University of Sussex
Business, Management & Economics

Economics Department Working Paper Series

No. 45-2012

Minimum Wages and Wage Inequality: Some Theory and an Application to the UK

Richard Dickens
Department of Economics
University of Sussex
Email: R.F.Dickens@sussex.ac.uk

Alan Manning
Centre for Economic Performance
London School of Economics

Tim Butcher
Secretariat
Low Pay Commission

Abstract:
Research suggests that, at the levels set in countries like the US and the UK, minimum wages have little effect on employment but do have impacts on wage inequality. However we lack models that can explain these facts – this paper presents one based on imperfect labour markets. The paper also investigates the impact of the UK's National Minimum Wage on wage inequality finding it can explain a sizeable part of the evolution of wage inequality in the bottom half of the distribution in the period 1998-2010. We also present evidence that the impact of the NMW reaches up to 40% above the NMW in 2010 which corresponds to the 25th percentile. These spillovers are larger in low-wage segments

JEL Classification: J38

Key Words: Minimum Wage, Wage Inequality

Acknowledgements
This work contains statistical data which is Crown Copyright; it has been made available by the Office for National Statistics (ONS) through the Low Pay Commission (LPC) and the Department for Business, Innovation and Skills (BIS) and has been used by permission. Neither the ONS nor the LPC bear any responsibility for the analysis or interpretation of the data reported here.

Tim Butcher is a member of the Secretariat at the Low Pay Commission. Richard Dickens is Professor of Economics, University of Sussex. Alan Manning is Director of the Communities Programme at the Centre for Economic Performance and Professor of Economics, London School of Economics and Political Science.

Published by
Centre for Economic Performance
London School of Economics and Political Science
Houghton Street
London WC2A 2AE

Introduction

The literature on the minimum wage is enormous. Most of that literature focuses on the employment effect or lack thereof (see, for example, Neumark and Wascher, 2008, for a recent survey or Dube, Lester and Reich, 2010; Giuliano, 2012, for more recent US studies than covered in that survey, or Metcalf, 2007 or Butcher, 2012 for surveys of the UK evidence). But, although the impact of minimum wages on employment remains a contentious issue, most of the studies suggest the effect is small, perhaps centred around zero, at least for levels of the minimum wage observed in countries like the US and UK. But it is also becoming apparent that the economic effect of the minimum wage on wage inequality is not small. For example, diNardo, Fortin and Lemieux (1996), Lee (1999) and Teulings (2000, 2003) concluded that the fall in the real value of the federal minimum wage in the US in the 1980s could explain all of the rise in lower-tail wage inequality in that period. Autor, Manning and Smith (2010) argue that impact may be exaggerated but nevertheless conclude that minimum wages do have a non-negligible impact on wage inequality. But, if the impact on wage inequality and not employment is the first-order effect of the minimum wage then the existing literature on the minimum wage has been poorly focused.

One of the weaknesses is the absence of a theoretical framework for thinking about how the minimum wage might affect wage inequality. Where we have competitive or monpsony or search models of the impact of the minimum wage on employment, we have much less in the way of models of the impact of the minimum wage on wage inequality. The second section of this paper reviews existing theories of the impact of the minimum wage on wage inequality and argues they have limitations, albeit ones that differ from model to model. In the third section, this paper goes on to develop a plausible model of the labour market in which the minimum wage has an impact on wage inequality but (possibly) no effect on employment. The model, presented in the next section, is one in which aggregate labour supply is inelastic but labour supply to an individual employer is not. Effectively this means that employers are competing with each other for market share of the available (fixed) supply of workers. They compete for workers using both the wage and hiring expenditure. In the benchmark model we present, the employment effect is constrained to be zero (to focus on the wage inequality issue) though a simple modification would change that.

The paper then goes on to consider the impact on wage inequality of the UK's National Minimum Wage (NMW) that was introduced in 1999. The fourth section of the paper introduces the data used and presents some background on trends in wage inequality showing that wage inequality at the bottom of the distribution has fallen. The fifth section then argues that the pattern of this reduction in wage inequality is consistent with an impact of the NMW as the reduction in wage inequality has been largest in low-wage segments of the labour MARKET (whether it is women as opposed to men, the young as opposed to the old or low-wage regions as opposed to high-wage regions). This section also investigates other possible hypotheses but finds little evidence for them. But this analysis does not tell us whether spillovers exist, and, if they do, their nature and extent. That is investigated in the sixth section, where we use the insights of the model developed earlier in the paper. We present simple direct evidence that there have been spillovers and show that the impact of the NMW extends up the wage distribution to the 25th percentile.

Our conclusion is that it is relatively simple to construct plausible models of the labour market in which minimum wages have large effects on wage inequality but no effect on employment – we present one but there are certainly others. Secondly, the UK's NMW does seem to have sizeable spillover effects and has resulted in a sizeable fall in wage inequality since its introduction in 1999.

2. Existing Models of the Impact of the Minimum Wage on Wage Inequality

There are not that many models designed to explain the impact of the minimum wage on wage inequality. But the few that there are, are reviewed here. Some of them explicitly seek to model the impact of minimum wages on wage inequality while in others it is an implication of the modelling.

In a perfectly competitive labour market in which workers have an exogenously given marginal product the effect of the minimum wage would be to truncate the latent wage distribution at the minimum wage. There would be associated job losses. In this case there are spill-over effects that come through the job loss. If the distribution function of wages in the absence of minimum wages is $F^*(w)$ and the minimum wage is w^m then the observed distribution of wages will be:

$$F(w) = \frac{F^*(w) - F^*(w^m)}{1 - F^*(w^m)} \tag{1}$$

In this case the minimum wage will affect the observed distribution of wages with apparent effects that reach above the minimum i.e. there are spillover effects. This idea was used by Meyer and Wise (1983a, 1983b) to estimate the effect of the minimum wage on employment though the actual model they estimated was more complicated as described below and Dickens, Machin and Manning (1998) argued that it is a method that seems very sensitive to assumptions about functional form. However, there are problems with it as a model of the impact of the minimum wage on inequality. First, the size of the impact depends on the size of the employment effect – if that is small then $F^*(w^m)$ is small and the impact on wage inequality in (1) must also be small.

This paradox is addressed in the work of Teulings (2000, 2003) who relaxes the assumption that marginal products are endogenously given independent of wages. Teulings (2000, 2003) uses a model with the feature that the elasticity of substitution between workers is increasing in the distance (measured in skills) between them. Workers with similar latent wages will be close substitutes so that something that affects the wage of one group must also affect the wage of workers who are very close substitutes. He argues that this high degree of substitutability between some groups of workers is consistent with estimates of the degree of substitution between different types of workers because these estimates suffer from an aggregation bias. Teulings (2000, 2003) shows there can be sizeable spill-overs even if the employment effect is small. But, there still has to be some employment affect – this is a competitive model with workers paid their marginal product so if there was no employment effect marginal products and wages would be unchanged which is inconsistent with the existence of a binding minimum wage.

In addition both the Meyer and Wise and Teulings models cannot predict the existence of a spike of workers at the minimum wage itself though this IS typically observed in the data. Meyer and Wise (1983a,b) introduce an assumption that a fraction of affected workers have their wage raised to the minimum (and also that there is a certain amount of non-compliance) justifying this assumption either that labour markets are segmented (though the patterns of substitution required for this are not plausible), that employers can adjust fringe benefits (though Simon and Kaestner, 1993, and Card and Krueger, 1995, find little evidence for this) or there is some monopsony. As Teulings (2003, p832) writes "The emergence of a spike in the wage distribution strongly suggests the existence of frictions in the labour market". So it seems likely that we need a model of the labour market with some degree of imperfect competition if one is going to be able to explain the fact that the minimum wage does not (for observed values of the minimum wage) seem to be associated with large changes in employment and there is a spike at the minimum wage.

Flinn (2006, 2010) presents a matching model where employers who vary in their productivity and homogeneous workers bargain individually over wages. This model predicts a spike, ambiguous effects on employment, and spill-overs[1]. However the assumption that minimum wage workers bargain individually over wages does not seem particularly appealing. For example, Machin and Manning (2004) look at the distribution of wages among care workers in UK retirement homes (an occupation where about 30% of workers were paid the minimum wage). They showed that a very large fraction of firms paid all their care assistants the same hourly wage and that the distribution of hourly wages was much more compressed within firms than any other characteristics of workers. It is hard to rationalize that using a model of individual wage bargaining. Similarly, it is hard to explain why employers often do not seem to take advantage of lower youth minimum wages when available if individual bargaining is taking place. The other tradition of modelling frictions in the labour market – wage-posting by firms – seems more appropriate. The next section develops such a model.

The reasons why wages are not individualized by firms is not clear but a number of authors have suggested it is because workers are motivated by concerns of fairness and that this can also

[1] The precise form of spill-overs in the Flinn model is probably not very realistic though we show below how one might modify the model to produce more realistic predictions.

generate spillovers from the minimum wage. For example, Grossman (1983), one of the first papers on the impact of the minimum wage on wage inequality develops an efficiency wage model in which effort is a function of relative wages and Falk, Fehr and Zehnder (2006) present some experimental evidence on the possible importance of such effects.

3. A Simple Theoretical Model of the Impact of the Minimum Wage on Wage Inequality

This section presents a model of wage-posting by employers where the labour supply curve to an individual employer is not perfectly elastic. The canonical model of this type is Burdett and Mortensen (1998) but, as is well-known, this model cannot predict a mass point at any place in the wage distribution. However, that result comes from the assumption that all workers will move for any wage gain, however small, an assumption that is very convenient for their analysis but not particularly plausible and something that is not an intrinsic feature of wage-posting. In contrast the model here uses a reduced-form static labour supply curve to the employer. This is a 'reduced form' model but can be derived from an underlying model of discrete choice in which worker preferences over employers are idiosyncratic so some workers prefer one employer to another if they pay the same wages, while other workers have the opposite preferences.

Assume that employers differ in their marginal products of labour – denote the distribution of log productivity by $g(a)$. Employers compete over a fixed supply of workers, L. The share of labour supply going to firm i can be influenced by the wage that it pays, W_i, and how much it spends on hiring, H_i. Assume the labour supply to an individual firm is given by:

$$N_i = \frac{W_i^{\varepsilon} H_i^{\beta}}{\int W(A)^{\varepsilon} H(A)^{\beta} dG(A)} L = W_i^{\varepsilon} H_i^{\beta} X \tag{2}$$

Where $W(A)$ is the wage chosen in equilibrium by a firm with productivity A, $H(A)$ is the expenditure on hiring and X is the denominator in (2). One would expect $\varepsilon, \beta > 0$ and, for reasons that will become apparent one needs to have $\beta < 1$ so there are decreasing returns to hiring activity (see the discussion in Manning, 2011). This could be justified by assuming that firms begin to exploit the readily available pool of workers. This specification means that aggregate employment in this model will be completely unchanged by the minimum wage as the integration of the numerator over all the firms is equal to the denominator. One could alter this assumption by, for example, making L depend on some index of aggregate wages and hiring activity. This would have no consequence for the distribution of equilibrium wages as long as it does not depend on variables under the control of individual firms. Thus, to keep notation simple, we assume L is fixed. So, this is a model custom-built for explaining changes in the distribution of wages in a situation where, as the evidence suggests, the minimum wage has little impact on aggregate employment but might redistribute employment across firms. But, it is not suitable as a model for thinking about the employment effect of the minimum wage over the full range of variation.

First consider the equilibrium in the absence of the minimum wage. An employer with productivity A will choose W and H to maximize profits:

$$\Pi_i = [A_i - W_i] N_i - H_i \tag{3}$$

This leads to the following first-order condition for the choice of hiring intensity:

$$\frac{\partial \Pi_i}{\partial H_i} = [A_i - W_i] \frac{\partial N_i}{\partial H_i} - 1 = 0 \tag{4}$$

As long as $A_i > W_i$. Re-arranging and using (2) leads to:

$$[A_i - W_i] = \beta \frac{H_i}{N_i} \tag{5}$$

The intuition for this first-order condition is that the more profitable is a worker the greater the expenditure on hiring per worker. The first-order condition for the choice of the wage will be given by:

$$\frac{\partial \Pi_i}{\partial W_i} = [A_i - W_i] \frac{\partial N_i}{\partial W_i} - N_i = 0 \tag{6}$$

That, re-arranging and using (2) can be written as:

$$W_i = \frac{\varepsilon}{1+\varepsilon} A_i \tag{7}$$

This should be recognized as the standard formula for the optimal wage chosen by a monopsonist - wages are below marginal products with the gap influenced by the wage elasticity of the labour supply to the firm. Taking logs and using lower-case letters to denote logs leads to the following expression for the log wage chosen by a firm with productivity A in a market with no minimum wage:

$$w^*(a) = \ln \varepsilon - \ln(1+\varepsilon) + a \tag{8}$$

If one is at the optimal wage one can obtain, after using (7) in (5) and taking logs that:

$$h^*(a) = n^*(a) + a - \ln(1+\varepsilon) - \ln \beta \tag{9}$$

And taking logs of the labour supply curve (2)we have that:

$$n^*(a) = \varepsilon w^*(a) + \beta h^*(a) - x \quad (10)$$

One can solve these equations for the equilibrium levels conditional on X. For employment this is given by:

$$n^*(a) = \frac{1}{1-\beta}\left[(\varepsilon+\beta)\left[a - \ln(1+\varepsilon)\right] + \varepsilon \ln \varepsilon - \beta \ln \beta - x\right] \quad (11)$$

One could then solve for X but as this affects employment in the same way, this has no consequence for the equilibrium wage distribution which is the ultimate focus of interest here.

