestive evidence that inequality is starting to increase again as the economy begins its recovery. Real wages at the bottom of the distribution fell slightly from 2012 to 2013, while wages at the top of the distribution rose for the first time since 2009. However, it is too early to say from these data whether or not this is the start of a persistent trend associated with the recovery.

It is well known that compositional changes can have a significant impact on the wage structure (Solon *et al*., 1994). Since low paid workers lost their jobs in relatively large numbers during the Great Recession (Nolan and Voitchovsky, 2016), the ensuing truncation of the wage distribution is likely to boost reported average wages of the remaining workers, mitigating any potential pro-cyclical pattern in average wages. The loss of these low paid workers from the sample of workers is also likely to affect the dispersion of wages among the remaining workers.

To examine the changes in the composition of the workforce in Ireland in more detail, Table 3 shows the educational distribution of workers in our sample from 2004 to 2013. What is particularly striking is the significant improvement in the

Table 3: Distribution of Education in the Working Population, 2004-2013 (Proportion)

	Primary	*Lower Secondary*	*Upper Secondary*	*Post Leaving Cert*	*Third Level*
2004	.12	.19	.27	.10	.32
2005	.13	.18	.26	.10	.33
2006	.12	.18	.25	.10	.36
2007	.11	.18	.25	.09	.37
2008	.11	.17	.24	.10	.38
2009	.08	.14	.24	.09	.43
2010	.08	.13	.23	.08	.46
2011	.07	.12	.21	.07	.51
2012	.06	.12	.23	.07	.51
2013	.05	.11	.22	.07	.53

Source: Authors' analysis.

[2] We consider the forces underlying these changes in Section V.

education levels of the workforce during the recession. The proportion of workers with a third-level education increased from 37 per cent in 2007 to over 50 per cent in 2013, a dramatic increase in such a short period. This was accompanied by a decline in the percentage of those with a primary education or less, from 11 per cent in 2007 to less than 5 per cent in 2013.[2] In the next section we examine the impact of these and other changes, on wage inequality in Ireland.[3]

IV DECOMPOSITION AND RESULTS

To identify the contributions of changes in the returns to skill and changes in the distribution of these skills on inequality we use the decomposition developed by Machado and Mata (2005). This technique decomposes changes in the wage distribution into a component due to changes in the distribution of covariates (skills) and a component due to changes in the returns to these covariates. In this way the Machado and Mata's (2005) decomposition extends the Oaxaca (1973) approach for mean decomposition to the entire wage distribution.

The approach is based on quantile earnings regressions, specified as

$$Q_\theta(w|z) = z'\beta(\theta) \tag{1}$$

where $\beta(\theta)$ is a vector of regression coefficients at the θ^{th} quantile.

To perform the required distributional counterfactual analysis Machado and Mata exploit the probability integral transformation to derive the marginal distribution of wages consistent with the conditional distribution given in (1). The probability integral transformation theorem implies that if $\theta_1, \theta_2, \ldots \theta_m$, are drawn from a uniform (0,1) distribution then the corresponding m estimates of the conditional quantiles of wages at $z = z^*$ for time t, $\{w_t^*(t)'\beta^t(\theta_i)\}_{i=1}^m$, represent a random sample from the estimated conditional distribution of wages given z^*. These conditional quantiles are the first stage in obtaining the unconditional marginal distribution, which is the ultimate distribution of interest. In order to estimate the marginal distribution consistent with these conditional distributions one only needs to average the conditional distributions over the z values at time t. This can be done either analytically or via simulation.

Given this approach, appropriate counterfactuals can be obtained by simply adjusting the distribution from which the characteristics are drawn, before combining the covariates and the returns. For instance it is straightforward to estimate what the distribution of wages in Year 1 would have been if all characteristics had remained at the levels observed in Year 0. To do this we begin

[3] Summary statistics of all the variables used in our analysis by position in the earnings distribution are given in Table 4.

Table 4: Characteristics of the Workforce

	2004 P10	*2008 P10*	*2013 P10*	*2004 P90*	*2008 P90*	*2013 P90*	*Mean 2004*	*Mean 2008*	*Mean 2013*
Male	.375	.376	.371	.570	.547	.543	.510	.488	.473
Experience	19.25	20.57	19.44	25.28	26.74	24.34	21.66	24.03	21.82
Primary Education	.203	.172	.086	.011	.028	.003	.118	.112	.050
Lower Secondary Education	.302	.245	.133	.039	.022	.010	.192	.170	.107
Upper Secondary Education	.305	.320	.265	.110	.085	.066	.273	.242	.221
Post Leaving Certificate Qualification (PLC)	.073	.088	.123	.042	.035	.003	.096	.097	.073
Third Level Education	.117	.176	.368	.798	.830	.914	.322	.379	.531
Irish	.919	.843	.699	.963	.978	.950	.950	.922	.852
Urban	.630	.655	.619	.782	.758	.715	.706	.686	.644
Border, Midlands and Western Region (BMW)	.326	.276	.275	.131	.123	.166	.205	.198	.244

Source: Authors'

by drawing a random vector θ, of size m, from a $U(0,1)$ distribution. Using the covariates for Year 1 we estimate m conditional quantile regressions, with the quantiles corresponding to θ. This provides m sets of Year 1 returns, one for each quantile; $\{\beta^1(\theta_i)\}_{i=1}^m$. Finally we combine these point estimates with a random sample of m-draws from the rows of the covariate matrix in Year 0. The corresponding estimates $\{w_i^*(t) \equiv z_i^*(0)'\beta^1(\theta_i)\}_{i=1}^m$ provide m random draws from the counterfactual distribution of wages in Year 1 with characteristics fixed at Year 0 levels. Alternative counterfactuals can be simulated using the same procedure.[4]

Before looking at the decomposition results in detail, Table 5 reports the returns to characteristics by decile of the earnings distribution for 2004, 2007, 2008 and 2013. These are a key input into the wage decomposition procedure described above. The results are as expected with a male premium of 10 per cent to 15 per cent, a premium to being Irish of the order of 20 per cent and an urban premium of the order of 10 per cent. Of particular interest are the returns to education over this period. Our estimates show that the returns rise steadily with education. The OLS regressions in the last four columns of Table 5 show a mean return of tertiary education over primary education of the order of 50 per cent to 70 per cent.

