

The Impact of the UK Minimum Wage:
Evidence from High-Frequency Firm-Level Data *

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Abstract

This paper investigates the impact of the UK's National Minimum Wage (NMW) on wage inequality across plants using a unique monthly panel data set of British plants. We find an effect of the NMW on low-wage plants, as we would expect, as well as evidence of spill-over effects across plants operating in low-wage localities. Investigation of the timing of the impact suggests that most of the effect is contemporaneous with changes in the minimum wage, though these estimates are less precise. No significant effect on employment is found.

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JEL Classification: J31, J88

* This work was based on data from the Monthly Wage and Salary Survey, produced by the Office for National Statistics (ONS) and supplied by the Secure Data Service at the UK Data Archive. The data are Crown Copyright and reproduced with the permission of the controller of HMSO and Queen's Printer for Scotland. The use of the data in this work does not imply the endorsement of ONS or the Secure Data Service at the UK Data Archive in relation to the interpretation or analysis of the data. This work uses research datasets which may not exactly reproduce National Statistics aggregates. We would like to thank the Office for National Statistics and the Secure Data Service for making available the data used in this study. This study was conducted under ESRC Grant RES-06202301434 'Wage-Setting in Britain: Evidence from High Frequency Firm-Level Data'. We would like to thank the ESRC for financial support.

Introduction

Most of the research on the effect of minimum wages on the labour market focuses on the employment effects. But, given that these effects seem to be small for observed levels of the minimum wage in countries like the US and the UK (for the UK see, for example, Machin, Manning and Rahman, 2003; Machin and Wilson, 2004; Stewart, 2002, 2004 and Stewart and Swaffield, 2008) it may be that the most interesting effects are on wage inequality. As there are a relatively small number of papers on this subject, this is a topic that remains under-researched.

In the US, Lee (1999), Teulings (2000, 2003) and Autor, Manning, and Smith (2016) investigate the impact of minimum wages on wage inequality exploiting the fact that the federal minimum has a different ‘bite’ in high and low-wage states and that some states have, at various times, had minimum wages above the federal minimum. Lee (1999) concluded that essentially all the rise in lower-tail wage inequality (e.g., the 50/10 log wage differential) in the 1980s was the result of the falling real value of the minimum wage. Because the fraction of workers actually paid the minimum wage was always below the 10th percentile such a conclusion implied substantial effects of the minimum wage on the earnings of workers paid more than the minimum, i.e., spill-overs. Teulings (2003) arrives at similar conclusions. Autor, Manning, and Smith (2016) update and refine Lee’s analysis arguing that a number of his modelling assumptions imply that he over-estimates the impact of the minimum wage – nevertheless, they also conclude that the minimum wage seems to have spill-overs.

In the UK we have less evidence. Butcher (2005) and Dickens and Manning (2004a,b) considered the introduction of the National Minimum Wage (NMW) in 1999

arguing, from national data and data on workers in retirement homes, that the minimum wage seemed to only have an effect on the wages of those directly affected, i.e., there was no evidence of spill-overs. However, this conclusion was based on data from the period very close to the introduction of the NMW. Using more recent data from the UK Annual Survey of Hours and Earnings (ASHE), Butcher, Dickens, and Manning (2012) argue that the NMW has had more pervasive effects on wage inequality and that the UK, like the US, does show evidence for sizeable spill-overs. Stewart (2010a,b) uses data from the ASHE both to look at individual wage growth and changes in the overall distribution of earnings. He finds little evidence for spill-over effects, though the quantile estimates are sensitive to the methodology used to construct the counter-factual wage distribution.

If there are spill-overs, then it is important to uncover the precise mechanism. It could be that there are spill-overs within plants so that employers, when faced with a rise in the minimum wage that forces some workers to be paid more, maintain pay relativities (at least to some extent) by raising the earnings of those not directly affected. Giuliano (2013) presents some evidence on this from a US retail firm. Or it might be that the spill-overs work across plants so that the competition for workers between plants forces those plants whose workers are not directly affected by the minimum wage to raise wages to maintain their ‘competitive advantage’ over plants whose workers are directly affected. Theoretical models of labour markets with frictions and on-the-job search like Burdett and Mortensen (1998) or Flinn (2011) have such a prediction as do more competitive models of Teulings (2000) in which workers paid similar wages are close substitutes.

This paper provides some evidence on the source of spill-overs. The data set is the UK’s Monthly Wages and Salaries Survey, the micro data behind the main UK

macroeconomic earnings series, the Average Earnings Index.¹ This has the advantage over many other data sets that it is very high frequency – monthly – so can be used to address interesting questions about the timing of the effect of minimum wage changes on earnings (Dickens and Manning, 2004a, concluded all the effect was contemporaneous to the actual minimum wage change) and we have access to detailed geographical data on the location of plants that allows us to look for evidence of spill-overs across plants. Hence, this data does allow us to look at different dimensions of the impact of minimum wages from those that use other data sources. The disadvantage is that we only observe average earnings per head at the plant level so cannot identify either what proportion of minimum wage workers each plant has or the extent of spill-overs within plants. However, Draca, Machin, and van Reenen (2011) have previously shown that one can use plant-level data to investigate successfully the impact of minimum wages (on profitability in their case).

We find that there is an effect of the minimum wage on wage at the plant-level with a larger impact on low-wage plants and that most of the effect is concentrated in the month of implementation. We also find evidence of spill-over effects of the minimum wage across plants operating in low-wage localities. Finally, no effect of the minimum wage on employment is found.

The plan of the paper is as follows. In the next section we describe the data set and provide some descriptive statistics. We also address the issue of the reliability of plant-level data for measuring the impact of minimum wages. The following section then presents a simple framework for thinking about the impact of the minimum wage. The third section presents evidence looking at the direct contemporaneous effect, the timing

¹ Details of the AEI can be found at <http://www.statistics.gov.uk/statbase/Product.asp?vlnk=2484&More=Y>

of effects, and the spill-overs across plants. Finally we look briefly at the employment effects.

1. The Monthly Wages and Salaries Survey

The Monthly Wages and Salaries Survey (MWSS) is a monthly survey conducted by the Office for National Statistics (ONS) of approximately 9,000 businesses in Great Britain. It started in 1989, but underwent a major re-design in 1999. For our analysis, we use data for the period January 2000- February 2016 inclusive. The data from the MWSS are used to produce the Average Weekly Earnings and the Average Earnings Index (AEI), the main macroeconomic series on earnings used in the UK.² The MWSS collects total gross pay from individual plants (separately for weekly and monthly staff), as well as total bonus payments and any pay award arrears. In our analysis, we use the pay bill excluding bonuses and arrears and the number of employees in the pay bill that is also included in the data to compute average earnings per head.

The MWSS is carried out monthly, with paper questionnaires sent out to companies that they are required by law to complete. Businesses are selected from the Inter-Departmental Business Register (IDBR), a comprehensive register of UK companies used by the government for statistical purposes. All businesses with more than 1,000 employees are surveyed every month. Below this threshold, sampling is random. However, employers with fewer than 20 employees are not sampled. Once selected into the sample these employers remain in it for 5 years. The unit of response is what is known as a ‘reporting unit’. This is the address to which the questionnaire is sent. For

² The closest equivalent series for the US, the Employer Cost Index, is collected using a very different methodology, see Lebow et al. (2003) for a study of wage flexibility underlying this survey.

businesses with only one plant, this will be the location of that plant. For businesses operating at more than one location, it may be that one questionnaire is only sent to one location (e.g., the head office) in which case the return will relate to all the locations in which the business operates or it may be that it is sent to every location (called a local unit in the jargon) in which case the return will be plant-specific. We will refer to the unit of analysis as a plant in what follows.

Some descriptive statistics are presented in Table 1. Figure 1 also shows the mean log wage growth for each month in the sample – the raw data in Figure 1a and smoothed data in Figure 1b. The mean is 0.25% per month, corresponding to an annual rate of 3.0%, what we would expect for this sample period. The sample period includes some data before and after the crisis and nominal wage growth is somewhat lower in the later part of the sample though there are large seasonal fluctuations. The only other paper that uses this data set is Georgiadis and Manning (2014) and that paper documents the high level volatility in monthly average earnings growth at plant level – this will be important in what follows.

2. The Evolution of Wage Inequality in the Monthly Wages and Salaries Survey

We start by presenting various measures of inequality in average wages across plants. Figures 1a and 1b present the evolution of the log of the 5th, 10th, and 25th percentiles relative to the median over our sample period. It also shows the value of the NMW relative to the median over the same period. The sawtooth pattern in the NMW reflects the fact that, in our sample period, the NMW was raised in October each year (with relatively large changes of 10.8% in 2001 and 7.8% in 2004 and relatively small changes

of 2.2% in 2010) and then declines relative to the median until the next October. Over time the drift of the minimum wage is to increase relative to the median as the NMW was pushed up faster than median earnings in this period.

There is a modest upward trend in the 5th, 10th, and 25th percentiles relative to the median in this period suggesting some compression in the bottom half of the average wage distribution across plants. This is exactly what one would expect if all plants have a mix of workers from across the skill distribution. For completeness, Figures 2a and 2b show the evolution of upper-tail wage inequality as measured by the log of the 75th, 90th and 95th percentiles relative to the median. There is an upward trend before 2008 that reverses after the crisis hits. If there is a clear impact of the minimum wage we would expect to see a compression in lower-tail wage inequality in October, the month in which the minimum is raised. It should be readily apparent that it is hard to detect any sizeable effect with the naked eye.

There are two possible reasons for this, apart from the possibility that the NMW has no effect on wage inequality. First, that it is very hard to pick up the effect of the NMW on wage inequality using figures on average weekly earnings at plant-level as in the MWSS. Suppose that the NMW only affects the wages of those directly affected (perhaps in line with the findings of Dickens and Manning, 2004a, b). Then if the NMW rises by 10%, average earnings in a plant will rise, in percentage terms, by 10 times the fraction of the wage bill in the plant who are paid the minimum wage. If minimum wage workers are widely scattered across plants there may be very little effect. However, the study of Draca, Machin, and van Reenen (2011) does report some success in using plant-level data to detect the impact of the NMW on wages, employment, and profitability so

this may not be the answer. To give some more insight into this question, Figure 3 plots the fraction of the wage bill paid to minimum wage workers by industry against average weekly earnings in the industry using data from the Labour Force Survey. One can see a clear negative relationship suggesting that one can pick up an effect.

The second possibility is that, as described in detail in Georgiadis and Manning (2014), the average earnings data in the MWSS is very noisy with monthly wage growth showing a lot of volatility. In this situation a plant at the 5th percentile one month is quite likely to be at a very different percentile another month so that the current percentile is not a very good indication of the permanent position of the plant in the wage distribution.

These considerations make it harder to detect any impact of the minimum wage on wage inequality using plant-level data, but, as we will see below, it is not impossible. We now move on to describe our empirical strategy.

3. A Model of the Impact of the Minimum Wage

A useful starting point for thinking about how to estimate the impact of the minimum wage on the average wage within a plant is the benchmark model in which there are no disemployment and spill-over effects from the minimum wage and the only impact of the minimum wage on the wage structure is to raise the wage of everyone directly affected. In this case a model for the change in average earnings in plant i at time t would be:

$$\Delta w_{it}^* = s_{it} \Delta w_t^m + \beta x_{it} + \varepsilon_{it} \quad (0.1)$$

Where s_{it} is the share of minimum wage workers in the total pay bill, Δw_t^m is the change in the log of the national minimum wage (so it only has a t subscript) and βx_{it} are other

factors influencing wage growth.³ This model says that if the minimum wage rises by 10% and minimum wage workers are 10% of the total pay bill then average earnings will rise by 1%. If there are spillovers within the plant we would expect the effect of changes in the minimum wage on average earnings to be larger than the share of workers paid the minimum wage in the pay bill. If one had data on s_{it} then one could test this directly. But, in our data we do not observe the share of the wage bill paid to minimum wage workers – instead we use the average level of earnings as a proxy – Figure 3 suggests this is not too bad an approximation. So our empirical model is:

$$\Delta w_{it} = s(\mu_{it})\Delta w_t^m + \beta x_{it} + \varepsilon_{it} + \Delta \eta_{it} \quad (0.2)$$

Where $s(\mu_{it})$ is some function of a measure of the average wage in plant i at time t , μ_{it} . One might think there are a few problems with this. First, if one includes time effects (and one should) one cannot identify the constant in $s(\mu_{it})$ from a time effect so one cannot anchor the effect of the minimum wage. We will identify it by assuming that the effect of the minimum wage on average earnings in high-wage plants is zero, i.e., that $s(\mu_{it})=0$ for sufficiently high μ_{it} . Second, one might wonder how one can separately identify spill-overs from the direct effect of the minimum wage if one does not directly observe the wage bill share of minimum wage workers. At the level of the individual plant one can only hope to estimate the total effect of changes in the minimum wage on average earnings but, by adding the effects across plants one can obtain an estimate of a total effect of the minimum wage on the change in average earnings in the economy.

³ Strictly speaking, this equation applies only for infinitesimal changes – for non-infinitesimal changes, the change in average earnings would be between the initial and final wage bill shares of minimum wage workers.

Autor, Manning and Smith (2016) show that if there are no spill-overs this should be equal to the fraction of minimum wage workers in the economy.

Finally, we should make some comment about the error structure assumed in (0.2). Georgiadis and Manning (2014) show that a good approximation to the movement of average earnings in the MWSS is that the underlying wage follows a random walk but there are large transitory shocks to the level of earnings. We assume ε_{it} and η_{it} are white-noise and this gives that structure.

The identification strategy in (0.2) is based on the idea that low-wage plants are more affected by rises in the minimum wage so that we should see greater increases in average earnings in low-wage plants in periods when the minimum wage is raised.

4. Empirical Results

The basics of our empirical strategy can be summarized very simply. We look for evidence that the change in plant-level average earnings is greater (smaller) in low-wage plants in periods in which the minimum wage increases (falls). This is the essence of the first term on the right-hand side of (1.2). When it comes to empirical implementation we need to make two modeling decisions – how we measure the change in the minimum wage and how we identify low-wage plants.

First, consider the change in the minimum wage. In the simple framework outlined above it is the minimum wage relative to median earnings that is the appropriate measure of the ‘bite’ of the minimum wage. This increases sharply each October when the minimum wage itself is increased but also – on average - decreases slightly every month as the minimum wage is constant in nominal terms and average earnings are rising

(by approximately 3.6% per annum on average in our sample period) – one can see this sawtooth pattern in Figure 1a. One might think of using both sorts of variation in our estimation of the impact of the minimum wage. But, in practice it is only the October up-rating that is a reliable measure of the changing bite of the minimum wage because there is a lot of volatility in median earnings and even the real variation may not be exogenous. So our change in the minimum wage variable is the log change in October and zero in every other month.

