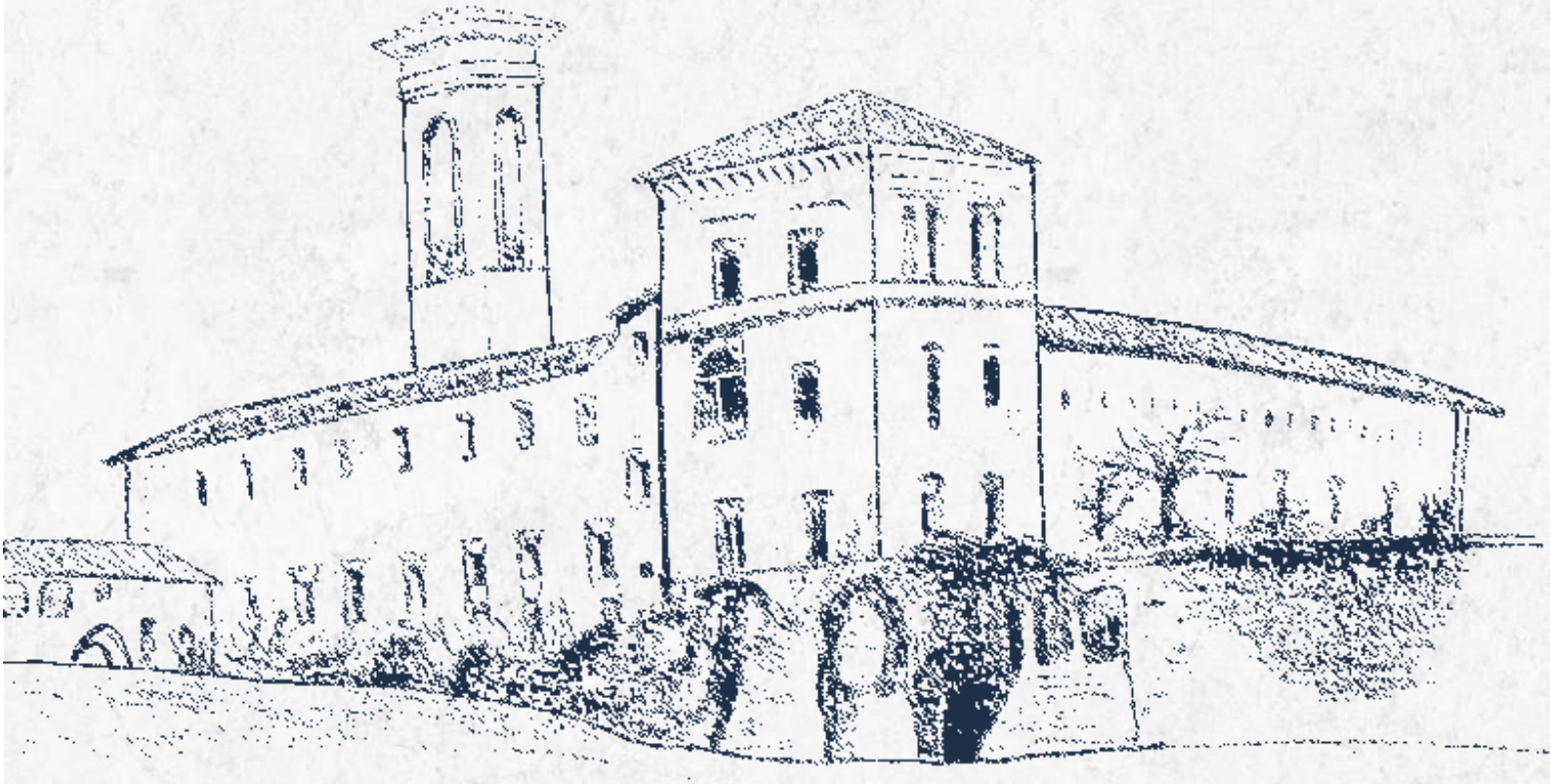
OPEN ACCESS
ISSN 2280-4056

E-Journal of International and Comparative

LABOUR STUDIES

Volume 1, No. 3-4 October-December 2012



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The Impact of the National Minimum Wage on Labour Productivity in Britain

Richard Croucher and Marian Rizov *

1. Introduction

While there is a large body of research examining the impact of national minimum wage (NMW) on employment and (wage) inequality, minimum wage effects on firm and industry performance is a significantly understudied area. A consensus has emerged that the overall effect of NMW on the level of employment in Britain is broadly neutral (see Stewart, 2004 for a survey of the literature). Therefore, the research has shifted to exploring other possible margins of adjustment. Wadsworth[1], following several previous studies, analyses a channel through which the effect of minimum wage could be directed. Firms that employ minimum-wage workers could have passed on any higher labour cost resulting from increases in minimum wage in the form of higher output prices. Further research on the NMW's impact on firm behaviour seems to be a promising area as firms' operations and productivity may also be affected. Galindo-Rueda and Pereira, and Draca *et al.*[2] are among the few studies that have attempted to analyse the NMW's impact on British firms. They

* Richard Croucher is Associate Dean for Research and Professor of Comparative Employment Relations at the Middlesex University Business School. Marian Rizov is Reader in Economics at the Middlesex University Business School.

[1] J. Wadsworth, *Did the National Minimum Wage Affect UK Prices? Fiscal Studies*, 31 No. 1, 2010, 81-120.

[2] F. Galindo-Rueda, S. Pereira, *The Impact of the National Minimum Wage on British Firms*: Report for the Low pay Commission, 2004, available at www.lowpay.gov.uk/lowpay/research/pdf/t0Z2NTSH.pdf (Last accessed 12 March 2012). M. Draca, S. Machin, J. Van Reenen, *Minimum Wages and Firm Profitability, American Economic Journal: Applied Economics*, 3 No. 1, 2011, 129-151.

find that firm profitability has fallen after the NMW introduction; they also find no significant effects on employment and productivity in the short run. These findings suggest that in the medium to long run, productivity might be induced to increase more in firms that are more affected by the NMW. Forth and O'Mahony[3] explicitly analyse the NMW's impact on labour productivity but use industry rather than firm level data and their study covers only a very short period (1998-2000) around the introduction of NMW. They decompose their measure of labour productivity growth into capital deepening and total factor productivity (TFP) growth. They find evidence of labour productivity increases in the larger low-paying sectors, retail and hospitality as well as in hairdressing. The labour productivity growth is mostly attributed to capital deepening. The findings call for further research given the fact that previous micro-data studies did not have an explicit focus on firm productivity and all studies only analysed the effects in a short period after the NMW introduction.

In this paper we explore the link between firm labour productivity and the introduction of the NMW over a more than ten-year span covering longer periods before and after the NMW introduction. We use the FAME dataset which contains firm level micro data to calculate firm-specific labour productivity measures and then aggregate them to the level of the low-paying sectors as identified by the Low Pay Commission (LPC). These include several service industries, agriculture and food processing, textiles and clothing manufacturing. The sectors, their overall position in the economy and employers' estimates of the impact of the NMW on them are described in Table No. 1. The low-paying LPC sectors appear to be the part of the economy most affected by the introduction of the NMW.

[3] J. Forth, M. O'Mahony, *The Impact of the National Minimum Wage on Labour Productivity and Unit Labour Costs*, National Institute of Economic and Social Research, 2003, (Available at www.lowpay.gov.uk).

Table No. 1 – Characteristics of Low Paying Sectors, 2010.

Industry	Growth since 1998	Proportion of workers paid NMW	Number of employees	Results of NMW
Retail	Continuous growth until the start of the recession	6.8%	3.2M	The ACS reported that differentials continued to be squeezed as a result of increases to the MW
Hospitality and Leisure, Travel and Sport	A substantial fall	18.1% in Hospitality 6.2% in Leisure, Travel and Sport	1.09M in Hospitality 648,000 in Leisure, Travel and Sport	The ALMR said that 82 per cent of members had to let staff go because of increases in the MW
Social care	Continuous growth	5%	1.2M	Care providers told LPC the squeeze they faced resulting from the level of fees paid by public bodies that purchase care services
Childcare	The Government continues to increase the provision of childcare	4.8%	373,000	The White Horse Child Care Ltd. said that increases in the NMW had led to increases in the fees charged to parents, which had reduced the size of the market and excluded many of the parents that most needed high quality childcare
Cleaning and Security	Continuous growth	21.8% in the Cleaning sector	472,000 in Cleaning sector; 178,000 in the Security sector	CSSA reported that clients might accept increases of the MW; however, often shorten hours of contract or lower specification.
Hairdressing		10.3%		The NHF stated any compulsory pressure to increase costs would inevitably result in continued job losses.
Agriculture	Falling employment and income	2.8%	242,000	The NFU claimed that it was harder for the producers to compete with competitors in

				countries with lower MW.
Textiles, Clothing and Food Processing (Manufacturing)	Falling employment and declining output	8.2%	82,000 in textiles and clothing; 348,000 in food processing sector	The FDF said that the industry is tending to pass any increase in wage costs to clients.