Now consider when a minimum wage of W^m (or w^m in logs) is introduced. Consider what happens. First for those firms with $w^*(a) > w^m$, they will continue to pay the same wage as before. But those firms with $w^*(a) < w^m$ will now pay the minimum wage. However this does not mean that the new wage distribution will be a simple censoring of the old distribution because the distribution of employment across firms will change. Those firms paying above the minimum wage will have the same level of $N^*(a)$ up to possible changes in X.

What happens in the firms paying the minimum wage is more complicated. First, note that firms with $A < W^m$ will have zero hiring expenditure and hence zero employment and will, hence, effectively go out of business[2]. So the minimum wage will act to truncate the distribution of active firms in the market. For firms with $A > W^m > W^*(A)$ the first-order condition for the choice of H as given by (5) will remain valid so that, taking logs we will have that:

$$h^*(a, w^m) = n^*(a, w^m) + \ln\left[e^a - e^{w^m}\right] - \ln \beta \quad (12)$$

Using (10) we then have that employment will be given by:

$$n^*(a, w^m) = \frac{1}{1-\beta}\left[\varepsilon w^m + \beta \ln\left[e^a - e^{w^m}\right] - \beta \ln \beta - x\right] \quad (13)$$

Changes in the minimum wage have an ambiguous effect on employment (conditional on X). Simple maximization of (13) shows that employment is maximized when:

$$W^m = \frac{\varepsilon}{\beta+\varepsilon} A > W^*(A) \quad (14)$$

[2] This is a product of our assumption that firms have constant returns to scale. If there were decreasing returns to scale then at least some of these firms would remain in business, not cutting their recruitment activity to zero.

This is analogous to the result that a just-binding minimum wage on a monopsonist must increase employment but if the minimum wage is too high then employment will begin to decline, eventually to zero. So, if we impose a minimum wage then, for a given X, employment will look like that drawn in Figure 1.

Now let us consider what this theory implies about the distribution of wages. First, consider the equilibrium wage distribution in the absence of the minimum wage – we will call this the latent wage distribution and denote it by $F^*(w)$. For every wage we can derive from (7) the firms which will have that level of wages – denote this by $a^*(w)$. We will then have:

$$F^*(w) = \frac{\int^{a^*(w)} N^*(a)\,dG(a)}{\int N^*(a)\,dG(a)} \tag{15}$$

We are now in a position to work out how the distribution of wages changes with the minimum wage. Note that X will also change but, from (11) and (13) this affects employment in all firms equally so we do not have to derive it to work out how the distribution of wages change.

We will have a spike at the minimum wage and the size of this spike will be given by:

$$F(w^m) = \frac{\int_{w^m}^{a^*(w^w)} N^*(a, w^m)\,dG(a)}{\int_{-\infty}^{a^*(w^w)} N^*(a, w^m)\,dG(a) + \int_{a^*(w^w)} N^*(a)\,dG(a)} \tag{16}$$

Where we will use the notation that $N^*(a, w^m) = 0$ if $a \le w^m$. For $w > w^m$ we will have that:

$$F(w) = \frac{\int_{w^m}^{a^*(w^w)} N^*(a, w^m)\,dG(a) + \int_{a^*(w^w)}^{a^*(w)} N^*(a)\,dG(a)}{\int_{-\infty}^{a^*(w^w)} N^*(a, w^m)\,dG(a) + \int_{a^*(w^w)} N^*(a)\,dG(a)} \tag{17}$$

Note that we can write (17) as:

$$F(w) = F(w^m) + \gamma\left[F^*(w) - F^*(w^m)\right] \tag{18}$$

As the highest wage must be the same we must have:

$$\gamma = \frac{1 - F(w^m)}{1 - F^*(w^m)} \tag{19}$$

When (18) can be written as:

$$1-F(w)=\frac{1-F(w^m)}{1-F^*(w^m)}\left[1-F^*(w)\right]=\gamma\left[1-F^*(w)\right] \tag{20}$$

γ is the ratio of the fraction of workers who are actually paid above the minimum compared to the fraction that would have been predicted to be paid above the minimum based on the latent wage distribution. In what follows we will use $\theta=\gamma-1$ which, from (19) will be given by:

$$\theta=\frac{1-F(w^m)}{1-F^*(w^m)}-1=\frac{F^*(w^m)-F(w^m)}{1-F^*(w^m)} \tag{21}$$

In what follows we will examine this so and we will give it a name – the Residual Spike as it is related to the difference between the actual and the predicted spike where the prediction is based on the wage distribution in the absence of the minimum wage.

How would we expect θ to vary with the level of the minimum wage? To investigate this note that, using (15) and (17) we can write:

$$\theta=\frac{\int_{-\infty}^{a^*(w^m)}\left[N^*(a,w^m)-N^*(a)\right]dG(a)}{\int_{-\infty}^{a^*(w^m)}\left[N^*(a,w^m)-N^*(a)\right]dG(a)+\int_{-\infty}^{+\infty}N^*(a)\,dG(a)} \tag{22}$$

From (22) one can see that an increase in the minimum wage reduces (raises) θ according to whether $\int_{-\infty}^{a^*(w^m)}\left[N^*(a,w^m)-N^*(a)\right]dG(a)$ rises (falls). How this term varies with the minimum wage is theoretically ambiguous because the term $\left[N^*(a,w^m)-N^*(a)\right]$ will be positive for a close to $a^*(w^m)$ but negative for low values of a. But we can say that θ will be equal to one for very low values of the minimum wage (when the minimum wage has essentially no effect on the wage distribution) and will tend to infinity as the minimum wage becomes very high. In the empirical section later in the paper we show how the residual spike seems to vary in the data with the bite of the minimum wage.

This model – see (20) - has a very specific prediction about the form of spill-overs namely that $\frac{1-F(w)}{1-F^*(w)}$ should be a constant and equal γ as defined in (19). One of the implications of this is that the density of wages for all wages above the minimum is shifted by the same proportion. To see this, differentiate (20) to get the density, then take logs to get:

$$\ln f(w)=\ln\gamma(w^m)+\ln f^*(w) \tag{23}$$

Differentiating this with respect to w^m we have that:

$$\frac{\partial \ln f(w)}{\partial w^m} = \frac{\gamma'(w^m)}{\gamma(w^m)} \tag{24}$$

So that the log density for all wages above the minimum wage is predicted to rise in the same proportion. However, this strong result is based on the assumption that we observe a single segment of the labour market in which all workers are homogeneous. In any empirical application this is a prediction that is unlikely to be satisfied and it is likely that what we will observe is a mixture of the outcomes of different labour markets. So we now turn to altering the model to allow for the existence of heterogeneous labour markets.

The particular way we will investigate the consequence of worker heterogeneity is the following. We will assume that within an observed labour markets there are different sub-markets e.g. workers are differentiated by skill – let us denote the skill of a worker by s. In the absence of the minimum wage we will assume that the distribution of wages in a skill segment is given by $\tilde{F}*(w-s)$ (we will use tilde's to denote outcomes in individual labour markets) so that labour markets differ in their wage distributions by a simple translation. Denote the distribution of skills by $g(s)$. What this means is that the aggregate latent wage distribution is given by:

$$1-F*(w)=\int\left[1-\tilde{F}*(w-s)\right]g(s)\,ds \tag{25}$$

Now consider what happens with the imposition of a minimum wage. We will use the model above as the basis for what happens within a skill segment and then aggregate up across skills to get the prediction for what happens at regional (aggregate) level. So, using (19) let us define:

$$\tilde{\gamma}(w^m-s)=\frac{1-\tilde{F}(w^m-s)}{1-\tilde{F}*(w^m-s)} \tag{26}$$

Using (20) we then have that:

$$1-\tilde{F}(w-s)=\tilde{\gamma}(w^m-s)\left[1-\tilde{F}*(w-s)\right] \tag{27}$$

From this we obtain the observed overall distribution as:

$$1-F(w)=\int\tilde{\gamma}(w^m-s)\left[1-\tilde{F}*(w-s)\right]g(s)\,ds \tag{28}$$

We are now in a position to prove the following result.

Result $\frac{1-F(w-\mu)}{1-F^*(w-\mu)}$ will be decreasing in the wage if $\left[1-\tilde{F}^*(w-s)\right]$ is log-concave in the wage and $\tilde{\gamma}\left(w^m-s\right)$ decreasing in its argument.

Proof: Differentiating (28) with respect to w we have that:

$$
\begin{aligned}
\frac{\partial}{\partial w}\left[\frac{1-F(w)}{1-F^*(w)}\right] &= \frac{\int \tilde{\gamma}\left(w^m-s\right)\frac{\partial \ln\left[1-\tilde{F}^*(w-s)\right]}{\partial w}\left[1-\tilde{F}^*(w-s)\right]g(s)\,ds}{\int\left[1-\tilde{F}^*(w-s)\right]g(s)\,ds} \\
&= -\frac{\int \tilde{\gamma}\left(w^m-s\right)\left[1-\tilde{F}^*(w-s)\right]g(s)\,ds.\int\frac{\partial \ln\left[1-\tilde{F}^*(w-s)\right]}{\partial w}\left[1-\tilde{F}^*(w-s)\right]g(s)\,ds}{\int\left[1-\tilde{F}^*(w-s)\right]g(s)\,ds.\int\left[1-\tilde{F}^*(w-s)\right]g(s)\,ds} \\
&= E\left(\tilde{\gamma}\left(w^m-s\right).\frac{\partial \ln\left[1-\tilde{F}^*(w-s)\right]}{\partial w}\right)-E\left(\tilde{\gamma}\left(w^m-s\right)\right)E\left(\frac{\partial \ln\left[1-\tilde{F}^*(w-s)\right]}{\partial w}\right) \\
&= Cov\left(\tilde{\gamma}\left(w^m-s\right),\frac{\partial \ln\left[1-\tilde{F}^*(w-s)\right]}{\partial w}\right)
\end{aligned}
\tag{29}
$$

Where all expectations are relative to the distribution $\left[1-\tilde{F}^*\right]g$. If $\left[1-\tilde{F}^*\right]$ is log-concave in the wage then $\frac{\partial \ln\left[1-\tilde{F}^*(w-s)\right]}{\partial w}$ is increasing in s. And the assumption is that $\tilde{\gamma}\left(w^m-s\right)$ is decreasing in s so that the covariance between the two is positive leading to the desired result.

Although the algebra behind this result may seem involved, the intuition for this is straightforward. For wages that are far up the distribution very few of these workers are from segments where the minimum wage has a large impact on the wage distribution. Hence, at this point a change in the minimum wage has very little impact on the distribution of wages.

This section has developed a model of the impact of the minimum wage on the wage distribution that remedies the deficiencies of other models. It suggests that the minimum wage is likely to have spillovers and suggests looking at the residual spike as a quick measure of ascertaining whether there are spillovers or not. It has shown how one would expect the spillover effects to dissipate as one moves up the wage distribution. It is likely that there are other models one could develop with similar predictions – the intention here is to show how one can construct a plausible model. We now turn to an empirical application, the impact of the UK's NMW on the wage inequality.

4. Trends in UK Wage Inequality

In this paper we use data from the British New Earnings Survey (NES) and its successor the Annual Survey of Hours and Earnings (ASHE) to investigate the impact of the NMW introduced in 1999. NES/ ASHE is the best source of wage data in the UK for such analysis. It is an employer reported survey of one percent of employees in employment taken in April of each year. Being employer reported, the wage measure is very reliable and is much less prone to measurement error problems than alternative data sources such as the Labour Force Survey (LFS) (Dickens and Manning, 2004a). However, the ASHE is not completely without its own problems and is likely to be subject to sampling issues. Since the 1% of employees are traced through tax records it can under-sample low paid workers who do not earn enough to pay tax and in the late 1990s it was perceived to under-sample highly-paid workers. In recent years weights are available to address these issues but typically make little difference to the conclusions so, to enable comparisons with earlier years, we use unweighted results throughout. We use the hourly wage excluding overtime and restrict attention to workers aged 22 and over as this is the group for whom the adult minimum wage has always applied.