There are a number of possible measures of the level of wages in a plant in the absence of the minimum wage. One might think about simply using the lagged level of the wage observed in the plant. However, there are a number of problems with this. First, the transitory volatility in earnings growth in the MWSS documented in Georgiadis and Manning (2014) induces a negative correlation between wage growth and initial wages that would have to be controlled for in the absence of the minimum wage. This consideration would suggest using some average level of wages in the plant. We took this approach to its limit and estimated a plant-level fixed effect in an equation of log average earnings on plant and time effects. We then use the difference between the plant fixed effect and the average plant fixed effect, i.e., the actual fixed effect we use has a mean value of zero. Plants that pay below the mean will have a negative fixed effect, those paying above a positive fixed effect. This will be a good measure of the average plant-level wage if plants have relatively stable positions in the wage distribution, something we believe to be a good approximation to reality. We also report an IV estimate in which we instrument the lagged wage with the fixed effect.

So our basic estimating equation is to regress plant-level wage growth on the change in the minimum wage interacted with a polynomial in the plant-level fixed effect in wages plus other controls (that vary across specifications). The simple model sketched above suggested a linear specification but we experiment with different functional forms.

The first row of Table 2 estimates a simple linear equation for the log wage growth on the change in the minimum wage interacted with the fixed effect. Time dummies are also included as is the fixed effect itself.⁴ Because the level effect of the change in the minimum wage cannot be identified separately from the time dummies, the estimated coefficients should be interpreted to be the effect of the minimum wage on earnings in a plant with a particular fixed effect relative to the effect in a plant with the mean level of the fixed effect. It is plausible to assume that this latter effect is zero in which case one can read the estimated effect as being the total effect of the minimum wage in a plant with a particular level of the fixed effect. But, if the effect of the minimum wage on the average plant is zero, it is also plausible to think it is zero for high-wage plants so that a test of the plausibility of the estimates is whether they suggest this is indeed the case.

The positive (though not significantly different from zero – the F-test is reported in the final column) effect of the minimum wage reported in the first row of Panel A of Table 2 is the opposite of what one expect to find as it suggests that it is higher wage plants that have higher wage growth when the minimum wage goes up. One possible explanation for this is a misspecification of functional form so the second row then estimates a quadratic – both linear and quadratic terms are significantly different from

⁴ Though the coefficient on the fixed effect is not significantly different from zero and results are very similar when it is excluded.

zero and the p-value for the F-test that both terms are zero is very low suggesting the linear specification of the first column was misspecified. But the implied pattern of effects remains implausible being biggest in both low-wage and high-wage plants. The third and fourth columns now estimate cubics and quartics – all of the estimated coefficients are now significantly different from zero.

Because it is hard to interpret the coefficients in higher-order polynomials, Figure 4 plots the predicted elasticity of wages with respect to the minimum wage against the percentile of the plant in the fixed effect distribution together with the 95% confidence intervals.⁵ Although every specification apart from the linear suggests that for plants that pay below the average there is a negative relationship between the impact of the minimum wage on wage growth and the level of wages, for higher-paying plants, one obtains the opposite relationship. The estimated response of earnings in the highest-wage plants to the minimum wage is as large, or larger, as that estimated for the lowest-wage plants. This obviously casts doubt on the validity of any of the estimates.

One possible explanation is seasonality. All of the changes in the minimum wage occur in October so the estimates in Panel A of Table 2 primarily compare how the change in average wages is related to the plant fixed effect in October compared to other months. If, for any reason, high-wage plants tended to have higher wage growth in October this would be detected as an impact of the minimum wage. To investigate this we estimate additional specifications restricting the sample to October.⁶ In this case our

⁵ The percentile is used as the horizontal axis because this gives a clearer indication of where the balance of plants will be (they will be approximately uniformly distributed). But because the relationship between the percentile and the fixed effect is not linear, even the prediction of the linear model does not appear this way in Figure 4.

⁶ An equivalent thing to do would be to use all months and interact the fixed effect with the calendar month.

identification of the minimum wage effect is based on comparing Octobers in which the minimum wage was raised a lot with those in which the raise was small (for example, it went up 10.8% in 2001 compared with 2.4% in 2001). These results for different polynomials are reported in rows Panel B of Table 2. Note that because the fixed effect is measured as deviation from the mean, it is only the linear term where the coefficient changes markedly with the introduction of the seasonal effects. Also note that the standard error on the linear term rises – this is because one is now only identifying off variation in the rise in the minimum wage in October.

The inclusion of seasonal effects has a dramatic effect on the estimated impact of the minimum wage. Even in the linear model the coefficient on the minimum wage variables is now negative as expected and significantly different from zero. Rows (6) through (8) then estimate a quadratic, a cubic, and a quartic. The results are summarized in Figure 5. The results are now much more plausible – the estimated impact effects for above-average wage plants is now very close to zero and it is largest for the lowest-wage plants. The coefficient on the plant fixed effect is significantly different from zero (this is not reported in table 2, but results are available from the authors on request) suggesting that, for some reason, high-wage plants tend to have higher wage growth in October in the absence of any change in the minimum wage.

It is useful to get some idea of the implied size of the effect of changes in the minimum wage on earnings. First, note that the point estimates of the effects are very close to zero once one gets above the 25th percentile. Close to the 25th percentile, the point estimates are not significantly different from zero (this has to be the case if, as one would expect, the effect of the minimum wage on earnings varies continuously with the

fixed effect) but they are at the lowest percentiles. At the 1st percentile of plants the estimated elasticity of earnings is about 0.2. One can get an estimate of the total effect on log average earnings using the estimated impact at each percentile, adding these up giving them weights in the total employment – the estimates imply that a rise in the minimum wage of 10% will lead to a rise in total earnings of about 0.17%. This is a bit below what one would expect given sources on the fraction of workers paid the minimum wage.

An alternative way of getting an estimate of the impact of the minimum wage is to restrict attention to plants with low wages on the grounds that the effect on higher-wage plants should be zero. Estimates from a sample restricted to plants with below-median fixed effects for the same specifications as Table 2 are reported in Table 3 and the predicted responses shown in Figures 6 and 7.

An alternative approach to the estimation of (3) that recognizes the problems with OLS is to instrument the lagged wage with the plant-level fixed effect. Table 4 presents estimates of these models for different polynomials for our preferred specification (October only). The IV responses are very similar to those estimated by OLS.

Overall the conclusion is that one can detect a modest effect of the minimum wage on the level of average earnings though to do this successfully one has to be careful with the identification strategy. This conclusion is in line with other studies. But, all of the estimates so far assume the impact of the minimum wage on wage growth is contemporaneous – the next section considers leads and lags. One of the big advantages of the MWSS is that its monthly frequency allows one to estimate the timing of responses far more accurately than one could with annual data.

5. The Timing of the Response to Changes in the Minimum Wage

There are a number of reasons for thinking that not all of the response to changes in the minimum wage may be contemporaneous. Typically the change in the minimum wage that occurs in October is the result of a recommendation contained in a Low Pay Commission Report that is most commonly published in March (though has sometimes been a bit earlier or later) and accepted soon after by the government. So, plants have about 6 months warning of increases in the minimum wage and may seek to raise wages before they have to, if that is the traditional month for wage settlements. This would show up in the data as a ‘lead’: future increases in the minimum wage lead to wage increases now. Alternatively it may take some time for all of the effects of the minimum wage to work themselves into earnings – this might be because not all plants comply from day 1 or because spillovers only manifest themselves slowly, e.g., a rise in the minimum wage compresses relativities within or across plants and this puts upward pressure on the wages of those paid above the minimum.

The natural way to investigate these timing issues is to interact leads and lags of changes in the minimum wage with a polynomial in the plant-level fixed effect just as we have done with the contemporaneous effect. But because the minimum wage is only raised in October we can actually do something much simpler. The fact that the rises are always in October means that the 4th lead of the minimum wage will always be about the effect in June and the 6th lag always about the effect in April. So, for each calendar month we estimate a model with the change in log average earnings in that month as the dependent variable, include the plant fixed effect as a control variable and then interact a

quartic in the plant fixed effect with the lead or lag of the minimum wage change in the following or preceding October. So when we estimate a model for June we include either a lead of 4 months or a lag of 8 months. It is easiest to present the results in graphical form - this is done for the lags in Figure 8 and the leads in Figure 9.

In both figures, the results reported for October are the contemporaneous effects reported previously in Figure 5. In Figure 8 the estimates are for lags so, for example, the estimate for December refers to a 2-month lag effect. For the October we have the estimate that there is faster wage growth in low-wage relative to high-wage plants in years in which the minimum wage is raised a lot. But the October is not the only month in which there seems to be a systematic pattern. There are other months in which there is a significant relationship, sometimes like the October pattern but sometimes an inverted U-shape. In Figure 9, we see a similar pattern for leads.

The main impression of these results is that it is hard to detect any consistent pattern. Although a plausible effect is generally found in the month of the change, it is not the case that the estimated effects smoothly decay to zero as we increase the leads and lags. There is a lot of apparently arbitrary month-to-month variation. Most of the leads and lags have coefficients that are not significantly different from zero though this is not true for all of them. Our conclusion from this analysis is that there seems to be a clear contemporaneous impact and perhaps no impact in other months, but that this conclusion cannot be a strong one. This conclusion is the same as that of Dickens and Manning (2004a,b) who found no significant lead or lag effects.

One possibility is that the rise in the NMW in October has caused low-wage firms to shift their annual settlement date to October while other firms keep to the more

traditional January or April. If this is the case we might see a mirror-image of the pattern found in October in some other months and the total effect adds up to nothing. To investigate this we look at annual changes in log average earnings using from April to April (as this is 6 months from the rise in the NMW). Figure 10 shows the estimates for all plants – for the cubic and quartic specifications one does see larger effects in low-wage firms, followed by a region of firms in which the effect is essentially zero. But, one also sees larger effects in the highest-wage firms that would have to be caused by something other than changes in the NMW. Figure 11 restricts attention to low-wage firms and one gets similar, though slightly larger, results as was found for the September to October changes. This suggests that most of the effect is in October, the month of the change.

5. Local Labour Market Spill-Overs

Results from specifications extended to account for potential spill-over effects of the NMW across plants are presented in Table 5. Our approach to modelling spill-overs across plants is similar to that for direct effects, with the main difference being that the extent of spill-overs depends on the share of workers in the locality directly affected by the minimum wage that in turns is approximated by polynomials of different order in the average log wage in the locality. This approach is based on recent evidence that labour markets are local and over-lapping (Manning and Petrongolo, 2017).

Because the MWSS does not include information on the location of plants, this was mapped into MWSS using two other data sets collected by the ONS, the Business Structure Database (BSD) and the Annual Respondents Database (ARD) (see Appendix

for details about these data sets and for the mapping procedure). The average wage in the locality, used as a measure of the ‘bite’ of the NMW in the local labour market each plant operates, was calculated as the average of the log wage of all plants within a given radius around each plant (see Appendix for details). Given that there is a priory uncertainty of how local labour markets are, we present results using different definitions of the local labour market, including all plants within a radius of different length around each plant.

Table 5 includes coefficients estimates of the terms in the different polynomials in the plant-level fixed effect and in the locality average wage for locality defined as within 5 km radius around each plant. Results are reported for the sample restricted to low-wage plants, which is our preferred estimation sample, in all localities and in low-wage local-wage localities that include low-wage plants with local average wage below the median. Figures 12 and 13 plot marginal direct and local spill-over effects of the NMW, the former across percentiles of the plant fixed effect distribution and the latter across percentiles of the locality average log wage distribution, for the sample including all localities and low-wage localities respectively, based on estimates from Table 5. Results for coefficients of the terms in the different polynomials in the plant-level fixed effect for all localities in Table 5 are very similar to those in Panel A of Table 3 and therefore marginal direct effects presented in Figure 12 A are similar to those in Figure 6, suggesting that inclusion of polynomials in local average wage does not change the magnitude of direct effects. The latter effects persist across different definitions of locality that includes all plants within a wider area around each plant, i.e., 10km, 20 km, and 50 km, (see Tables A.1-A.3 in the Appendix).

Coefficient estimates of the terms of polynomials in the local average wage for all localities in Table 5 and Figure 12 B plotting the associated marginal effects are indicative of small spill-over effects of the NMW across plants in low-wage localities. Moreover, Figures 14A, 15A, and 16A that plot these effects for locality definition within 10, 20, and 50 km radius around each plant do not seem to suggest marked differences in spill-overs for different definitions of local labour market. The latter figures also reveal patterns consistent with a non-zero spill-over effect of the MW on the wage growth of plants in high-wage localities that may be suggestive, as in previous cases, of failure of identifying assumptions. This is why, similarly to the case of direct effects, in order to address this, we restrict the estimation sample to low-wage localities.

Results in Table 5 for the sample restricted to low-wage localities and Figure 13 A that plots the associated marginal direct effects suggest that direct effects become more pronounced compared to the sample including all localities. Moreover, this pattern persists across definitions of locality (see Tables A.1-A.3 in the Appendix). One explanation of this is that because low-wage plants are concentrated in low-wage localities,⁷ the share of affected workers in the locality is expected to be correlated with the share of affected workers at the firm, and given that the average wage in the locality is not a perfect measure of the share of affected workers in the locality part of the spill-over effect is picked up by the average wage at the plant. Alternatively, it may be that across-plant spill-overs also depend on the share of directly affected workers.

Figure 13 B suggest that spill-over effects also become more pronounced once the sample is restricted to low-wage localities. Moreover, Figures 14B, 15B, and 16B

⁷ We find evidence supporting this hypothesis, as the plant-level fixed effect is strongly and positively correlated with the local average wage.

indicate that this is particularly the case when locality is defined as the area with 10km around each plant and that no spill-over effects can be detected for locality definition within 50 km around the plant (see Table A.4 in the Appendix). The latter result could be explained by the fact that coefficient estimates and their associated standard errors, particularly for higher-order terms, increase in magnitude for locality definitions including plants in a larger range within the plant. This is because more extensive definitions of local labour market lead to larger overlap in local areas across plants that reduce variation in local average wage.

Overall, our results are consistent with spill-over effects of the NMW across plants, as suggested by evidence of larger effects of the NMW among plants in low-wage localities that decrease exponentially and converge to zero for plants further up the local average wage distribution. We also investigated whether spill-over effects take effect gradually using a similar approach as that for the timing of the direct effects and found evidence, presented in Figure 17, supporting that spill-over effects are contemporaneous with changes in the minimum wage.

6. Employment Effects

There is a large pre-existing literature on the employment effects of the UK's National Minimum Wage (see, for example, Machin, Manning and Rahman, 2003; Machin and Wilson, 2004; Stewart, 2002, 2004 and Stewart and Swaffield, 2008). A fair summary of this literature is that no significant disemployment effects have been found. But it is worth investigating the MWSS to see whether any effect can be found in this data set.

Our empirical strategy is the same as before, but the dependent variable is now the change in log employment not the change in log average earnings. The identification strategy is as before – see whether employment growth is significantly different in high and low-wage plants in times when the minimum wage is raised and times when it is not. The regression results comparable to those in Tables 2 and 3 (i.e., for all months or October only, all plants or only low-wage plants are presented in Tables 6 and 7. The predicted responses for the October only estimates are graphically in Figures 18 and 19.