[4] Recent work by Firpo *et al*. (2009) establishes a procedure for estimating unconditional quantile regressions. While the regression results based on this approach differ from the quantile regressions reported in our paper (they are after all estimating different parameters), decomposition results based on either approach both rely on the unconditional marginal distribution of earnings.

Table 5: Regression Results 2004, 2007, 2008 and 2013 (Standard Errors in Parentheses)

	2004 P10	*2007 P10*	*2008 P10*	*2013 P10*	*2004 P90*	*2007 P90*	*2008 P90*	*2013 P90*	*OLS 2004*	*OLS 2007*	*OLS 2008*	*OLS 2013*
Male	.132	.120	.161	.093	.148	.149	.151	.098	.172	.153	.157	.081
	(.022)	(.031)	(.027)	(.023)	(.022)	(.028)	(.018)	(.041)	(.014)	(.015)	(.016)	(.017)
Exp	.028	.026	.032	.021	.042	.040	.049	.040	.037	.038	.042	.034
	(.003)	(.004)	(.005)	(.003)	(.004)	(.004)	(.005)	(.004)	(.002)	(.002)	(.002)	(.003)
Exp^2	–.001	–.0004	–.001	–.0004	–.0006	–.0006	–.0007	–.0006	–.001	–.0006	.007	–.005
	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)
Lower Sec.	.067	.054	.034	–.011	.156	.182	.057	–.138	.132	.087	.058	–.022
	(.039	(.039)	(.040)	(.030)	(.036)	(.068)	(.059)	(.104)	(.027)	(.030)	(.031)	(.041)
Upper Sec.	.201	.172	.108	.077	.316	.338	.248	.046	.329	.258	.210	.110
	(.036)	(.048)	(.048)	(.026)	(.038)	(.082)	(.074)	(.102)	(.027)	(.029)	(.031)	(.038)
PLC	.238	.211	.226	.070	.404	.399	.298	–.052	.368	.329	.265	.078
	(.039)	(.053)	(.056)	(.031)	(.032)	(.080)	(.089)	(.106)	(.032)	(.035)	(.037)	(.045)
Third Level	.501	.450	.471	.266	.874	.918	.824	.632	.750	.724	.676	.525
	(.033)	(.053)	(.052)	(.037)	(.036)	(.065)	(.065)	(.098)	(.026)	(.029)	(.030)	(.036)
Irish	.260	.251	.350	.221	.108	.244	.265	.259	.161	.294	.340	.280
	(.054)	(.058)	(.079)	(.031)	(.055)	(.039)	(.057)	(.031)	(.032)	(.029)	(.030)	(.024)
Urban	.097	.082	.040	.029	.047	.078	–.018	.048	.089	.069	.047	.068
	(.038)	(.030)	(.024)	(.021)	(.034)	(.035)	(.026)	(.029)	(.016)	(.017)	(.018)	(.018)
BMW Region	–.115	–.060	–.037	–.047	–.079	–.073	–.113	–.078	–.089	–.089	–.075	–.075
	(.036)	(.033)	(.030)	(.023)	(.027)	(.027)	(.036)	(.031)	(.018)	(.019)	(.020)	(.020)
Constant	1.21	1.39	1.33	1.68	1.96	1.98	2.06	2.29	1.50	1.59	1.60	1.83
	(.077)	(.112)	(.124)	(.070)	(.061)	(.105)	(.072)	(.121)	(.045)	(.045)	(.047)	(.048)

Source: Authors' analysis.

As in Table 4, BMW refers to the Borders, Midlands and Western Region of Ireland and PLC refers to Post-Leaving Certificate Education.

Looking at the results of the individual quantiles we see that the return to tertiary education is substantially bigger the higher the conditional quantile. For example in 2004, the return to tertiary education at the 10th percentile was 50 per cent, while the corresponding return at the 90th percentile was 87 per cent. This pattern is consistent with international work in this area. Martins and Pereira (2004) examined data for 16 countries from the mid-1990s and found that the returns to schooling were higher for the more skilled individuals, conditional on their observable characteristics. They suggest a number of possible explanations including over-education, ability-schooling interactions, school quality effects or differences in the fields of study.

Given our interest in changes in inequality over this time, it is interesting to examine the change in returns to education over this period. The results in Table 5 show a fall in returns between 2004 and 2007 at the lowest decile but increasing returns at the higher decile. However, the period from 2008-2013 saw a substantial fall in returns to skill at both deciles. At the top decile only tertiary education records a statistically significant return over primary education by 2013, and even here the return is 63 per cent compared to 82 per cent in 2008.