We start by presenting some background trends in wage inequality. Figure 2 shows some headline statistics for UK Wage inequality. Reported are the percentile ratios for the (log) of the $90^{th}/50^{th}$ percentiles, $50^{th}/10^{th}$ percentiles and $50^{th}/5^{th}$ percentiles for all workers aged over 22 years (to whom the adult minimum wage has always applied). Figure 2 clearly shows the rise in wage inequality that occurred from the late 1970s. Wage gaps at the top and bottom of the pay distribution widened with increasing differences between the 90^{th} and 50^{th} percentiles and the 50^{th} and 10^{th} percentiles, and indeed even the 50^{th} and 5^{th} percentile. However, since the late 1990s wage gaps at the top and bottom have taken a different course. While inequality at the top of the pay distribution has continued to rise over the period it is clear that inequality at the bottom has been falling quite sharply. This fall is most striking at the very bottom with the $50^{th}/5^{th}$ ratio falling by almost 10% points.[3]

Interestingly this divergence in the behaviour of wage inequality at the top and bottom of the wage distribution coincides approximately with the introduction of the NMW (as was pointed out by Butcher, 2005). But can it be put down to the minimum wage? That is the subject of the next section.

5. The Impact of the National Minimum Wage and Wage Inequality

a. *Aggregate Evidence*

In April 1999 the National Minimum Wage (NMW) was introduced in the UK which at that time had no form of minimum wage legislation since the abolition in 1993 of the Wages Councils that

[3] Note that this wage compression is only evident in hourly wages. Weekly wage inequality at the bottom of the pay distribution has been largely unchanged in the recent decade (Machin, 2011).

had set industry-level minimum wages (see Butcher, 2012 for a recent overview of the NMW). The adult NMW that applied to those aged 22 and above, was introduced at £3.60 an hour or at approximately 46% of the median hourly wage. There was a lower rate for those aged 18-21 inclusive and 16-17 year-olds were not initially covered. Subsequently a lower rate for 16-17 year-olds has been introduced and the adult rate extended to those aged 21. We restrict our analysis to those aged 22 and above for whom the adult minimum has always applied.

After a couple of years of relatively modest increases, the NMW was increased substantially faster than both inflation and average wage growth between 2001 and 2007. Figure 3 presents the change in "toughness" of the NMW against the change in the summary inequality measure; the $50^{th}/5^{th}$ percentile. "Toughness" is measured here as the ratio of the NMW to median pay. On introduction, the NMW was 46% of median pay. The NMW was only increased modestly in the following years. However, toughness increased sharply in the early to mid-2000s with some 4-6% points increases in the ratio of the NMW to the median wage. One can see a strong correlation between these changes in toughness and the $50^{th}/5^{th}$ percentile ratio. In years when the NMW is raised in relation to median wages we see a fall in bottom end wage inequality.

Figure 4 presents the wage inequality changes in a little more detail. Here we report the change in the (log) real wage at each percentile between 1998 and 2010 for adult workers. The largest wage increases are at the very bottom of the pay distribution; with the bottom percentile experiencing just under 50% real wage growth over this period, compared to approximately 18% at the median. The largest wage increases are among the bottom 5 percentiles of the distribution, consistent with a direct impact of the NMW. But we observe increases relative to median wage change further up the wage distribution. Wages at the bottom appear to be rising relative to the median right up to about the $20\text{-}25^{th}$ percentile.

It is tempting to assign these relative wage increases at the bottom of the distribution to the National Minimum Wage. But it is important to realize that such a conclusion would imply sizeable spillover effects. Although the Low Pay Commission initially estimated that about 8% of workers would be paid the minimum wage (Low Pay Commission, 1998) this turned out to be an over-estimate and the actual numbers paid the minimum wage probably did not exceed 5%.

However, this aggregate time series evidence is suggestive but hardly conclusive – there are other factors that may have been at work in influencing wage inequality. But there is a fundamental problem in determining whether the fall in wage inequality can be ascribed to the minimum wage that is caused by the fact that the NMW is what it says on the tin, a **national** minimum wage with only time series variation. Obviously there is not much we can do about that so our approach in this section is to provide more evidence that it is likely to be the minimum wage that is causing the fall in wage inequality. We do this in two ways. First by showing that the declines in wage inequality vary across labour market segments in exactly the way we would predict if it was caused by the NMW. Secondly, we try to control for other relevant factors that might be influencing wage inequality and discover they have little explanatory power.

b. *Gender and Age*

The NMW has much more bite in the segments of the labour market where the general level of wages is lower so we would expect changes in wage inequality to be largest in low-wage segments of the labour market. We first provide evidence that this is the case. Figures 5a and 5b compare the reduction in wage inequality for men and women respectively. At the top of the distribution we see pay inequality rising much faster among men than women. At the bottom end we see compression among both men and women but this is both larger among women and also works further into the distribution. The fall in the $50^{th}/5^{th}$ ratio for women is about 10% compared to 4% for men. In addition, the $50^{th}/10^{th}$ ratio falls significantly for women but barely changes for men. The reduction in wage inequality is much more marked for women than men. This is consistent with the impact of the NMW.

Figure 6 compares the reduction in wage inequality across different age groups. Here we report wage inequality at the very bottom of the distribution; the ratio of the $50^{th}/5^{th}$ percentile (log) hourly wage. We restrict our attention to workers aged over 22 as this is the age at which an individual qualifies for the adult NMW. The reduction is sharpest for the youngest age groups where the level of wages is lowest and the minimum wage has the biggest impact. This reduction is particularly noticeable among the under 30s. In fact, inequality among all age groups other than the under 30s is largely unchanged since 1999.

c. *Region*

Both of these findings are consistent with an impact of the NMW but are also consistent with a general change in the price of skill e.g. if the demand for lower-skill workers rises relative to the average (perhaps because of polarization – see Autor, Katz and Kearney, 2006; Goos and Manning, 2007). One way to address this concern is to look at the change in wage inequality in high and low-wage regions (Lee (1998) used a similar approach to investigating the impact of minimum wages in the US in the 1980s, a period when few states deviated from the federal minimum). In a low-wage part of the UK (like Wales) the NMW has a larger impact than in a high-wage area (like London) so, if the NMW has reduced wage inequality, we would find a larger reduction in wage inequality in Wales than London. The advantage of this approach is that differences in wages across regions are not driven primarily by differences in skill, rather by differences in house prices which in turn reflect differences in the demand for labour.

We define our regions in the same way as in Dickens, Riley and Wilkinson (2011). Here we group Unitary Authority level data from both ASHE and the Labour Force Survey (LFS) into 135 local labour markets. As a measure of the level of wages in each area we use the log of the median hourly wage in 1998 i.e. before the introduction of the minimum wage. Our results are robust to using other measures e.g. the fraction of workers paid below some threshold wage in 1998.

Figure 7 plots (for our 135 areas) log changes in the 5th percentile of hourly wages against the log median wage in 1998. The linear regression and kernel regression lines are also shown. There is a significant negative relationship showing that areas with lower wages in 1998 experienced greater wage growth over the following decade. This is consistent with the impact of the minimum wage. Although these results are consistent with the NMW having had an important impact on wage inequality, one has to recognize that identification is achieved through variation in median wages across areas not variation in the (national) minimum wage. We perform a number of robustness tests to allay concerns in this regard.

First, it might be the case that, for whatever reason, there is a correlation between changes in wage inequality in general and the initial level of wages. Our first robustness check is to see whether we find a relationship between wage change and initial wages at other percentiles. The figures reported so far are for selected percentiles. We have plotted these for all percentiles but to summarize we present the OLS regression coefficients from these plots. Figure 8 presents the coefficient β_1 from the equation below, and the associated 95% confidence bands.

$$\Delta_{2010-1998}\log(\text{Wage at percentile i})_r = \beta_0 + \beta_1 \log(\text{Median in 1998})_r$$

The coefficients at the lowest percentiles are negative and significantly different from zero. For example, in the bottom 5 percentiles we estimate coefficients in the range -0.2 to -0.3. This implies that a region with a 10% lower median wage in 1998 will experience 2-3% higher wage growth at those percentiles over the period from 1998 to 2010. The estimated coefficients increase at higher percentiles so that by the 35th percentile we find no significant relationship between initial median and subsequent wage growth. None of the higher percentiles are significantly different from zero which adds weight to the argument that this is a minimum wage effect. We do see (insignificant) negative coefficients for the top few percentiles but this could be due to measurement error in these percentiles.

As a further robustness check we conduct the same exercise on a period before the introduction of the National Minimum Wage. A concern with our identification assumption is that latent wage growth is correlated with the initial wage, so that wages grow faster in low wage regions even in the absence of the minimum wage. We can check to see if we find this pattern in the 1990s. For this we use data from the New Earnings Survey (NES) from 1993 to 1998. We only go back to 1993 since before then the Wages Councils set industry level minimum wages in certain low paying sectors. The area information in the NES is somewhat different and less detailed than that contained in the ASHE data. Here we have consistent information on 97 areas across Great Britain, which largely follow the Counties that were in existence, plus the London boroughs. Figure 9 presents the OLS coefficients from the regression below of wage growth in the period 1994-1998 across the regions.

$$\Delta_{1998-1994}\log(\text{Wage at percentile i})_r = \beta_0 + \beta_1\log(\text{Median in 1993})_r$$

The results are quite reassuring. We do find a significant negative impact in the 1st percentile and also around percentiles 6-8. But for the other percentiles the coefficients are not significant. The effect at the very bottom may be a result of measurement error. In general, we do not find the very clear relationship that we observed from the ASHE data in Figure 8. This is suggestive of no relationship between initial wages and wage growth in the period before the NMW was introduced, which is reassuring for our identification assumption.

The evidence presented so far is consistent with an impact of the NMW but we have only considered one variable at a time. The next section combines gender, age and region in a panel data analysis that also allows us to consider alternative hypotheses for the changes in wage inequality.

e. *Panel Regressions*

To combine gender, age and region we segment the labour market into two age groups (above and below the age of 30), the two genders and the 135 areas described above so there are a total of 540 segments. Because of small cell sizes in some areas some of the segments are not populated in all years. Hence, we exclude four areas from this analysis (West Somerset, Orkney, Shetland and Western Isles) leaving 524 cross section segments. These segments differ in the general level of wages and the hypothesis that we seek to test is that those segments with lower levels of wages will have had sharper falls in wage inequality at the bottom end as a result of the NMW. Some descriptive statistics are presented in Table 1.

We estimate panel data models where the dependent variable is the change in the percentile from one year to the next in our 524 segments. Some of these segments have small numbers of observations in individual years so the estimate of the percentiles is imprecise but all the regressions that follow are weighted to take account of the greater sampling variability in some segments. We are interested in the correlation of changes in the NMW with changes in the different percentiles. Of course all areas are subject to the same change in the NMW from one year to the next so one cannot identify this aggregate effect from the time effects that one also has to include. Our identification is based on the idea that the impact of changes in the NMW should be greater in low-wage than high-wage areas. So, if the NMW increases by more than national median earnings then we would expect to see relatively faster growth in earnings at low percentiles in the low-wage regions. So the crucial variable we use to test our hypothesis that the minimum wage can explain changes in wage inequality is the interaction of the change in the NMW as a fraction of aggregate median earnings with a measure of the segment-level wage. This estimate is computed by estimating a model for log median earnings with aggregate year effects and segment effects and then using the segment level coefficients, β_r, as our measure of the general level of wages in the segment. We actually use the exponent of the negative of the regression coefficient as our measure as this predicts that as the segment wages becomes very large the impact of changes in the NMW will go to zero. However we obtain similar results if we use the regression coefficients themselves.

So the models we estimate are of the following form:

$$\Delta w_{rt}^{p} = \gamma e^{-\beta_r} \Delta NMW_t + \beta x_{rt} + \varepsilon_{it} \tag{30}$$

Where Δw_{rt}^{p} is the annual change in the pth percentile in segment r in year t, β_r is a measure of the average level of wages in segment r, ΔNMW_t is the change in the NMW as a fraction of median earnings, and x_{rt} are other controls. We use the level of the toughness of the NMW rather than the more conventional log because we include in our sample period the period before 1999 when the minimum wage was zero.

