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IZA DP No. 12651

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ISSN: 2365-9793

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ABSTRACT

The Decline of Overtime Working in Britain*

The share of overtime hours within total hours worked in Britain has declined from 4.8% to 2.9% between 1999 and 2018. This is equivalent to 321 thousand full-time jobs. We investigate this decline focussing on full-time and part-time males and females together with overtime pay effects that include the implications for the gender pay gap. We test for economic, structural and cyclical influences via a two-part regression model that allows us to differentiate between the incidence of overtime working and the average weekly hours of overtime workers. This investigation features collective bargaining coverage, job mobility, the minimum wage, industrial composition and the public/private sector dichotomy. The analysis covers the whole economy embracing nineteen 1-digit industries as well as a separate insight into the manufacturing industry where we feature vehicle manufacture.

JEL Classification: J21, J22, J31, J52

Keywords: overtime hours, overtime pay, two-part regression model

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* Office for National Statistics. (2018). *Annual Survey of Hours and Earnings, 1997-2018: Secure Access*. [data collection]. *13th Edition*. UK Data Service. SN: 6689, http://doi.org/10.5255/BRITAINDA-SN-6689-12

1 Introduction

For the past two decades there has been a considerable decline in overtime working in Britain. In terms of aggregate annual paid-for hours worked by all British workers (full-time and part-time males and females), the share of overtime hours within total hours has fallen from 4.8% in 1999 to 2.9% in 2018. In magnitude, this is equivalent to 321 thousand 38-hour workweek jobs. Based largely on our primary data source, the Annual Survey of Hours and Earnings (ASHE), we investigate structural, cyclical and economic factors that have contributed to the decline.

We start in Section 2 by reviewing the extent of the decline in terms of overtime incidence, average weekly overtime hours and overtime pay. Our data cover two periods. First, hours and wage statistics for full-time (f/t) and part-time (p/t) men and women are analysed for the period 1999 to 2018. Second, we examine the incidence of overtime working in 19 one-digit industries over the period 2004 to 2018. This allows us to control for industrial structural change in our regression analysis. We show that the decline in overtime hours importantly concerned both the incidence of overtime working and average weekly overtime hours. Also, the decline has not been confined to the advent and immediate aftermath of the Great Recession; rather it has been taking place both before and, particularly strongly, after this episode.

In Section 3, we discuss long- and medium-term reasons for the decline. One reason for the long-term decline has been an attempt by firms to move away from an 'overtime culture' featuring guaranteed and custom and practice elements of overtime working. Flexitime arrangements, extended use of shift working, and annualised hours contracts have been among the preferred alternatives. The ability of firms to achieve desired changes in working time organisation have been aided and abetted by a continuing marked decline in collective bargaining in Britain since the 1980s. As for the shorter-term effects of the 2007/8

financial crisis, the percentage decline in total hours worked was considerably larger than that in employment. We would expect cuts in overtime hours to feature significantly in total hours' cutbacks, given their relatively high costs.

Our descriptive and regression analyses involve a number of labour market policy areas of current interest. We show that the decline in overtime hours is linked both to job mobility and to changes in the minimum wage. On the pay side, we show that the decline in overtime hours has had a significant bearing on the recent narrowing of the gender pay gap, when measured using weekly pay. We also attempt to illustrate that differences in the use of production technology affect the use of overtime. We investigate whether the relative importance of machine-paced technology and just-in-time supply organisation within vehicle manufacture might have affected the use of overtime when compared with manufacturing as a whole, and with metal manufacturing.

Based on a two-part regression model, introduced in Section 4, we use the ASHE microdata to test our suggested influences on the decline in respect of both the incidence of overtime working and the average length of overtime hours given overtime working. Results are reported in Section 5. Section 6 concludes.

2 The extent of the decline

(i) Overtime incidence and weekly overtime hours

Converting our employment data on f/t and p/t males and females into weekly hours-worked equivalents, Figure 1 shows the share of overtime in total hours worked in Britain from 1999 to 2018. With some fluctuation around the fitted trend line, especially the drop at start of the recession period in 2007/8, there has been a strong decline from a 4.8% to a 2.9% share of total hours worked over the period. The fall in overtime hours between 1999 and

2018 was equivalent to 321 thousand f/t jobs[1] and to 184 thousand f/t jobs between 2007 and 2018.[2]

Figure 1: Share of Overtime Hours in Total Hours (%)

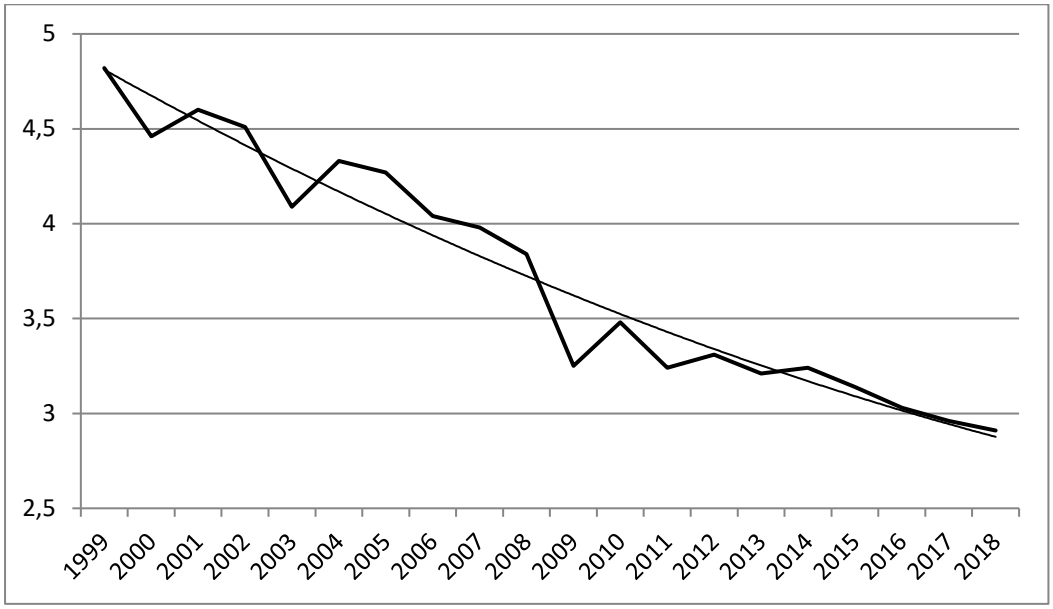
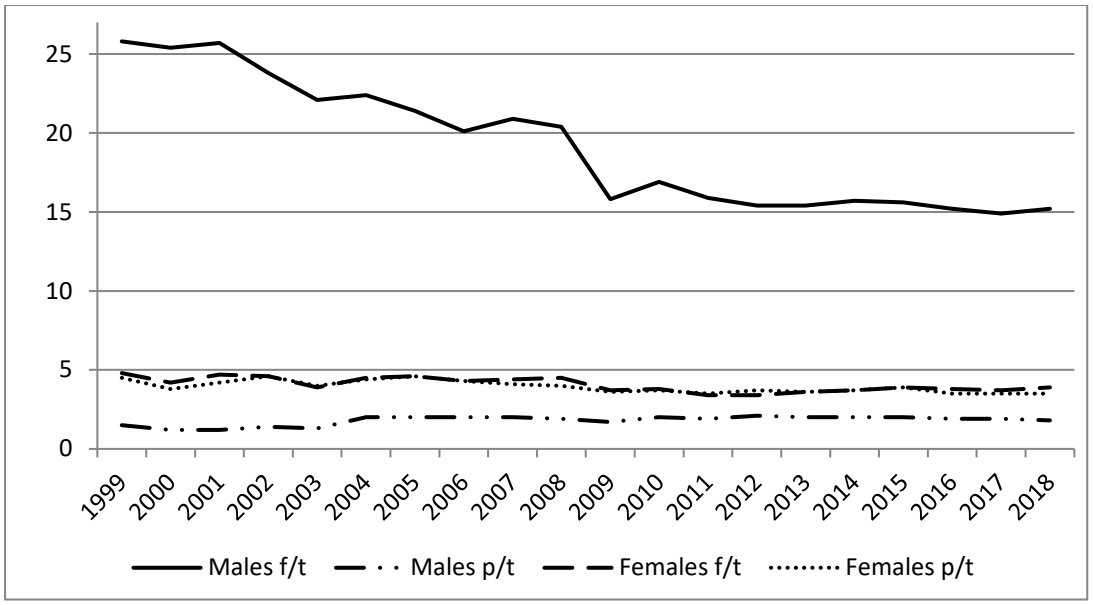


Figure 2: Total overtime hours worked (millions of weekly hours)