Source: National Minimum Wage, Chapter 3, p.p. 54-77, Low Pay Commission Report 2010.

Our results from difference-in-differences analysis show that, with notable exceptions, aggregate LPC sector labour productivity has been significantly positively affected by the NMW in the long run; the effects' magnitudes vary by sector. In most of the sectors the impact is statistically significant and positive with the exception of hairdressing, leisure and agriculture where the impact is positive but not statistically significant. We also analyse labour productivity by firm-size groups, according to the LPC classification and find substantial heterogeneity in responses to the NMW over time as the increases in productivity are more marked in larger firms.
The paper is organised as follows. In Section 2 we introduce a theoretical framework similar to that of Forth and Mahoney[4], defining labour productivity and decomposing it into capital deepening and TFP. In Section 3 we describe the data and report summary statistics for each of the LPC sectors and our counterfactuals. We also present the relationship between aggregate productivity and the NMW by aggregate LPC sectors and firm-size groups graphically over time. In Section 4 we perform difference-in-differences analysis and verify NMW productivity effects. In Section 5 we discuss the results in the context of relevant literature on the effects of NMW and conclude.

2. Theoretical Framework: Defining Labour Productivity

Increases in the real value of the NMW affect the price of labour and thus the wage distribution, employment and, ultimately, productivity. The effects of minimum wages on wage distribution and employment have been

[4] J. Forth, M. O'Mahony, *op. cit.*

extensively studied in the U.S.[5] and in the UK[6]. Most minimum wage models predict that as the minimum wage rises, the distribution of earnings will become more compressed. Findings on employment changes are more mixed but in general, a weak positive or no association of minimum wage and employment is suggested. For the UK NMW, no adverse employment effects have been detected[7].

Studies of minimum wage effects on the wage distribution and employment provide a basis for hypothesising a positive link between the NMW and productivity. Such a hypothesis is consistent with findings that increases in the NMW are associated with a decline in dispersion of the wage distribution and a non-negative response of employment. Machin and Manning[8], Card and Krueger[9], and Dickens *et al.*[10] explain these effects by employing dynamic monopsony models of the labour market. The extent of labour and output markets competition has important implications for prices and thus for productivity[11]. Under perfect competition, wages equal

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[5] D. Aaronson, *Price Pass-through and the Minimum Wage, Review of Economics and Statistics*, No. 83, 2001, 158-169. L. Katz, A. Krueger, *The Effect of Minimum Wage on the Fast Food Industry, Industrial and Labor Relations Review,* 1992, 46 No. 1, 6-21. J. DiNardo, N. Fortin, T. Lemieux, *Labor Market Institutions and the Distribution of Wages, 1973-1992: a Semiparametric Approach, Econometrica*, 1996, No. 65, 1001-1046. D. Card, A. Krueger, *Myth and Measurement: the New Economics of the Minimum Wage*, Princeton University Press, Princeton, NJ, 1995. R. Croucher, G. White, *Enforcing a National Minimum Wage: T the British Case*, Policy Studies 28 No. 2, 2007, 145-161. D. Lee, *Wage Inequality in the United States during the 1980s: Rising Dispersion or Falling Minimum Wage? Quarterly Journal of Economics*, No. 114, 1999, 977-1023.

[6] S. Machin, A. Manning, *The Effects of Minimum Wages on Wage Distribution and Employment: Evidence from the U.K. Wages Councils, Industrial and Labor Relations Review*, 47 No. 2, 1994, 319-329. R. Dickens, S. Machin, A. Manning, *The Effects of Minimum Wages on Employment: Theory and Evidence from Britain, Journal of Labor Economics*, No. 17, 1999, 1-22. D. Metcalf, *The National Minimum Wage: Coverage, Impact and Future, Oxford Bulletin of Economics and Statistics,* No. 64, 2002, 567-582. M. Stewart, *Estimating the Impact of the Minimum Wage Using Geographical Wage Variation, Oxford Bulletin of Economics and Statistics,* No. 64, 2002, 583-605. S. Machin, A. Manning, L. Rahman, *Where the Minimum Wage Bites Hard: the Introduction of the UK National Minimum Wage to a Low Wage Sector, Journal of the European Economic Association,* No. 1, 2003, 154-180. S. Machin, J. Wilson, *Minimum Wages in a Low Wage Labour Market: Care Homes in the UK, Economic Journal Conference Volume,* No. 114, 2004, 102-109.

[7] M. Stewart, *The Employment Effects of National Minimum Wage, Economic Journal,* No. 114, 2004, par. *C110-C116*.

[8] S. Machin, A. Manning, *The Effects of Minimum Wages on Wage Distribution and Employment: Evidence from the U.K. Wages Councils, op. cit*.

[9] D. Card, A. Krueger, *op. cit.*

[10] Dickens *et al.*, *op. cit.*

[11] D. Card, A. Krueger, *op. cit.*

the marginal cost of labour. The rise in wages due to minimum wage regulation results in rise in marginal cost of production. Then the impact of the minimum wage on firm profitability and ultimately productivity will depend on the ability of firms to pass costs on, and increase output prices. Under monopsony, the minimum wage may not increase marginal costs, since the firm no longer has to raise wages to attract marginal workers. Lower marginal cost will lead to a raise in demand for labour and hence an increase in output. Higher output should act to lower output prices and again induce a squeeze on the firm's profit margins which could ultimately lead to an increase in measured (labour and/or total factor) productivity, other things being equal.

To understand better the channels through which a minimum wage may affect labour productivity we formulate a simple production function model where the level of output (real value added, V) of firm j at time t can be expressed as a function of aggregate capital inputs (K), aggregate labour inputs (L) and the production technology (A):

$$V_{jt} = A_{jt} f(K_{jt}, L_{jt}). \quad (1)$$

The values of capital and labour inputs capture both quantity and quality. The production technology refers to the rate at which units of capital and labour are converted into output and is often referred to as total factor productivity (TFP).

The growth in firm output j over the period (t-1 to t) will be determined by changes in labour inputs, changes in capital inputs and changes in TFP.[12] The most commonly employed formalisation is based on the assumption of a Translog production function and obtained via the Törnqvist discrete approximation to the Divisia index (e.g., Jorgenson et al., 1987). If with dX_{jt} we denote the proportionate change in a variable X_{jt} (standing for V, L, K, or A) between period t-1 and t, i.e. $dX_{jt} = \ln (X_{jt} / X_{jt-1})$, and impose constant returns to scale then the Törnqvist index is given by:

[12] Generally, we do not observe TFP directly. This problem is addressed by the traditional growth accounting method, which has its theoretical underpinnings in the neoclassical growth model. Under the assumption that all markets function perfectly, the growth accounting method permits changes in TFP to be calculated as a residual having subtracted changes in inputs from output growth. There also are econometric methods (e.g., J. Van Biesebroeck, *The Sensitivity of Productivity Estimates: Revisiting three Important Debates. Journal of Business and Economics Statistics,* 26 No. 3, 2008, 311-328) that are often employed to estimate TFP.

$$dV_{jt} = a_{jt}dL_{jt} + (1 - a_{jt})dK_{jt} + dA_{jt}, \quad (2)$$

where a_{jt} is the share of labour in value-added, averaged over the two time periods. Under neo-classical assumptions, the shares of labour and capital, a_{jt} and $(1-a_{jt})$ equal the output elasticity of labour and capital respectively and since we imposed constant returns to scale, sum to one. The rate of change in A_{jt} is a catch-all for technological or organizational improvements, such as process innovations and changes in work organization, that increase the level of output for a given amount of input. Changes in the quality of factor inputs, e.g., a greater use of new technology equipment or highly skilled labour, may be incorporated within this framework by weighting each of a number of types of capital or labour by their value added shares[13]. If this adjustment for quality is not carried out directly then the TFP term also includes the impact of input quality changes.