In Table 2 we report specifications with a variety of other control variables. In our base specification we simply include aggregate time effects to catch general movements in wages, a gender dummy to capture the falling gender wage gap and an age dummy to capture increasing returns to experience. We also include an interaction between the gender and age dummies. The inclusion of time effects means we cannot identify the total effect of the NMW just the differential effect between high and low-wage segments. The first row of results shows the estimated impact of our NMW variable (γ) on earnings at the 5th, 10th, 25th, 50th, 75th and 90th percentiles for our base specification. This shows a significant effect at the 5th and 10th percentiles and an effect that is significant at the 10% level at the 25th percentile but insignificant effects at higher percentiles. The estimated coefficients decline in magnitude with higher percentiles. This is consistent with an impact of the NMW. The second row of estimates then includes area dummies as well so potentially allows regional wage differentials to have a trend. In this specification identification of the minimum wage effect comes from a comparison of years in which the increase was large with the years in which it wasn't. The effects are very similar to those in the base specification, except now the impact at the 25th percentile is insignificant. It is worth noting that the area dummies themselves are jointly insignificantly different from zero (F(130, 6665) = 0.39).

These estimates assume that all the impact of changes in the NMW are contemporaneous – it is possible that the process of adjustment takes time. So the third row of results reports specifications where we include a lag of the minimum wage variable. Here we report the γ coefficient on the current period and lagged minimum wage term. The lagged terms are generally insignificant except at the 25th percentile where it is significantly different from zero at the 10% level suggesting that it does take time for the minimum wage to have its full effect further up the wage distribution. This finding is capable of explaining why the earlier studies of the impact of the NMW on wage inequality (Dickens and Manning, 2004a,b) found a small effect and the studies that only investigate year-to-year changes (Stewart, 2012a,b) find no evidence for spill-over effects (though Butcher, 2005, did suggest there might be some spillover effects).

We now investigate whether these conclusions are robust to the inclusion of other controls by discussing other possible explanations for changes in underlying wage inequality. The last decade or so has seen significant changes in the skill structure of the workforce, with increasing education levels (Machin, 2011). Furthermore, net immigration rose sharply particularly in the mid-2000s with the accession of countries to the EU. These, and other, changes may help to explain part of the change in wage inequality observed during this period. These changes in the distribution of individual characteristics such as skills may have resulted in wage changes themselves. In addition, there may have been changes in the "price" associated with different characteristics. In order to understand the former we conduct the following exercise. Using the ASHE data we can estimate the extent to which changes in the observed characteristics of individuals can explain wage changes. Taking data from just the years 1998 and 2010, we estimate the probability that an individual is present in 2010 using a probit model on the following characteristics; sex, age dummies, full time/part time status, occupation and industry dummies. We then use the predicted probabilities from this model to re-weight the wage from the 1998 distribution. This gives an estimate of the wage distribution in 1998 if individual's characteristics changed to how they are in 2010.

Figure 10 presents the estimated (log) real wage change at each percentile arising from changes in characteristics, and also reports the actual change for comparative purposes. We can see that changes in characteristics explain very little of the observed wage change over this time period. In fact, characteristics changed in such a way that would have reduced wages at the lower percentiles of the distribution relative to median wages. The characteristics we observe in the ASHE data do a very bad job of explaining the observed pattern of aggregate wage changes over this period.

However, this re-weighting procedure is based on the assumption that the wages associated to different characteristics are stable over time. This may be a poor assumption and there are a number of reasons why one might think that the wages of low-skilled workers might have been increasing even in the absence of the NMW. The other main hypothesis put forward to explain the evolution of regional wage inequality in this period is immigration (Dustmann, Frattini and Preston, 2012). They present evidence for the period 1997-2005 that areas with high levels of immigration have experienced relatively lower rises in wages at lower percentiles and higher rises at higher percentiles. They do not control for the impact of the NMW which is introduced in the sample period and, as this is a period of a fall in wage inequality in the bottom half of the wage distribution their conclusion is that the fall would have been even larger in the absence of immigration. The fourth row of Table 2 includes a measure of the change in the proportion of migrants measured at the area level. The minimum wage effects are unchanged with significant impacts from the minimum wage variable at the 5th and 10th percentiles[4].

It is natural to ask how what fraction of the change in wage inequality these estimates imply can be ascribed to the impact of the NMW. But answering that question is hard because while the estimates can give us an estimate of the differential impact between low and high wage segments of the labour market it cannot tell us what the effect common to all segments is as the aggregate change in the NMW cannot be identified separately from the year effects. However if we are prepared to make the assumption – not altogether implausible – that the NMW has had no effect on wage inequality in the highest wage segments then one can provide some estimates. If the NMW has had some effect on all segments then this represents a lower bound for the contribution of the NMW. Table 3 presents some estimates of the contribution of the NMW to the change in wage inequality. We present estimates for 4 broad segments – men and women, under and over 30. Our estimates are the following. First we estimate models for the evolution of percentiles without any control variables apart from age, gender and their interaction and a full set of year dummies. The sum of all the relevant coefficients give us an estimate of the total evolution of each percentile in the period 1997-2010. These estimates are reported in the first two rows of Table 3 for the log 50/5 and the log 50/10. We then estimate the model reported in the first row of Table 2 – this now allows for some impact of the NMW. We can add up all the segment and year coefficients in this specification to get an estimate of the underlying trends controlling for the NMW. The difference between the two estimates gives us an estimate of the contribution of the NMW to the observed trends in wage inequality. This is reported in the third and fourth rows of Table 3.

These results suggest that for young women the contribution of the NMW to the change in the log50/5 is 0.072 when the total change is 0.135 i.e just over 50% of the decline can be put down to the minimum wage. For the log 50/10 the contribution is 0.027 out of a total change of 0.064 i.e. a bit over 40%. For men under 30 the predicted contribution of the NMW to the change in wage inequality is lower (as one would expect) but still sizeable. For the older workers the observed changes are lower, but the NMW can explain more than the total observed change in lower end wage inequality.

These estimates should be interpreted with caution. As discussed above, one cannot identify a pervasive effect of the NMW on all segments separate from the year effects so the identifying assumption is that there is no NMW effect in the highest-wage segments. The functional form estimated in (30) was chosen to have the feature that the minimum wage effect goes to zero as the median wage in a segment becomes very large. But it is possible that the functional form is mis-specified e.g. (30) forces the NMW effect to go to zero at a particular rate. We did

[4] It is also worth noting that, differently from Dustmann, Frattini and Preston (2012) we find that immigration has raised wages at the lowest percentiles though the results are not directly comparable as we cannot distinguish between natives and migrants in the ASHE.

experiment with trying to estimate a two-parameter functional form for the impact of the minimum wage but the variation in the data is insufficient to estimate that. So it is possible that we over-estimate the impact of the NMW in the higher-wage segments and under-estimate in the lower wage segments.

The panel regressions presented in this section are consistent with the view that the NMW has had an effect on the wage distribution, with it possibly taking some years to see the full effect further up the wage distribution. But the estimates tell us little about the existence, nature and extent of spillover effects. That is the subject of the next section.

6. Spillover Effects

The first adult minimum wage of £3.60 per hour was predicted by the initial report of the Low Pay Commission to affect 8% of adults (Low Pay Commission, 1998, Table 7.1) but this turned out to be an over-estimate caused by deficiencies in the earnings statistics and the true number was closer to 5%. Dickens and Manning (2004a, 2004b) provided evidence that the NMW only benefitted those who were directly affected, the implication of this being that the minimum would only have an impact up to the 5th percentile and had been set too low to make a significant difference to wage inequality. Figure 11 presents the actual proportions of adults paid below, at and slightly above the minimum wage in our data. The proportion at or below the NMW never comes to more than about 4.5%[5].

Given that the direct impact of the NMW falls on the bottom 5% of workers, at most, this cannot explain the observed wage changes at the bottom of the distribution, where we have documented wage increases reaching much further up the distribution than the 5th percentile. This is suggestive of spillovers, whereby those workers with wages just above the minimum also experience wage increases. However, the existing UK evidence finds no evidence of significant spill-overs. Dickens and Manning (2004a) use Labour Force Survey data to look at the impact on the wage distribution and can find no evidence of spill-over effects shortly after introduction. Dickens and Manning (2004b) use data from a postal survey of Residential Care Homes. The minimum wage is much more binding in this sector with 30% of workers affected by introduction. Despite this they still find no spill-over effect a short period after introduction. More recently, Stewart (2012a) investigates the change from year-to-year in different percentiles while Stewart (2012b) investigates whether, from year to year, low-wage workers have significantly higher wage growth. Both studies find little evidence of spillovers though

[5] This is lower than the typical estimate of the proportion of workers affected by the NMW that is reported by the Low Pay Commission. They report and an estimate of the numbers of workers directly affected when the NMW is raised in October – because of aggregate wage growth the numbers actually paid the minimum wage in our data that comes from April is lower.

conclusions are sensitive to the counterfactual assumption made about wage growth in the absence of the minimum wage.

Taken at face value, these results about the lack of spillovers in the UK are in contrast with evidence from the US. Lee (1998) and Teulings (2000, 2003) find quite large spill-over effects that explain a significant proportion of the 1980s and 1990s increase in US wage inequality. Autor, Manning and Smith (2008) also find significant spill-over effects from the US minimum wage though argue that it is hard to rule out that these apparent spill-overs are the result of measurement error in the measures of wages used[6].

To look for direct evidence on spillovers we return to our model. That model suggests looking at the residual spike, the gap between the fraction of workers who would have been paid at or below the minimum wage in its absence and the actual spike at the minimum wage. The former is observed, the latter not so needs to be estimated. We estimate this by taking the wage distribution observed prior to the introduction of the NMW and up-rating it using some assumption. Our main assumption is to up-rate using the aggregate change in the median though we also use cell-specific median wage growth.

Figure 12 presents the time series for the residual spike using a number of assumptions to derive the counter-factual latent wage distribution. As we can see the residual spike is always positive indicating that the actual percentage of workers paid at or below the minimum is always below what one would have predicted from the wage distribution in 1998. This is direct evidence for spillovers. Note that the estimate of the residual spike is very low for the period 1999-2001 so that it is perhaps not surprising that the studies of the impact at introduction concluded spillovers were small. However the residual spike is higher in the later years perhaps because the value of the minimum wage is higher but also perhaps because it took some time for the effects of the minimum wage to work its way through the wage distribution.

The residual spike is computed at the minimum wage according to the formula in (21). But the model of the homogeneous labour market suggests that the same formula $\frac{F^*(w)-F(w)}{1-F^*(w)}$ when computed at other levels of the wage should be a constant. In contrast the heterogeneous labour market model suggests it should decline as one increases the wage. Figure 13 plots the residual for different multiples of the minimum wage in 2010. We observe a positive residual between the predicted and actual wage distribution up to 1.4 times the 2010 NMW but it is zero after that.

While this gives some idea of the aggregate impact of the NMW, it does not tell us how the spillovers vary with the bite of the minimum wage. But if we segment the labour market by gender, age and broad region we can see from Figure 14 that the relationship between the

[6] In the US data the fraction of workers observed to be paid below the minimum wage is higher than the fraction observed at the minimum wage. However, this is not the case in the UK data we use here as we observe under 1% paid below the NMW in each year. So measurement error does not seem a plausible explanation for the findings.

residual spike and initial wage is a clearly convex one. This suggests that spillovers increase at an increasing rate as the minimum wage bites more. In terms of the theoretical model this implies that the lower-wage firms are cutting back on recruitment activity as the minimum wage binds on them.

7. Conclusions

Research suggests that, at the levels set in countries like the US and the UK, minimum wages have no detectable impact on employment but they do seem to have sizeable impacts on wage inequality that stretch beyond those workers directly affected i.e. there are spillover effects. However we lack models that can explain even the broad facts about the impact of the minimum wage on the wage distribution - this paper has presented one. We then studied the impact of the UK's National Minimum Wage on wage inequality. We presented evidence that the decline in wage inequality in the bottom half of the wage distribution has been most marked in the lowest-wage segments of the labour market, consistent with an impact of the NMW. Our estimates suggest that for young workers something over half of the change in the log 50/5 from the period 1998-2010 can be ascribed to the NMW and 40% of the change in the log 50/10. For older workers, the impact of the NMW is smaller but the overall trends are weaker and the NMW seems to be able to explain all of the observed changes. We also presented evidence that the impact of the NMW reaches up to 40% above the NMW in 2010 which corresponds to the 25th percentile. These spillovers are larger in low-wage segments.

References

Autor, David, Alan Manning and Christopher Smith (2010) "The Contribution of the Minimum Wage to U.S. Wage Inequality over Three Decades: A Reassessment", NBER Working Papers No. 16533.

Burdett, Kenneth, and Dale T. Mortensen, 1998, "Wage Differentials, Employer Size, and Unemployment", *International Economic Review*; 39(2), May pages 257-73.

Butcher, Tim, 2005, "The hourly earnings distribution before and after the National Minimum Wage", *Labour Market Trends*, 2005, 427-435.

Butcher, Tim, 2012, "Still Evidence-Based? The Role of Policy Evaluation in Recession and Beyond: The Case of the National Minimum Wage" *National Institute Economic Review*, No.219, R26-R40.