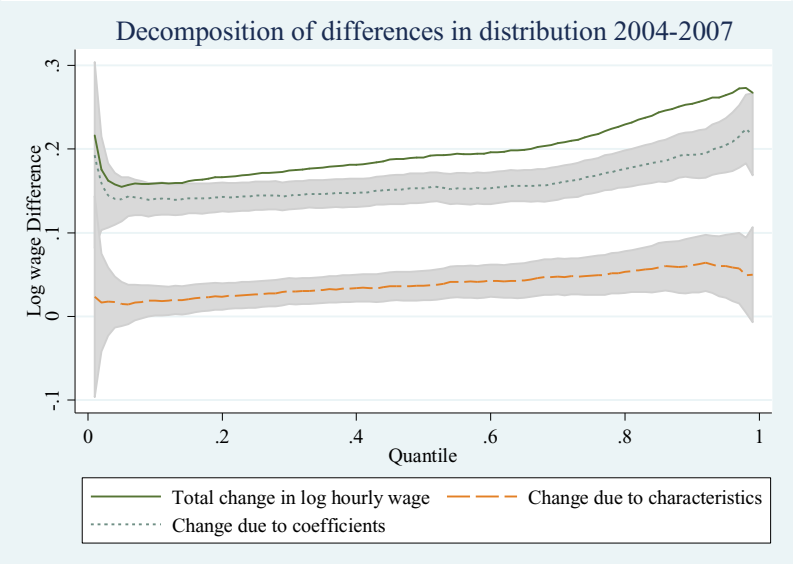
To examine the role of changing returns and workforce composition on inequality over this period we implement the Machado and Mata decomposition outlined above.[5,6] The results are presented in Figures 2 and 3. Figure 2 examines the period from 2004 to 2007 corresponding to the peak of the boom, while Figure 3 looks at the period from of the Great Recession from 2007 to 2013. Looking at the boom period our results are in keeping with those of Voitchovsky *et al*. (2012). The solid line shows a general pattern of increasing wage growth throughout most of the distribution, resulting in a substantial increase in inequality during the boom. As with the earlier work our decomposition shows that this increase was driven almost entirely by rising returns to skill.[7] Although changing composition contributed to wage growth throughout the distribution, the magnitudes of these changes were small compared to the impact of rising returns. Throughout the wage distribution, changes in returns are estimated to account for approximately 80 per cent of the observed wage changes. At the top of the distribution, returns were estimated to have increased wages by almost 20 per cent, compared to a 5 per cent increase due to characteristics.

[5] The procedure is implemented using the Stata code provided by Melly (2006). This procedure uses the same framework as Machado and Mata but evaluates the necessary integrals using summations rather than simulation. The two approaches are numerically identical as the number of random draws in Machado and Mata goes to infinity.

[6] In the analysis reported in the paper gender is captured by a gender dummy variable in the quantile regressions. We have also estimated the decomposition separately for men and women; our findings and conclusions are robust across genders.

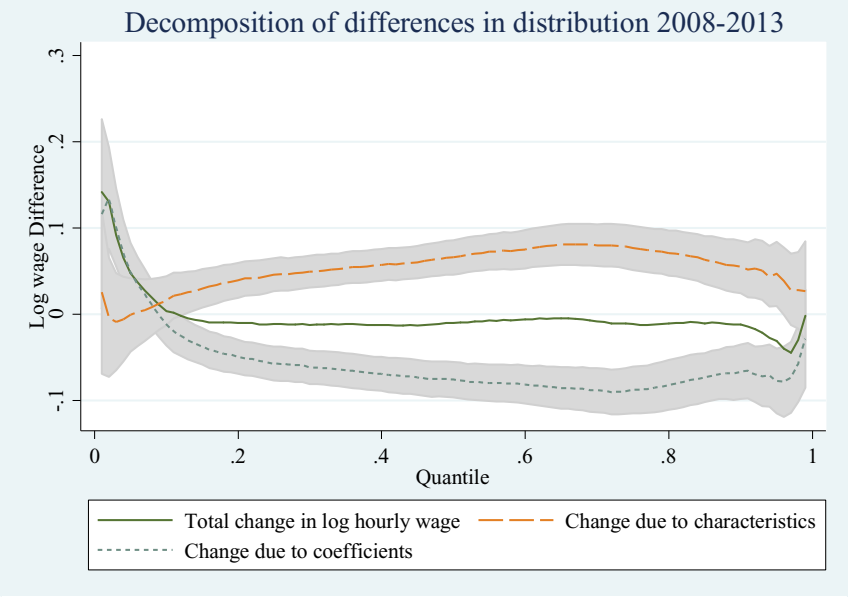
[7] The shaded regions around the decomposition components correspond to bootstrapped 95 per cent pointwise confidence intervals.

Figure 2: Decomposition of Hourly Earnings Changes for all Workers, 2004-2007



Source: Authors' analysis.