This method of accounting for growth in output can be easily extended to permit a focus on changes in labour productivity[14]. Having identified the impact of changes in the quantity of labour input – for example the number of employees – we can subtract this from the changes in output in Equation (2), and using the fact that the input weights sum to one, derive a labour productivity equation of the form:

$$d(V_{jt}/L_{jt}) = (1 - a_{jt})\, d(K_{jt} / L_{jt}) + dA_{jt}. \quad (3)$$

Thus changes in labour productivity (V_{jt}/L_{jt}) depend on changes in the capital-labour ratio (K_{jt} / L_{jt}) or capital deepening and TFP[15]. This equation provides a framework for better understanding the sources of labour productivity changes after the introduction of the NMW.

In the case of a marginal cost increase due to the introduction of the NMW, all domestic firms producing the same product will experience a degree of cost pressure, which will depend on their exposure to the NMW, usually defined as the share of NMW labour in their production process[16]. Firms

[13] D. Jorgenson, F. Gallup, and B. Fraumeni, *Productivity and US Economic Growth,* Harvard University Press, Cambridge, MA, 1987.

[14] Forth and O'Mahony, *op. cit.*

[15] An alternative approach is to start with gross output (gross value added plus purchases) and include purchases as intermediate inputs in the above formulae. As our goal is to provide a simple framework for understanding the channels through which NMW may impact labour productivity we choose the value added formulation.

[16] If spillover effects occur from the NMW, putting upward pressure on wages further along the wage distribution, as found in some cases by previous UK research (LPC, 2000), then the effects on costs will be magnified. Draca *et al., op. cit.*

operating in competitive industries will be unable to pass on cost increases if substitute products do not face similar cost increases. Then labour-for-capital substitution may be an effective adjustment mechanism if labour is a substitute for capital, thus reducing the number of employees and inducing labour productivity improvements. However, in some industries such as services, the scope of labour-for-capital substitution is typically limited. Thus, service industries should be expected to experience greater upward pressure on costs and by Equation (3) there will be more pressure on increasing TFP.

Further, the more a good competes with potential substitutes produced abroad not affected by the UK NMW, the harder it will be for UK firms to pass on cost increases and maintain market share, other things equal. Thus, firms exposed to international trade may be less able to pass on cost increases and thus harder pressed to either substitute labour-for-capital or improve TFP depending on the nature of production. At the same time many service industries, which typically are not internationally traded may be more able to pass on cost increases.

3. Data and Descriptive Analysis

We calculate labour productivity as defined in Equation 3, while in the next section we carry out our difference-in-differences analysis using the FAME dataset from the Bureau van Dijk. The dataset covers all firms filed at Companies House in the UK and includes information on detailed unconsolidated firm-level financial statements, wage (remuneration) bill, ownership structure, location by post code, activity description, and direct exports. The data used in our analysis contain annual records on more than 360,000 firms over the period 1994-2009. The coverage of the data compared to the aggregate statistics for the industries analysed as reported by the UK Office for National Statistics (ONS) is highly representative, as for sales it is around 80 per cent and for employment around 82 per cent[17]. The sectors analysed are identified on the basis of the 2003 UK SIC at the 4-digit level, following the LPC groupings of low-paying industries (see

[17] Harris and Li (R. Harris, R. Q. Li, *Exporting, R&D, and Absorptive Capacity in UK Establishments, Oxford Economic Papers*, 61 No.1, 2009, 74-103) argue that FAME is biased towards larger firms, particularly in the non-exporting populations. Even though we size-weight our aggregations over firm labour productivity we note this caveat. However, for the purposes of our analysis, the interest is more in larger firms where the NMW legislation is expected to have more significant effects due to higher compliance.

Table A1 in the Appendix). We also create counterfactuals from both manufacturing and service industries. The counterfactuals are composites of a set of 4-digit industries which have been identified on the basis of limited exposure to the NMW using literature and expert opinions[18]. All nominal monetary variables are converted into real values by deflating with the appropriate 4-digit UK SIC industry deflators taken from ONS. We use PPI to deflate value-added and asset price deflators for capital.

The descriptive statistics for the LPC sectors and the counterfactuals are reported in Table No. 2. We compare average firm characteristics across the LPC sectors by starting with the average labour productivity (LPR) measure. The sectors with the highest average labour productivity are food processing, security and retail while social care shows the lowest labour productivity. The average value added is highest in food processing, security and retail while it is lowest in agriculture, hairdressing and social care. The value of fixed capital assets is highest in food processing, retail and hospitality sectors. The largest firms by average number of employees are found in the security and cleaning sectors while the smallest exist in agriculture, hairdressing and leisure. In all sectors except agriculture a large proportion of firms are located in urban areas. The highest share of exporters is in the textile and food processing industries[19]. Exits are highest, especially at the end of the period of analysis, in 2008, amongst retail, cleaning and security firms, as the latter are also characterised by the lowest average age.

[18] The industries included in the counterfactual are all 4-digit industry codes comprising the following SIC 2003 2-digit industries: 23, 27, 29, 33, 34, 35, 40 for the manufacturing counterfactual and 64, 65, 66, 67 for the services counterfactual.

[19] Firms are classified by location following the 2004 DEFRA definition of rural and urban areas and an application in Rizov and Walsh (M. Rizov, P. Walsh, *Is there a Rural-urban Divide? Location and Productivity of UK Manufacturing, Regional Studies,* 45 No. 5, 2011, 641-656). Exporters are identified as in Rizov and Walsh (M. Rizov, P. Walsh, *Productivity and Trade Orientation of UK Manufacturing, Oxford Bulletin of Economics and Statistics,* 71 No. 6, 2009, 821-849).

Table No. 2 – Summary Statistics by LPC Sector 1996-2009.

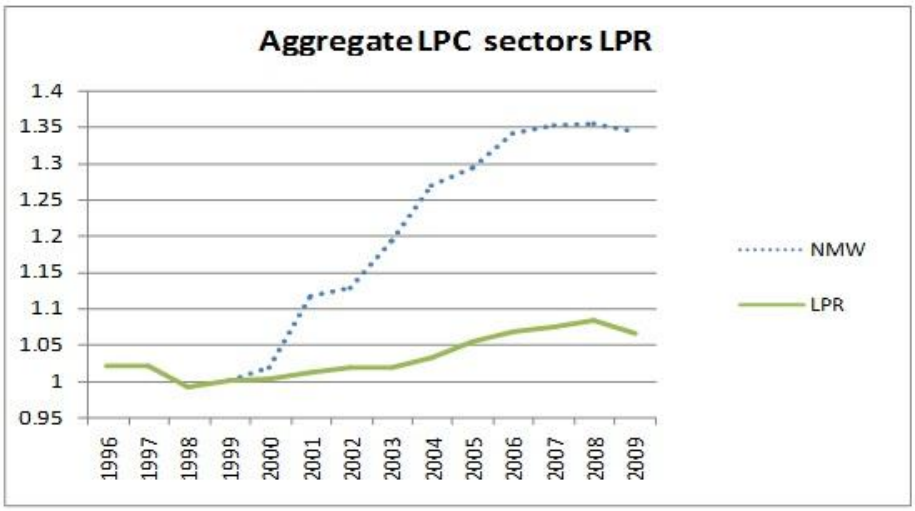
Variables	Social care	Retail	Hospitality	Cleaning	Security	Hair-dressing	Textiles	Agriculture	Food process	Leisure	Counter M	Counter S
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Aggregate LPR	1.60 (0.37)	3.12 (1.17)	2.32 (1.28)	1.98 (1.02)	2.96 (0.74)	2.24 (0.64)	2.81 (0.23)	2.38 (0.60)	3.12 (0.17)	2.25 (0.19)	3.12 (0.31)	3.08 (0.73)
Value added, th £	1615 (7284)	13045 (162869)	4449 (24991)	4971 (36823)	16011 (191088)	1255 (4833)	6052 (30598)	1097 (3957)	18836 (121504)	4583 (25568)	52946 (491646)	13256 (222233)
Fixed assets, th £	4698 (39576)	17303 (278458)	17114 (158836)	11108 (117243)	15711 (172632)	719 (3253)	4597 (31690)	2547 (10899)	26542 (222056)	8398 (71295)	140916 (1729177)	39147 (1302974)
Number of employees	174 (728)	470 (5148)	336 (5030)	1305 (6947)	2872 (34567)	80 (360)	328 (2339)	55 (335)	557 (3057)	121 (694)	659 (3835)	156 (1483)
Age, years	17 (17)	24 (20)	19 (19)	22 (21)	11 (8)	11 (10)	31 (26)	30 (19)	26 (23)	24 (24)	27 (24)	14 (13)
Exporters	0.02	0.12	0.03	0.05	0.18	0.06	0.57	0.11	0.40	0.14	0.50	0.19
Exits 1998	0.02	0.01	0.00	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.01
Exits 2008	0.02	0.05	0.02	0.04	0.05	0.02	0.02	0.01	0.02	0.02	0.01	0.03
Urban	0.90	0.90	0.88	0.93	0.96	0.90	0.92	0.44	0.82	0.87	0.89	0.93
Rural less sparse	0.09	0.08	0.10	0.05	0.03	0.09	0.06	0.52	0.15	0.12	0.10	0.07
Rural sparse	0.01	0.02	0.02	0.02	0.01	0.01	0.02	0.04	0.03	0.01	0.01	0.00
Number of observations	5156	70668	22019	3491	935	1864	8232	13408	10169	24665	15325	30681

Note: Unweighted means and standard deviations (s.d.) are reported. Counter M comprises the manufacturing industries counterfactual and Counter S - service industries one.
Source: Authors' calculations.