There are a number of points worth noting. First, for the preferred specifications (October only), one cannot generally reject the hypothesis that the estimated coefficients on the minimum wage variables are not jointly significantly different from zero. So, unlike the estimated wage effects we can find no significant employment effects – this conclusion is in line with those of other studies. Secondly, the point estimates of the employment effect are negative in the lowest-wage plants suggesting as one might expect that there are modest job losses in very low-wage plants (as found, for example, in Machin, Manning and Rahman, 2003). The estimated elasticity in plants at the 5th percentile is about -0.1. In addition, there is perhaps a hint in Figure 19 that, for plants where the minimum wage is just-binding, there is actually a positive effect on employment. The inverted u-shape is what many monopsony models of the labour market would predict (e.g., see Manning, 2003).

These estimates are just for the change in employment from September to October – one might think that employment adjustment takes longer. So Figures 20 and 21 do the same exercise, but for the annual change in employment from April to April. There is even less evidence of an employment impact here.

7. Conclusion

This paper has used high-frequency plant-level data to investigate the impact of the minimum wage on wages and on employment. The main conclusions are the following. First, there does seem to be a detectable effect of the minimum wage on wages at plant-level with, as one would expect, a larger impact on low-wage plants. The estimated elasticity of wages with respect to the minimum wage is about 0.2 at the 5th percentile of the plant-level wage distribution. It then falls to zero at the twentieth percentile. Second, most of the effect seems to be concentrated in the month of implementation – we did not detect any systematic pattern of leads and lags. Third, there is evidence of spill-over effects of the minimum wage across plants manifesting as higher wage growth among plants in low-wage, more affected by the minimum wage, localities that decrease exponentially and converge to zero for plants further up the local average wage distribution. Fourth, no effect of the minimum wage on employment is found, as estimated employment effects were not significantly different from zero, though the point estimates do suggest that the employment effect is negative in the lowest-wage plants, but slightly positive in higher-wage plants where the minimum wage is just binding.

Table 1: Descriptive Statistics of Key Variables in the Monthly Wages and Salaries Survey

	All Plants
Total weekly paybill (£000)	645.382 (2291.047)
Employment	1551.248 (5953.285)
Average weekly earnings (£)	446.448 (257.943)
Average log weekly earnings	5.957 (0.550)
Average change in log weekly earnings	0.0023 (0.102)
Average change in log employment	-0.0013 (0.113)
Number of reporting units	42586
Number of observations	1525503

Notes: Sample is January 2000-February 2016 inclusive. Figures are averages with standard deviations in parentheses.

Table 2: The Impact of the Minimum Wage on Earnings Growth: All Plants

Change in Log NMW Interacted with	Plant Fixed Effect	Square of Plant Fixed Effect	Cube of Plant Fixed Effect	4 th Power of Plant Fixed Effect	F-test (p-value)
A. All Months					
(1)	0.005 (0.019)				0.788
(2)	0.020 (0.017)	0.071*** (0.023)			0.001
(3)	0.060** (0.029)	0.050** (0.019)	-0.041 (0.025)		0.003
(4)	0.099*** (0.024)	0.123*** (0.038)	-0.088*** (0.020)	-0.039** (0.016)	0.000
Observations	1402370	1402370	1402370	1402370	
B. October Only					
(1)	-0.032 (0.032)				0.325
(2)	-0.016 (0.032)	0.071*** (0.023)			0.007
(3)	0.022 (0.042)	0.049** (0.019)	-0.042* (0.025)		0.022
(4)	0.064* (0.037)	0.122*** (0.038)	-0.088*** (0.020)	-0.038** (0.016)	0.000
Observations	117242	117242	117242	117242	

Notes: Standard errors clustered at the reporting unit level in parentheses. All specifications include time effects and the plant fixed effect, but their coefficients are not reported.

Table 3: The Impact of the Minimum Wage on Earnings Growth: Low-Wage Plants

Change in Log NMW Interacted with	Plant Fixed Effect	Square of Plant Fixed Effect	Cube of Plant Fixed Effect	4 th Power of Plant Fixed Effect	F-test (p-value)
A. All Months					
(1)	-0.128*** (0.047)				0.006
(2)	0.057 (0.124)	0.131 (0.094)			0.022
(3)	0.452** (0.202)	0.685** (0.299)	0.191* (0.115)		0.004
(4)	0.567* (0.295)	0.927 (0.592)	0.357 (0.387)	0.034 (0.076)	0.000
Observations	602277	602277	602277	602277	
B. October Only					
(1)	-0.142* (0.081)				0.079
(2)	0.039 (0.155)	0.131 (0.093)			0.070
(3)	0.444** (0.212)	0.683** (0.298)	0.190* (0.114)		0.010
(4)	0.559* (0.287)	0.930 (0.598)	0.359 (0.392)	0.034 (0.078)	0.016
Observations	50156	50156	50156	50156	

Notes: Standard errors clustered at the reporting unit level in parentheses. All specifications include time effects and the plant fixed effect, but their coefficients are not reported. The sample is restricted to plants with a wage fixed effect below the median.

Table 4: IV Estimates of the Impact of the Minimum Wage on Earnings Growth

Change in Log NMW Interacted with	Plant Fixed Effect	Square of Plant Fixed Effect	Cube of Plant Fixed Effect	4 th Power of Plant Fixed Effect	F-test (p-value)
A. October only-All Plants					
(1)	-0.032 (0.032)				0.324
(2)	0.019 (0.034)	0.070*** (0.023)			0.007
(3)	0.051 (0.044)	0.035* (0.021)	-0.043* (0.025)		0.020
(4)	0.106*** (0.039)	0.099** (0.041)	-0.100*** (0.023)	-0.038** (0.018)	0.000
Observations	602277	602277	602277	602277	
B. October only-Low-Wage Plants					
(1)	-0.140* (0.080)				0.078
(2)	0.105 (0.195)	0.131 (0.092)			0.066
(3)	0.714** (0.323)	0.807** (0.385)	0.212 (0.133)		0.010
(4)	0.797* (0.448)	0.954 (0.788)	0.305 (0.490)	0.018 (0.096)	0.016
Observations	50156	50156	50156	50156	

Notes: Standard errors clustered at the reporting unit level in parentheses. All specifications include time effects and the plant fixed effect, but their coefficients are not reported. Low-wage plants are those with plant fixed effect below the median. Endogenous variables are the interactions of the log change in the minimum wage with

Table 5: Direct and Local Spill-Over Effects of the Minimum Wage on Earnings Growth: Low-Wage Plants, Locality within 5 Km Radius around the Plant

	A. All Localities				B. Low-Wage Localities			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Change in Log NMW Interacted with								
Plant Fixed Effect	-0.138*** (0.047)	0.035 (0.126)	0.457** (0.205)	0.595** (0.301)	-0.198*** (0.060)	-0.074 (0.160)	0.289 (0.247)	0.241 (0.394)
Square of Plant Fixed Effect		0.122 (0.095)	0.711** (0.303)	1.007* (0.601)		0.085 (0.119)	0.573 (0.358)	0.477 (0.772)
Cube of Plant Fixed Effect			0.202* (0.116)	0.407 (0.391)			0.159 (0.133)	0.096 (0.486)
4 th Power of Plant Fixed Effect				0.042 (0.077)				-0.012 (0.091)
Average Log Wage in Locality	-0.412** (0.181)	-0.409** (0.175)	-0.456** (0.197)	-0.438** (0.191)	-0.769** (0.329)	-1.772*** (0.570)	-1.176 (1.427)	-1.834 (2.710)
Square of Average Log Wage in Locality		-0.102 (0.760)	-0.119 (0.752)	1.211 (1.140)		-3.449** (1.344)	-0.066 (7.364)	-6.162 (21.305)
Cube of Average Log Wage in Locality			0.735 (1.651)	0.322 (1.015)			3.971 (8.005)	-14.952 (58.637)
4 th Power of Average Log Wage in Locality				-5.580** (2.391)				-16.223 (47.844)
F-test for Interactions with Plant fixed-effect (p-value)	0.003	0.013	0.003	0.005	0.001	0.003	0.006	0.013
F-test for Interactions with Average Log Wage in Locality (p-value)	0.022	0.057	0.109	0.007	0.019	0.008	0.008	0.018
Observations	580841	580841	580841	580841	337805	337805	337805	337805

Notes: Standard errors clustered at the reporting unit level in parentheses. All specifications include time effects, the plant fixed effect, and the average log wage in the locality, but their coefficients are not reported. Locality is defined as the area within 5 km radius around the plant. Low-wage plants are those with plant fixed effect below the median. Low-wage localities are those with average log wage below the median.

Table 6: The Impact of the Minimum Wage on Employment Growth: All Plants

Change in Log NMW Interacted with	Plant Fixed Effect	Square of Plant Fixed Effect	Cube of Plant Fixed Effect	4 th Power of Plant Fixed Effect	F-test (p-value)
A. All Months					
(1)	-0.050** (0.021)				0.017
(2)	-0.065*** (0.019)	-0.070*** (0.025)			0.000
(3)	-0.051* (0.031)	-0.077*** (0.021)	-0.014 (0.025)		0.000
(4)	-0.087*** (0.028)	-0.144*** (0.037)	0.028 (0.022)	0.035** (0.014)	0.000
Observations	1402370	1402370	1402370	1402370	
B. October Only					
(1)	-0.046 (0.034)				0.184
(2)	-0.061* (0.034)	-0.070*** (0.025)			0.006
(3)	-0.048 (0.046)	-0.077*** (0.021)	-0.014 (0.025)		0.000
(4)	-0.087** (0.042)	-0.144*** (0.037)	0.028 (0.022)	0.035** (0.014)	0.000
Observations	117242	117242	117242	117242	

Notes: Standard errors clustered at the reporting unit level in parentheses. All specifications include time effects and the plant fixed effect, but their coefficients are not reported.

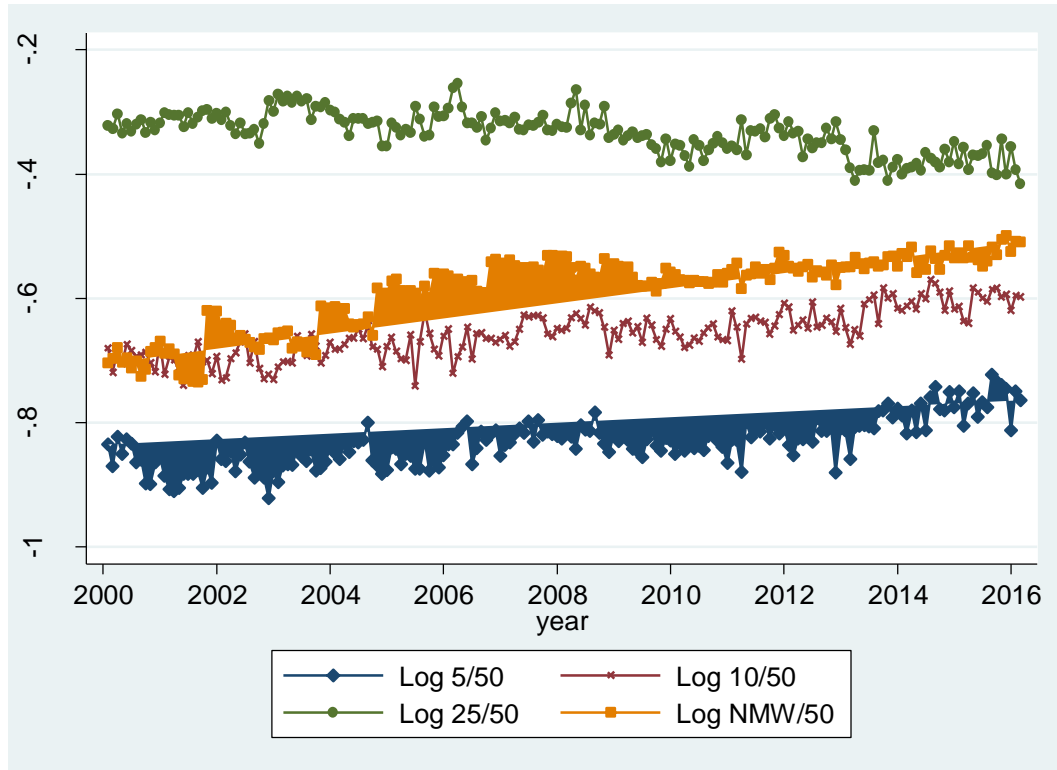
Table 7: The Impact of the Minimum Wage on Employment Growth: Low-Wage Plants

Change in Log NMW Interacted with	Plant Fixed Effect	Square of Plant Fixed Effect	Cube of Plant Fixed Effect	4 th Power of Plant Fixed Effect	F-test (p-value)
A. All Months					
(1)	0.062 (0.053)				0.238
(2)	0.178 (0.137)	0.082 (0.101)			0.232
(3)	-0.141 (0.210)	-0.365 (0.282)	-0.154 (0.102)		0.239
(4)	-0.277 (0.357)	-0.653 (0.711)	-0.351 (0.467)	-0.040 (0.088)	0.362
Observations	602277	602277	602277	602277	
B. October Only					
(1)	-0.142* (0.081)				0.515
(2)	0.039 (0.155)	0.131 (0.093)			0.622
(3)	0.444** (0.212)	0.683** (0.298)	0.190* (0.114)		0.474
(4)	0.559* (0.287)	0.930 (0.598)	0.359 (0.392)	0.034 (0.078)	0.591
Observations	50156	50156	50156	50156	

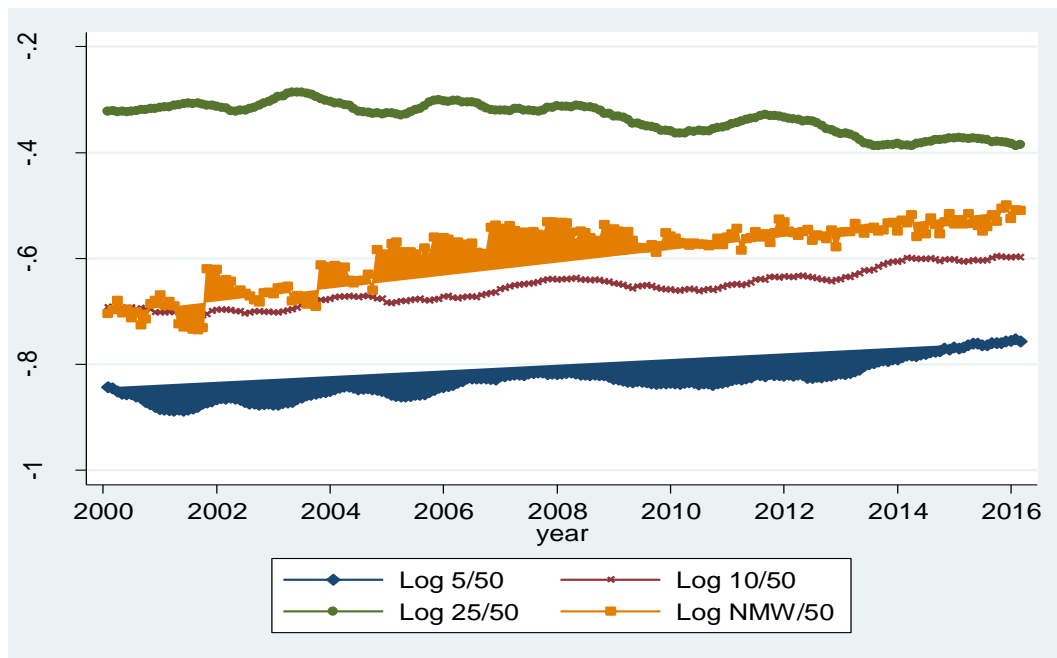
Notes: Standard errors clustered at the reporting unit level in parentheses. All specifications include time effects and the plant fixed effect, but their coefficients are not reported. The sample is restricted to plants with a wage fixed effect below the median.