Card, David and Alan B. Krueger. 1994. "Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania." *American Economic Review*, 84(4), 772-793

Card, David and Alan B. Krueger, 1995 "*Myth and Measurement: The New Economics of the Minimum Wage*", Princeton: Princeton University Press.

Card, David and Alan B. Krueger. 2000. "Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania: Reply." *American Economic Review*, 90(5), 1397-1420.

Card, David. and T. Lemieux (1996) "Wage Dispersion, Returns to Skill and the Black-White Wage Differential", Journal of Econometrics, 74, 319-361

Dickens, R., S.Machin and A. Manning, 1998 "Estimating the Effect of Minimum Wages on Employment from the Distribution of Wages: A Critical View", Labor Economics, 1998, 5, 109-134.

Dickens, Richard and Alan Manning (2004a) "Has The National Minimum Wage Reduced UK Wage Inequality?", Journal of the Royal Statistical Society Series A, 167, 613-626.

Dickens, Richard and Alan Manning (2004b) "Spikes and Spill-overs: The Impact of the National Minimum Wage on the Wage Distribution in a Low-Wage Sector", Economic Journal Conference Papers, 114, C95-C101 .

Dickens, Richard, Rebecca Riley and David Wilkinson, 2011, "The UK Minimum Wage at Age 22: A Regression Discontinuity Approach", NIESR Discussion Paper.

DiNardo, John, Nicole M. Fortin and Thomas Lemieux. 1996. "Labor Market Institutions and the Distribution of Wages, 1973-1992: A semiparametric approach." *Econometrica*, 64(5), September, 1001 -1044.

Dube. Arindrajit, T. William Lester and Michael Reich (2010) "Minimum Wage Effects Across State Borders: Estimates Using Contiguous Counties", *Review of Economics and Statistics*, 92, 945-964.

Falk, Armin, Ernst Fehr and Christian Zehnder, 2006, "The Behavioral Effects of Minimum Wages", *Quarterly Journal of Economics*, 121, 1347-1381.

Flinn, Christopher (2006), "Minimum Wage Effects on Labor Market Outcomes under Search, Bargaining, and Endogenous Contact Rates," *Econometrica*, 74, 1013-1062.

Flinn, Christopher (2010), "*The Minimum Wage and Economic Outcomes*", Cambridge Mass: MIT Press.

Goos, Maarten and Alan Manning, 2007, "Lousy and Lovely Jobs: The Rising Polarization of Work in Britain", *Review of Economics and Statistics*, 89,118-133

Guiliano, L (2012) "Minimum Wage Effects on Employment, Substitution, and the Teenage Labor Supply: Evidence from Personnel Data," Forthcoming, *Journal of Labor Economics.*

Grossman, J.B (1983) "The impact of the minimum wage on other wages", *Journal of Human Resources*, 18, 259–278.

Lee, David. 1999. "Wage Inequality in the United States During the 1980s: Rising Dispersion or Falling Minimum Wage?" Quarterly Journal of Economics, 114(3), August, 977-1023.

Low Pay Commission (1998) "The National Minimum Wage First Report of the Low Pay Commission", June 1998.

Low Pay Commission (2009) "National Minimum Wage. Low Pay Commission Report 2009", May 2009.

Machin, Stephen, 2011, "Changes in UK Wage Inequality Over the Last Forty Years", in P. Gregg and J. Wadsworth (eds.) *The Labour Market in Winter*, Oxford University Press, (2011)

Machin, Stephen & Alan Manning, (2004) "A test of competitive labor market theory: The wage structure among care assistants in the South of England," *Industrial and Labor Relations Review*, 57, 371-385.

Manning, Alan (2003) *Monopsony in Motion: Imperfect Competition in Labor Markets*", Princeton: Princeton University Press.

Manning, Alan (2011) "Imperfect Competition in Labour Markets", in in O.Ashenfelter and D.Card (eds) *Handbook of Labor Economics*, volume 4, North-Holland: Amsterdam, 2011

Metcalf, David (2007) **"**Why Has the British National Minimum Wage Had Little or No Impact on Employment?" CEP Discussion Paper, No, 781, April 2007.

Meyer, Robert and David Wise (1983a) "The effects of the minimum wage on the employment and earnings of youth", *Journal of Labor Economics*, 1, 66–100.

Meyer, Robert and David Wise (1983b) "Discontinuous distributions and missing persons: The minimum wage and unemployed youth", *Econometrica*, 61, 1677–1698.

Neumark, David and William Wascher. 2000. "Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania: Comment." *American Economic Review*, 90(5), 1362-1396.

Neumark, David and William Wascher. 2008, *Minimum Wages*, Cambridge, Mass.: MIT Press.

Simon, Kosali Llayperuma and Robert Kaestner, 2004, "Do Minimum Wages Affect Non-Wage Job Attributes? Evidence On Fringe Benefits," *Industrial and Labor Relations Review*, 58, 52-70.

Stewart, Mark (2004a) "The Impact of the Introduction of the UK Minimum Wage on the Employment Probabilities of Low Wage Workers", *Journal of the European Economic Association*, 2, 67-97.

Stewart, Mark (2004b) "The Employment Effects of the National Minimum Wage", *Economic Journal*, 114, C110-116.

Stewart, Mark (2012a) "Quantile Estimates of Counterfactual Distribution Shifts and the Impact of Minimum Wage Increases on the Wage Distribution"**,** *Journal of the Royal Statistical Society Series A*, 175, 263-287.

Stewart, Mark (2012b) "Wage Inequality, Minimum Wage Effects and Spillovers", *Oxford Economic Papers*, forthcoming.

Teulings, Coen N. 2000. "Aggregation Bias in Elasticities of Substitution and the Minimum Wage Paradox," *International Economic Review*, 41, 359–398.

Teulings, Coen N. 2003. "The Contribution of Minimum Wages to Increasing Inequality." *Economic Journal*, 113, October, 801-833.

Table 1: Descriptive Statistics on Age, Sex, Area Panel

	Mean	SD
e(-r)*(NMW/Median)	0.036	0.113
NMW/Median	0.040	0.123
Migrant/Native Ratio	0.118	0.096
Change in Migrant/Native	0.004	0.016
Change ln(hourly wage)		
5th percentile	0.039	0.044
10th percentile	0.036	0.039
25th percentile	0.035	0.039
50th percentile	0.035	0.040
75th percentile	0.037	0.052
90th percentile	0.037	0.067
95th percentile	0.038	0.089

Table 2: Panel regressions estimates for log wage percentiles: 1998-2010

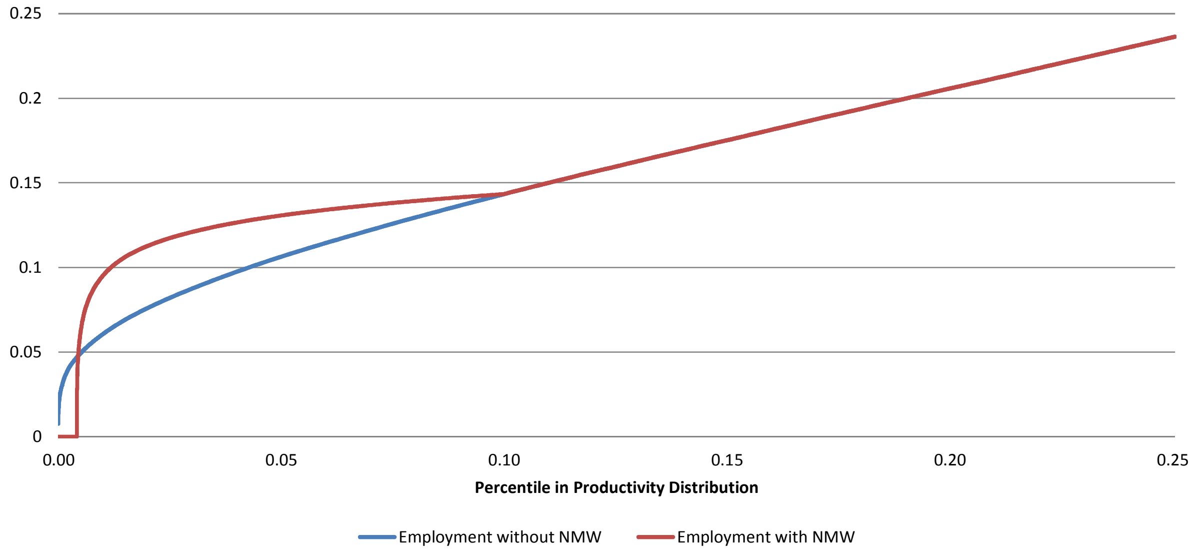
Dependent Variable: Change in ln(hourly wage) at percentile p

Model Specification			**5th**	**10th**	**25th**	**50th**	**75th**	**90th**	**95th**
(1)	**Basic Specification**	**NMW_t (ɣ)**	0.161***	0.077***	0.024	0.028	-0.004	-0.021	0.021
			(0.022)	(0.020)	(0.019)	(0.020)	(0.026)	(0.034)	(0.046)
(2)	**+ Area Dummies**	**NMW_t (ɣ)**	0.137***	0.056***	0.013	0.033	0.002	-0.011	0.037
			(0.022)	(0.020)	(0.020)	(0.021)	(0.027)	(0.035)	(0.047)
(3)	**+ lagged NMW**	**NMW_t (ɣ)**	0.133***	0.056***	0.019	0.028	0.005	-0.016	0.027
			(0.023)	(0.020)	(0.020)	(0.021)	(0.027)	(0.036)	(0.048)
		NMW_{t-1} (ɣ)	-0.031	0.001	0.040**	-0.036*	0.020	-0.042	-0.073
			(0.023)	(0.020)	(0.020)	(0.021)	(0.027)	(0.036)	(0.048)
(4)	**+ Migrant variable**	**NMW_t (ɣ)**	0.135***	0.055***	0.011	0.032	0.002	-0.012	0.036
			(0.022)	(0.020)	(0.020)	(0.021)	(0.027)	(0.035)	(0.047)
		$\Delta Migrant_{it}$	0.061*	0.043	0.063**	0.038	0.016	0.066	0.066
			(0.032)	(0.029)	(0.028)	(0.030)	(0.039)	(0.051)	(0.068)
		Segments	524	524	524	524	524	524	524
		Observations	6,812	6,812	6,812	6,812	6,812	6,812	6,812

Table 3: Changes in ln(50/5) and ln(50/10) and estimated impact of NMW for Selected Groups

	Women, Under 30	Men, Under 30	Women, Over 30	Men, Over 30
Actual Change in 50/5th	-0.135	-0.121	-0.067	-0.025
Actual Change in 50/10th	-0.064	-0.050	-0.010	-0.007
Estimated contribution to 50/5th from NMW	-0.072	-0.067	-0.070	-0.052
Estimated contribution to 50/10th from NMW	-0.027	-0.025	-0.026	-0.019

Figure 1: Simulated Employment Effects of NMW



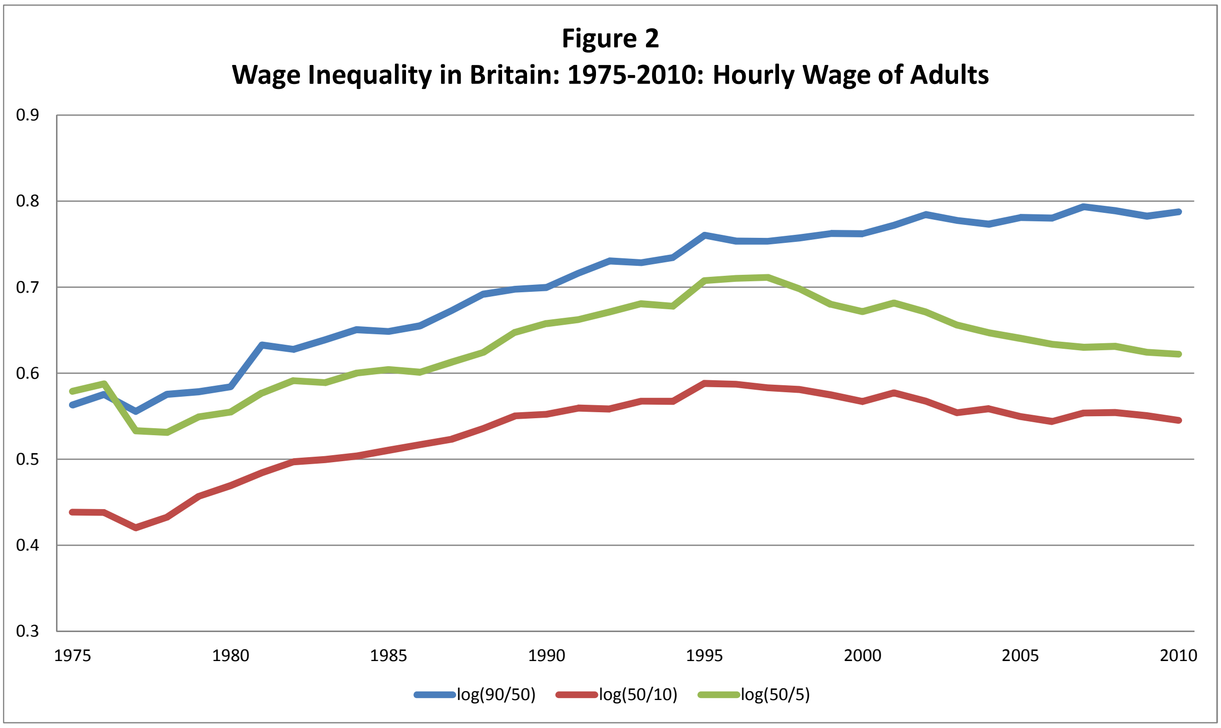


Figure 2
Wage Inequality in Britain: 1975-2010: Hourly Wage of Adults
0.9
0.8
0.7
0.6
0.5
0.4
0.3
1975
1980
1985
1990
1995
2000
2005
2010
log(90/50)
log(50/10)
log(50/5)