Figure 3: Decomposition of Hourly Earnings Changes for all workers, 2008-2013

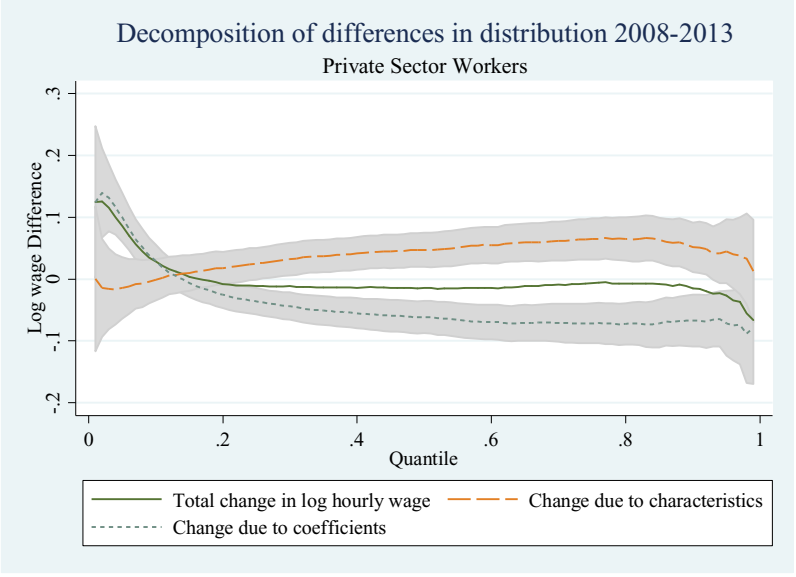


Source: Authors' analysis.

Figure 3 shows that this pattern changed dramatically with the onset of the recession. The pattern of wage changes between 2007 and 2013 resulted in a significant fall in inequality. This is driven by wage gains at the bottom of the distribution and stagnant or declining wages throughout the rest of the distribution. Wages declined across most of the distribution despite substantial improvements in the skills of the workforce. Indeed, our analysis reveals that the improvements in characteristics, by themselves, would have resulted in substantial wage gains, of the order of 8 per cent, throughout much of the distribution. The failure of the improved characteristics to translate into wage gains over this period reflects the significant decline in returns to these skills that occurred during the recession. This decline in the returns to skill caused the wages of all but the lowest paid workers to decline over this period, a fact that may reflect the protective impact of the National Minimum Wage on the wages of the lowest paid. We examine the role of the minimum wage in explaining our findings in detail in Section V.

The combination of changing returns and composition resulted in relative wage gains for the lowest paid workers and by extension lower inequality. Had the returns to skill not declined during the recession, we estimate that wages at the 10th percentile of the wage distribution would have increased by 1.5 per cent during the recession rather than the observed increase of 0.4 per cent, while wages at the 90th

Figure 4: Decomposition of Hourly Earnings Change for Private Sector Workers, 2008-2013



Source: Authors' analysis.

percentile would have increased by 5.5 per cent as opposed to the observed decline of 1.3 per cent. Under the counterfactual of fixed returns to skill, inequality would have continued to rise during the economic crisis due to the changing composition of the workforce. In the next section of the paper we consider a number of alternative explanations for our findings in detail.

V DISCUSSION

5a. Private Sector Analysis

For comparison with Voitchovsky *et al*. (2012) the analysis in Section IV included all workers, both in the public and private sectors. However, as noted in Section II, one of the responses of the Irish government to the Great Recession was a series of direct pay cuts for public sector workers in both 2010 and 2013. These pay cuts were deliberately progressive in nature, with the biggest pay cuts (up to 10 per cent) applying to those with the highest salaries. These pay cuts, in and of themselves, would have had the effect of reducing inequality along the lines reported in Section II. To examine the extent to which our earlier findings are being driven by wage cuts in the public sector, we repeat the decomposition analysis, focusing only on private sector workers.[8] The results are given in Figure 4. The results presented here mirror those presented in Figure 3. For all but the lowest percentiles, wages showed little change between 2008 and 2013. However, this pattern is masking two offsetting forces. One would have expected wages at all percentiles to have risen in line with the significant improvement in the characteristics of the workforce over this period. The fact that wages were instead stagnant reflects the fall in returns to skill that occurred during the Great Recession. It is clear from this that the patterns identified earlier reflect labour market forces independent of direct government pay cuts to public sector workers.

5b. Compositional Changes: Unemployment, Cohort Effects and Migration

In Table 3, we documented the dramatic fall in the proportion of the workforce with a primary education between 2008 and 2013 from 12 per cent to 5 per cent and the corresponding increase in the proportion with a third-level education, from 38 per cent to 53 per cent. Given these changes and the role compositional changes play in determining the evolution of wages throughout this period, it is important to

[8] The Public Sector identifier is only available in our RMF data from 2007 onwards. Throughout this period the proportion of private sector workers in our sample ranges from 64 per cent to 68 per cent which is consistent with population data. Also as noted earlier the earnings measure used in our analysis refers to gross wages and as such does not capture the public sector pension levy introduced by the government in 2009. For readers interested in a detailed comparison of earnings dynamics in the public and private sectors in Ireland during the Great Recession based on the entire population using administrative data see Doris *et al*. (2015).

understand the forces behind these changes. In this section we focus on three factors that are potentially important in this respect; unemployment, cohort effects, and migration.

In equilibrium, employment of skilled labour relative to unskilled labour can increase as a result of either an increase in the relative demand for skilled labour (resulting in an increase in the return to skill) or an increase in the relative supply of skilled labour (resulting in a decrease in the return to skill). Demand for skilled labour can rise as firms turn to more educated workers during times of difficulties in search of efficiency gains or as a response to sectoral changes in the composition of output, while supply can increase due to factors relating to demographics or migration (see for example Katz and Murphy 1992, Autor *et al*., 1998)