Figure 1
The Evolution of Lower-Tail Wage Inequality in the MWSS

a. Raw Data



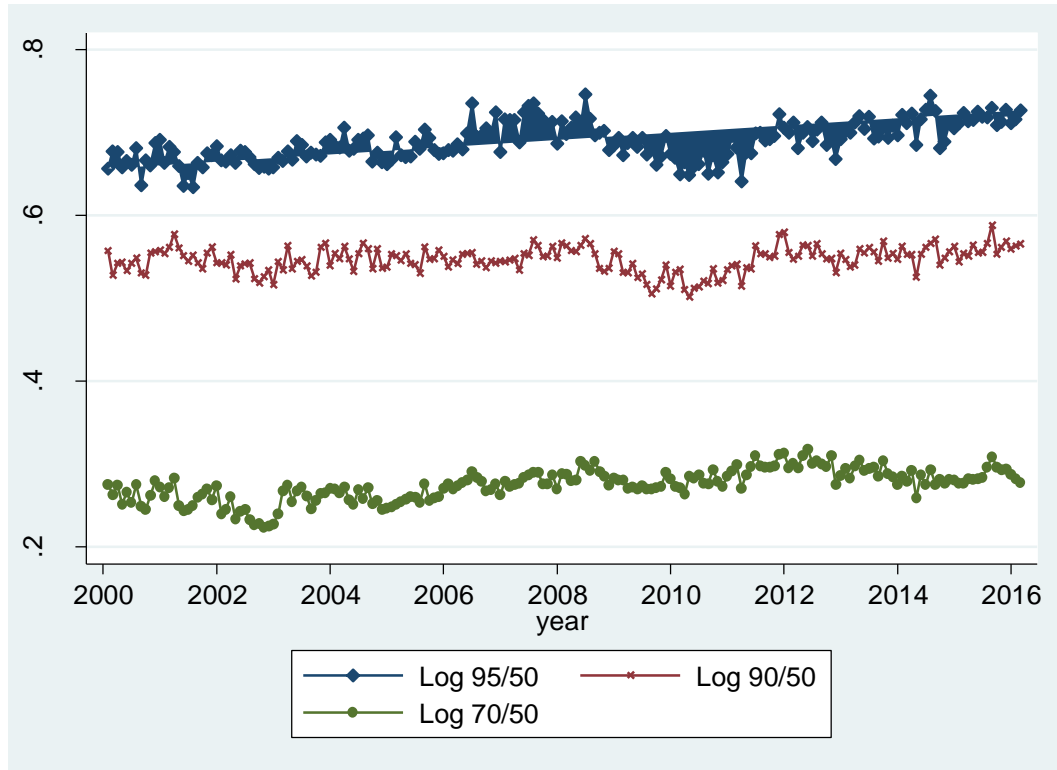
b. Smoothed Data



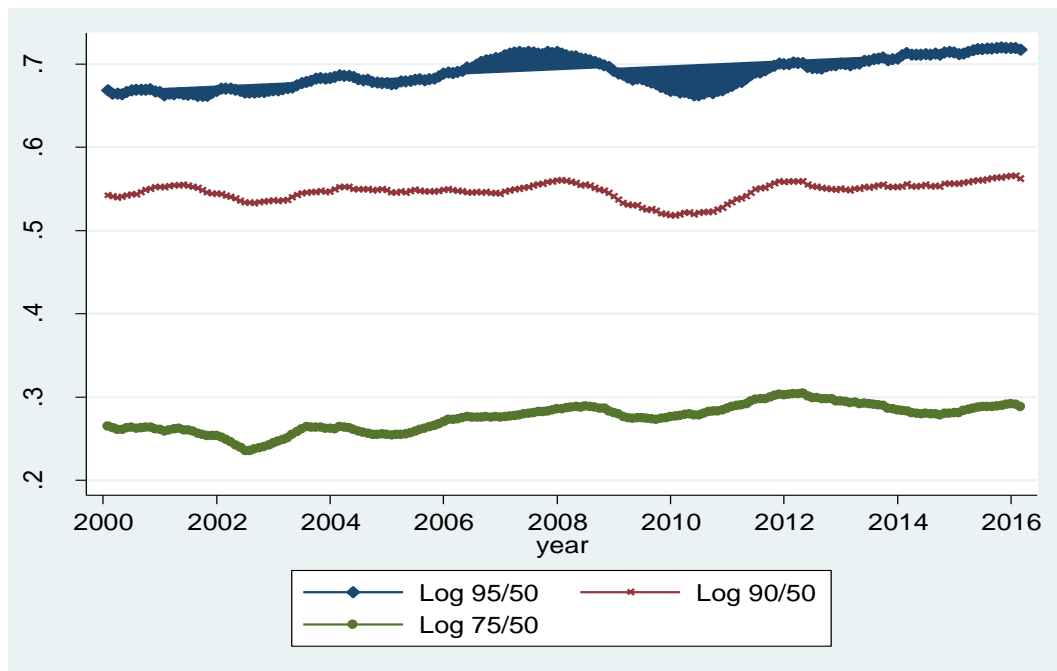
Notes: Series are smoothed using a 12-month moving average

Figure 2
The Evolution of Upper-Tail Wage Inequality in the MWSS

a. Raw Data

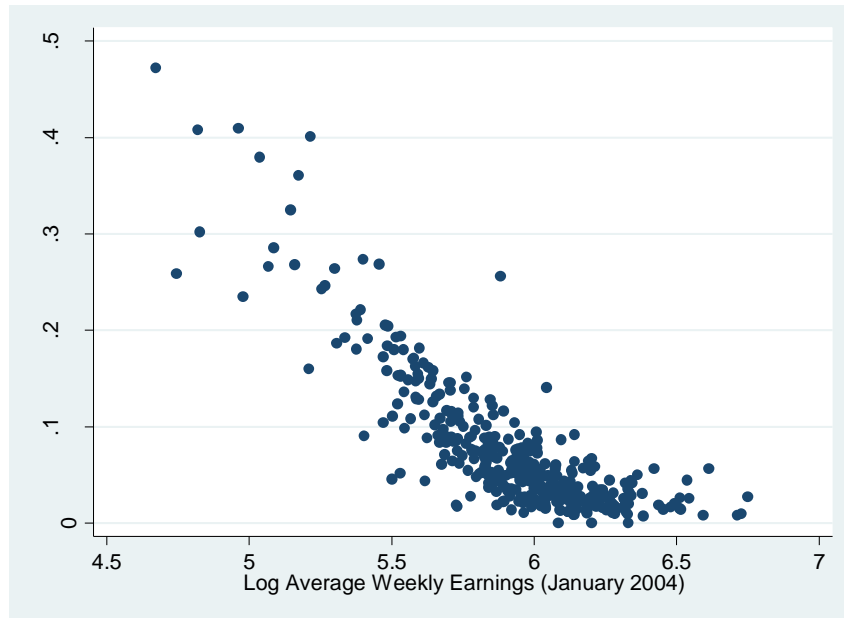


b. Smoothed Data



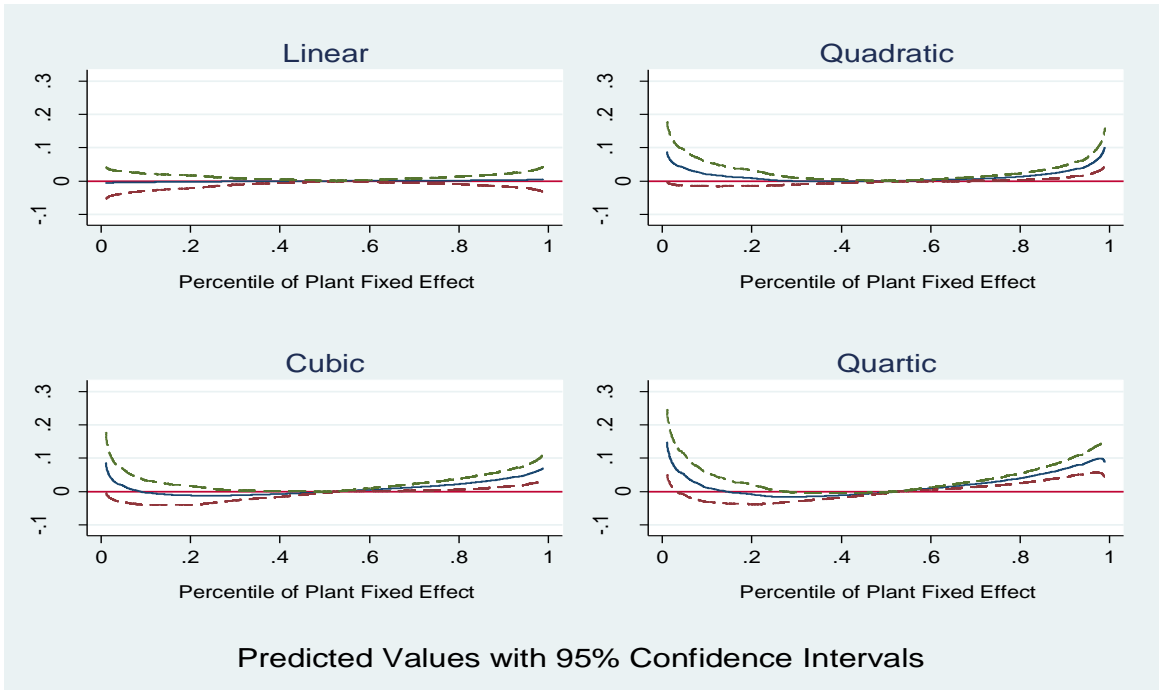
Notes: Series are smoothed using a 12-month moving average

Figure 3
The Relationship Between the incidence of low pay and average weekly earnings at industry level



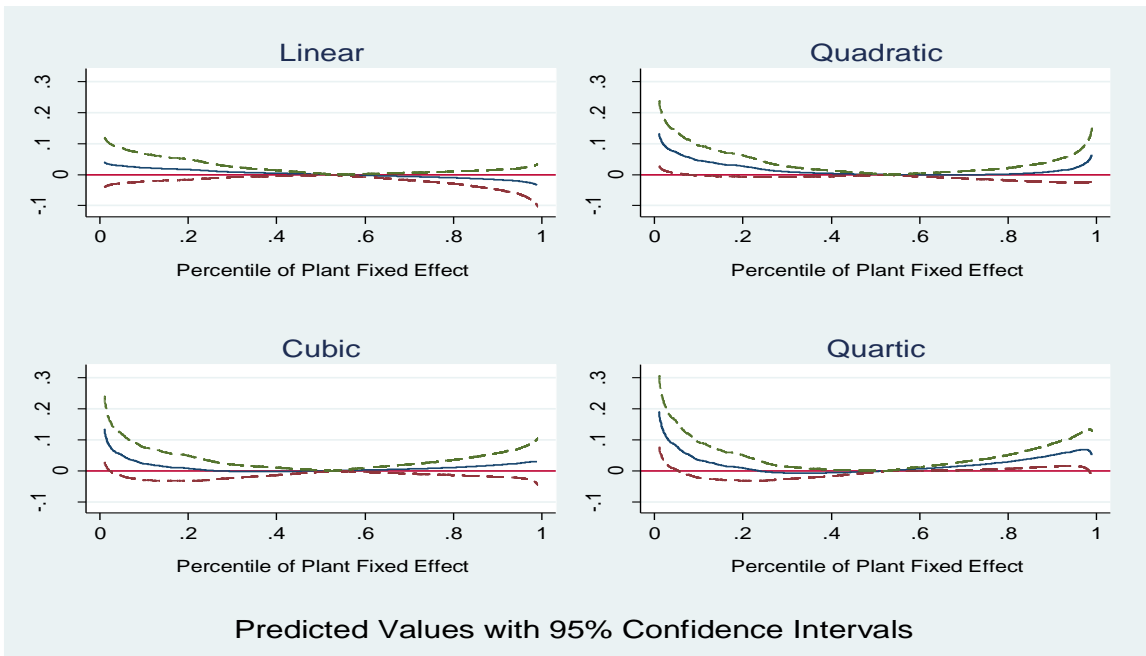
Notes: Source, authors' computations from Labour Force Survey

Figure 4
The Estimated Elasticity of Earnings with Respect to the Minimum Wage:
All Months, All Plants



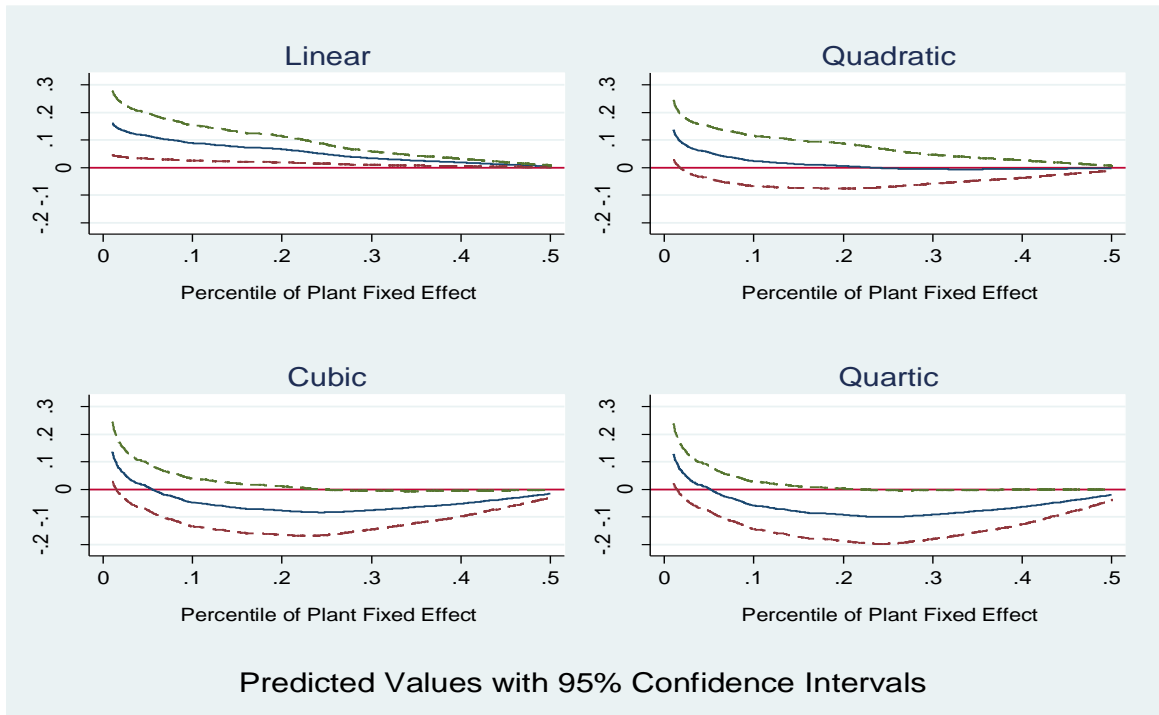
Notes: Figures produced are based on estimated results from Table 2, Panel A.