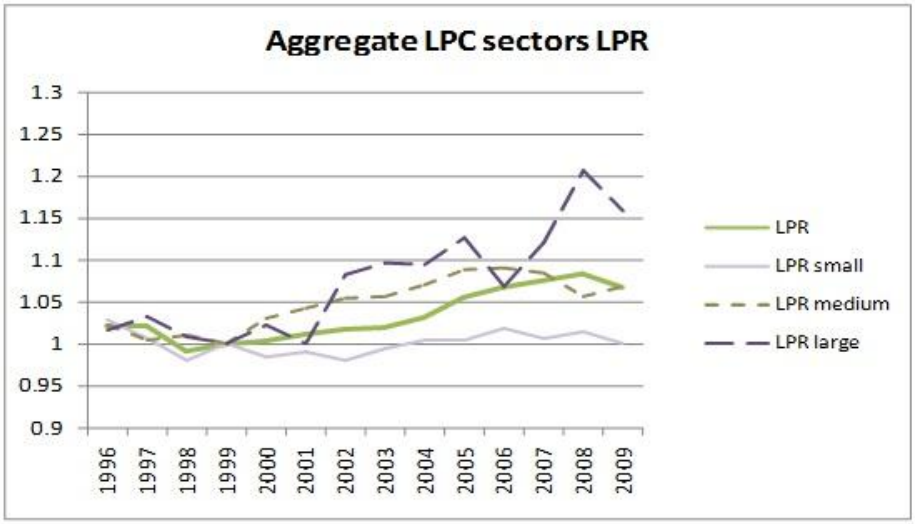
Next we illustrate graphically over time our labour productivity results for the aggregate of all the LPC sectors and for separate aggregates of manufacturing and service sectors[20]. The graphs in Figure No. 1a show results for all the LPC sectors in aggregate while in Figure No. 1b results for the aggregate counterfactual industries (manufacturing and services) are presented. Figures No. 2a and 2b and Figures No. 3a and 3b similarly report results for the aggregate manufacturing and service sectors respectively. The main message from the figures is that the NMW seems to have had a clear and positive impact on aggregate labour productivity of Britain's low-paying sectors over the ten-year period since its introduction. The elasticity of aggregate labour productivity with respect to NMW is between 0.5 and 1.0 with large (always above 2) *t*-statistics. Productivity of the service sector is about 1.5 times more sensitive to increases in the NMW than that of the manufacturing sector. For the counterfactuals the elasticities are not statistically different from zero. This simple graphical analysis suggests that there is indeed a systematic relationship between NMW and labour productivity which merits more detailed investigation.

[20] Everywhere aggregate labour productivity is calculated using value-added as weight. Using number of employees as weight produces similar results.

Figure No. 1a – LPR for Aggregate LPC Sectors.

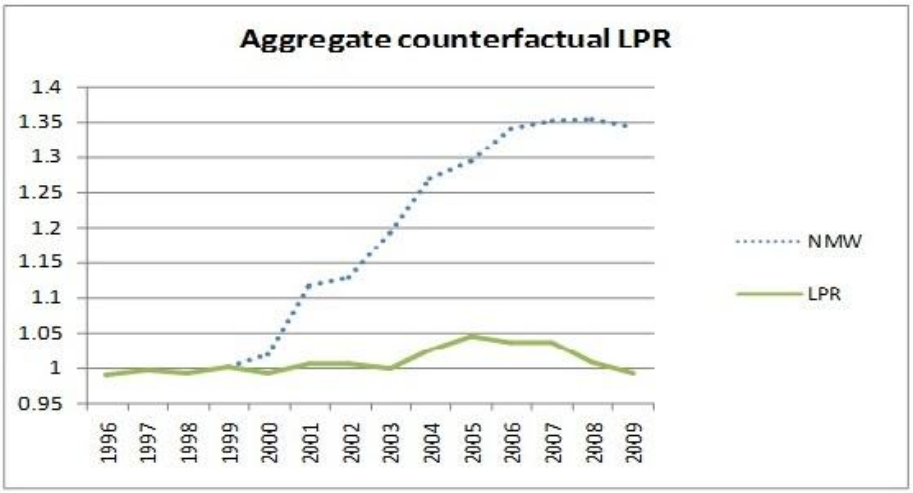


Note: Elasticity of LPR wrt NMW: 0.58 (t=9.94).

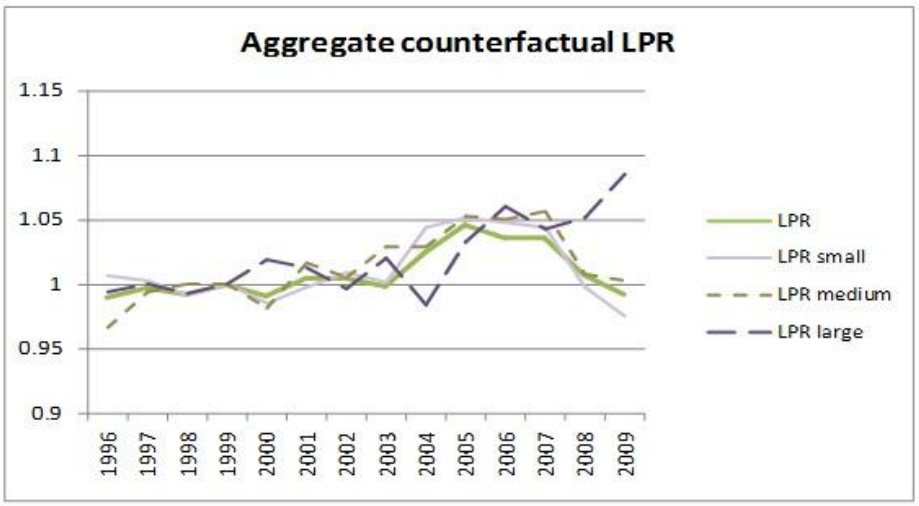


Source: Authors' calculations.

Figure No. 1b – LPR for Aggregate Counterfactual.

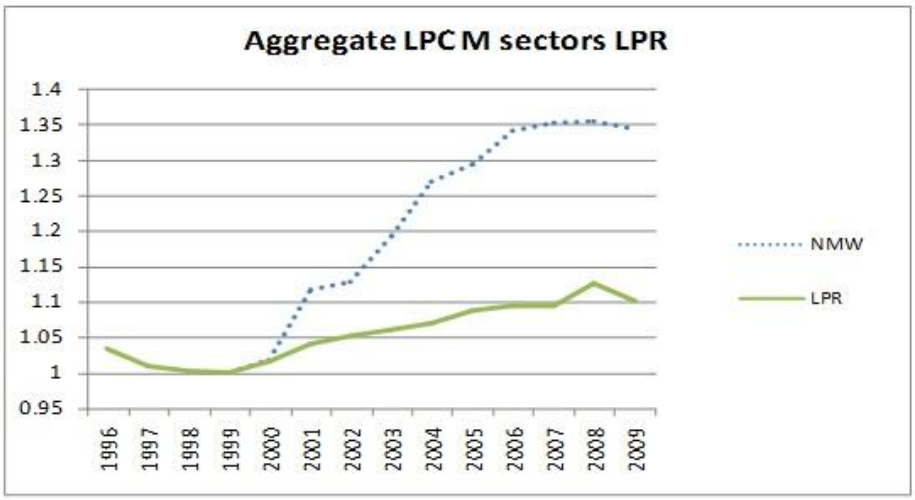


Note: Elasticity of LPR wrt NMW: 0.24 (t=1.65).