To understand the contribution of these forces to changes in the composition of the workforce we begin by noting that the ratio of the proportion of highly educated workers to less educated workers can be written as

$$\frac{P_H}{P_L} = \frac{(1 - UR_H) \# N_H}{(1 - UR_L) \# N_L} \tag{2}$$

where *Pj* is the proportion of education group *j* in the workforce, *URj* is the unemployment rate for group *j*, and *#Nj* is the number of education group j in the labour force. In line with Katz and Murphy (1992) and Autor *et al*. (1998) we may interpret $\frac{\# N_H}{\# N_L}$ as a measure of the relative supply of skilled to unskilled labour. Clearly an increase in the relative supply of skilled labour will increase the relative employment of this group. Abstracting from changes in the relative supply, Equation (2) also shows that an increase in the unemployment rate for low educated workers will increase the proportion of high educated workers relative to low educated workers.[9]

Eurostat provides unemployment rates by education level for Ireland for the period from 2004 to 2013. These are reproduced in Table 6. The unemployment rate of adults with less than an upper secondary education increased from 7.8 per cent in 2004 to 22.2 per cent in 2013. For those with tertiary education the unemployment rate increased from 2.3 per cent to 7.3 per cent. The large rise in unemployment among the less educated largely reflects the collapse of the construction sector, a sector with relatively low levels of education.[10] CSO data show employment in the relatively low skilled construction sector fell from 225,100 in 2005 to 103,300 in 2012. These unemployment data are consistent with recent work by Nolan and

[9] Murphy and Welch (1992) use innovations to the aggregate unemployment rate as a proxy for relative labour demand shifts in their analysis of inequality in the US.

[10] Analysis of Quarterly National Household Survey (QNHS) microdata shows that in 2005, 38.6 per cent of workers in the construction sector had less than an upper secondary education. The corresponding figure across all sectors was 28.36 per cent.

Table 6: Unemployment Rates of those Aged 15-64 by Education: Ireland 2004-2013

Year	*Unemployment Rate: Lower Secondary Education or Less (%)*	*Unemployment Rate: Third Level Education or More (%)*
2004	7.8	2.3
2005	7.4	2.5
2006	7.0	2.7
2007	7.8	2.8
2008	10.5	3.8
2009	18.1	7.2
2010	22.2	7.9
2011	24.4	7.9
2012	25.9	7.6
2013	22.2	7.3

Source: Eurostat.

Voitchovsky (2016) who used the EU-SILC data to examine job loss by wage level during the Great Recession. They found that the probability that an employee remains in employment from one year to the next is positively related to their monthly earnings during both the boom and the recession. However, the wage gradient is much more pronounced during the Great Recession.

We can combine the unemployment rates in Table 6 with Equation (2) to get an indication of the contribution of unemployment to the changes in the composition of the workforce reported earlier. Using Quarterly National Household Survey (QNHS) microdata for 2004 we estimate $\frac{\#N_H}{\#N_L} = 1.02$, where $\#N_H$ is the number of those in the labour force with tertiary education and $\#N_L$ is the number in the labour force with lower secondary education or less. For convenience we set this ratio equal to 1. Using Equation (2) we can then estimate the ratio of the proportion of high educated workers to low educated workers in 2004 as $\frac{(1-UR_H)}{(1-UR_L)} = \frac{(1-.023)}{(1-.078)} = 1.06$. This estimate is close to the actual observed ratio of 1.03 obtained from Table 3.

To examine the impact of changing unemployment rates we keep the labour force ratio fixed at 1 and adjust the unemployment rates using the Eurostat data.[11] Doing this gives an estimated ratio of the proportion of high educated workers to low educated workers in 2013 as $\frac{(1-UR_H)}{(1-UR_L)} = \frac{(1-.073)}{(1-.222)} = 1.19$. As expected,

[11] This simple analysis ignores the fact that the relative unemployment rates may change because of changes to the denominator (relative supplies) rather than the numerator (unemployment levels).

changes in the patterns of unemployment across education can account for some of the observed change in the educational profile of workers. However, the estimated 2013 ratio of 1.19 is still substantially smaller than the actual reported ratio from Table 3, which equals 3.3.

An alternative way of examining the impact of unemployment on the composition of the workforce is to consider the education distribution of all those of working age, irrespective of employment status. If the compositional changes in the workforce are driven by low educated workers losing their jobs, we would expect the compositional changes to be more muted when we consider all those of working age. Comparing the working age population with the workforce we find, as expected, that the education level of the working age population is lower than that of the working population. For example in 2013, 4.9 per cent of the workforce had a primary education level or less; the corresponding figure for the working age population as a whole was over twice as high at 11.8 per cent.[12] Conversely the percentage of the working age population with a third-level degree is 42 per cent but over 53 per cent in the workforce.

Of greater interest to us however is how these distributions changed over time. From 2008 to 2013 the share of the working age population with a primary education or less decreased by 44 per cent (from 0.21 to 0.12), compared to a decline of over 55 per cent (from 0.11 to 0.05) in the workforce. Consistent with the analysis in the previous paragraph, we find that part of the decline in the educational composition of our working sample reflects disproportionate job losses among lower educated workers. Nevertheless a significant improvement in the educational composition of the sample is still evident, even when we consider all those of working age.[13] As earlier, the evidence implies that the differences in unemployment rates across education levels explain part, but not all, of the compositional changes we observe.

The above analysis shows that a complete understanding of the change in the composition of the workforce between 2004 and 2013 must take account of changes in relative supply $\frac{\#N_H}{\#N_L}$. Analysis of QNHS microdata show that this ratio increased from 1.02 in 2004 to 2.55 in 2013. In the remainder of this section we consider two

[12] We have checked the reliability of these figures by comparing the EU-SILC education data to the education distribution obtained from the QNHS microdata files. The QNHS has the advantage of much larger sample sizes than the EU-SILC, though the absence of detailed wage data means that it cannot be used for the detailed decomposition. In 2013 the proportion of the workforce in the QNHS with a primary degree or less was 4.39 per cent, while the proportion of those of working age in the QNHS with a primary degree or less was 10.23 per cent. These are similar to the figures reported in the text for the EU-SILC data.