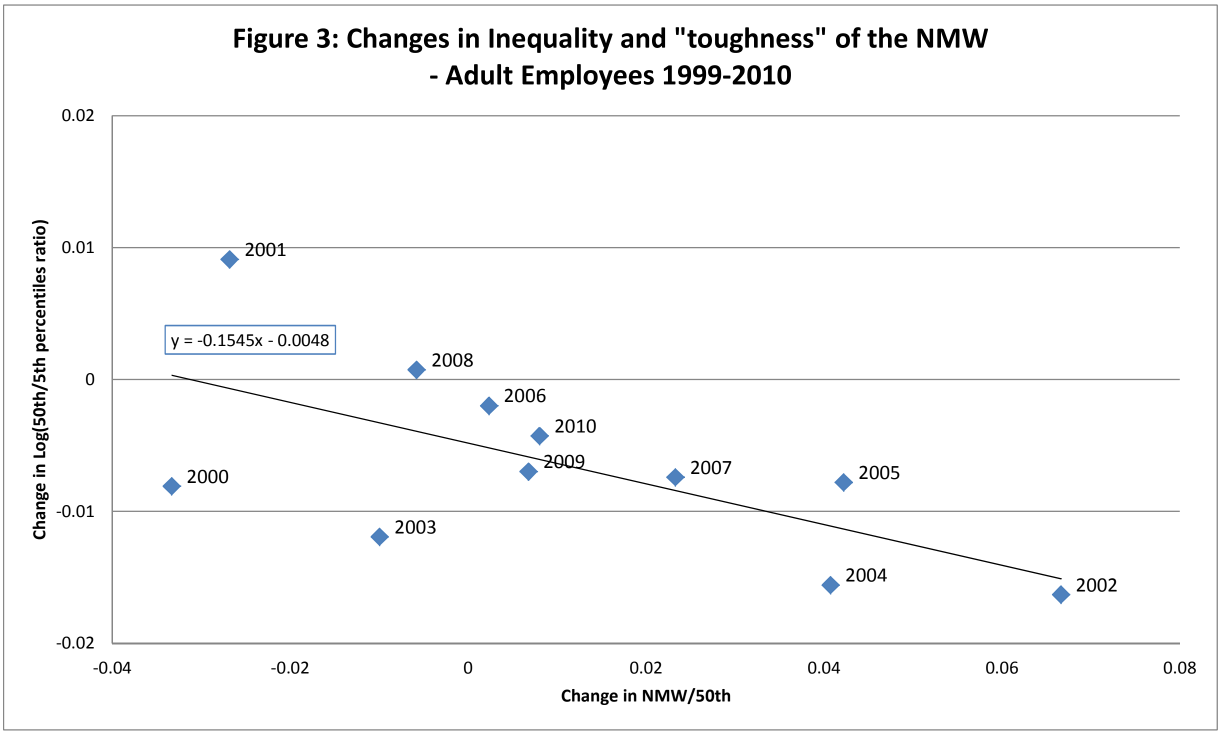


Figure 3: Changes in Inequality and "toughness" of the NMW
- Adult Employees 1999-2010
Change in Log(50th/5th percentiles ratio)
0.02
0.01
0
-0.01
-0.02
y = -0.1545x - 0.0048
2001
2008
2006
2010
2009
2007
2005
2000
2003
2004
2002
-0.04
-0.02
0
0.02
0.04
0.06
0.08
Change in NMW/50th

Figure 4:
Change in real hourly pay percentiles: All Adults 1998-2010

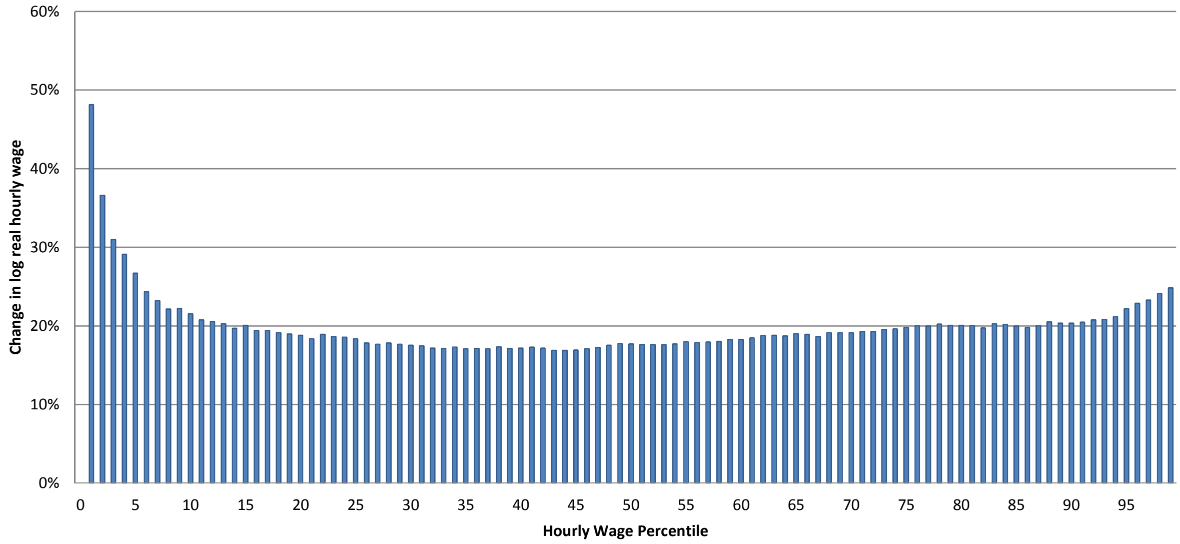
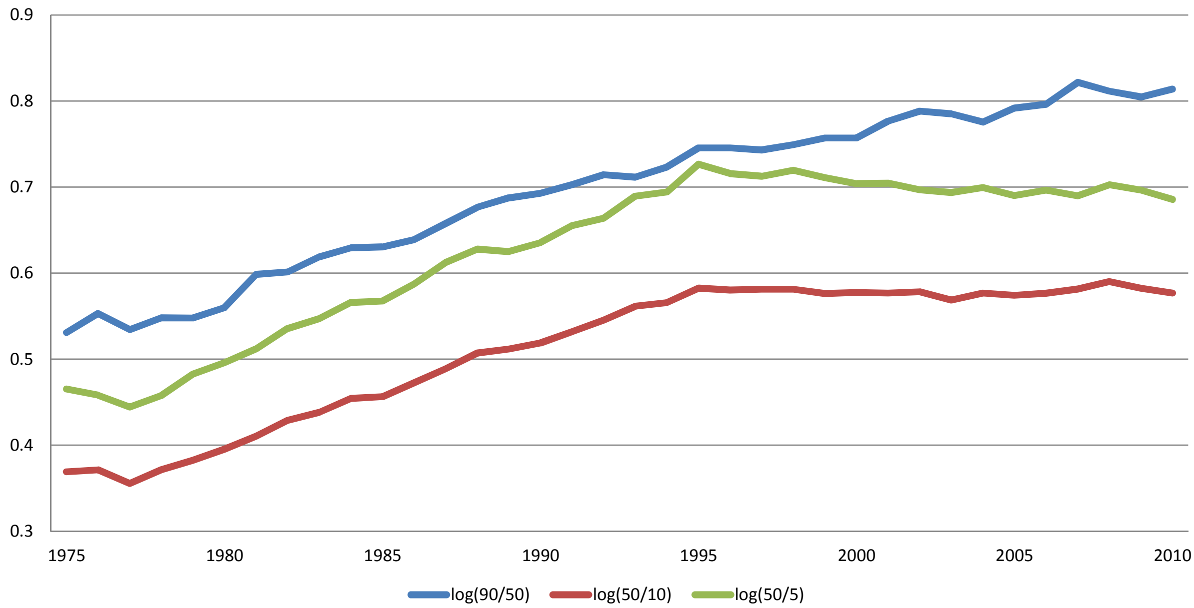


Figure 5a:
Wage Inequality in Britain: 1975-2010: Hourly Wage of Adult Males



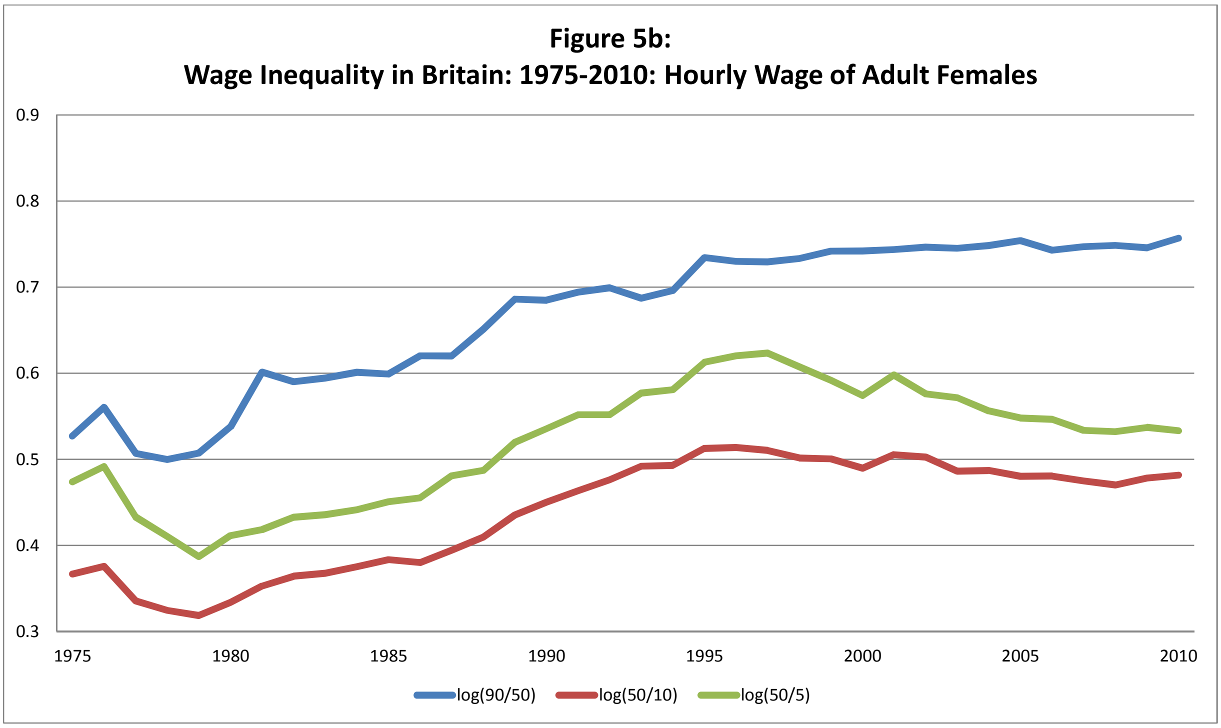


Figure 5b:
Wage Inequality in Britain: 1975-2010: Hourly Wage of Adult Females
0.9
0.8
0.7
0.6
0.5
0.4
0.3
1975
1980
1985
1990
1995
2000
2005
2010
log(90/50)
log(50/10)
log(50/5)