Figure 5
The Estimated Elasticity of Earnings with Respect to the Minimum Wage:
October Only, All Plants



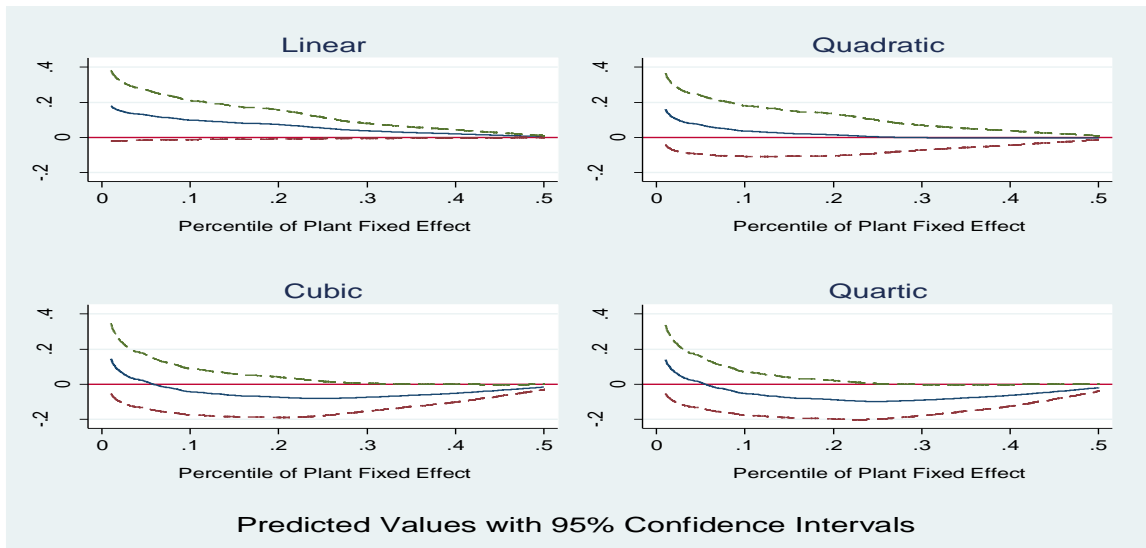
Notes: Figures produced are based on estimated results from Table 2, Panel B.

Figure 6
The Estimated Elasticity of Earnings with Respect to the Minimum Wage:
All Months, Low-Wage Plants



Notes: Figures produced are based on estimated results from Table 3, Panel A. Low-wage plants are all plants with a plant fixed effect below the median.

Figure 7
The Estimated Elasticity of Earnings with Respect to the Minimum Wage:
October Only, Low-Wage Plants



Notes: Figures produced are based on estimated results from Table 3, Panel B. Low-wage plants are all plants with a plant fixed effect below the median.

Figure 8
The Impact of Lags of Changes in the National Minimum Wage

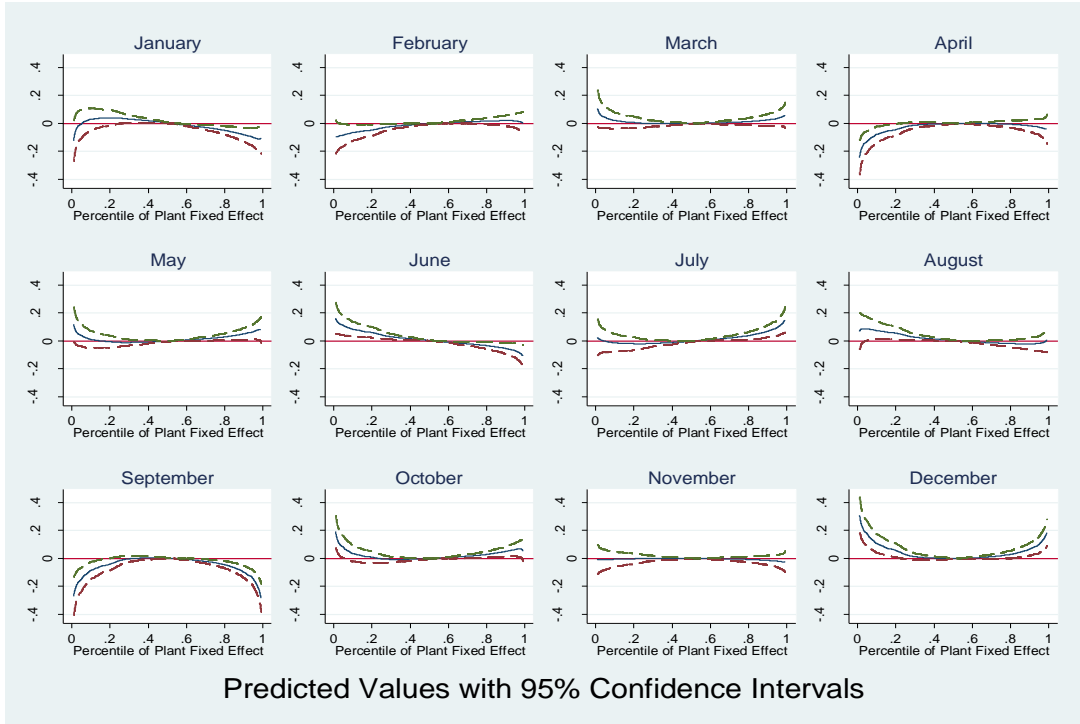


Figure 9
The Impact of Leads of Changes in the National Minimum Wage

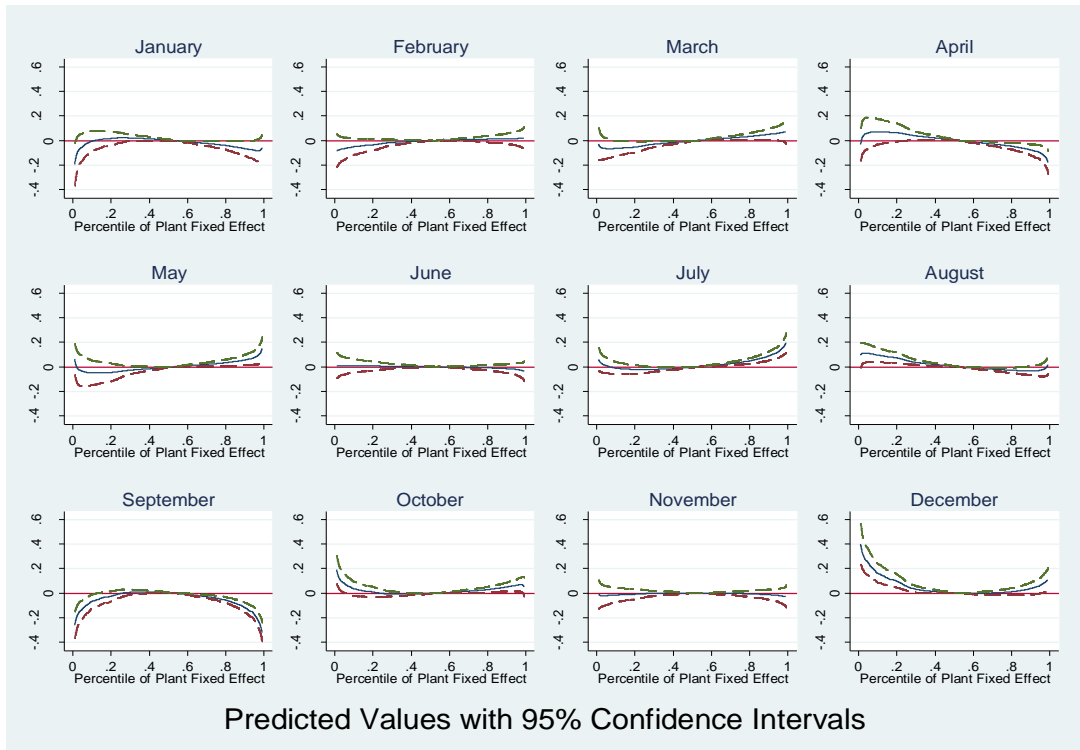
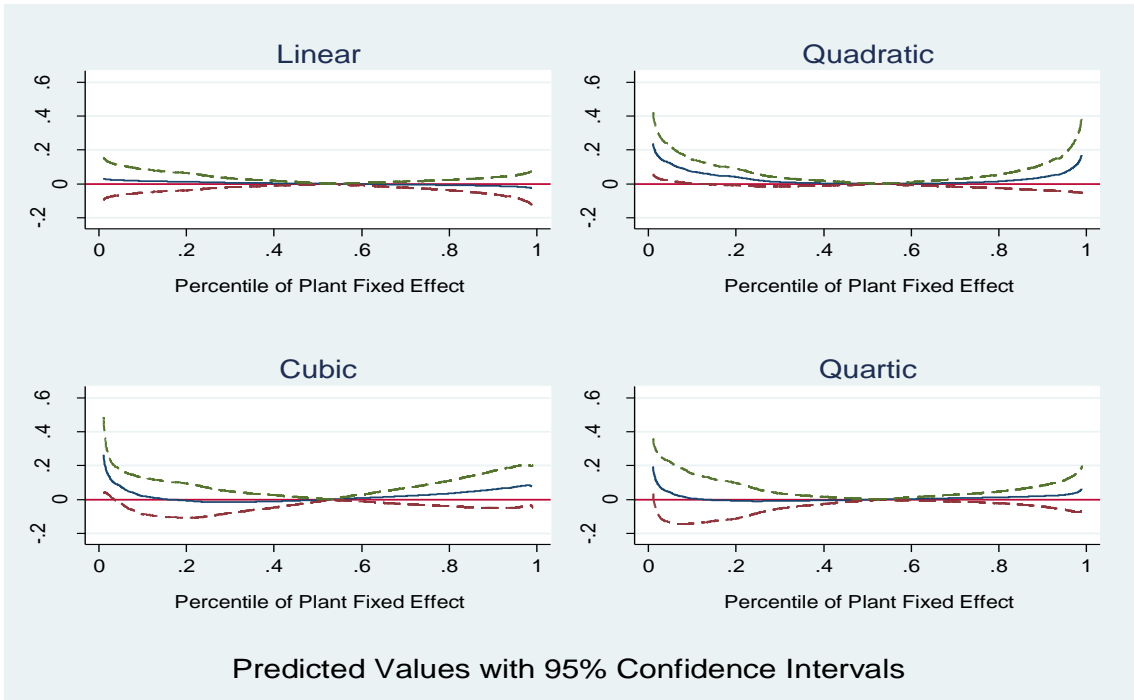
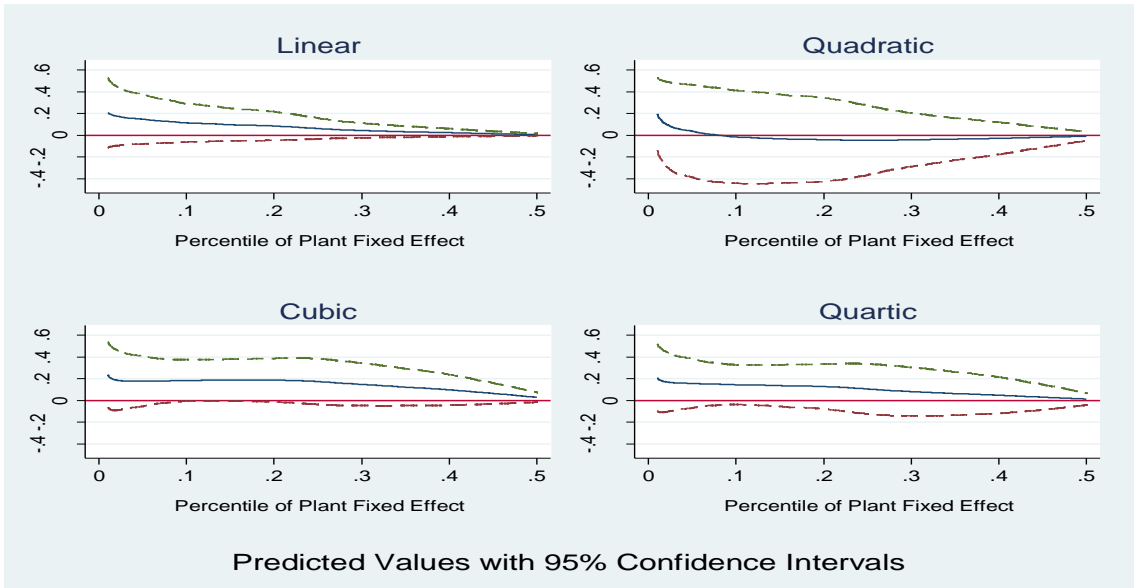


Figure 10
Long-Period Changes in Average Earnings: All Plants



Notes: Figures produced are based on specifications as those in Table 2, Panel A, with the dependent variable being the annual change in the average plant wage from April to April.

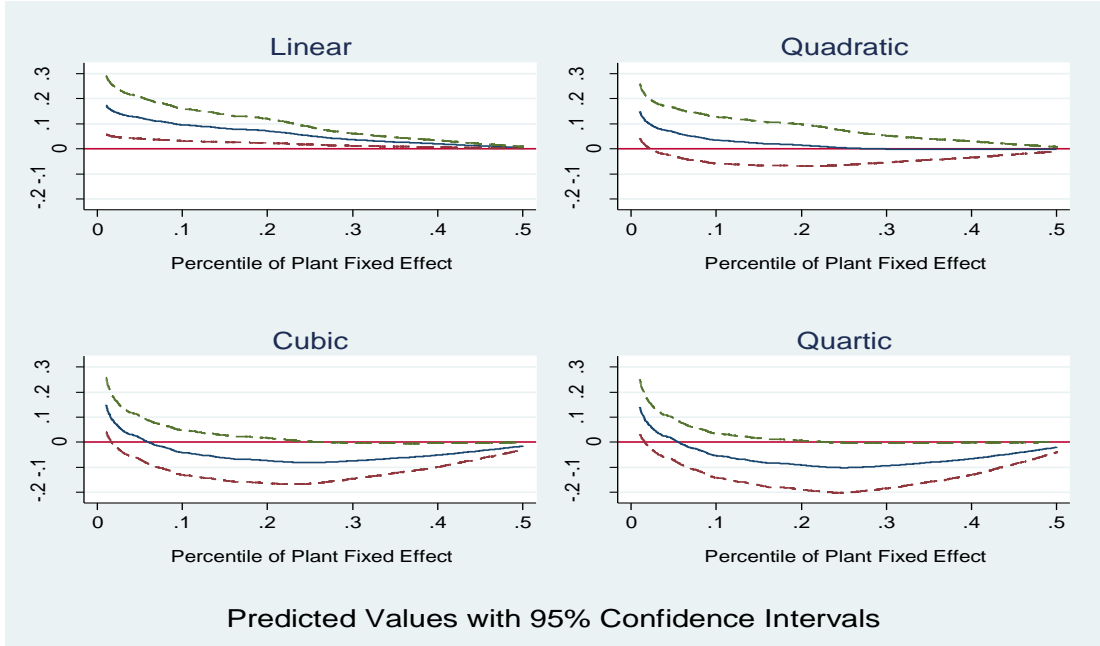
Figure 11
Long-Period Changes in Average Earnings: Low-Wage Plants



Notes: Figures produced are based on specifications as those in Table 3, Panel A, with the dependent variable being the annual change in the average plant wage from April to April. Low-wage plants are all plants with a plant fixed effect below the median.