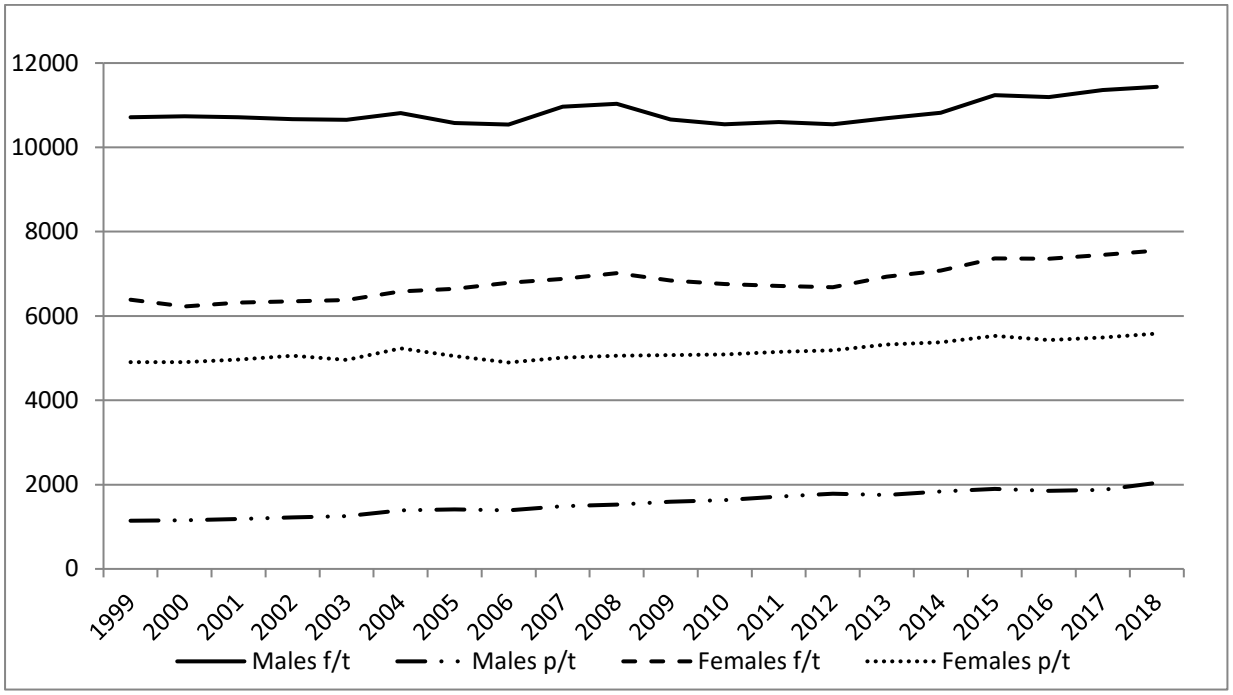


[1] Taken to be 38 hours per week based on the ASHE weighted average between f/t males and females.

[2] See also D'Arcy (2017) for a discussion of aspects of these long-term trends as well as a highlight of overtime employment and remuneration in 2016,

Overtime working in Britain is dominated by f/t male workers. The decline in overtime hours for this group dominates the overall decline in the share of overtime within total hours. Figure 2 shows the weekly overtime hours worked for each of the four worker categories. At the start of the period, total f/t male overtime hours were about 5 times greater than those of either f/t or p/t females. That had reduced to about 3-times by 2018. Generally, the downward trend in overtime hours for f/t and p/t females has been far less severe. The respective differentials between f/t and p/t men are wider than those between f/t men and both f/t and p/t women, principally reflecting much smaller numbers of p/t male workers. These male overtime differentials have also narrowed through time almost completely due to the fall in overtime hours among f/t males.

Figure 3: Employment by f/t and p/t males and females (thousands)



The decline in overtime working has occurred despite increases in the number of employees, as shown in Figure 3, in each of our four employment categories between 1999 and 2018. Figure 4 shows that there have been falls in the proportions of overtime workers in all four worker categories. The downward trends in shares started before the onset of the

Great Recession, accelerated in the early years of the financial crisis, and maintained a strong downward momentum to 2018.

Figure 4: Overtime workers as a proportion of total workers in each worker category

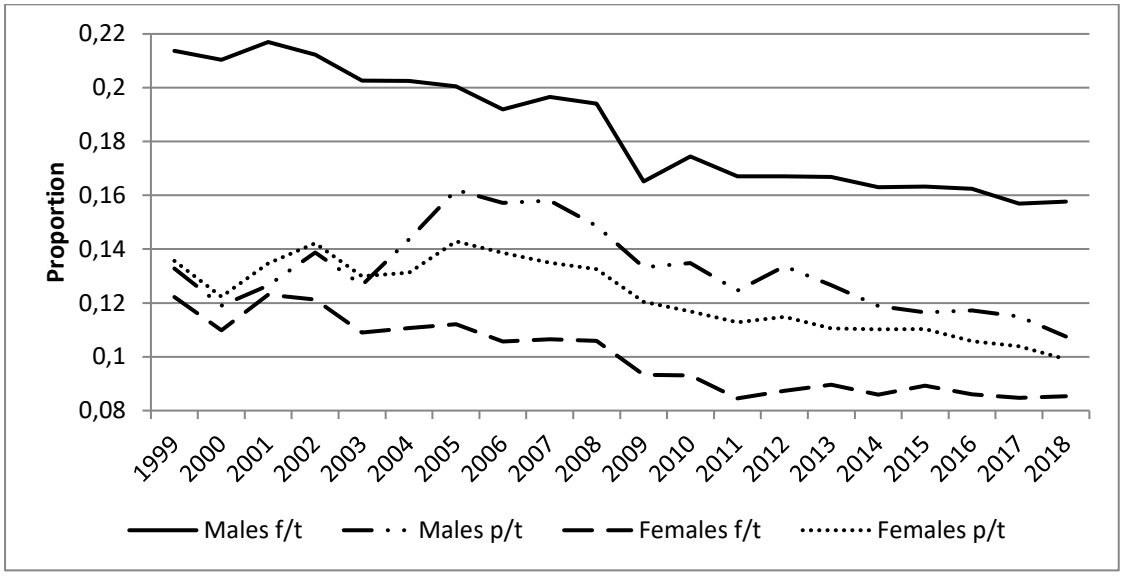
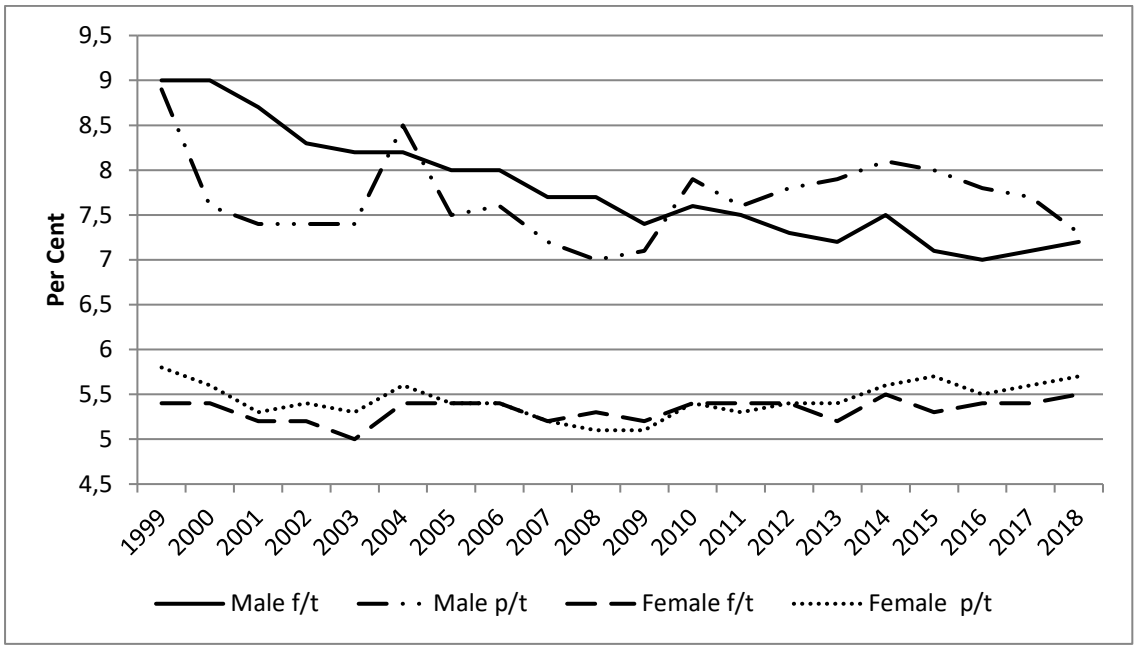