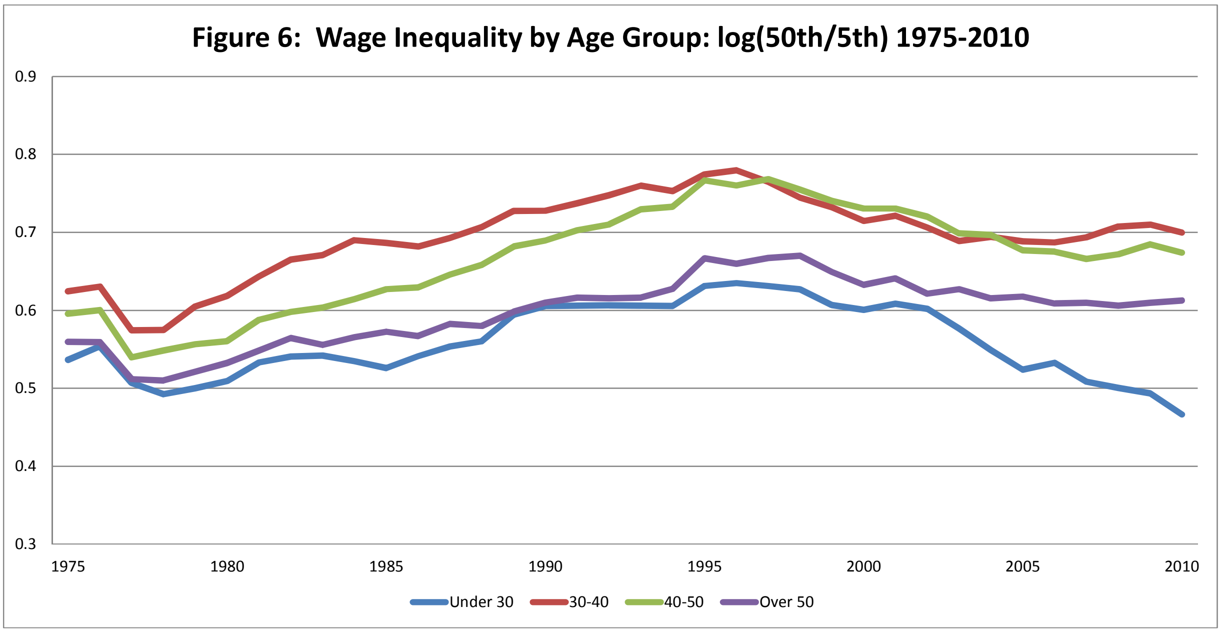


Figure 6: Wage Inequality by Age Group: log(50th/5th) 1975-2010
0.9
0.8
0.7
0.6
0.5
0.4
0.3
1975
1980
1985
1990
1995
2000
2005
2010
Under 30
30-40
40-50
Over 50

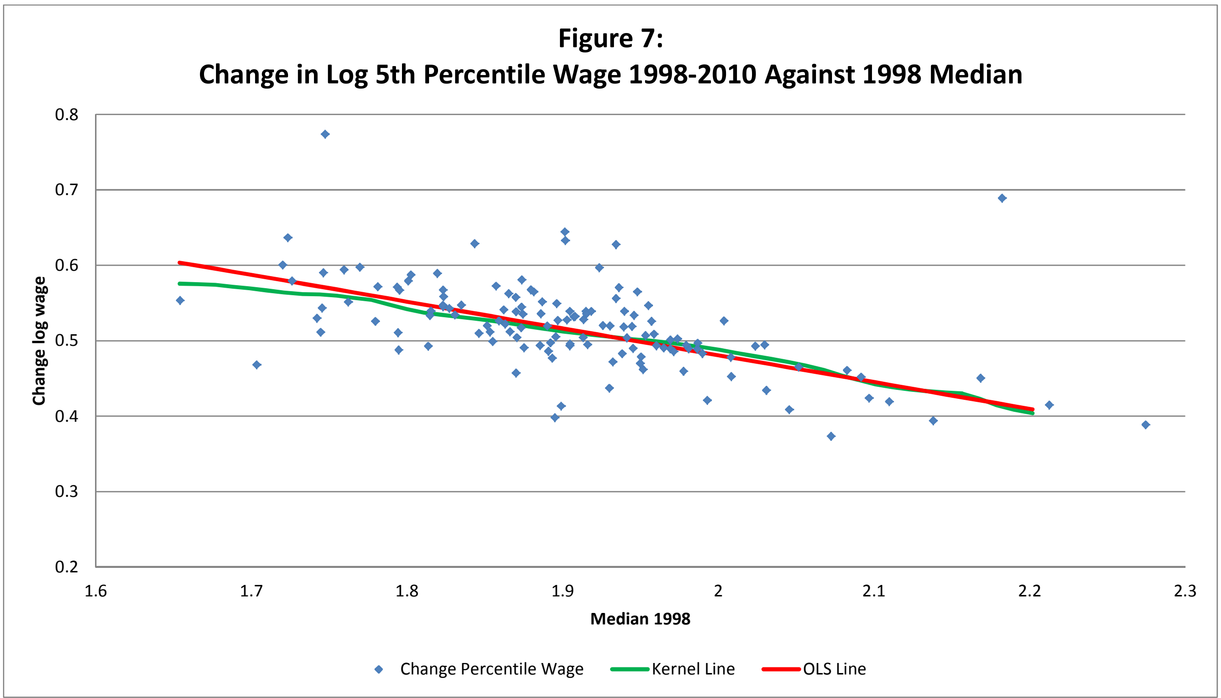


Figure 7:
Change in Log 5th Percentile Wage 1998-2010 Against 1998 Median
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Change log wage
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
Median 1998
Change Percentile Wage
Kernel Line
OLS Line

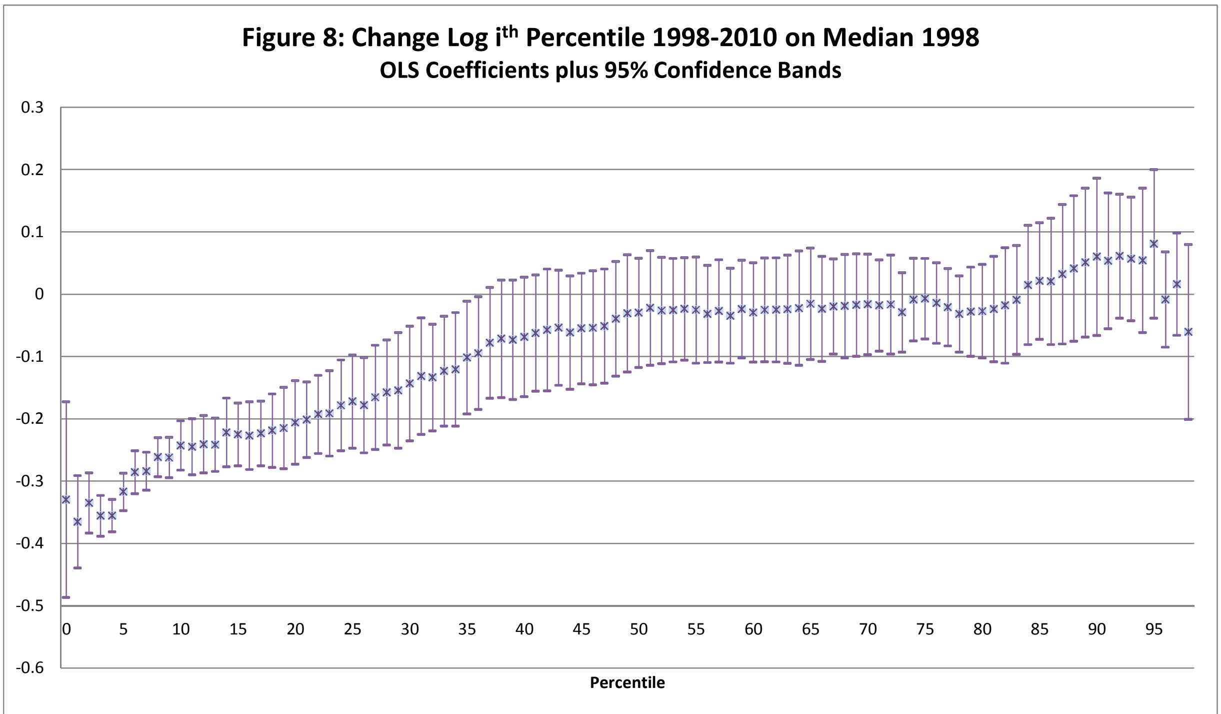


Figure 8: Change Log ith Percentile 1998-2010 on Median 1998
OLS Coefficients plus 95% Confidence Bands
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
Percentile

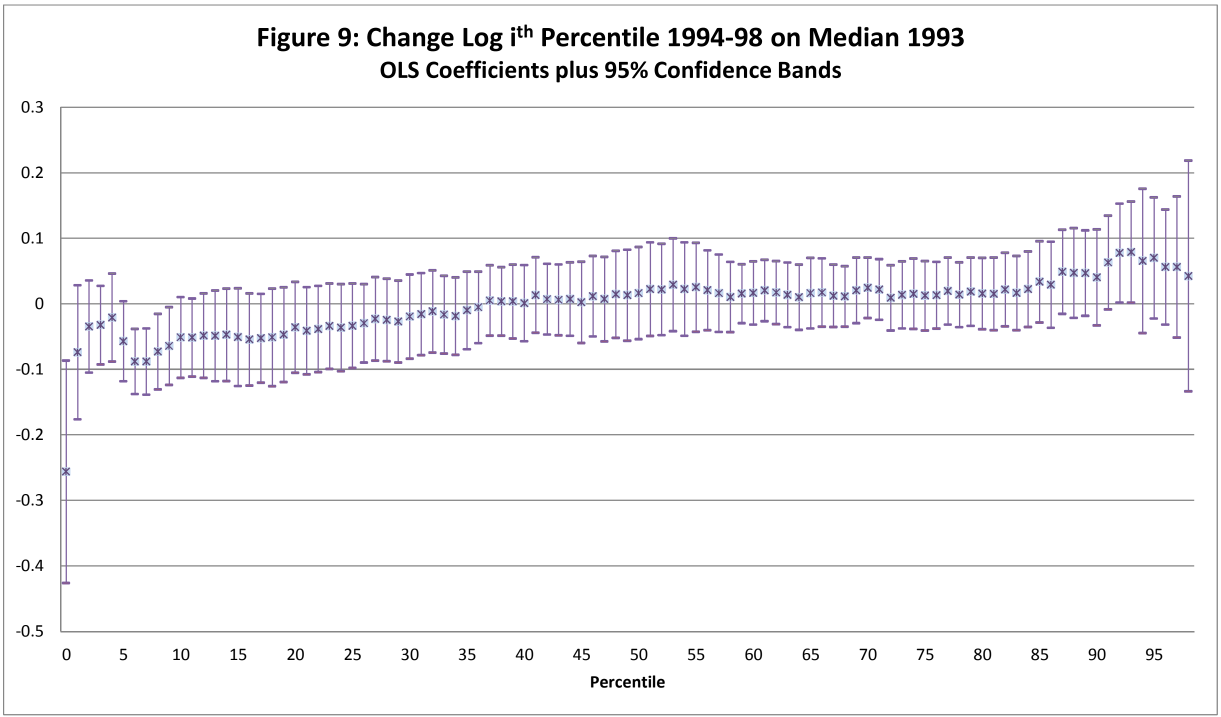


Figure 9: Change Log ith Percentile 1994-98 on Median 1993
OLS Coefficients plus 95% Confidence Bands
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
Percentile