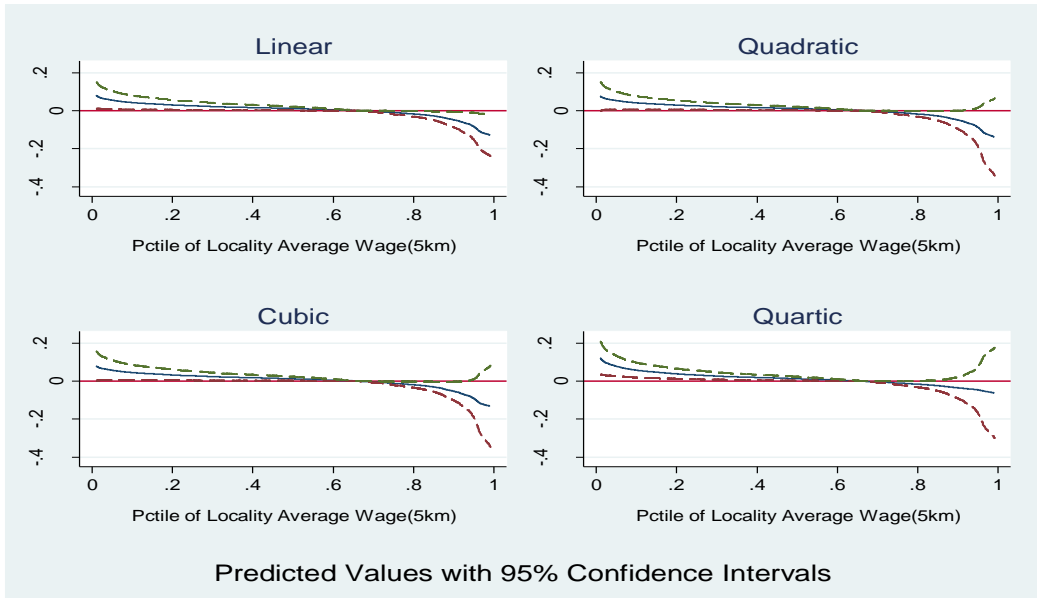
Figure 12
The Estimated Elasticity of Earnings with Respect to the Minimum Wage:
All Months, Low-Wage Plants

A. Direct Effects



Notes: Figures produced are based on estimated results in rows three to six of Table 5, Panel A. Low-wage plants are all plants with a plant fixed effect below the median.

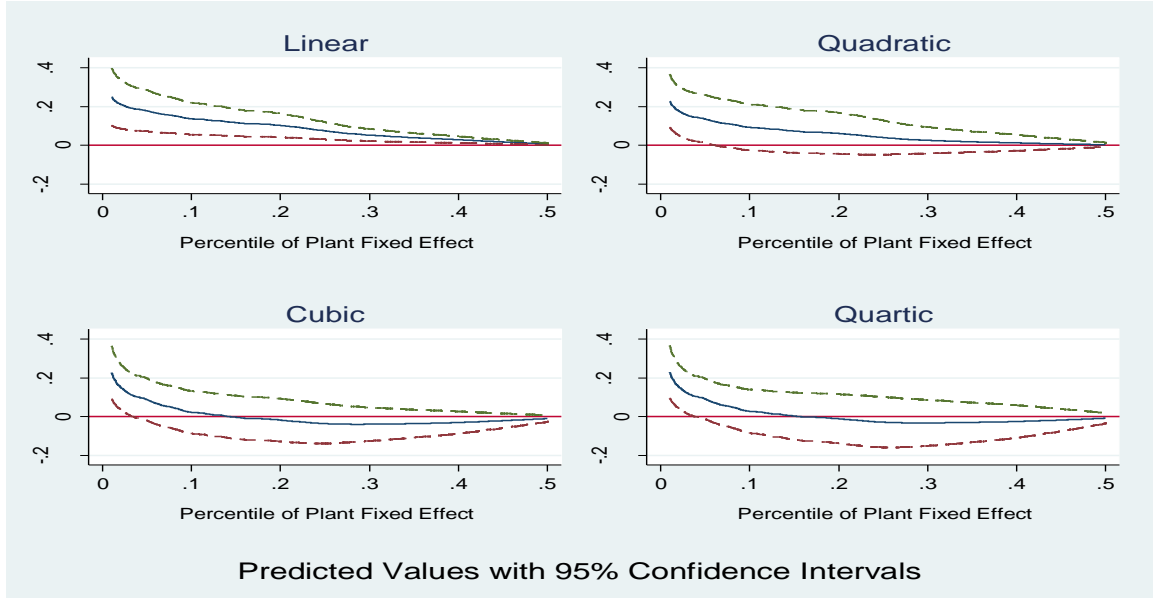
B. Local Spill-Over Effects, Locality within 5 km Radius around the Plant



Notes: Figures produced are based on estimated results in rows seven to ten from Table 5, Panel A. Low-wage plants are all plants with a plant fixed effect below the median.

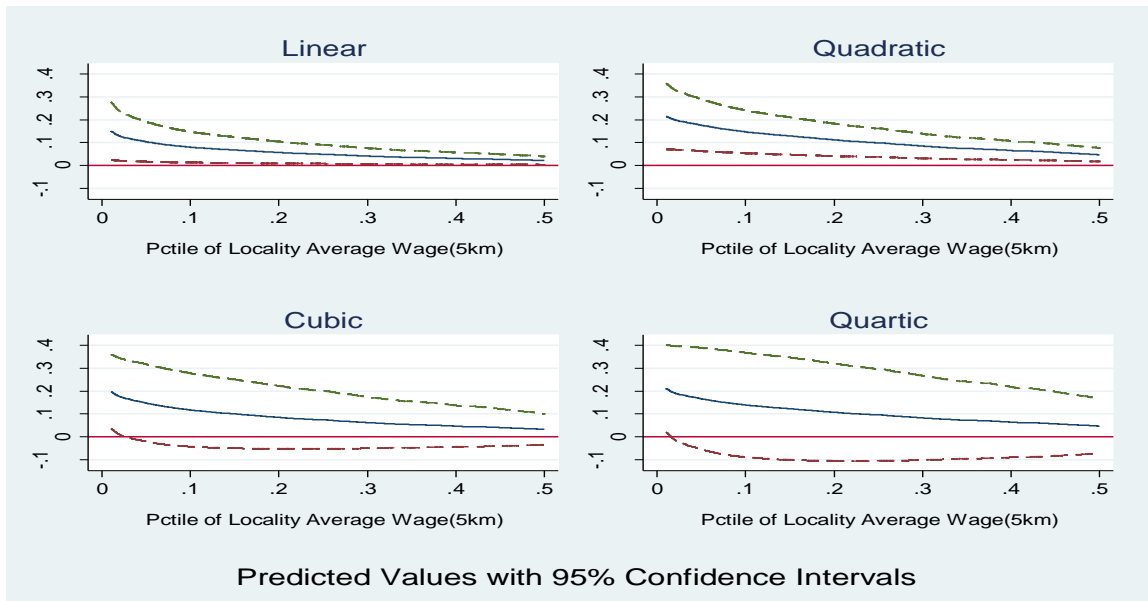
Figure 13
The Estimated Elasticity of Earnings with Respect to the Minimum Wage:
All Months, Low-Wage Plants, Low-Wage Localities

A. Direct Effects



Notes: Figures produced are based on estimated results in rows three to six of Table 5, Panel B. Low-wage plants are those plants with plant fixed effect below the median. Low-wage localities are those with average log wage below the median.

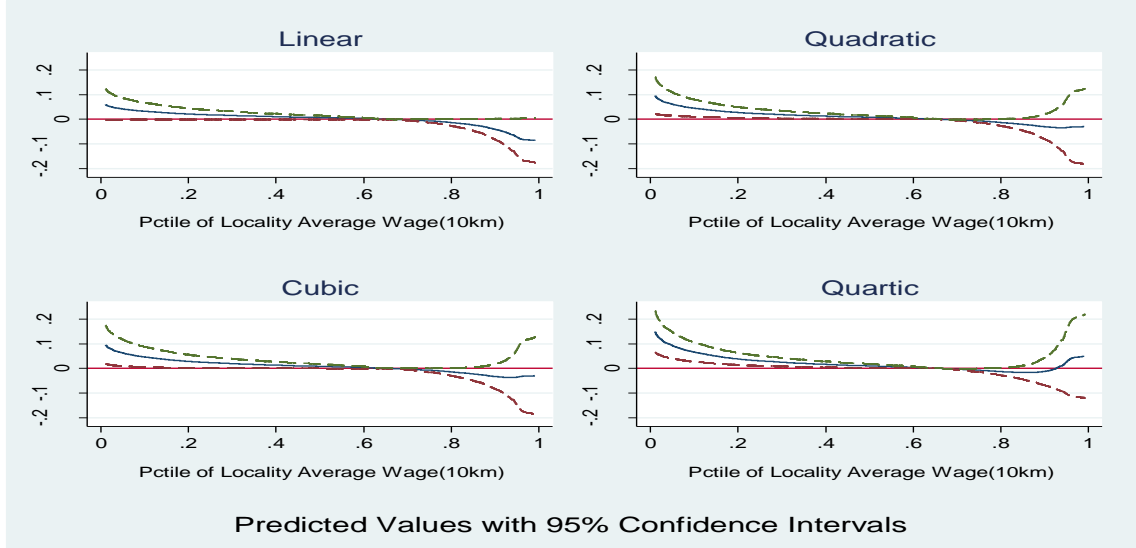
B. Local Spill-Over Effects, Locality within 5 Km Radius around the Plant



Notes: Figures produced are based on estimated results in rows seven to ten from Table 5, Panel B. Low-wage plants are all plants with a plant fixed effect below the median. Low-wage localities are those with average log wage below the median.

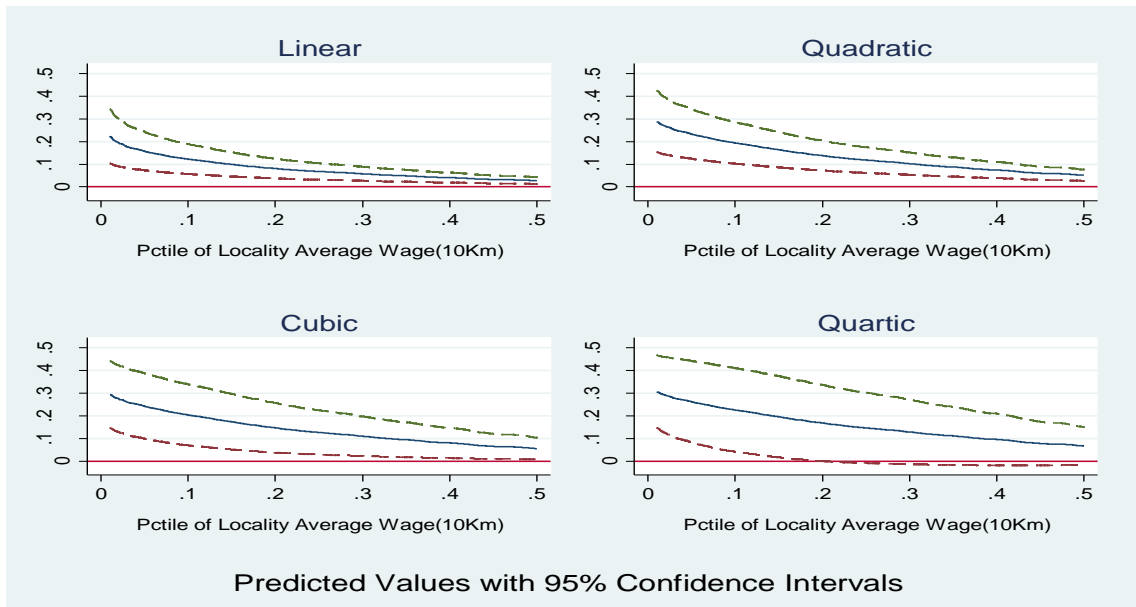
Figure 14
Local Spill-Over Effects of the Minimum Wage on Earnings Growth: Low-Wage
Plants, Locality within 10 km Radius around the Plant

A. All Localities



Notes: Figures produced are based on specifications as those in Table 5, Panel A, with locality being defined as within 10 km radius around the plant. Low-wage plants are those plants with plant fixed effect below the median.

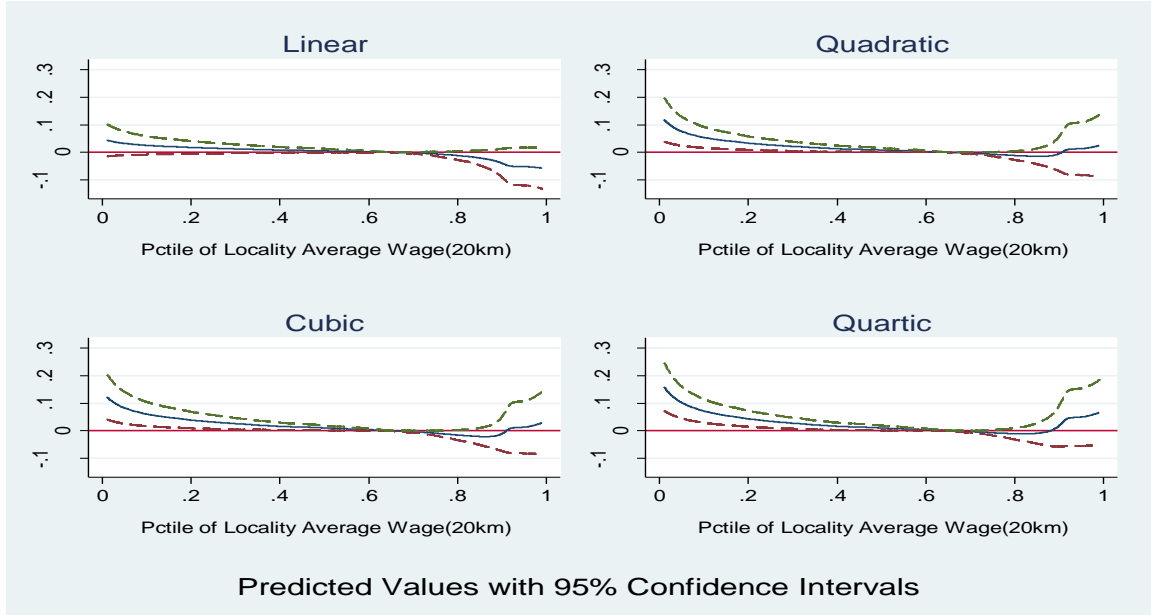
B. Low-Wage Localities



Notes: Figures produced are based on specifications as those in Table 5, Panel B, with locality being defined as within 10 km radius around the plant. Low-wage plants are those plants with plant fixed effect below the median. Low-wage localities are those with average log wage below the median.