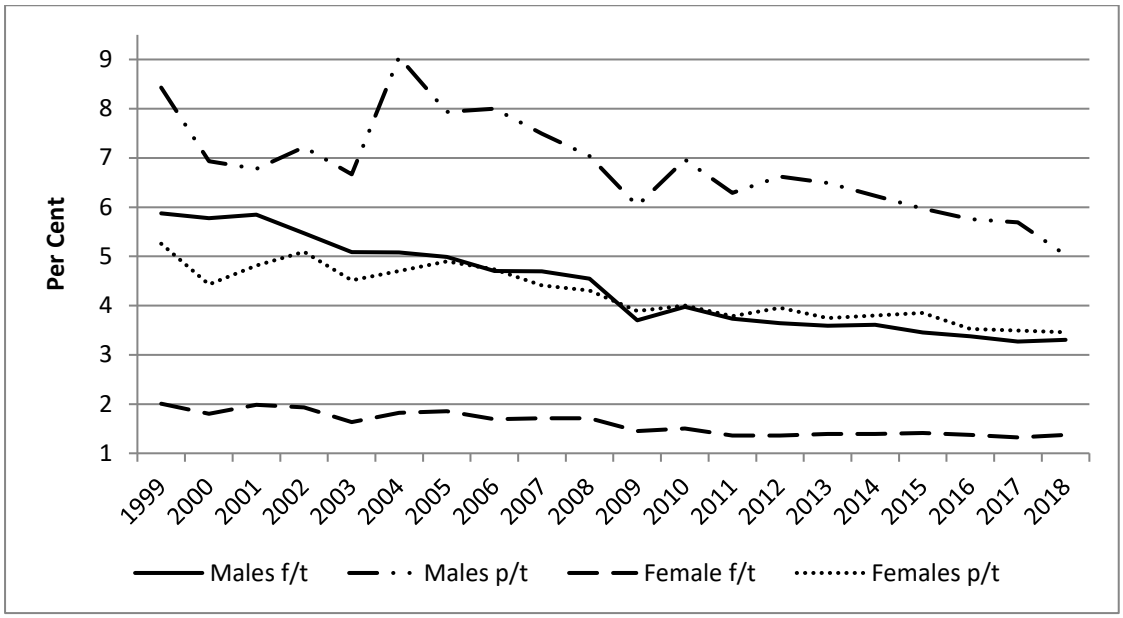
Figure 5: Average weekly overtime hours by overtime workers



Has the decline in the incidence of overtime workers been matched by a fall in average weekly overtime hours of overtime workers? The patterns are shown in Figure 5. In the case of f/t males, the answer is yes, falling by almost 2 hours per week over the entire

period. In the cases of both f/t and p/t females, average weekly overtime hours of overtime workers have virtually flat-lined at about 5.5 overtime hours per week. Irrespective of relative changes, levels of average weekly overtime hours of both f/t and p/t males have been considerably higher than their female equivalents.

Figure 6: Percentage share of overtime hours in total hours by worker category



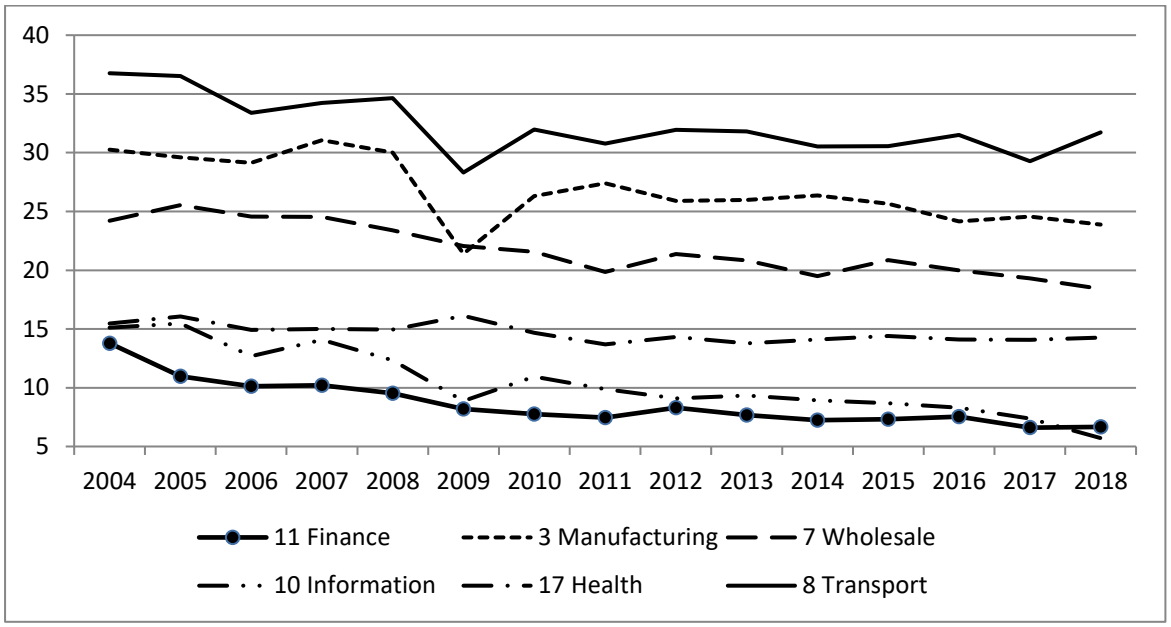
Combining the drop in the incidence of overtime working with that of the reduction in average weekly overtime hours worked, Figure 6 shows the percentage share of overtime hours to total hours in each worker category. In all cases there has been a fall in the share between 1999 and 2018. The decline in share over the whole period has been particularly marked for f/t males while that the share of p/t females has behaved in similar fashion after 2005. The pattern for p/t males is more erratic, probably reflecting the small sample size, but undoubtedly p/t males have been working longer average weekly overtime than all other categories. A relatively modest downward trend among f/t female workers reflects their much lower propensity to work overtime at all.

The ASHE data can be classified by nineteen 1-digit industries. These are listed in Table 1. Consistent data are available for the period 2004 to 2018. Their construction is based

on Standard Industrial Classification 2007 and uses the cross-over data provided by Richard Harris from the reference section of the SDS ASHE data area.

Table 1 One-digit industries from ASHE data	
1 Agriculture, forestry and fishing	11 Financial and insurance activities
2 Mining and quarrying	12 Real estate activities
3 Manufacturing	13 Professional, scientific and technical activities
4 Electricity, gas etc. supply	14 Administrative and support service activities
5 Water supply, sewerage etc.	15 Public administration and defence
6 Construction	16 Education
7 Wholesale and retail trade, repairs	17 Human health and social work
8 Transport and storage	18 Arts, entertainment and recreation
9 Accommodation and food services	19 Other service activities
10 Information and communication	

Figure 7: Percentage shares of overtime hours in total hours by selected industries



While all nineteen industries feature in our subsequent regression analysis, we confine attention graphically to the share of overtime hours in total hours for a group of six of the largest industries. As shown in Figure 7, the largest shares of overtime hours in total hours is in transport and manufacturing industries, at 37% and 30% respectively in 2004. By 2018 the respective shares had fallen to 32% and 24%. Both industries display especially large dips in their shares between 2008 and 2010, the main recession period. Three other industries also

show sizeable percentage falls in their shares between 2004 and 2018: from 24% to 18% in Wholesale and Retail, 15% to 6% in Information and Communication, and 14% to 7% in Financial and Insurance. By contrast, Health and Social Work display a relatively small fall of 15% to 14% with very modest year to year variations.

(ii) Overtime pay

We now turn to the wage implications of the decline in overtime working. A typical firm's weekly wage bill comprises standard hourly wage rates over all employees combined with overtime hours paid at premium rates over the proportion of employees working overtime. The basic wage element comprises the product of workers (N), basic hours (h_B), and the basic hourly wage rate (w_B). The overtime element comprises the product of the fraction of the workforce who work overtime ($\lambda N, \lambda < 1$), the basic hourly wage, the premium paid for overtime hours (p), and the number of overtime hours worked (h_O). The total weekly wage bill is given by

$$W = Nw_B h_B + \lambda N p w_B h_O = Nw_B \left(h_B + \lambda p h_O \right). \qquad (1)$$

The average weekly wage is then given by

$$\omega = \frac{W}{N} = w_B \left(h_B + \lambda p h_O \right). \qquad (2)$$

The contribution of paid overtime working to the average weekly wage is

$$\mu = \frac{\lambda p h_O}{h_B + \lambda p h_O} \qquad (3)$$

where the evolution of the quantity μ traces the changing share of overtime pay in total weekly pay through time.