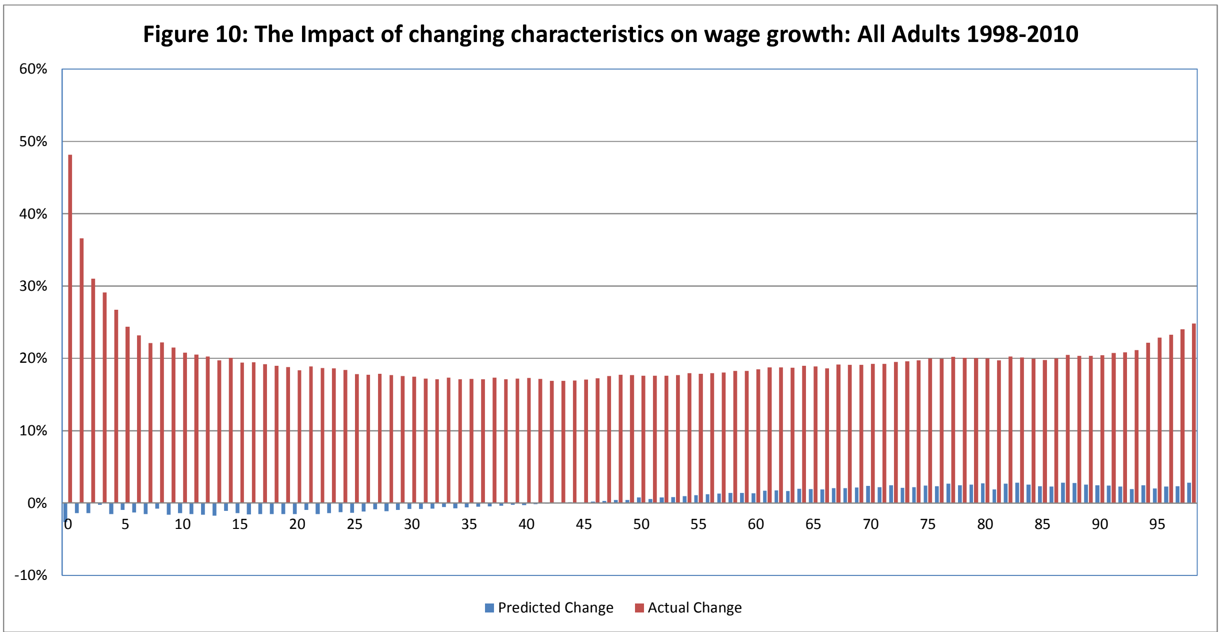
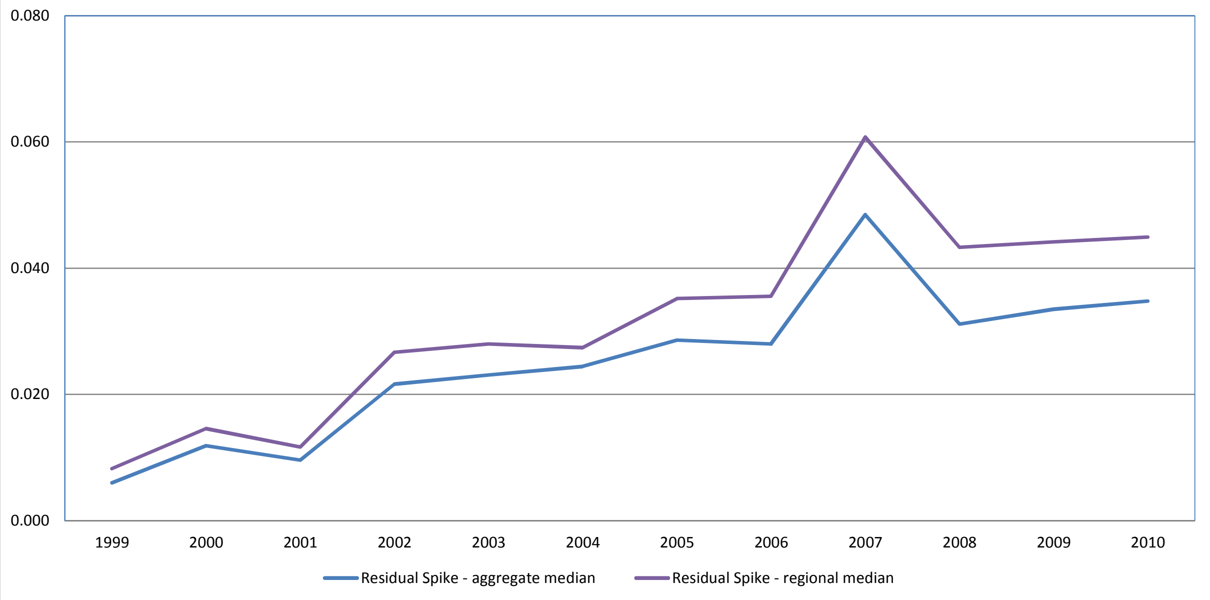


Figure 10: The Impact of changing characteristics on wage growth: All Adults 1998-2010
60%
50%
40%
30%
20%
10%
0%
-10%
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
Predicted Change
Actual Change

Figure 11: % Directly affected by the NMW

Figure 12: Residual Spike by Year



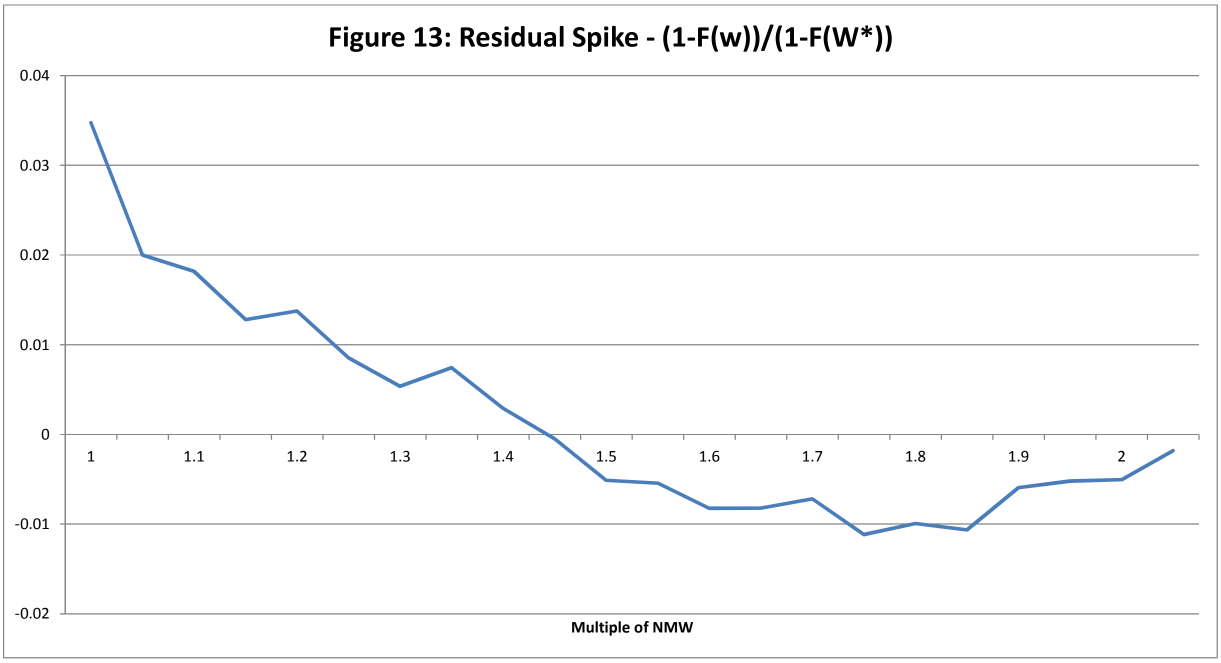


Figure 13: Residual Spike - (1-F(w))/(1-F(W*))
0.04
0.03
0.02
0.01
0
-0.01
-0.02
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
Multiple of NMW

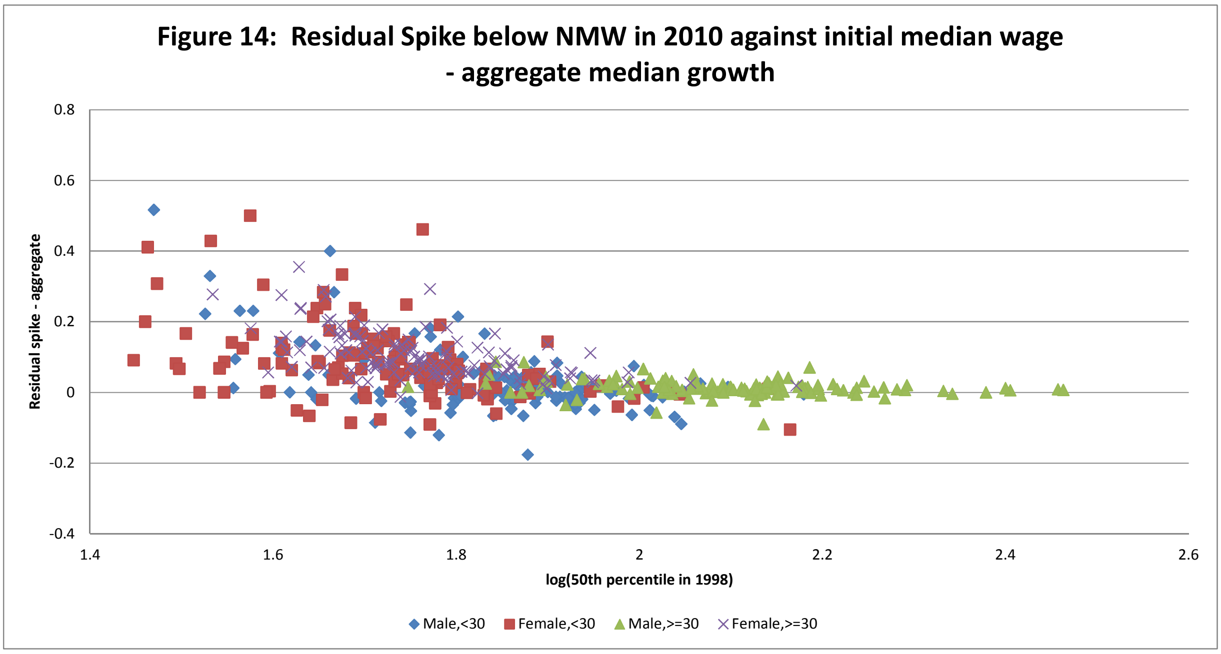


Figure 14: Residual Spike below NMW in 2010 against initial median wage - aggregate median growth
Residual spike - aggregate
0.8
0.6
0.4
0.2
0
-0.2
-0.4
1.4
1.6
1.8
2
2.2
2.4
2.6
log(50th percentile in 1998)
Male,<30
Female,<30
Male,>=30
Female,>=30

CENTRE FOR ECONOMIC PERFORMANCE
Recent Discussion Papers

1176	Jan-Emmanuel De Neve Andrew J. Oswald	Estimating the Influence of Life Satisfaction and Positive Affect on Later Income Using Sibling Fixed-Effects
1175	Rachel Berner Shalem Francesca Cornaglia Jan-Emmanuel De Neve	The Enduring Impact of Childhood on Mental Health: Evidence Using Instrumented Co-Twin Data
1174	Monika Mrázová J. Peter Neary	Selection Effects with Heterogeneous Firms
1173	Nattavudh Powdthavee	Resilience to Economic Shocks and the Long Reach of Childhood Bullying
1172	Gianluca Benigno Huigang Chen Christopher Otrok Alessandro Rebucci Eric R. Young	Optimal Policy for Macro-Financial Stability
1171	Ana Damas de Matos	The Careers of Immigrants
1170	Bianca De Paoli Pawel Zabczyk	Policy Design in a Model with Swings in Risk Appetite
1169	Mirabelle Muûls	Exporters, Importers and Credit Constraints
1168	Thomas Sampson	Brain Drain or Brain Gain? Technology Diffusion and Learning On-the-job
1167	Jérôme Adda	Taxes, Cigarette Consumption, and Smoking Intensity: Reply
1166	Jonathan Wadsworth	Musn't Grumble. Immigration, Health and Health Service Use in the UK and Germany
1165	Nattavudh Powdthavee James Vernoit	The Transferable Scars: A Longitudinal Evidence of Psychological Impact of Past Parental Unemployment on Adolescents in the United Kingdom
1164	Natalie Chen Dennis Novy	On the Measurement of Trade Costs: Direct vs. Indirect Approaches to Quantifying Standards and Technical Regulations
1163	Jörn-Stephan Pischke Hannes Schwandt	A Cautionary Note on Using Industry Affiliation to Predict Income

1162	Cletus C. Coughlin Dennis Novy	Is the International Border Effect Larger than the Domestic Border Effect? Evidence from U.S. Trade
1161	Gianluca Benigno Luca Fornaro	Reserve Accumulation, Growth and Financial Crises
1160	Gianluca Benigno Huigang Chen Christopher Otrok Alessandro Rebucci Eric R. Young	Capital Controls or Exchange Rate Policy? A Pecuniary Externality Perspective
1159	Paul Dolan Georgios Kavetsos	Happy Talk: Mode of Administration Effects on Subjective Well-Being
1158	Alan Manning	Steady-State Equilibrium in a Model of Short-Term Wage-Posting
1157	Joan Costa-Font Mireia Jofre-Bonet Steven T. Yen	Not all Incentives Wash out the Warm Glow: The Case of Blood Donation Revisited
1156	Christian Siegel	Female Employment and Fertility - The Effects of Rising Female Wages
1155	Albrecht Ritschl	The German Transfer Problem, 1920-1933: A Sovereign Debt Perspective
1154	Gabriel M. Ahlfeldt Stephen J. Redding Daniel M. Sturm Nikolaus Wolf	The Economics of Density: Evidence from the Berlin Wall
1153	Nattavudh Powdthavee Yohanes E. Riyanto	Why Do People Pay for Useless Advice?
1152	Thomas Sampson	Selection into Trade and Wage Inequality
1151	Tim Barmby Alex Bryson Barbara Eberth	Human Capital, Matching and Job Satisfaction
1150	Ralf Martin Mirabelle Muûls Laure de Preux Ulrich J. Wagner	Industry Compensation Under Relocation Risk: A Firm-Level Analysis of the EU Emissions Trading Scheme
1149	Albrecht Ritschl	Reparations, Deficits, and Debt Default: the Great Depression in Germany

The Centre for Economic Performance Publications Unit
Tel 020 7955 7673 Fax 020 7955 7595
Email info@cep.lse.ac.uk Web site http://cep.lse.ac.uk