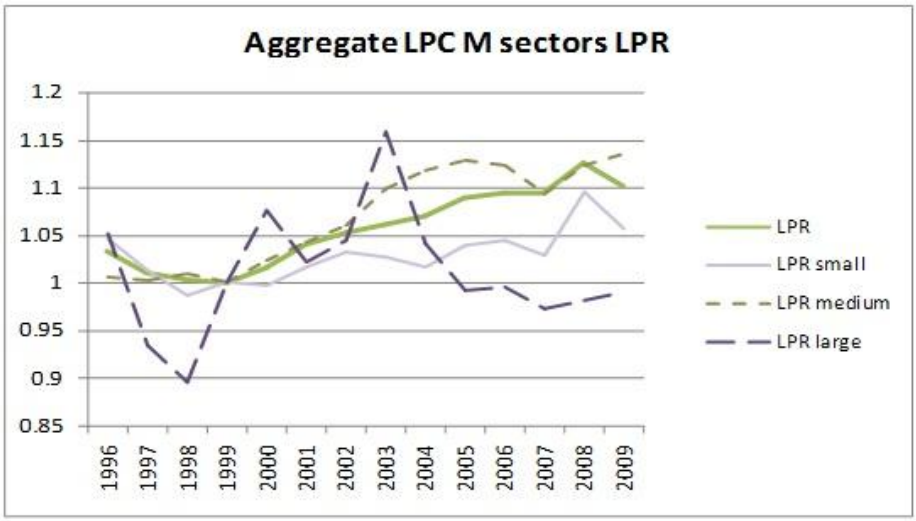


Source: Authors' calculations.

Figure No. 2a – LPR for Aggregate LPC Manufacturing Sectors.

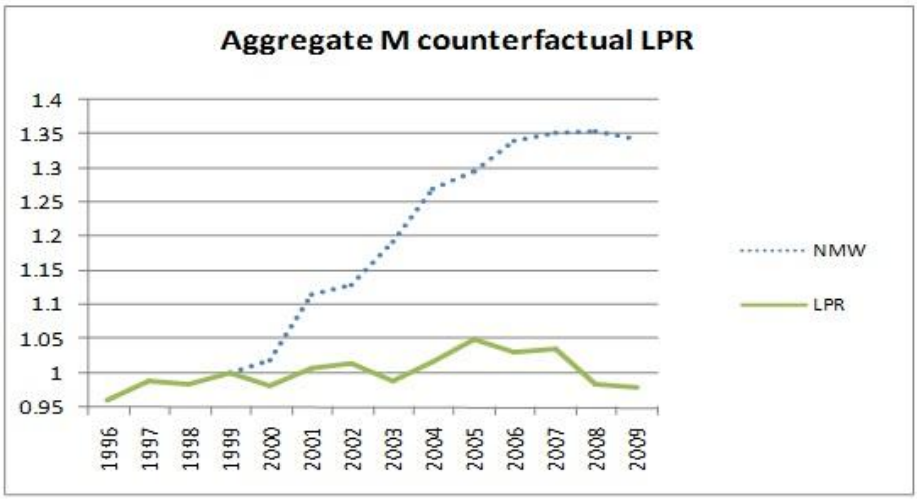


Note: Elasticity of LPR wrt NMW: 0.78 (t=11.20).

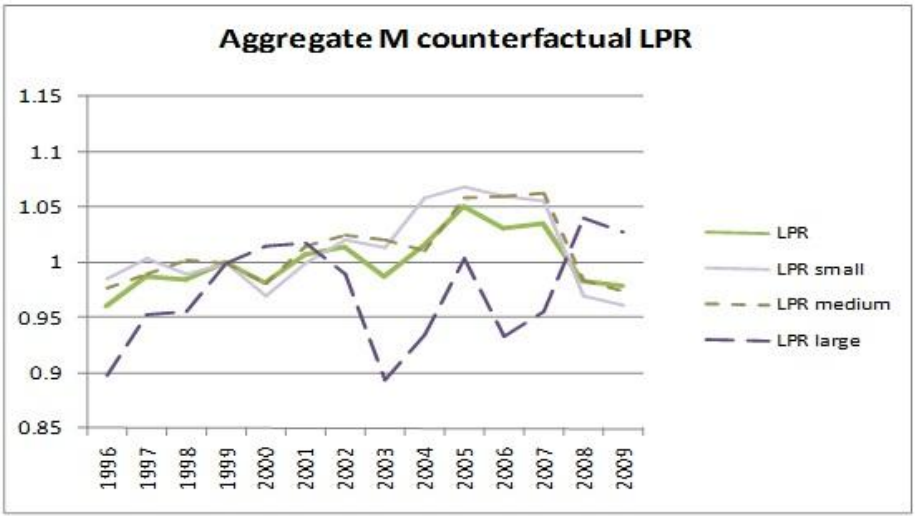


Source: Authors' calculations.

Figure No. 2b – LPR for Aggregate M Counterfactual.

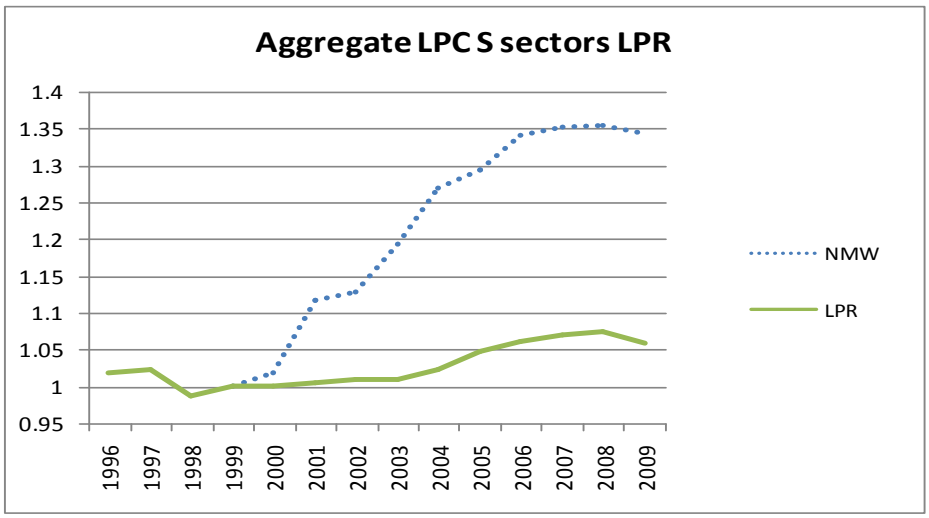


Note: Elasticity of LPR wrt NMW: 0.23 (t=1.52).

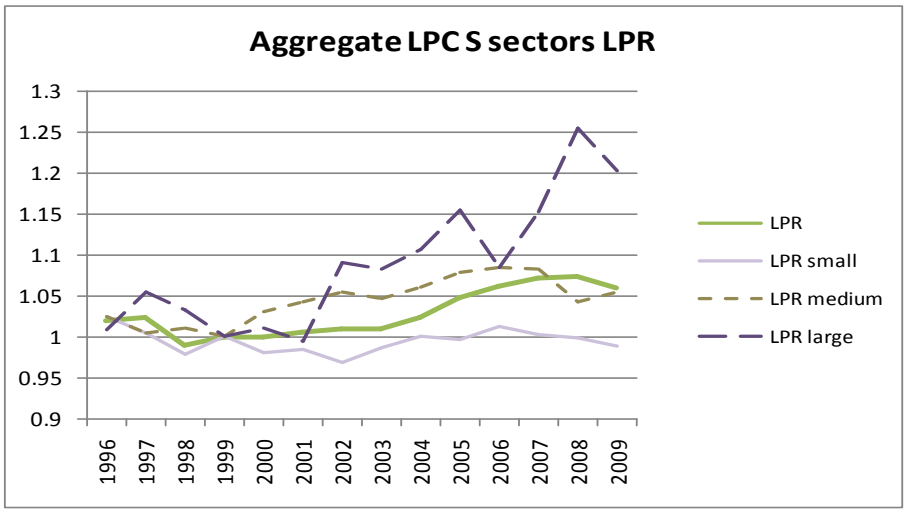


Source: Authors' calculations.