Table 2 Overtime premia, 1999 - 2018

	Males f/t	Males p/t	Females f/t	Females p/t
Mean	1.359	1.149	1.311	1.13
Standard Deviation	0.030	0.060	0.068	0.053

TABLE 3 Overtime premia by 1-digit industry, 2004-2018

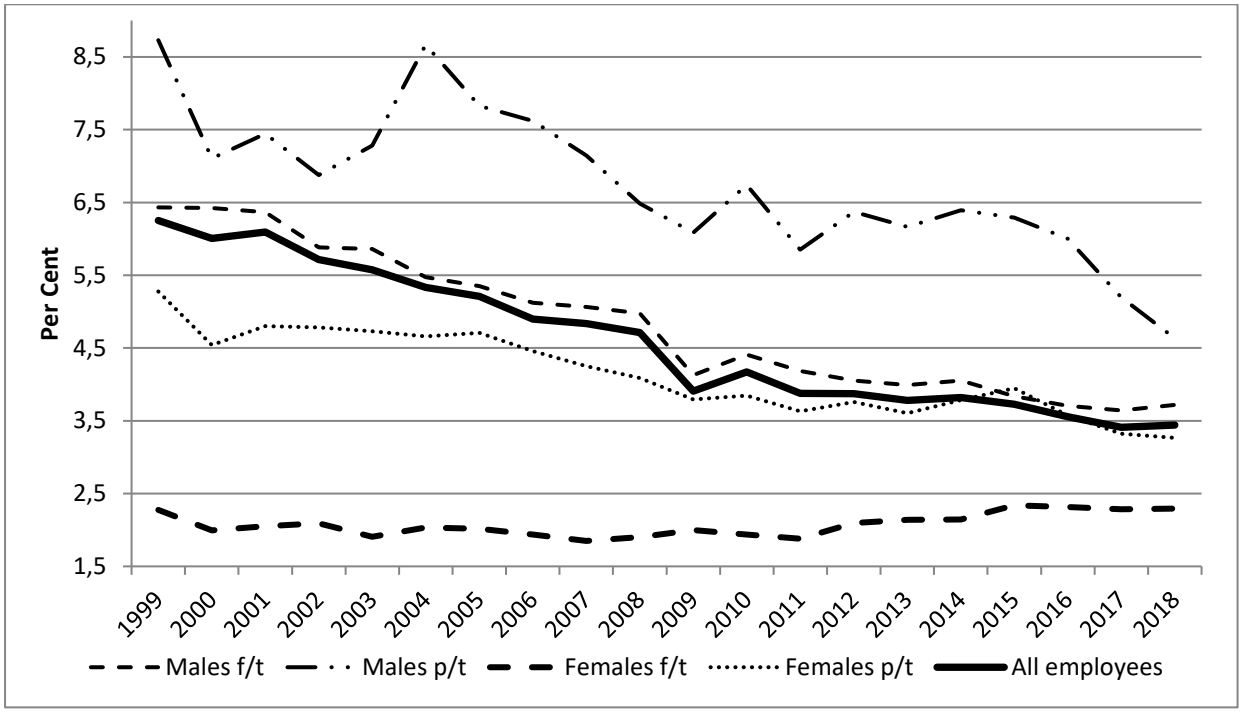
	Mean (st.dev.)		**Mean (st.dev.)**
1 Agriculture	1.358 (0.037)	**11 Financial/Insurance**	1.399 (0.037)
2 Mining	1.437 (0.032)	**12 Real Estate**	1.176 (0.034)
3 Manufacturing	1.416 (0.014)	**13 Professional/Scientific**	1.292 (0.022)
4 Electricity/gas	1.576 (0.043)	**14 Administrative**	1.263 (0.023)
5 Water Supply	1.435 (0.030)	**15 Public Admin/Defence**	1.311 (0.046)
6 Construction	1.326 (0.019)	**16 Education**	1.207 (0.019)
7 Wholesale/Retail	1.207 0.048)	**17 Health/Social Work**	1.177 (0.019)
8 Transport	1.2 (0.020)	**18 Arts/Entertainment**	1.208 (0.097)
9 Accommodation	1.143 (0.046)	**19 Other Services**	1.254 (0.029)
10 Information	1.393 (0.049)		

Weekly overtime premia in the ASHE data vary little through time. For each of our four work categories, Table 2 shows the average premium and its very small standard deviation over the period 1999 to 2018. For all work categories, the mean overtime premium has effectively remained constant over the entire period. There is no evidence, for example, of it responding to cyclical fluctuations. As might be expected, f/t males and f/t females average overtime premia are higher than their p/t counterparts. Table 3 summarises the average premium for each 1-digit industry, again exhibiting low variation through time. There is slightly more variation across industry averages (mean=1.31, s.d.= 0.114) since industries will vary in skill levels, collective bargaining agreements etc.

Figure 8 shows the share of overtime pay within total average weekly wage earnings, as expressed in equation (3). The overtime share within the total wage bill of f/t males has fallen by 42% between 1999 and 2018. The comparable respective falls for p/t males and p/t

females are 47% and 38%. In sharp contrast, the f/t female share has hardly changed, remaining in the narrow band of 2% to 2.3%.

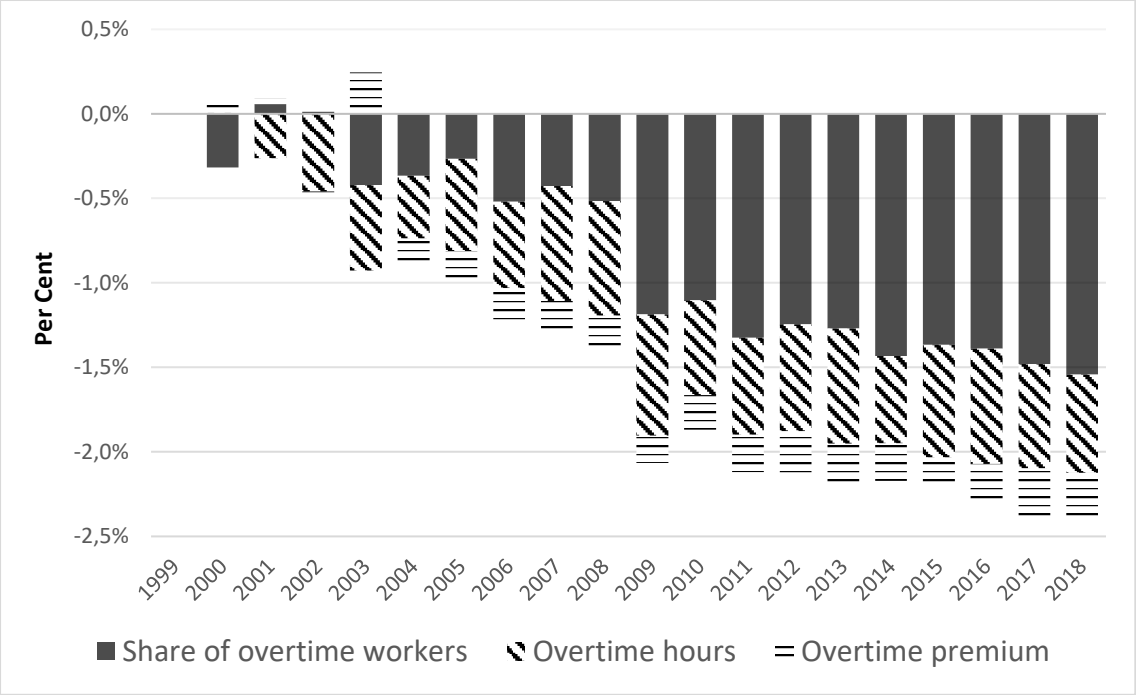
Figure 8: Percentage share of overtime pay within average weekly wage bills.



As also shown in Figure 8, the *aggregate* share of overtime pay within total weekly earnings, clearly dominated by f/t males, falls from 6.3% in 1999 to 3.4% in 2018. We make use of equation (3) to decompose the relative contributions to the reduction in the share due to (a) the proportion of workers working overtime (λ), (2) the overtime premium (p), and (3) weekly overtime hours (h_o). Results are reported in Figure 9. Over the entire period, the reduction in the proportion of employees working overtime has been the most important source of downward wage pressure. This was mainly due to the rapid reduction in the share of overtime workers, starting in 2008 and continuing through to 2018. The effects of reductions in weekly overtime hours have also played a significant role. These reductions grew over the early part of the century and then stabilised between 0.5% and 0.7% after 2005.

As expected, the overtime premium has had a negligible effect on the aggregate wage share over the period.