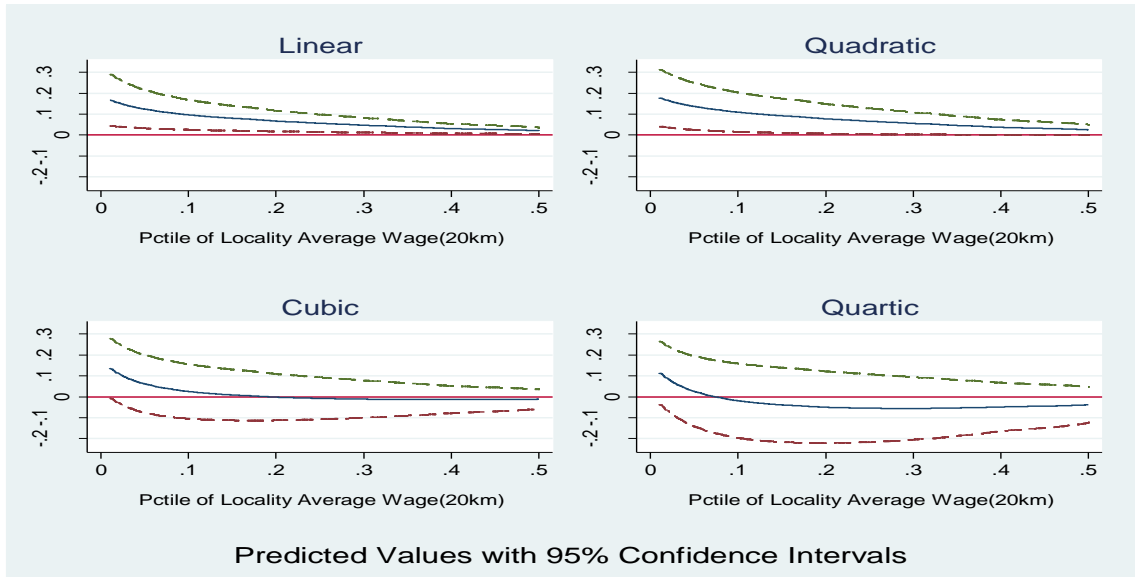
Figure 15
Local Spill-Over Effects of the Minimum Wage on Earnings Growth: Low-Wage
Plants, Locality within 20 km Radius around the Plant

A. All Localities



Notes: Figures produced are based on specifications as those in Table 5, Panel A, with locality being defined as within 20 km radius around the plant. Low-wage plants are those plants with plant fixed effect below the median.

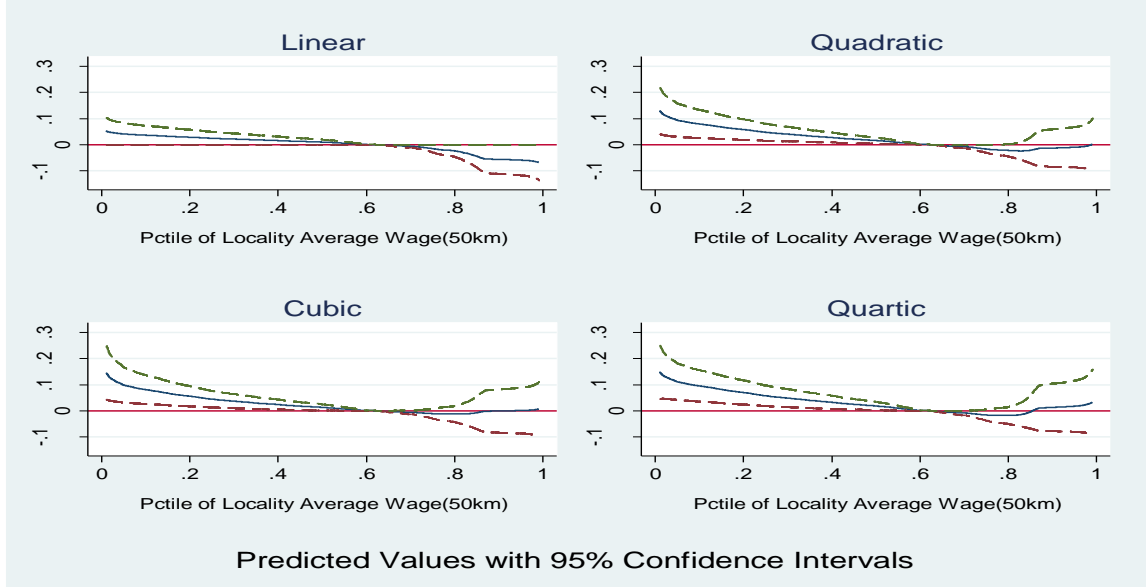
B. Low-Wage Localities



Notes: Figures produced are based on specifications as those in Table 5, Panel B, with locality being defined as within 20 km radius around the plant. Low-wage plants are those plants with plant fixed effect below the median. Low-wage localities are those with average log wage below the median.

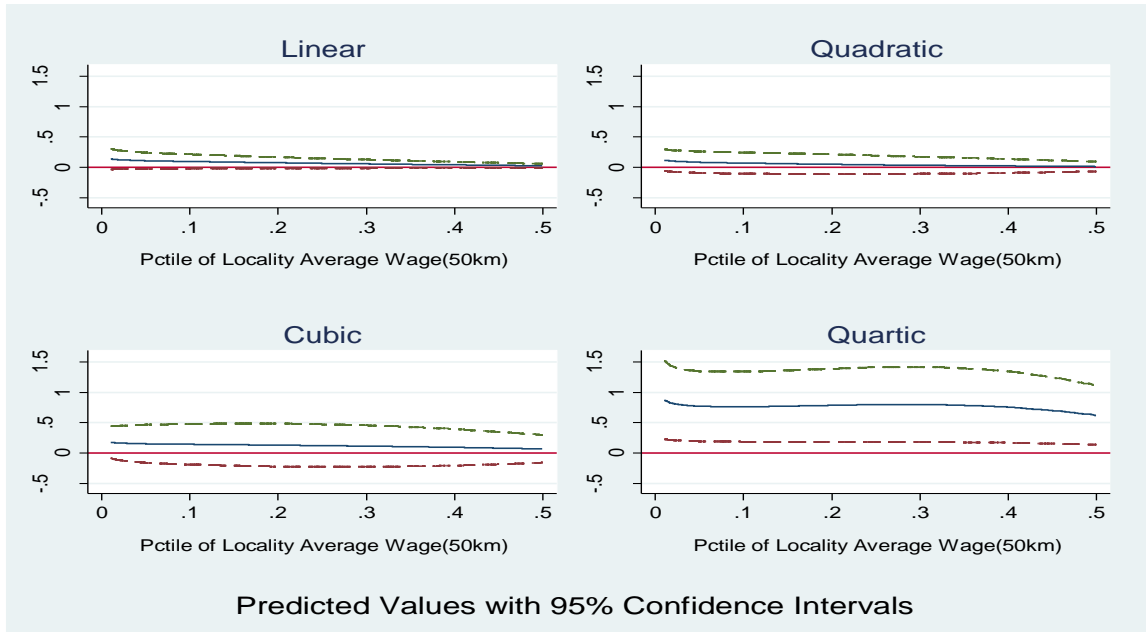
Figure 16
Local Spill-Over Effects of the Minimum Wage on Earnings Growth: Low-Wage Plants, Locality within 50 km Radius around the Plant

A. All Localities



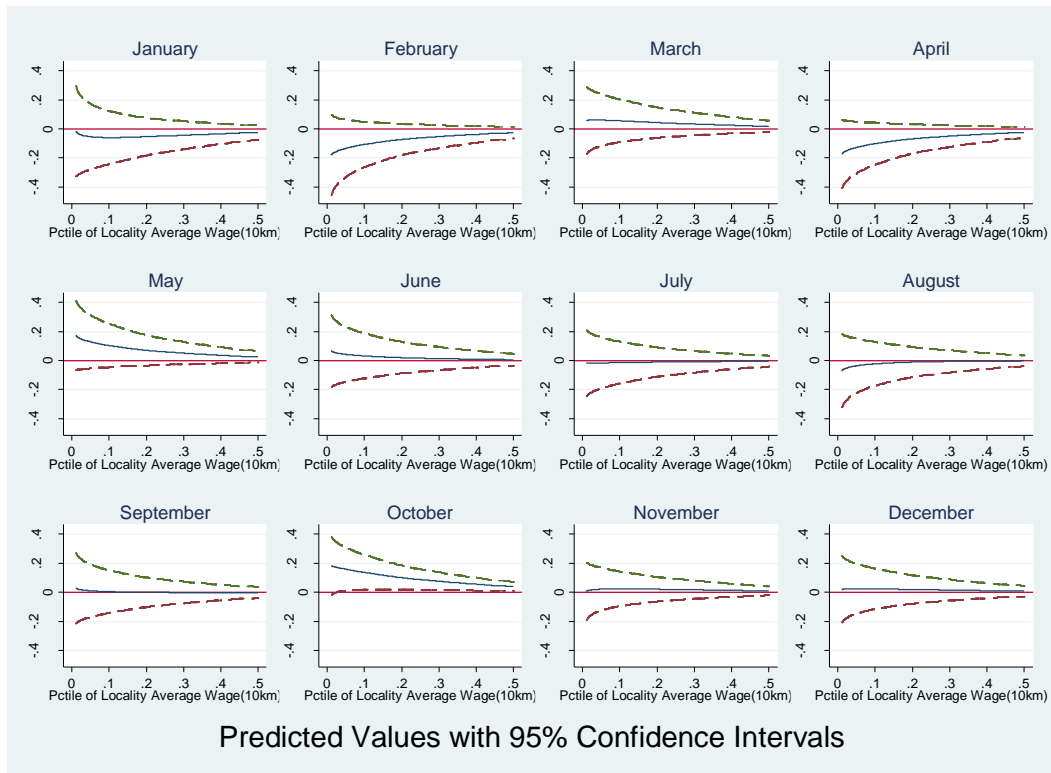
Notes: Figures produced are based on specifications as those in Table 5, Panel A, with locality being defined as within 50 km radius around the plant. Low-wage plants are those plants with plant fixed effect below the median.

B. Low-Wage Localities



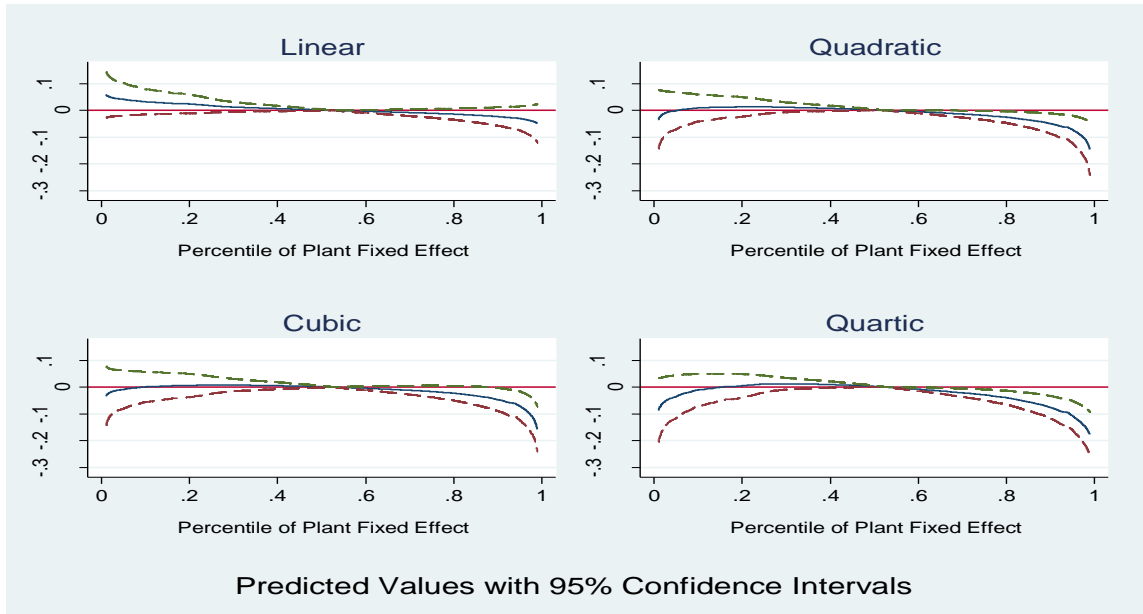
Notes: Figures produced are based on specifications as those in Table 5, Panel B, with locality being defined as within 50 km radius around the plant. Low-wage plants are those plants with plant fixed effect below the median. Low-wage localities are those with average log wage below the median.

Figure 17
The Timing of Local Spill-Over Effects of the Minimum Wage on Earnings Growth:
Low-Wage Plants and Low-Wage Localities



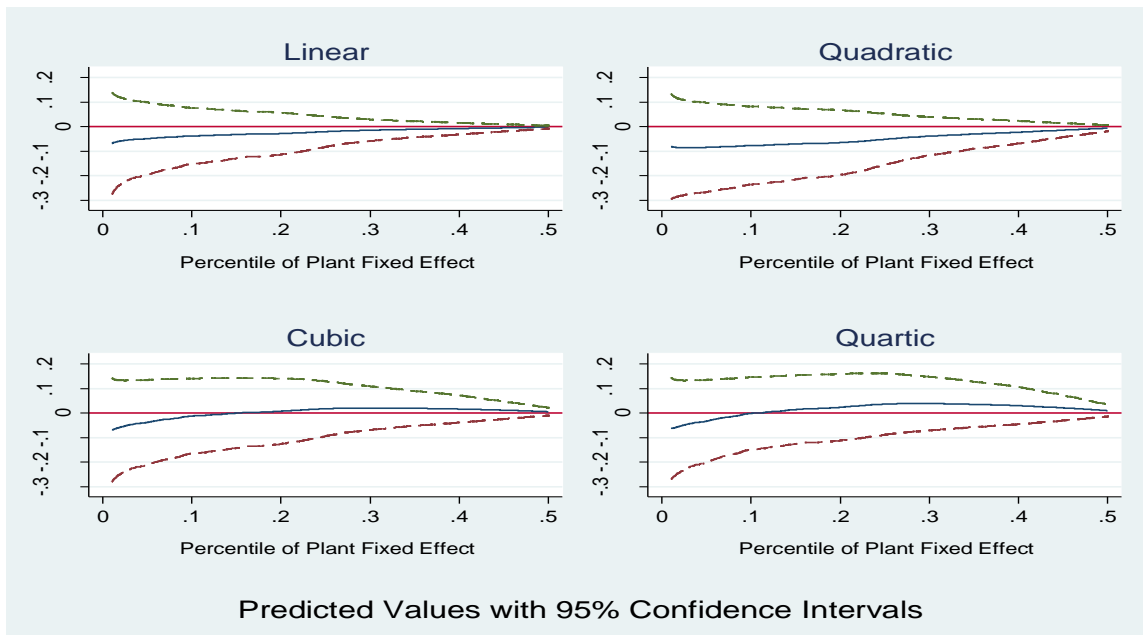
Notes: Specifications include a quadratic in the lag of plant level average wage and a quadratic in the lag of average wage in the locality, where the lag order is determined by the number of periods elapsed between the latest change in the minimum wage and the period wage growth is measured. Low-wage plants are those plants with plant fixed effect below the median. Low-wage localities are those with average log wage below the median.