[13] This is consistent with data from OECD (2014) that reports the percentage of those aged 25-64 with a tertiary education increased from 29 per cent to 40 per cent in Ireland between 2005 and 2012, while the percentage of those with less than upper secondary decreased from 35 per cent to 25 per cent.

possible factors contributing to changes in $\frac{\# N_H}{\# N_L}$; cohort effects and migration.

Even in normal economic circumstances one would expect the educational composition of workers to improve over time due to cohort effects; older less educated cohorts leave the sample due to retirement and are replaced by younger more educated entrants to the labour force (Card and Lemieux, 2001; Centeno and Novo, 2014). Indeed Nolan *et al*. (2000) drew attention to a marked improvement in the education profile of employees during their earlier time period (1987-1994), an increase they attributed to cohort effects.

To examine the role of cohort effects in explaining our compositional changes, we focus on a particular pseudo-cohort of workers over the period 2004-2013. That is, rather than follow the entire sample we look at changes in the composition of workers born in 1959-1969 and follow this cohort throughout 2004-2013. The results are given in Table 7. Since we are following a pseudo-cohort these results are free of cohort effects; by construction older less educated workers are not being replaced by younger more educated workers in this pseudo-cohort sample. The results in Table 7 show that focusing on a specific cohort reduces the compositional changes somewhat. The percentage of those with an upper secondary education or less falls from 58 per cent to 43 per cent, compared to a fall from 58 per cent to 38 per cent for all workers. Likewise the rise in the percentage of those with a tertiary education is somewhat more muted for this sample. For the pseudo-cohort the percentage with a tertiary education increased from 32 per cent to 49 per cent, while for all workers the percentage increased from 32 per cent to 53 per cent. From this it would seem that cohort effects may explain some of the compositional effects we

Table 7: Distribution of Education among Workers for the Cohort Born Between 1959 and 1969 (aged 35-45 in 2004)

	Primary	*Lower Secondary*	*Upper Secondary*	*Post Leaving Cert*	*Third Level*	*Average Age*
2004	.08	.22	.28	.10	.32	40.2
2005	.09	.20	.28	.10	.34	41.2
2006	.08	.19	.24	.12	.37	42.2
2007	.07	.19	.24	.11	.39	43.3
2008	.07	.18	.25	.12	.39	44.0
2009	.07	.15	.24	.10	.43	45.2
2010	.06	.15	.25	.09	.43	46.1
2011	.05	.15	.23	.07	.48	46.9
2012	.06	.15	.24	.06	.48	47.7
2013	.06	.16	.21	.06	.49	48.8

Source: Authors' analysis.

observe. However, even when cohort effects are removed from our analysis, it is evident that compositional changes in the workforce are still evident.

A final possible explanation for the observed rise in $\frac{\#N_H}{\#N_L}$, which in turns feeds into the changing educational composition of the workforce, is the selective nature of emigration observed in Ireland during the Great Recession. The CSO[14] provides data on migration patterns in Ireland during this period. These data show that Ireland was a net recipient of migrants from 1996 to 2009. Net inward migration was over 25,000 each year from 2000 to 2008, reaching a high of 104,800 in 2007. However, this changed dramatically with the beginning of the Recession. Net migration was close to zero in 2009 and for each year from 2010 to 2013 Ireland experienced net outward migration of over 25,000 individuals. Furthermore many of those leaving the country were working prior to leaving. In 2009 almost 60 per cent of people who emigrated from Ireland had been in work the previous year, while the corresponding number for 2013 was 44.4 per cent.

These migration trends, while large, would not affect the relative supply of skilled and unskilled workers if the net migration were balanced, in the sense that the migration flows had the same skill composition as the existing workforce (Borjas *et al*., 1997). However, differences in either the education level of migrants versus stayers, or of emigrants versus immigrants, may have a large impact on the educational composition of the Irish labour force. Since 2009 the CSO reports migration by education level. Between 2009 and 2013 the proportion of emigrants with a third-level education increased from 35 per cent to 42 per cent, while the proportion with a secondary education or less was relatively unchanged (45.3 per cent versus 45.8 per cent).[15] In addition to changes in the profile of emigrants from Ireland however, there were also large changes in the education profile of immigrants into Ireland. The proportion of immigrants into Ireland with a third-level education rose from 47 per cent to 58 per cent between 2009 and 2013. As with emigrants, there was little change in the percentage of immigrants with a secondary degree or less, this percentage falling from 31.7 per cent to 31.3 per cent. The net result of these changes in migration patterns is that between 2009 and 2013 net outward migration of those with a secondary school level of education or less increased by 74,600, while net outward migration of those with a third-level degree increased by 35,700. Although migration affected workers of all education levels, these data suggest that net migration was larger among the lowest educated. The CSO reports that the size of the total labour force in Ireland in 2009 was equal to 2.26 million. Based on data from the QNHS microdata for the second quarter of 2009 we estimate that the number of those in the labour force with a secondary

[14] www.cso.ie/en/releasesandpublications/er/pme/populationandmigrationestimatesapril2014.
[15] Unfortunately the CSO data do not provide a finer breakdown by lower levels of education.

education or less was 1.10 million, while the number with a third-level education or higher was 856,314. Combining the labour force data with the migration data we see that recent Irish migration patterns were unbalanced, in the sense that the less educated were over represented in migration flows relative to their position in the labour force. Migration therefore increased the relative supply of skilled labour remaining in the Irish labour force and in doing so contributed to the compositional changes noted earlier. However, the baseline figures clearly show that the changes in net migration patterns, by themselves, are likely to account for only a small part of the compositional changes reported in Section III.