Figure 9: Shares of changes in overtime working on the aggregate weekly wage (%)



The relative differences in the declines of the shares of overtime pay between males and females is likely to have implications for the recent observation of a fall in the gender wage gap over the past two decades. Using the Labour Force Survey, Dias, Joyce and Parodi (2018) report that that the average hourly wage gap between males and females has declined from almost 30% in 1993 to 20% in 2016. It is clear from Figure 8 that the f/t male share of overtime pay within total pay has far exceeded that of f/t females. Concentrating on f/t workers, we now investigate whether the weekly gender pay gap has changed relative to the hourly pay gap as a result of the changes in relative shares of overtime pay.

Drawing on Eqn. 2 the hourly gender pay gap is given by

$$g^H = \frac{w_B^M - w_B^F}{w_B^M} = 1 - \frac{w_B^F}{w_B^M} \approx \ln\left(w_B^M\right) - \ln\left(w_B^F\right) \quad (4)$$

where g^H is the hourly pay gap and the superscripts ^{M} and ^{F} stand for males and females respectively. Similarly, the weekly gender pay is given by

$$\begin{aligned} g^W &= 1 - \frac{\omega^F}{\omega^M} = \ln\left(\omega^M\right) - \ln\left(\omega^F\right) \\ &= \ln\left(w_B^M\right) - \ln\left(w_B^F\right) + \ln\left(h_B^M + \lambda^M p^M h_O^M\right) - \ln\left(h_B^F + \lambda^F p^F h_O^F\right) \end{aligned} \quad (5)$$

Thus the difference between the weekly and hourly gender pay gaps is given by:

$$g^W - g^H = \ln\left(h_B^M + \lambda^M p^M h_O^M\right) - \ln\left(h_B^F + \lambda^F p^F h_O^F\right) \quad (6)$$

which depends on basic hours, the share of overtime workers, the overtime premium and the number of overtime hours. Changes in any of these variables will increase or decrease the difference between the hourly and weekly gender pay gaps independently of changes in hourly pay.

Figure 10: Differences in the weekly and hourly pay gaps between f/t males and f/t females accounted for by changes in overtime patterns

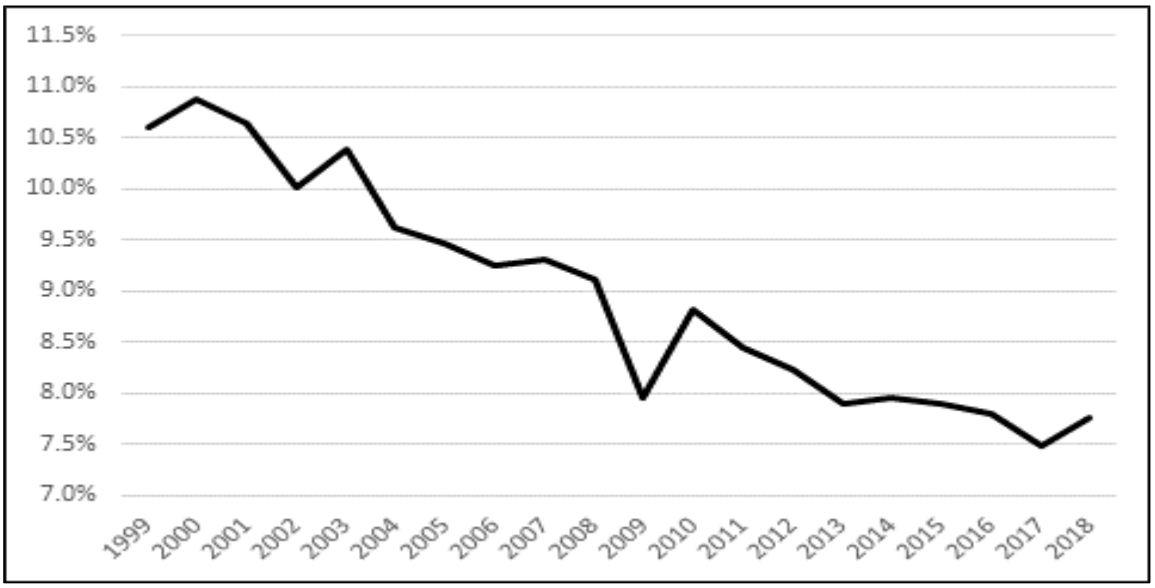


Figure 10 shows the graph of the gender pay gap, as expressed in equation (6), for the period 1999-2018. The weekly gender pay gap for full-time workers was 10.6% greater than

the equivalent hourly gender pay gap in 1999. On average, males worked 3.2 more overtime hours per week than females, but only 1.9 more basic hours. Interestingly, there was little difference in the overtime premium paid to men and women. But the largest driver of the difference in the weekly and hourly pay gap was that the share of male full timers working overtime (27%) was almost double the equivalent share for female full timers (14%).

By 2018, the difference between the weekly and hourly gender pay gaps had fallen to 7.8 per cent, a reduction of 2.8 percent. The share of males working overtime had fallen substantially to 19%, but was still around double the equivalent share for women of 9%. There was no change in the difference between male and female basic hours and the overtime premium declined slightly more for women than for men. So the main driver of the narrowing of the difference between the weekly and hourly gender pay gaps was the much faster reduction in average overtime hours worked by males, which fell from 9 to 7.2 hours per week, while overtime hours for females remains largely unchanged at 5.5 hours per week. It is this change in average overtime hours that was mainly responsible for the 25% reduction in the weekly gender pay gap relative to the hourly gender pay gap.

3 Contributory factors to the decline of overtime

We now review a number of long-term and medium-term factors that have contributed to the decline in overtime working and that motivate the empirical work that follows.

(i) Guaranteed and institutionalised overtime

An argument in the working time literature is that in many instances overtime represents a recurring long-term form of labour remuneration that is made irrespective of the state of demand. There are two kinds of this type of overtime - guaranteed overtime that is

directly incorporated in workers' contracts and institutionalised overtime that results from custom and practice.

For several decades, firms have attempted to counter the inefficiency of a so-called related 'overtime culture' by attempting to reach agreements with workers over adopting alternative and more flexible forms of working time arrangements. Examples include a greater recourse to shift-working or to altering shift patterns and introducing flexitime schemes whereby workers earn credit for additional hours worked, usually in the form of extra paid leave (Incomes Data Services, 1997 and 2006). A further important example involves the adoption of annual hours' contracts. The three principal reasons given for their introduction are to (a) minimise or eliminate overtime, (b) better match staffing levels with customer demands, and (c) improve operational efficiency (Incomes Data Services 2002).[3] These typically consist of an agreed total number of annual working hours sub-divided into rostered hours and reserve hours. The latter, usually comprising a relatively small share of the total, are largely used to iron-out short term obstacles to planned production scheduling.

It might be added that the decline of overtime almost certainly applies to firms that have retained overtime working. There have been concerted attempts strictly to control the costs associated with overtime hours. Controls on overtime use include the need for direct approval by managers or line managers or team leaders or shift leaders, approval to exceed laid down overtime budgets, undertaking *ex ante* forecasts of employment needs with a view to avoiding overtime if possible, limiting the use of overtime only to exceptional circumstances such as production breakdowns (see Incomes Data Services, 2006 for 32 case studies).

3 This IDS study contains case studies of 34 major organisations.

(ii) *The length of working hours as a job attribute*

Based on male non-managerial workers, three features of overtime pay and hours have been found in Britain (Bell and Hart, 2003; Hart, 2004). First, the level of the overtime premium is found to be independent of the length of weekly hours. Second, the level of the premium correlates negatively with hourly basic wage rates.[4] Third, the length of overtime hours also correlates negatively with hourly basic wage rates. In effect, this suggests that overtime firms in a given competitive labour market can ensure that they can meet the going average hourly wage rate for specific jobs and skill-levels without recourse to changing the overtime premium. Where overtime premiums are traditionally high, firms will reduce standard wage rates so as to achieve competitive hourly rates, when averaged across *both* basic and overtime hours. Where premiums are low, higher standard rates will apply. Workers who prefer to work long weekly hours will earn higher weekly wages but their hourly rates will match those of correspondingly qualified workers elsewhere who prefer shorter working time. A parallel argument pertains in respect of differing lengths of weekly overtime hours and the ability to manipulate standard rates.

If both the hourly basic wage rate and the overtime premium are set within long-term efficient contracts then this implies that overtime premia are indeterminate. To circumvent the problem, firms and workers can simply resort to an established long-term norm for setting the rate of the overtime premium.[5] Alternatively, why don't the parties simply agree on an undifferentiated wage rate consistent with employer-worker mutually agreed preferences over

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[4] See Hart and Ma (2010) who develop an efficient wage-hour contract model which embeds an inverse relationship between the contractual wage and the overtime premium.