Figure No. 3a – LPR for Aggregate LPC Service Sectors.

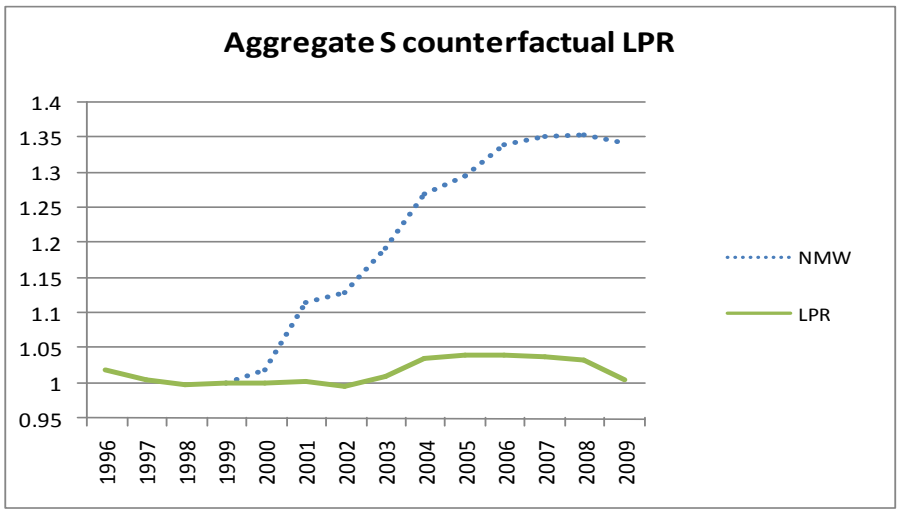


Note: Elasticity of LPR wrt NMW: 0.54 (t=8.36).

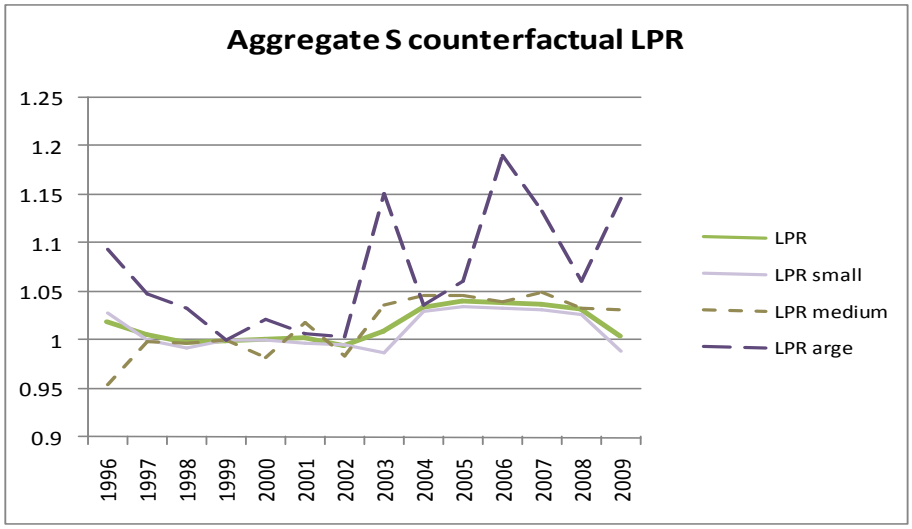


Source: Authors' calculations.

Figure No. 3b – LPR for Aggregate S Counterfactual.



Note: Elasticity of LPR wrt NMW: 0.25 (t=1.18).



Source: Authors' calculations.

4. NMW and Aggregate Labour Productivity: Difference-in-differences Analysis

In this section we follow Draca *et al.*'s[21] unconditional difference-in-differences approach. First, we identify a group of firms within a sector that is more affected by the NMW introduction than a control group. In this treatment group, wages are expected to rise more due to the introduction of the NMW and thus the NMW's effect on productivity is expected to be larger. A treatment indicator variable is defined as T=1 for below – NMW firms in the pre-policy period and T=0 for a group of firms whose pre-policy wage exceeds a threshold equal to the NMW at introduction. Thus, the unconditional difference-in-differences (DD) estimate of the impact of the NMW on aggregate labour productivity is:

$$DD = (LPR^{T=1}_{NMW=1} - LPR^{T=1}_{NMW=0}) - (LPR^{T=0}_{NMW=1} - LPR^{T=0}_{NMW=0}). \quad (4)$$

In a similar manner, we estimate difference-in-differences for aggregate capital-labour (K/L) ratios – e.g. the capital deepening effect – to aid our attempt to shed light on the possible channels of productivity changes. We evaluate the effects before (NMW=0) and after (NMW=1) NMW introduction in all LPC sectors, aggregates of the manufacturing and service sectors, and by individual low-paying (LPC) sectors.
Empirically, we define our treatment groups as in Draca *et al.*[22], based on average remuneration information from FAME[23]. We divide the total remuneration figure for each firm by the full-time equivalent average number of employees to calculate an average wage. The treatment group (T=1) includes low-wage firms, with an average wage of less than £12,000 prior to the introduction of the NMW[24]. The comparison group (T=0) contains firms similar to the treatment group firms but with an average

[21] Draca *et al., op. cit.*
[22] *Ibid.*
[23] Draca *et al., (ibid.).*, use information from FAME, the Labour Force Survey (LFS) and the Workplace Employment Relations Survey (WERS) both to construct and validate their treatment group indicators. Specifically, they use within-establishment information from matched worker-establishment data in WERS to investigate the association between low pay incidence and average wages and to verify the effectiveness of their empirical strategy.
[24] For the results reported we identify as low-wage the firms with average remuneration of less than £12,000 over the three years prior to the introduction of the NMW in April 1999. This allows the elimination of outliers and also a more consistent identification of the low-wage firms.

wage between £12,000 and £24,000, a figure close to the median firm wage in our samples. The main premise of the identification strategy is that the firm wages below the threshold will experience a significant boost from the NMW introduction relative to the higher wage firms. Our identification strategy is further enhanced by the fact that the comparison group contains firms with average wages not exceeding the median wage (£24,000). Firms with much higher average wages are likely to be quite different in terms of their characteristics and therefore subject to different unobservable trends compared to the treatment group.

To check the robustness of our results we also create counterfactuals which contain firms from industries where the NMW's "bite" is expected to be weak. We select the industries based on literature evidence and expert opinions from both manufacturing and service sectors to roughly approximate the composition of the aggregate low-paying LPC sectors. We expect that in the counterfactuals' NMW effects on wages and ultimately on labour productivity will be much less pronounced. The empirical findings confirm our expectations.

The results for the effects of NMW introduction on labour productivity of the aggregate (all) LPC sectors and for manufacturing and service sector aggregates respectively are reported in the first panels of Tables 3 to 5[25]. Our findings with respect to the impact of NMW on labour productivity are quite consistent across LPC sectors. It appears that the firms in the treatment groups where the NMW "bite" is stronger have experienced relative increases in productivity over the period 1999-2009. The effects are statistically significant in all LPC sectors except for hairdressing, leisure and agriculture. When considering productivity effects by firm size groups, the largest relative increases in productivity are observed for large firms in the aggregate (all sectors) sample and in the service sector sample. In the aggregate manufacturing sector the relative productivity increases are largest for medium-size firms.

In the second (bottom) panel of Tables 3 to 5 we also report results for the capital-labour (K/L) ratio measuring capital deepening. Changes in the K/L ratio may reflect technology adjustments in firms as a result of the NMW over the ten-year period since its introduction. Such adjustments can be seen as a long-term effect of the NMW and a potential source of labour productivity changes. It seems that in some of the LPC sectors, such as hospitality and social care, labour productivity improvements

[25] In Table A2 in the Appendix we provide detailed results on labour productivity effects of the NMW for each of the LPC sectors.

resulting from NMW introduction are indeed driven by substitution of labour for capital to a large degree compared with other LPC, mostly manufacturing, sectors where increases in TFP appear to be the main driving force.

For the aggregate (all sectors) and service sector samples there is statistical evidence for substitution of labour for capital in the low-paying sectors while in the counterfactual samples such evidence does not occur. An alternative explanation to this long-run adjustment mechanism besides the TFP changes could be firm exit. In Table No. 2 we report exit rates by LPC sector for 1998 and 2008 – just before the introduction of the NMW and ten years later. It appears that in sectors with relative productivity gains where the labour-for-capital substitution is weaker, the exit rates are higher in 2008. This observation seems to support the argument that in the long-run less productive firms may exit under the pressure of increasing costs due to the introduction of the NMW.