Having looked at a range of possible explanations for the dramatic improvement in the educational composition of the workforce reported earlier we conclude that these changes are not due to any one single dominant factor but rather represent a combination of forces, including cohort effects, increased unemployment concentrated among the less educated and selective patterns of net migration.

5c: Minimum Wage.

Finally in this section we consider the role of institutions and in particular the National Minimum Wage in helping understand our findings. Ireland introduced a National Minimum Wage on April 1, 2000. The rate was set at €5.58, which at the time corresponded to approximately 60 per cent of median earnings. The rate has been increased a number of times since then, most recently on January 1, 2016 and the adult rate currently stands at €9.15.[16] By its very nature the minimum wage sets a floor below which the hourly wage paid by employers cannot fall. By truncating the wage distribution from the left, one would automatically expect an effective minimum wage to reduce inequality, absent very large spillover effects.

A number of international studies have looked at the role of the minimum wage in determining inequality. Lee (1999) concluded that more than the entire rise in the 50/10 earnings differential in the US between 1979 and 1988 was due to the falling federal minimum wage. A recent re-examination of this work by Autor *et al*. (2016), exploiting two additional decades of data, also found that the minimum wage reduced inequality but that the net effects were less than half as large as previously claimed. Dolton *et al*. (2012), found that wage inequality in the UK was lower in regions where the National Minimum Wage had its biggest effect, while Lindley and Machin (2013) found that the introduction of the National Minimum Wage in the UK had a compressing effect on lower tail wage inequality.

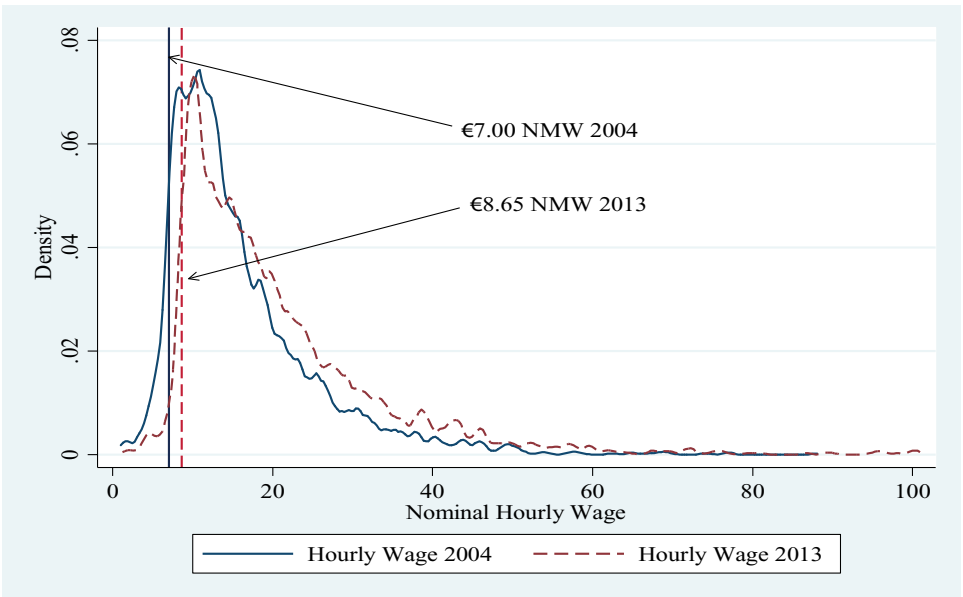
A key determinant of the impact of the minimum wage on inequality is its bite, both in terms of compliance and where in the wage distribution it is located. The evidence to date suggests that compliance with the Irish Minimum Wage is high (Low Pay Commission, 2015). Further evidence in support of this is provided in

[16] For more details on the Irish National Minimum Wage see Low Pay Commission (2015).

Figure 5. Figure 5 shows the density of nominal hourly wages, both in 2004, when the minimum wage was €7.00, and in 2013, by which time the minimum had increased to €8.65. In both years we see that the legislated minimum wage effectively truncates the wage distribution to the left.[17]

To examine the implications of the minimum wage for our analysis we first determine the effective percentile of the wage distribution corresponding to the legislated wage. We focus on 2008 and 2013. In 2008, the minimum wage of €8.65 corresponded to the 6.5th percentile of the wage distribution for our sample, while in 2013 it corresponded to the 5.9th percentile. When measuring the bite of the minimum wage using survey data, some studies allow for measurement error by expressing the effective minimum wage as an interval around the legislated wage. For example, in his analysis of minimum wage workers in Ireland in 2015, Collins (2015) classifies those earning between €8.22 and €9.08 (±5 per cent from €8.65) as minimum wage workers. Using Collins's (2015) upper bound we find that the minimum wage corresponds to the 9th percentile of the wage distribution in both 2008 and 2013. From both the bite and location of the minimum wage it is evident

Figure 5: Nominal Hourly Wage Distribution 2004 and 2013 and the Respective National Minimum Wages.