[5] This contrasts with economies like the USA where there are three parties involved. Where there is government regulation over the maximum length of the standard workweek and the minimum level of the overtime premium then changes in premium rates offer a statutory means of influencing employment, hours and earnings growth rates (see Sagyndykova and Oaxaca, 2019).

the length of working hours? A switch to an annual hours' formulation offers one such arrangement. The relevant economic models are those of the hedonic wage-hours literature (Lewis, 1969; Kinoshita, 1987) in which length of working hours are regarded as a job attribute with workers and firms signalling preferences across differing job-lengths/hourly wage combinations. Working hours are treated as indivisible and the hourly wage rate is a function of the length of working hours.[6]

There is a strand of the hedonic wage-hours literature that concerns US government attempts to encourage work sharing via legislative controls on the sizes of overtime wage premiums (Ehrenberg 1971, Ehrenberg and Schumann 1982, Trejo 1991). Suppose that a worker-employer wage and hours agreement has been set in the spirit of the hedonic model yet includes overtime working. If the government unexpectedly increases the minimum overtime premium, the parties can realise their existing earnings/hours contract by simply agreeing to offset the higher overtime costs by an offsetting reduction in the basic wage rate.

An interesting related possibility is how might overtime firms react when a government imposed annual percentage minimum wage increase that exceeds the percentage increase in the annual basic hourly wage? This may occur during periods in which there are tight constraints on basic wage rate increases. A clear example of relevance here are the years following the 2007/8 financial crisis, especially in respect of public sector pay awards. This would result in a degree of wage compression with workers at or near the minimum wage achieving higher pay increases than those on higher basic rates. However, *ex ante* differentials might be restored by means of allocating overtime hours and related premium pay more towards workers on higher basic rates. The corollary may be smaller changes in employment than might be expected from the effects of the minimum wage on basic hourly

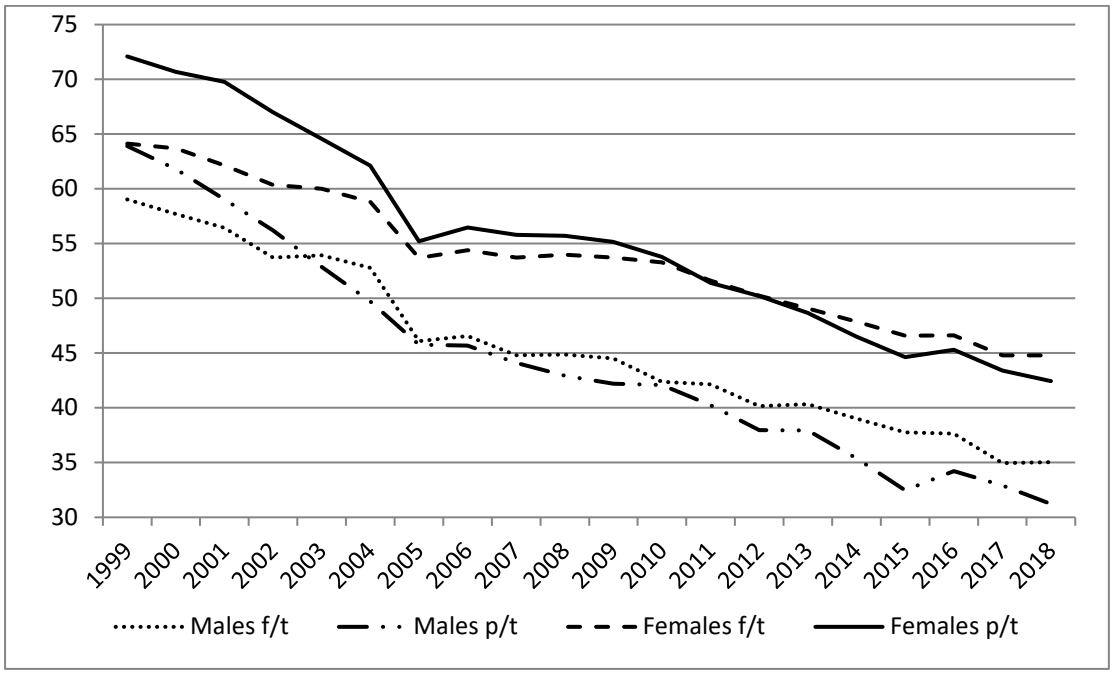
[6] Agreements over wage rates and length of hours are achieved at points where there is a tangency between the firm's isoprofit curve and the worker's indifference curve. See Kinoshita (2017) for full details.

rates. We later test for the possibility that minimum wages affect the relative overtime outcomes of the low paid.

(iii) The decline of collective bargaining

The more radical proposals to eliminate or severely constrain the use of overtime often involve difficult and protracted negotiations between employers and worker representatives.[7] In the absence of formal collective bargaining coverage we might expect that time related negotiation costs and the agreed settlement costs would be significantly reduced. In fact, there has been a substantial decline in British collective bargaining coverage since the 1980s (Brown, Bryson and Forth, 2008). As an extension to the period covered in this latter work, Figure 11 shows that collective bargaining coverage has continued to decline substantially from 1999 to 2018. This has taken place for each of our four worker categories. Increasingly, this trend should have eased the risks to employers of instigating proposals to switch to alternative working time schemes.

Figure 11 Covered by a collective agreement 1999-2018 (%)



[7] See Incomes Data Services (2002, p. 5) in relation to attempting to introduce annual hours schemes.

The erosion of collective bargaining may also signal an alternative explanation for the decline in overtime. It may represent a relative weakening of workers' market power resulting in firms reducing the availability of overtime hours at premium rates of pay in order to exert a downward pressure on wages. There is a literature that argues that traditional union-employer bargaining has been giving way to employer-led arrangements in respect of working time (e.g. Rubery et al. 2005).

(iv) Hours adjustments in the Great Recession

Traditionally, labour demand and supply theories have emphasised the short-term benefits of overtime working. One aspect of this concerns the creation of an intensive margin buffer for meeting unanticipated shortfalls in labour service provision, perhaps due to absenteeism or rush orders. Another concentrates on the fact that overtime extensions and contractions provide speedier adjustments to unexpected changes in business conditions. The financial crisis of 2007/8 provides a major example of this latter role.

We would expect both the incidence of overtime working and the average length of overtime hours to be negatively impacted by the financial crisis. The whole-economy reduction in labour inputs was more severe in respect of working time compared with employment (Hart, 2017). Employment fell by 2.3% peak-to-trough (2008 Q2–2010 Q1). In contrast, worker-hours (i.e. employment multiplied by average weekly hours) fell by 4.3% peak-to-trough (2008 Q1–2009 Q3). In the empirical analysis discussed in Section 5, we show that reductions in paid overtime hours were significant in the recession period. This fits with the evidence of Bils (1985) who finds that USA overtime pay plays an important role in the explanation of wage procyclicality.

An additional consideration concerns labour mobility. While there were relatively mild reductions in total employment during the Great Recession, there were increased hires of part-time workers as well as hours' reductions attached to entry-level jobs (Schaefer and

Singleton, 2019). We test whether reduced overtime has comprised part of such shorter hours by testing the association between weekly overtime hours and new hires.

(v) Work organisation and technological change

The long-term decline of overtime may also have been associated with changes in technology related work organisation. As technology makes working patterns more predictable, the need for having a reserve of overtime labour that can be called on at short notice diminishes. Such predictability is likely to vary across industries and employment sectors. Our regression modelling therefore controls for our nineteen 1-digit industries and additionally for public and private sector employment. At a more micro industrial level, we might expect a decline in overtime working to accompany the growth of machine-paced technology and just-in-time (JIT) production scheduling. This is especially important within manufacturing industry. In vehicle manufacture, the constraints imposed by JIT parts delivery, worker inputs controlled by line speeds, and the common use of multiple shift systems may all have served to limit the need for overtime working. We compare the behaviour of overtime working in vehicles manufacture with that in metal manufacture and manufacturing as a whole in what follows.

4 Two-part regression model

We established in Section 2 that the decline in overtime working has derived principally from changes in the incidence of overtime working and in the average weekly overtime hours of overtime workers. Accordingly, we make use of the two-part model (Belotti et al., 2015; Drukker, 2017), a method for dealing with limited dependent variables that allows us to distinguish between the prevalence of overtime working and the average weekly overtime hours of those workers who are offered and accept overtime working.

We control for a range of structural and economic variables that relate to the discussion of the previous section. Note that we are not seeking to model a selection process where individuals may potentially opt in, or out, of overtime working. Rather, in the spirit of Lewis and Kinoshita, our argument is that overtime is a feature of the work contract between employer and employee and that we therefore seek to model *actual* overtime outcomes.