5. Discussion and Conclusion

Overall, our analyses show an improvement in labour productivity in all low-paying sectors as a result of the introduction of the NMW. Our analyses also reveal evidence of substantial heterogeneity across and within sectors across firm size groups, as the effects are particularly marked in larger firms while small firms show the least improvement in labour productivity. Our results provide significant empirical support for the long-standing theoretical argument in favour of a national minimum wage initially and tentatively advanced by the Webbs in the late Nineteenth Century[26].

Documenting the phenomenon and providing contemporary empirical evidence brings us to the limits of the type of analysis conducted here. Thus, we can only offer tentative hypothetical explanations of our results based on our discussions in previous sections. We attempt this in two areas: market position and internal company changes contributing to productive processes. As Mayhew and Neely and Keep *et al.*[27] argue, in-company processes leading to higher productivity remain a "black box".

[26] S. Webb, B. Webb, *Industrial Democracy*, Longmans, London, 1897.

[27] K. Mayhew, A. Neely, *Improving Productivity – Opening the Black Box, Oxford Review of Economic Policy,* 22 No. 4, 2006, 445-456. E. Keep, K. Mayhew, J. Payne, *From Skills Revolution to Productivity Miracle – Not as Easy as it Looks? Oxford Review of Economic Policy,* 22 No. 4, 2006, 539-559.

This tends to suggest a need for further in-depth econometric testing as well as for detailed case study investigation.

Greater productivity gains in larger firms suggest possible pass-through effects in firms with more monopoly power who can pass on cost increases to customers. Their higher public profile is associated with high levels of compliance with the NMW legislation compared with smaller firms which may maintain a strategy to "stay underground", i.e., keep low levels of visibility to all regulatory agencies rather than to move up market and improve[28]. For larger firms, "staying underground" and seeking to avoid full compliance with NMW requirements is not a viable option. Thus, large firms are likely to experience large increases in labour costs compared with small firms. Large firms are also likely to exercise higher monopoly power compared with small firms.

The pass-through argument is also supported by our cross-sectoral evidence. Less competitive and mostly domestically-traded sectors such as social care show greater relative increases in productivity. Social care is a very varied sector that includes considerable social work, childcare and welfare segments as well as the residential home segment. Thus, much of it escapes the price-capping common in the latter segment[29]. Even if it is impossible because of price-capping to pass costs on, a context of rising demand may provide incentives to improve productivity. There is also evidence in the social care sector of labour-for-capital substitution in the ten-year period. Hairdressing on the other hand does not seem to have been able to pass on labour cost increases or to substitute labour for capital. Furthermore, the industry has a long history of the problematic application of minimum rates of pay, suggesting that a non-compliance strategy appears a viable option for adaptation in the context[30]. Druker *et al.*[31] show that hairdressing employers prefer to maintain a "steady state", limiting innovation and maintaining prices. Thus, pay increases cannot be

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[28] M. Ram, P. Edwards, T. Jones, *Staying Underground: Informal Work, Small Firms and Employment Regulation in the UK, Work and Occupations, No.* 34, 2007, 318-344. R. Croucher, G. White, *Enforcing a National Minimum Wage: the British Case*, *Policy Studies* 28 No. 2, 2007, 145-161.

[29] S. Machin, A. Manning, *A Test of Competitive Labor Market Theory: the Wage Structure Among Care Assistants in the South of England, Industrial and Labor Relations Review*, 57 No. 3, 2004, 371-385.

[30] J. Druker, C. Stanworth, G. White, *The Impact of the National Minimum Wage on the Hairdressing Industry, Report to the Low Pay Commission*, London, 2002. R. Croucher, G. White, *op. cit.*

[31] J. Druker *et al., op. cit.*

passed on and innovation is ruled out, closing off both of the obvious options.

Internal firm reorganisation, besides long-run technology adjustments through labour-for-capital substitutions, also seems likely to be relevant and would ultimately lead to improvements in TFP. Larger firms may have more capacity to reorganise productive processes simply because there is more labour available, making solutions such as increased use of functional and time flexibility more possible. They may be more able to develop adaptive strategies because of more articulated management structures and more sophisticated or "progressive" HRM[32] and operations management practices.

On the other hand, weak adoption of efficient operations management is characteristic of small British firms and especially "micro" and family firms employing less than twenty workers. They tend to be characterised by fragmented practices that are reactive to the environment[33]. Many of the smaller companies, for example individual nursing homes are among the type of employers identified as likely to be "black hole" organisations in terms of their HRM and employment relations[34]. They are unlikely to have a strategic approach to HRM and this may reduce their capacity to introduce and manage functional and time flexibility and hence improve productivity[35]. Larger firms are more likely to adopt what Rainbird *et al.*[36], reporting on the social care sector, called "pro-active" rather than the "reactive" approach also found in the industry whereby companies simply react to regulatory pressure. Adam-Smith *et al.*[37] reached a similar conclusion in the hospitality industry: there was no evidence for a regulatory "shock" to management practices after the introduction of the NMW, but rather a reinforcement of existing hierarchies and ways of

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[32] J. T. Delaney, M. A. Huselid, *The Impact of HRM Practices on Perceptions of Organisational performance, Academy of Management Journal,* 39 No. 4, 1996, 949-969.

[33] R. Cagliano, K. Blackman, C. Voss, *Small Firms Under the Microscope: International Differences in Production/Operations Management Practices and Performance, Integrated Manufacturing Systems,* 12 No. 7, 2011, 469-482.

[34] D. Guest, N. Conway, *Peering into the Black Hole: the Downside of the New Employment Relations in the UK, British Journal of Industrial Relations,* 37 No. 3, 1999, 367-389.

[35] A. Friedrich, R. Kabst, W. Weber, M. Rodehuth, *Functional Flexibility: Merely Reacting or Acting Strategically? Employee Relations*, 20 No. 5, 1998, 504-523.

[36] H. Rainbird, E. Leeson, A. Munro, *Skills Development in the Social Care Sector*, Department of Health Policy Research Programme, Social Care Workforce Initiative, London, 2009.

[37] D. Adam-Smith, G. Norris, S Williams, *Continuity or Change? The Implications of the National Minimum Wage for the Hospitality Industry, Work, Employment and Society* 17 No. 1, 2003, 29-47.

working. This is consistent with the LPC 2008 survey of employers which showed that in hospitality, employers were most likely simply to reduce the numbers employed as a reaction to an increase in the NMW. More sophisticated adaptive responses were not perceived as viable.

Thus, notwithstanding our speculation on its causes, we provide significant evidence that the introduction of NMW led to increases in labour productivity in all low-paying sectors and the increases are more marked in larger firms. There is also evidence of heterogeneity in responses across the low-paying sectors.

Appendix

Table No. A1 – SIC and SOC Coding of the Low-paying Sectors Defined by Industry and Occupation.

Low-paying sector/occupation	Old industry-based definition (SIC 2003)	New industry-based definition (SIC 2003)	Occupation-based definition (SOC 2000)
Retail	52	50, 52, 71.405	711, 721, 925
Hospitality	55	55	5434, 9222, 9223, 9224, 9225
Social care (residential and non-residential)	n.a.	85.3, 85.113	6115
Cleaning	74.7	74.7, 93.01	6231, 9132, 923
Security	74.6	74.6	9241, 9245, 9249
Hairdressing	93.02, 93.04	93.02, 93.04	622
Textiles and clothing	n.a.	17, 18	5414, 5419, 8113, 8136, 8137
Agriculture	01 – 05	01 – 05	911
Food processing	n.a.	15.1, 15.2, 15.3, 15.4, 15.5, 15.6, 15.7, 15.8	5431, 5432, 5433, 8111
Leisure, travel and sport	n.a.	92.13, 92.3, 92.6, 92.7	6211, 6213, 9226, 9229

Source: LPC.

Table No. A2 – Difference-in-differences Analysis of Labour Productivity Across LPC Sectors.