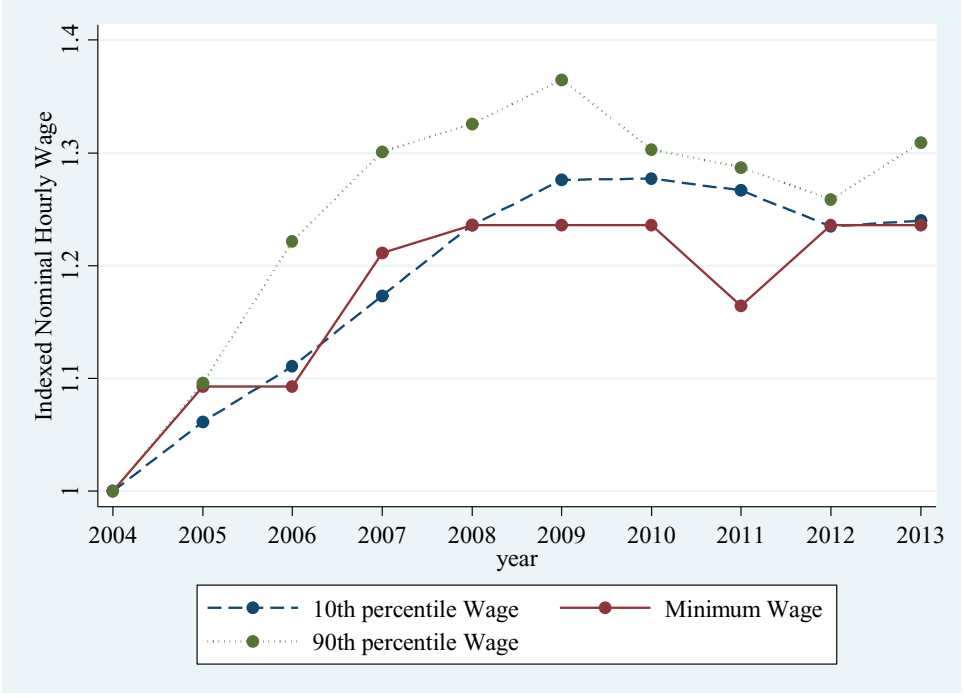
Source: Authors' analysis.

[17] Some of the mass in the wage distribution below the minimum wage reflects sub-minimum wages for young workers or those on training schemes.

that the minimum wage potentially exerts a very strong influence on wages in the bottom decile of the wage distribution.

To see this more clearly Figure 6 plots the evolution of the 10th percentile wage, the minimum wage and the 90th percentile wage for our sample from 2004 to 2013. The influence of the minimum wage on the wages of the bottom decile is clear. Wage growth at the 10th percentile tracks growth in the minimum wage very closely throughout the entire period. This is in contrast to the 90th percentile wage. During the boom the 90th percentile wage grew much faster than either the 10th percentile wage or the minimum wage, resulting in the increase in boom-time inequality noted previously. However, during the Great Recession, while both the 90th percentile wage and the 10th percentile wage declined, the fall in the 90th percentile wage was substantially larger. This reflects the influence of the minimum wage on the bottom decile. Although the legislated minimum wage was constant during the Recession[18] it seems to have provided an effective floor for the bottom of the wage

Figure 6: Indexed Nominal Hourly Wages by Percentile and Indexed National Minimum Wage, 2004-2013.



Source: Authors' analysis.

[18] The minimum wage was reduced by €1 in January 2011 but this cut was reversed in July of the same year.

distribution, preventing falls of the magnitude seen at the top of the distribution. The reduction in wage inequality shown earlier arose because workers in the bottom decile did not suffer the fall in wages and returns experienced at all other points of the distribution. The results here suggest that the National Minimum Wage, and in particular the provision of an effective wage floor during the Recession, played a key role in this process.[19]

VI CONCLUSIONS

Although the economic downturn beginning in 2007 reflected a global recession that affected many countries, the combination of falling global output, a housing bubble and a financial crisis meant that Ireland was one of the countries most affected by the Great Recession. The collapse in output and spiralling unemployment rates during the Great Recession in Ireland provides a rare opportunity to study the response of wage inequality to dramatic changes in economic conditions. To do this we examine how wage inequality in Ireland changed as we moved from the height of the boom through the Great Recession.

We find a strong cyclical pattern to wage inequality in Ireland, with inequality rising during the boom and falling during the Great Recession. Like previous work we find that the rise in inequality during the boom was largely driven by a rise in the returns to skill, reflective of the tightness of the labour market at that time. Any consideration of the subsequent change in wage structure during the Great Recession must account for the large changes in the composition of the labour force that occurred during this period. We find that the education levels of the workforce improved significantly during the crisis, with the proportion of the workforce with tertiary education increasing from approximately 35 per cent to over 50 per cent. Further analysis suggests that the improvement in the skills of the workforce during the Recession reflected a combination of factors such as cohort effects, emigration and unemployment.

Despite the improvement in education of the remaining workforce over this time, wages were stagnant or declined slightly throughout most of the wage distribution. This reflects a decline in the returns to skill during the Recession. Only those workers in the bottom decile of the earnings distribution did not experience a fall in returns to skill during the Recession. Our analysis highlights the important role played by the National Minimum Wage in protecting the wages of the least skilled workers and in doing so reducing inequality. This may be especially true during deep recessions, when the forces leading to wage reductions for many

[19] This analysis abstracts from any potential effects the minimum wage may have on the employment or hours of low skilled workers. For an overview of the literature in this respect see Low Pay Commission (2015).

workers may be particularly strong. The relative strength of the minimum wage and the role it plays in protecting wages at the bottom of the distribution must be borne in mind when interpreting cross-country differences in the cyclicality of wage inequality.

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