The two-part model specifically deals with the case where a large number of zeros are recorded as well as observations drawn from a probability distribution defined over positive real numbers. In our case, the probability of observing positive overtime hours is given by

$$\phi(h_o) = \Pr(h_o > 0 \mid x) = F(x\beta)$$

where x is a set of explanatory variables and β their corresponding parameters. F is the distribution function of an iid error term. Then, conditional on positive overtime hours, their level is described by:

$$\phi(h_o \mid h_o > 0, x) = g(x\gamma)$$

where again x is a set of explanatory variables with γ the corresponding parameters. Since the log likelihood function is additively separable in β and γ, the models for the zeros and the positives can be estimated separately. In our case, we model the zeros using a probit approach and the positives with an OLS regression. Alternative functional forms are feasible. Note that we make no assumption about the correlation of the errors on the "zeros" and "positives" equations: independence is not a necessary condition to derive consistent estimates of β and γ. We favour this approach because we do not believe there are plausible exclusion restrictions within our dataset to distinguish between "zeros" and "positives". In these circumstances, the two-part model provides a generally superior method for estimating mixed discrete-continuous outcomes.

To identify associations with overtime working, we include workers' ages, whether a worker is in the public and private sector, and whether a given job is covered by a collective bargaining agreement. New hires are proxied using a binary variable denoting whether or not an individual had changed jobs over the past 12 months. A low paid worker is classified as someone earning an hourly wage that is in the bottom five percentiles of a wage distribution whose lower bound is the National Minimum Wage. Wage restraint, especially in the public sector, was quite severe post-2008. We include dummies for our 1-digit industries as well as for 11 geographical regions. Finally, sets of year dummies allow us to examine the incidence of overtime and lengths of overtime hours among workers working overtime.

5 Regression outcomes, 2004 - 2018

The top section of Table 4 shows results in logit regression in respect of impacts of our explanatory variables on the incidence of overtime working.

In Section 3, we report on attempts by firms to replace overtime working with other forms of working time arrangements. These initiatives can involve costly and protracted negotiations. As shown in Figure 11, however, collective bargaining coverage has significantly reduced over our study period. This may well have served to reduce the expected costs of implementing alternative hours' schemes. For all four wage groups we find unequivocal support for a strong positive association between the probability of working overtime and the presence of collective bargaining.

Table 4 Two-part model of overtime hours 2004-2018

First part - logit

Variable	Males f/t	Males p/t	Females f/t	Females p/t
Age	-0.001	-0.003	-0.014***	-0.012***
Age squared	0.000**	0.000***	0.000***	0.000
Public sector	-0.126***	0.157***	-0.403***	-0.360***
Collective bargaining	0.374***	0.237***	0.224***	0.051***
Changed job	-0.128***	0.052**	-0.184***	0.032**
Hourly wage relative to minimum wage	-0.154***	-0.397***	0.147***	-0.168***
year				
2005	-0.016	0.027	0.043*	0.073**
2006	-0.093***	0.149***	-0.054*	0.066**
2007	-0.041**	0.103*	-0.035	0.010
2008	-0.055***	-0.012	-0.025	-0.006
2009	-0.292***	-0.193***	-0.150***	-0.147***
2010	-0.199***	-0.193***	-0.149***	-0.162***
2011	-0.257***	-0.264***	-0.277***	-0.189***
2012	-0.223***	-0.168***	-0.250***	-0.182***
2013	-0.237***	-0.186***	-0.213***	-0.220***
2014	-0.273***	-0.220***	-0.276***	-0.215***
2015	-0.259***	-0.244***	-0.228***	-0.211***
2016	-0.239***	-0.208***	-0.260***	-0.250***
2017	-0.283***	-0.224***	-0.289***	-0.262***
2018	-0.270***	-0.350***	-0.267***	-0.353***
sic07_class				
Agriculture, Forestry etc	0.903***	-0.401***	0.055	-0.895***
Mining, quarrying etc	0.673***	0.767***	-1.001***	-0.831*
Manufacturing	0.541***	0.252***	-0.124***	-0.705***
Electricity, gas etc. supply	0.153***	-0.740***	-0.604***	-1.093***
Water supply	0.935***	0.445***	-0.474***	-0.235*
Construction	0.390***	-0.160**	-0.965***	-1.157***
Wholesale trade	0.058**	0.962***	-0.291***	0.642***
Transport & storage	0.819***	0.788***	0.147***	-0.006
Accommodation & Food Serv.	-0.831***	-1.457***	-0.711***	-1.181***
Information and communication	-0.426***	-0.698***	-1.019***	-0.869***
Financial services..	-0.948***	-0.537***	-0.635***	-0.596***
Real estate	-0.829***	-0.591***	-1.041***	-0.416***
Professional etc. services	-0.608***	-1.116***	-1.060***	-0.857***
Administrative & support services	0.092***	-0.435***	-0.592***	-0.909***
Public admin & defence	-0.036	-0.835***	-0.171***	-0.411***
Education	-0.802***	-0.879***	-1.132***	-0.291***
Human health	-0.005	-0.349***	-0.039	-0.223***
Other services	-0.374***	-1.270***	-1.215***	-1.212***
Constant	-0.996***	-1.012***	-1.085***	-1.015***
N	978037	164344	680810	530490
pseudo r^2	0.0580	0.0328	0.1227	0.0603

Second part – linear regression

Variable	Males f/t	Males p/t	Females f/t	Females p/t
Age	0.170***	0.203***	0.071***	-0.091***
Age squared	-0.002***	-0.003***	-0.001***	0.001***
Public sector	-0.763***	0.357	-0.375***	0.287***
Collective bargaining	0.196***	0.104	0.104*	0.110*
Changed job	0.093*	0.266**	0.069	0.295***
Hourly wage relative to minimum wage	0.046	-0.471***	0.555***	-0.339***
year				
2005	-0.180*	-0.962**	0.065	-0.186
2006	-0.205**	-0.854**	0.014	-0.064
2007	-0.447***	-1.080***	-0.008	-0.343**
2008	-0.520***	-0.944**	0.034	-0.337**
2009	-0.756***	-1.487***	-0.214*	-0.529***
2010	-0.653***	-0.612*	-0.010	-0.145
2011	-0.825***	-0.926**	-0.076	-0.253*
2012	-0.907***	-0.733*	-0.114	-0.118
2013	-1.054***	-0.616*	-0.280**	-0.160
2014	-0.858***	-0.388	-0.060	0.059
2015	-1.177***	-0.383	-0.221*	0.175
2016	-1.284***	-0.584*	-0.125	-0.076
2017	-1.224***	-0.790**	-0.157	0.031
2018	-1.186***	-1.247***	-0.080	0.199
sic07_class				
Agriculture, Forestry etc	5.642***	0.428	2.325***	0.557
Mining, quarrying etc	5.366***	5.264*	-0.259	-1.064
Manufacturing	1.155***	2.083***	0.465***	0.096
Electricity, gas etc. supply	0.154	-2.442*	-1.084***	-0.828
Water supply	1.916***	4.694***	-0.829**	1.548*
Construction	2.382***	1.913***	-0.246	-0.074
Wholesale trade	-0.657***	-0.315	-1.608***	-0.406***
Transport & storage	2.599***	2.645***	0.955***	1.601***
Accommodation & Food Serv.	0.160	0.720*	-0.246	0.453**
Information and communication	-0.445***	-0.800	-0.594***	-0.525*
Financial services..	-1.208***	-2.669***	-1.283***	-1.522***
Real estate	-0.298	0.214	0.098	0.505*
Professional etc. services	0.111	-0.954*	-0.955***	-1.122***
Administrative & support services	1.601***	1.470***	0.433**	0.331
Public admin & defence	-0.100	-1.267**	-0.023	-0.136
Education	-0.303*	-1.090***	-0.534***	-0.480***
Human health	1.099***	0.250	0.831***	-0.154
Other services	0.251	-1.075	-1.101***	-0.010
Constant	3.383***	5.377***	3.643***	8.165***
N	213744	72071	26553	72448
r^2	0.0498	0.0333	0.0424	0.0207

Notes: Regressions control for 11 British regions. * p < 0.10; ** p < 0.05; *** p < 0.01
Year 2004 is omitted variable for time-dummies and Arts/Entertainment is omitted in industries.

Where overtime arrangements continue to exist, we argue that there is an incentive to reduce the use of overtime working among low paid workers. At times of relatively high annual increases in the statutory minimum wages relative to basic wage rate increases, reductions in the availability of overtime among for the lowest paid workers may be used to offset the resulting compression in company wage rates. For three of our work groups the associated negative relationship between the incidence of overtime working and the minimum wage is strongly supported. The exception concerns f/t female employees, where the relationship is strongly positive. It is difficult to account for this except for the fact that, as shown in Figure 6, f/t female workers have by far the lowest share of overtime within total hours.