Sectors and subsamples	Total sample			Small firms			Medium firms			Large firms		
	Pre 1999	Post 1999	Difference	Pre 1999	Post 1999	Difference	Pre 1999	Post 1999	Difference	Pre 1999	Post 1999	Difference
Retail (T) LPR	2.801 (0.014)	2.826 (0.015)	+0.025 (0.009)	2.823 (0.018)	2.835 (0.019)	-0.012 (0.010)	2.752 (0.029)	2.805 (0.027)	+0.052 (0.018)	2.695 (0.045)	2.744 (0.045)	+0.049 (0.027)
Retail (C) LPR	3.253 (0.010)	3.252 (0.010)	-0.001 (0.006) ***+0.025****** ***(0.010)***	3.243 (0.013)	3.242 (0.013)	-0.001 (0.008) *+0.013* *(0.012)*	3.230 (0.017)	3.242 (0.016)	+0.012 (0.009) ***+0.040***** ***(0.019)***	3.310 (0.033)	3.329 (0.034)	+0.019 (0.021) *+0.030* *(0.033)*
Hospitality (T) LPR	2.554 (0.026)	2.611 (0.025)	+0.057 (0.015)	2.687 (0.036)	2.722 (0.036)	+0.035 (0.018)	2.628 (0.038)	2.540 (0.041)	+0.088 (0.024)	2.160 (0.098)	2.203 (0.104)	+0.042 (0.073)
Hospitality (C) LPR	3.128 (0.032)	3.084 (0.034)	-0.043 (0.017) ***+0.100****** ***(0.024)***	3.280 (0.040)	3.237 (0.043)	-0.043 (0.025) ***+0.078****** ***(0.031)***	3.113 (0.044)	3.108 (0.045)	-0.006 (0.024) ***+0.094****** ***(0.036)***	2.660 (0.157)	2.492 (0.174)	-0.168 (0.095) ***+0.210***** ***(0.121)***
Social care (T) LPR	1.509 (0.111)	1.482 (0.111)	-0.028 (0.068)	1.626 (0.134)	1.524 (0.130)	-0.102 (0.075)	1.267 (0.262)	1.335 (0.281)	+0.068 (0.075)			
Social care (C) LPR	1.862 (0.157)	1.670 (0.165)	-0.192 (0.073) ***+0.164***** ***(0.101)***	2.264 (0.166)	1.989 (0.196)	-0.274 (0.102) ***+0.172**** ***(0.124)***	1.468 (0.263)	1.381 (0.272)	-0.086 (0.062) ***+0.154**** ***(0.114)***			
Cleaning (T) LPR	1.778 (0.079)	1.929 (0.077)	+0.150 (0.030)	2.464 (0.191)	2.400 (0.224)	-0.064 (0.073)	1.948 (0.144)	2.033 (0.168)	+0.084 (0.056)	1.381 (0.070)	1.566 (0.063)	+0.184 (0.034)
Cleaning (C) LPR	2.808 (0.081)	2.791 (0.078)	-0.017 (0.033) ***+0.167****** ***(0.050)***	3.030 (0.138)	3.026 (0.128)	-0.004 (0.048) *-0.060* *(0.086)*	2.673 (0.116)	2.679 (0.106)	+0.007 (0.055) *+0.077* *(0.079)*	2.365 (0.237)	2.355 (0.220)	-0.009 (0.101) ***+0.194***** ***(0.108)***

Table A2 – Continued

Sectors	Total sample			Small firms			Medium firms			Large firms		
	Pre 1999	Post 1999	Difference	Pre 1999	Post 1999	Difference	Pre 1999	Post 1999	Difference	Pre 1999	Post 1999	Difference
Security (T) LPR	1.174 (0.363)	1.436 (0.335)	+0.262 (0.068)				1.172 (0.257)	1.345 (0.169)	+0.173 (0.122)	1.205 (0.615)	1.508 (0.599)	+0.302 (0.027)
Security (C) LPR	1.756 (0.131)	1.673 (0.140)	-0.083 (0.065) ***+0.345***** ***(0.170)***				2.086 (0.351)	2.038 (0.426)	-0.048 (0.121) *+0.221* *(0.218)*	1.495 (0.101)	1.425 (0.124)	-0.070 (0.091) ***+0.372**** ***(0.245)***
Hairdressing (T) LPR	2.188 (0.154)	2.209 (0.176)	+0.021 (0.053)	2.245 (0.183)	2.196 (0.198)	-0.049 (0.045)	2.072 (0.312)	2.254 (0.413)	+0.181 (0.128)			
Hairdressing (C) LPR	2.744 (0.136)	2.654 (0.125)	-0.090 (0.103) *+0.111* *(0.162)*	2.695 (0.123)	2.591 (0.144)	-0.104 (0.098) *+0.055* *(0.166)*	4.138 (0.357)	3.969 (0.167)	-0.269 (0.190) ***+0.350**** ***(0.225)***			
Textiles (T) LPR	2.290 (0.048)	2.460 (0.056)	+0.169 (0.038)	2.399 (0.073)	2.477 (0.083)	+0.078 (0.042)	2.253 (0.080)	2.441 (0.100)	+0.188 (0.069)	2.204 (0.075)	2.386 (0.098)	+0.182 (0.073)
Textiles (C) LPR	2.982 (0.036)	3.016 (0.037)	+0.034 (0.025) ***+0.135****** ***(0.044)***	3.197 (0.059)	3.186 (0.060)	-0.011 (0.035) ***+0.090***** ***(0.054)***	2.900 (0.051)	2.885 (0.053)	-0.015 (0.028) ***+0.203****** ***(0.062)***	2.890 (0.062)	2.927 (0.074)	+0.037 (0.048) ***+0.145***** ***(0.086)***
Agriculture (T) LPR	2.237 (0.052)	2.231 (0.056)	-0.006 (0.032)	2.295 (0.056)	2.293 (0.060)	-0.032 (0.035)	2.066 (0.168)	2.203 (0.131)	+0.137 (0.132)	1.051 (0.387)	0.928 (0.440)	-0.122 (0.033)
Agriculture (C) LPR	2.819 (0.052)	2.807 (0.052)	-0.012 (0.033) *+0.006* *(0.046)*	2.861 (0.065)	2.829 (0.065)	-0.032 (0.039) *+0.030* *(0.053)*	2.608 (0.101)	2.705 (0.090)	+0.097 (0.071) *+0.040* *(0.137)*	1.997 (0.463)	2.076 (0.150)	+0.078 (0.410) *-0.201* *(0.472)*

Table A2 – Continued

Sectors	**Total sample**			**Small firms**			**Medium firms**			**Large firms**		
	Pre 1999	Post 1999	Difference	Pre 1999	Post 1999	Difference	Pre 1999	Post 1999	Difference	Pre 1999	Post 1999	Difference
Food processing (T) LPR	2.450 (0.040)	2.582 (0.042)	+0.133 (0.029)	2.530 (0.083)	2.696 (0.075)	+0.167 (0.050)	2.435 (0.051)	2.514 (0.058)	+0.079 (0.039)	2.429 (0.091)	2.532 (0.092)	+0.103 (0.057)
Food processing (C) LPR	3.128 (0.028)	3.215 (0.027)	+0.087 (0.017) ***+0.046**** ***(0.034)***	3.298 (0.064)	3.403 (0.066)	+0.105 (0.027) *+0.062* *(0.052)*	3.124 (0.039)	3.155 (0.038)	+0.030 (0.024) *+0.049* *(0.048)*	2.951 (0.052)	3.084 (0.057)	+0.134 (0.039) *-0.030* *(0.076)*
Leisure (T) LPR	2.490 (0.051)	2.490 (0.056)	+0.000 (0.034)	2.550 (0.064)	2.490 (0.068)	-0.059 (0.042)	1.976 (0.166)	1.999 (0.166)	+0.023 (0.091)	2.378 (0.139)	2.665 (0.119)	+0.287 (0.113)
Leisure (C) LPR	3.016 (0.044)	3.000 (0.044)	-0.016 (0.033) *+0.015* *(0.048)*	3.079 (0.049)	3.067 (0.050)	-0.011 (0.035) *-0.048* *(0.054)*	2.675 (0.144)	2.743 (0.131)	+0.067 (0.093) *-0.044* *(0.131)*	3.007 (0.139)	3.051 (0.126)	+0.044 (0.082) ***+0.243***** ***(0.137)***

*Note: Figures in italics indicate the difference-in-differences (DD) and figures in bold indicate sectors and firm size groups with statistically significant (at 10% or better) DD in labour productivity (LPR) after the implementation of the NMW in 1999. The levels of significance are denoted as follows: *** 1% or better; ** 5% or better; * 10% or better. (T) denotes the treatment group and (C) denotes the comparison group.*
Source: Authors' calculations.

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