Figure 18
The Estimated Elasticity of Employment with Respect to the Minimum Wage,
October only, All Plants



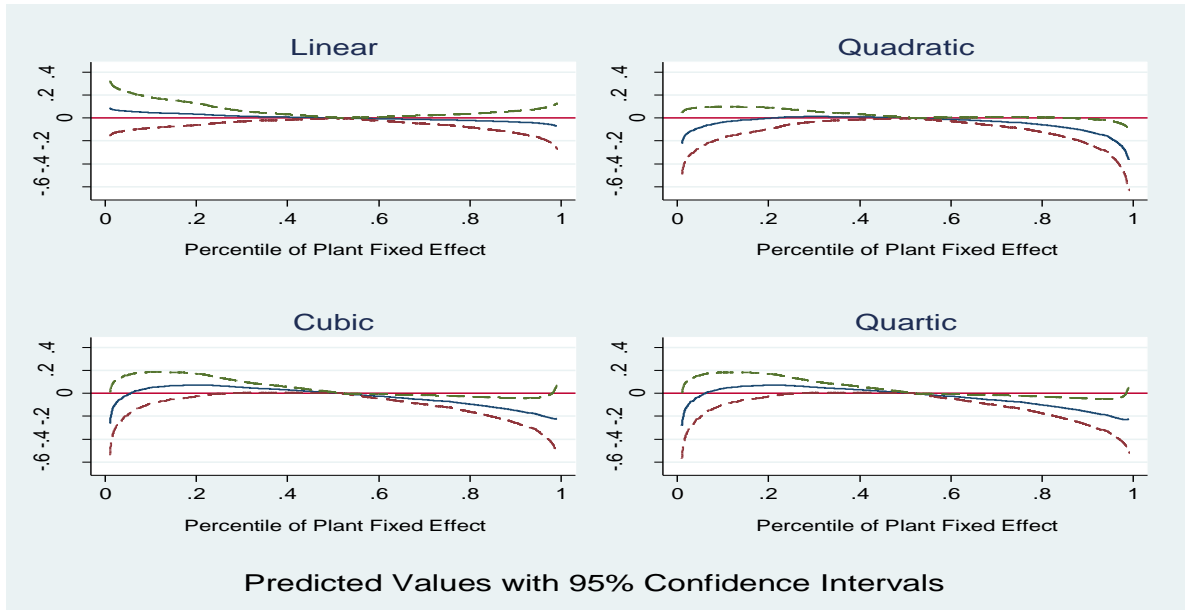
Notes: Figures produced are based on estimated results from Table 6, Panel B.

Figure 19
The Estimated Elasticity of Employment with Respect to the Minimum Wage,
October only, Low-Wage Plants



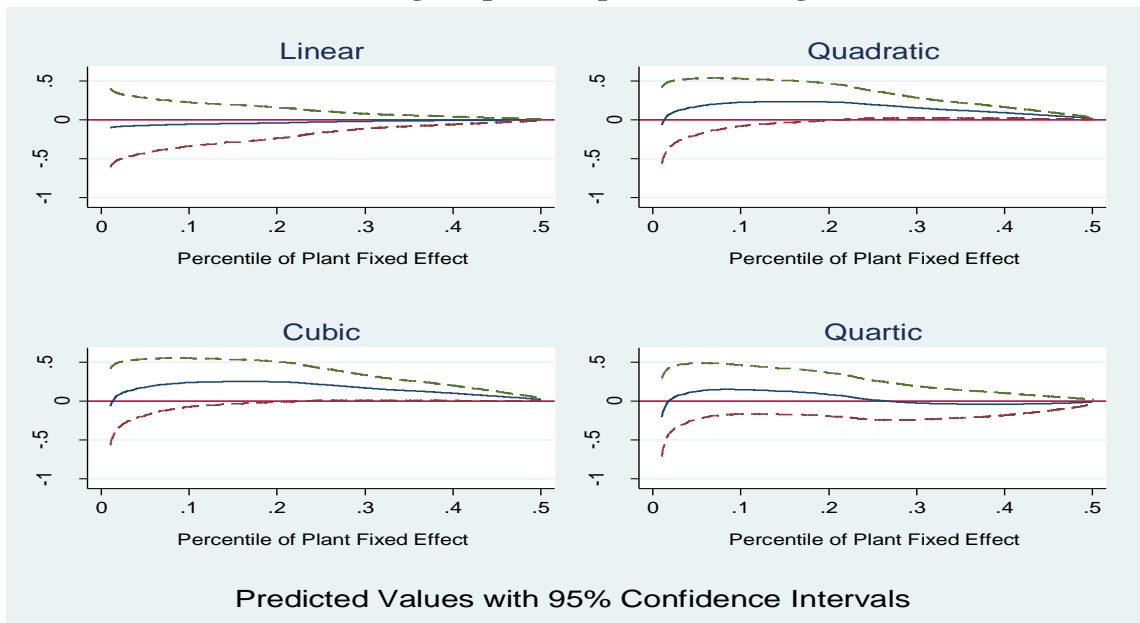
Notes: Figures produced are based on estimated results from Table 7, Panel B. Low-wage plants are those plants with plant fixed effect below the median.

Figure 20
The Estimated Elasticity of Employment with Respect to the Minimum Wage:
Annual Change (April to April), All Plants



Notes: Figures produced are based on specifications as those in Table 6, Panel A, with the dependent variable being the annual change in plant employment from April to April.

Figure 21
The Estimated Elasticity of Employment with Respect to the Minimum Wage:
Annual Change (April to April), Low-Wage Plants



Notes: Figures produced are based on specifications as those in Table 7, Panel A, with the dependent variable being the annual change in plant employment from April to April.

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APPENDIX

Our analysis on NMW spill-overs across plants operating in the same labour market is predicated on recent evidence that labour markets are local and over-lapping (Manning and Petrongolo, 2017) and thus requires information on the location of each reporting unit so that we identify reporting units operating in the same locality. Because the MWSS does not include location information, we mapped this information to the MWSS using two other data sets collected by the ONS, the Business Structure Database (BSD) and the Annual Respondents Database (ARD). These data sets are collected annually, the BSD since 1997, and the ARD between 1997 and 2008, and include detailed geographical location information for local units – the BSD also includes geographical location information for the enterprise – associated with enterprises and reporting units in the IDBR.

In particular, the BSD is an annual ‘snapshot’ of the IDBR taken every March and includes information mainly on business ownership structure at the enterprise and the local unit level, whereas the ARD includes information on a subset of reporting units in the IDBR and their associated local units, as it is a census of large businesses and a random sample of small businesses collected around December each year. Nevertheless, for the years that both data sets are available, the ARD is not a perfect subset of the BSD, because it provides a snapshot of some of the businesses in the IDBR at a different point in time as that of the BSD and the IDBR is a live register that is updated regularly to account for firm demographics, i.e., deaths, births, mergers, etc., of local units. For this reason and also because the MWSS is collected at a monthly frequency, we used both data sets to map locality information to reporting units included in each year and month of the MWSS. In particular, reporting units in each year and month of the MWSS were merged separately with the same, previous, and next year of the ARD and BSD and the data set produced the more precise match was used to map locality information to the MWSS. Matching precision was assessed on the basis of the share of reporting units in the MWSS that were successfully matched and the share of reporting units for which employment of the matched associated local units taken together is equal to that of the reporting unit. This procedure allowed us to map successfully locality information to

around 93% of reporting units in the MWSS with a matching precision of around 90% along either of the matching precision criteria.

We used information on the geographical coordinates of the postcode of local units of each reporting unit in the MWSS to identify local units operating in the same locality and compute a locality average log wage for each reporting unit. In the case, a reporting unit had a single local unit (44% of cases), the average local wage for the reporting unit was the average wage in the locality the associated local unit operated. When a reporting unit had multiple local units operating in different locations, the average wage of the locality of the reporting unit was computed as the weighted average of average wages in the different localities the reporting unit operated using as weights the shares of the total employment of the reporting unit in each locality. Local unit wages were either those of the associated reporting unit, if the reporting unit had a unique local unit or it was imputed, as the BSD and ARD do not include information on wages at the local unit level. In particular, the imputed wage was the sum of the reporting unit, year, and locality fixed effects estimated from a regression of reporting unit log average wage per employee on reporting unit dummies, year dummies, and the shares of employment of each reporting unit across all travel to work areas (TTWA) in the UK. Locality was defined as the area within a given radius around each local unit postcode. We report results for narrow and wider identification of locality using a 5, 10, 20, and 50 km radius around each postcode that allows us to examine not only the magnitude, but also the geographical extent of spill-over effects of the NMW across plants.

Table A.1: Direct and Local Spill-Over Effects of the Minimum Wage on Earnings Growth: Low-Wage Plants, Locality within 10 km Radius around the Plant

	A. All Localities				B. Low-Wage Localities			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Change in Log NMW Interacted with								
Plant Fixed Effect	-0.141*** (0.047)	0.032 (0.126)	0.448** (0.205)	0.577* (0.301)	-0.185*** (0.061)	0.065 (0.134)	0.077 (0.267)	0.829* (0.429)
Square of Plant Fixed Effect		0.122 (0.095)	0.702** (0.302)	0.983 (0.601)		0.177* (0.099)	0.196 (0.402)	1.874** (0.955)
Cube of Plant Fixed Effect			0.199* (0.116)	0.395 (0.392)			0.007 (0.149)	1.245* (0.708)
4 th Power of Plant Fixed Effect				0.040 (0.077)				0.277* (0.163)
Average Log Wage in Locality	-0.373* (0.199)	-0.407** (0.193)	-0.434* (0.231)	-0.477** (0.211)	-1.391*** (0.381)	-2.695*** (0.675)	-2.936** (1.379)	-3.632 (2.587)
Square of Average Log Wage in Locality		1.210 (1.089)	1.163 (1.048)	3.394** (1.442)		-5.592*** (2.090)	-7.310 (8.383)	-14.217 (24.032)
Cube of Average Log Wage in Locality			0.713 (3.365)	1.353 (2.050)			-2.541 (11.093)	-25.039 (74.681)
4 th Power of Average Log Wage in Locality				-13.071*** (4.643)				-20.937 (68.335)
F-test for Interactions with Plant fixed-effect (p-value)	0.003	0.011	0.003	0.005	0.002	0.007	0.018	0.011
F-test for Interactions with Average Log Wage in Locality (p-value)	0.061	0.036	0.080	0.004	0.000	0.000	0.000	0.011
Observations	580841	580841	580841	580841	335971	335971	335971	335971

Notes: Standard errors clustered at the reporting unit level in parentheses. All specifications include time effects, the plant fixed effect, and the average log wage in the locality, but their coefficients are not reported. Locality is defined as the area within 10 km radius around the plant. Low-wage plants are those with plant fixed effect below the median. Low-wage localities are those with average log wage below the median.

Table A.2: Direct and Local Spill-Over Effects of the Minimum Wage on Earnings Growth: Low-Wage Plants, Locality within 20 km Radius around the Plant

	A. All Localities				B. Low-Wage Localities			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Change in Log NMW Interacted with								
Plant Fixed Effect	-0.142*** (0.047)	0.028 (0.126)	0.441** (0.205)	0.580* (0.301)	-0.196*** (0.061)	-0.040 (0.139)	0.157 (0.272)	0.790* (0.436)
Square of Plant Fixed Effect		0.119 (0.095)	0.697** (0.302)	0.992* (0.601)		0.109 (0.103)	0.386 (0.412)	1.793* (0.974)
Cube of Plant Fixed Effect			0.198* (0.115)	0.403 (0.392)			0.096 (0.156)	1.128 (0.723)
4 th Power of Plant Fixed Effect				0.042 (0.077)				0.229 (0.166)
Average Log Wage in Locality	-0.341 (0.229)	-0.461** (0.226)	-0.582** (0.277)	-0.527* (0.290)	-1.311*** (0.494)	-1.612* (0.844)	1.051 (1.676)	3.182 (3.343)
Square of Average Log Wage in Locality		3.602** (1.610)	3.580** (1.570)	6.185*** (2.225)		-1.740 (3.490)	22.049* (13.252)	51.596 (41.069)
Cube of Average Log Wage in Locality			5.261 (6.362)	0.782 (8.229)			42.861** (21.702)	174.134 (164.635)
4 th Power of Average Log Wage in Locality				-13.071*** (4.643)				157.009 (187.955)
F-test for Interactions with Plant fixed-effect (p-value)	0.002	0.011	0.003	0.006	0.001	0.005	0.016	0.017
F-test for Interactions with Average Log Wage in Locality (p-value)	0.136	0.014	0.029	0.010	0.008	0.030	0.014	0.018
Observations	580841	580841	580841	580841	350050	350050	350050	350050

Notes: Standard errors clustered at the reporting unit level in parentheses. All specifications include time effects, the plant fixed effect, and the average log wage in the locality, but their coefficients are not reported. Locality is defined as the area within 20 km radius around the plant. Low-wage plants are those with plant fixed effect below the median. Low-wage localities are those with average log wage below the median.

TableA.3: Direct and Local Spill-Over Effects of the Minimum Wage on Earnings Growth: Low-Wage Plants, Locality within 50 km Radius around the Plant

	A. All Localities				B. Low-Wage Localities			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Change in Log NMW Interacted with								
Plant Fixed Effect	-0.144*** (0.047)	0.019 (0.126)	0.433** (0.205)	0.573* (0.302)	-0.185*** (0.062)	0.049 (0.140)	0.207 (0.215)	0.569 (0.375)
Square of Plant Fixed Effect		0.115 (0.095)	0.689** (0.302)	0.989 (0.602)		0.164 (0.104)	0.383 (0.301)	1.124 (0.737)
Cube of Plant Fixed Effect			0.197* (0.116)	0.404 (0.392)			0.074 (0.106)	0.567 (0.458)
4 th Power of Plant Fixed Effect				0.042 (0.077)				0.097 (0.082)
Average Log Wage in Locality	-0.603** (0.305)	-0.855*** (0.324)	-0.650* (0.365)	-0.954** (0.470)	-1.586 (0.994)	-0.643 (2.910)	-5.142 (9.302)	-58.292** (23.444)
Square of Average Log Wage in Locality		7.665** (3.789)	9.713* (5.024)	12.395** (5.649)		8.488 (27.065)	-68.478 (149.699)	-1476.470** (617.389)
Cube of Average Log Wage in Locality			-30.234 (28.248)	16.775 (59.844)			-378.064 (672.325)	-14935.331** (6,507.047)
4 th Power of Average Log Wage in Locality				-258.302 (242.356)				-49665.499** (22,635.601)
F-test for Interactions with Plant fixed-effect (p-value)	0.002	0.010	0.003	0.006	0.002	0.010	0.025	0.017
F-test for Interactions with Average Log Wage in Locality (p-value)	0.048	0.015	0.037	0.024	0.110	0.289	0.278	0.10
Observations	580841	580841	580841	580841	356888	356888	356888	356888

Notes: Standard errors clustered at the reporting unit level in parentheses. All specifications include time effects, the plant fixed effect, and the average log wage in the locality, but their coefficients are not reported. Locality is defined as the area within 50 km radius around the plant. Low-wage plants are those with plant fixed effect below the median. Low-wage localities are those with average log wage below the median.