Relative to working in Arts/Entertainment/Recreation, the incidence of overtime is especially high in Agriculture, Mining, Manufacturing, Water/Gas supply, and Transport while it is especially low in Accommodation and Food Services, Finance and Insurance, Real Estate, and Education. The incidence of overtime working has reduced more in the public sector compared to the private sector, except for the relatively small group of p/t males.

The variable 'change job' refers to individuals who changed employer in the previous 12 months. The incidence of overtime working among f/t male and f/t female job movers is lower than that of equivalent job stayers. This fits with the Schaefer and Singleton finding of hours' reductions associated with entry-level jobs during the recession. However, the direction of this result is reversed in respect of p/t males and p/t female movers, although with lower estimated coefficients.

After controlling for industry and regional variations and for the public/private dichotomy, the annual year dummies show the decline in the incidence of overtime across all four work categories between 2004 and 2018. As expected, the years 2008 and 2009 reveal

that this decline gathered pace during the early onset of the Great Recession. Interestingly, however, while the Recession served to accelerate the decline, the higher rate of decrease continued unabated to 2018.

In the bottom section of Table 4, the part-two OLS results show the influence of our explanatory variables on weekly overtime hours conditional on being an overtime worker. In the cases of collective bargaining coverage and low pay the signs and significances of the explanatory variables correspond reasonably well with the estimates in the upper part of Table 4. There are three main differences.. First, while the incidence of overtime working is negatively, though weakly, associated with age, overtime rises with age among those who actually work overtime. Second, while the incidence of overtime working among f/t male and f/t female job changers was found to be negatively related to that of job stayers, f/t male job changers who work overtime work longer overtime hours than male job stayers while f/t females work the same overtime hours as female job stayers. Third, weekly overtime hours of p/t females in the public sector exceed those in the private sector, in contrast to the reverse association in respect of their relative overtime incidence.

The industries with high weekly overtime hours relative to the omitted industry are Agriculture, Mining, Manufacturing, Water Supply, Construction, Transport, and Human Health and Social Work. Relatively low overtime hours are in Accommodation and Food Services, Finance and Insurance, Real Estate, Professional/Scientific/Technical Activities, and Education.

Starting in 2009 and through to 2018, f/t male overtime workers have experienced a fall in weekly overtime hours of about 1 hour per week. Noticeably, the rate of decrease peaked in the last four years, 2015-2008. A similar fall in average overtime hours among p/t males occurred over an earlier period, 2004-2009. Along with a low incidence of overtime

working among f/t females, changes in overtime hours have been slight throughout the period. Significant falls in overtime hours among p/t females have been confined to the Great Recession period, 2007 - 2011,

Of course, 1-digit industrial aggregation fails to capture the possibilities that different sub-sections of industry may display significantly different propensities to employ overtime working and different average lengths of weekly overtime hours. We select manufacturing industry to illustrate this point. As reported in Section 2, this is one of the industries that has exhibited large reductions in overtime hours.

Manufacturing embraces a very wide range of industrial subheadings that include vehicle manufacture, metal manufacture, agricultural engineering, food processing, electrical goods, chemical engineering. While overtime changes may well feature throughout manufacturing, some sections might be expected to have relatively low recourse to overtime work. Vehicle manufacture, for example, is dominated by just-in-time parts supply, line assembly and the heavy use of machine-paced technology. Working time is likely to be relatively tightly conditioned by systematised production and just-in-time delivery schedules in supply companies and by machine-paced end-point vehicle assembly plants. Multiple shift working is also a common feature of this industry. In these circumstances, there may be a relatively low overtime requirement.

Concentrating on f/t male workers, we apply the two-part regression model to manufacturing in general as well as to the sub-sections metal manufacture and vehicle manufacture. Results are shown in Table 5. For the industry as a whole, the results in respect of the incidence of overtime behave much the same way as for f/t males in the economy as a whole (Table 4). Collective bargaining exerts a positive influence, job changes

and low pay display negative associations. From 2009 to 2018, there was an unbroken annual fall in incidence. Metal manufacture behaves in very similar fashion.

5 Two-part model of overtime hours in manufacturing, metal manufacture and vehicles (males f/t), 2004-2018.

First part - logit

Variable	Manufacturing	Metal Manufacture	Vehicle Manufacture
Age	-0.003	-0.003	0.036**
Age Squared	0.000	0.000	0.000***
Collective bargain	0.295***	0.272***	0.267***
Changed job	-0.069***	-0.075**	0.038
Hourly wage relative to minimum wage	-0.166***	-0.323***	-0.561***
Year			
2005	-0.045	-0.047	-0.150
2006	-0.068**	-0.036	-0.013
2007	0.033	0.060	0.259**
2008	0.001	0.052	0.187*
2009	-0.470***	-0.573***	-1.299***
2010	-0.183***	-0.288***	-0.279**
2011	-0.103***	-0.145***	-0.087
2012	-0.189***	-0.201***	-0.204*
2013	-0.186***	-0.276***	-0.078
2014	-0.137***	-0.178***	0.047
2015	-0.171***	-0.291***	-0.006
2016	-0.215***	-0.328***	-0.061
2017	-0.167***	-0.249***	-0.013
2018	-0.199***	-0.290***	-0.122
Constant	-0.328***	0.047	-0.434
Statistics			
N	179224	79227	14788
pseudo r^2	0.0097	0.0143	0.0121

Second part – linear regression

Variable	Manufacturing	Metal Manufacture	Vehicles Manufacture
Age	0.159***	0.195***	0.124*
Age Squared	-0.002***	-0.002***	-0.001
Collective bargain	0.206***	-0.106	-0.259
Changed job	-0.033	-0.156	-0.817**
Hourly wage relative to minimum wage	-0.098	-0.611***	0.366
Year			
2005	-0.320*	-0.653***	-0.970**
2006	-0.311*	-0.305	0.092
2007	-0.256	-0.177	-0.031
2008	-0.340*	-0.613**	-1.164**
2009	-0.522***	-1.041***	-1.727***
2010	-0.368**	-0.990***	-0.554
2011	-0.405**	-0.679***	-0.325
2012	-0.551***	-0.782***	-0.355
2013	-0.673***	-0.780***	-0.175
2014	-0.510***	-0.875***	-0.197
2015	-0.974***	-1.305***	-0.800*
2016	-1.097***	-1.209***	-0.152
2017	-1.152***	-1.385***	-0.208
2018	-1.130***	-1.395***	-0.877*
Constant	4.139***	4.288***	3.433**
Statistics			
N	56397	27012	14788
r^2	0.0096	0.0145	0.0136
Notes: Regressions control for 11 British regions. * p < 0.10; ** p < 0.05; *** p < 0.01 Year 2004 is omitted variable for time-dummies			

In vehicle manufacture, collective bargaining and low pay show respective positive and negative associations with overtime incidence. Overtime incidence with respect to job changers does not differ from that of stayers. At odds with earlier results, workers' ages are positively associated with the incidence of overtime working. There are strong differences in the incidence of overtime working through time in vehicle manufacture. During the recession, 2007 to 2010, there are clear drops in the incidence of overtime together with a small significant reduction in 2012. In sharp contrast to manufacturing as a whole and to

metal manufacture (and the results in Table 4), overtime incidence among f/t males from 2013 to 2018 did not change in the vehicle sector.

In Table 5 part-two, while the incidence of overtime working among job changers did not differ from those of job stayers in vehicle manufacture, those workers entering vehicle manufacture in the past year worked significantly fewer overtime hours compared to job stayers. Along with metal working, collective bargaining cover in vehicle manufacture is not significant in relation to overtime hours worked. Overtime weekly hours among overtime workers display significant falls in 2008 and 2009 as well as in three other years on either side of the Great Recession. Otherwise, as with overtime incidence, very slight changes in overtime hours contrast markedly with the systematic year-on-year declines in total manufacturing as a whole and in metal manufacture.

6 Concluding Comments

Undoubtedly, there has been and will continue to be important short-run reasons for using overtime. It is used as a short-run intensive margin buffer with which to adjust labour service flows given unanticipated demand and supply shocks. It provides a cost-effective way of meeting a range of unplanned contingencies within the workplace, such as absenteeism, rush orders, fixing production bottlenecks/machine breakdowns and ensuring a subsequent speedy production catch-up. It also offers a means of reacting to anticipated seasonal surges in demand.

Nonetheless, there has been a systematic decline of overtime working in Britain, much of which has straddled a much longer period of time than that commonly associated with short-term hours' perturbations. Our evidence reveals that both the incidence of overtime and the average weekly overtime hours worked by overtime workers have been declining for at least the past two decades. In the case of the largest overtime group, f/t male

workers, the decline in weekly overtime hours has been accelerating in the post-recession years. The share of overtime pay within total pay has displayed associated falls. One outcome of the dominant overtime reductions among f/t males has been that the pay gap between f/t males and f/t females has narrowed as a result.

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