Are we working less? An examination of Changing UK Labour supply decisions since the 1990s

Abstract

The desire to substitute leisure for work as we grow richer is anticipated in the work of Becker and was famously predicted by Keynes. With reference to the UK from 1994q2 to 2015q2, this study examines labour supply decisions with respect to earnings and considers whether we are willing or indeed able to work less. We specifically focus on the three points of time i.e. beginning of the sample, pre and post Global Financial Crisis. The results suggest that we are far from income-satiated. The elasticity of hours worked with respect to earnings is stubbornly inelastic and for some demographic cohorts positive, implying the desire to work more. We find that job flexibility matters in facilitating reduced hours of work, but that jobs are not becoming more flexible. We do see a secular reduction in hours worked, accompanied by a shift to working later in life, but these appear to be down to factors other than higher wages.

Keywords: - Labour Supply, Employment, Hours of Work

JEL Classification: J21, J22, J23, J82

1. Introduction

In this study, we look at the UK Labour market to examine the dynamics of the time individuals allocate to work, and how this has shifted over the period since 1994. The motivation for the paper relates to the notion that we might reasonably expect people to work less, as time goes by, as they become consumption-satiated facilitated by higher incomes. This idea has been around a long time. Keynes (1930) in his easy on the '*Economics Possibilities for our Grandchildren*', suggested that by the end of the (last) century average hourly work per week would shrink to 15 hours. Such ideas were also developed by Bell (1973) in his seminal work on society in his book entitled '*The Coming of Post-Industrial Society: A Venture in Social Forecasting*' in which Bell argued that the post-industrialist society, led by information and services, would reshape the world of work.

These ideas have been recently re-popularised by Skidelsky & Skidelsky (2013) in their book 'How much is enough?' They argued that the drop in the average work hours has not happened as Keynes predicted, pointing out a number of possible reasons, as follows. First, due to the utility or 'the joys of work' which were underestimated by Keynes. Second, most people would not know what to do if they were suddenly deprived of work. Third, our hunger for new goods, driven by constant product innovation. Fourth, 'conspicuous consumption' and the desire to impress others. Fifth, rising income inequality might drive the need to work. Finally, that the powerful business class which determines the earnings, hours, and conditions of work, give most people little 'choice' over their hours. We also acknowledge at this juncture that a broader understanding in the literature on the income (specifically non labour) labour supply nexus is that an increase in income decreases labour supply i.e. a pure income effect. However, the effect of an increase in the wage rate (or labour income) depends on the combination of an income effect (which reduces labour supply) and a substitution effect which increases labour supply given that the wage rate is also the opportunity cost of leisure time. It is intuitive and empirical evidence supports the notion that the low earning individuals often have a more pronounced substitution effect. See, for instance, Owen (1969), Haworth and Veal (2004) and most recently Veal (2018). We also point out that Keynes' argument , from a microeconomic perspective, to that of Becker (1965) in his 'Theory of time allocation'. Becker was the first of many to point out that individuals/households allocate time optimally and that the time spent working will therefore depend, in part, on wage rates. Moreover, that as wage rates rise people may seek to reduce hours worked as the marginal utility of consumption becomes dominated by a desire for greater leisure - the basis for a so called 'backward bending' labour supply curve (see Hanoch, 1965).

This begs an obvious empirical question: is labour supply sensitive to real wage rates at today's incomes? Moreover, are these sensitivities changing over time? Bargain et al (2011) survey empirical studies relating to the elasticity of labour supply and find labour supply to be generally inelastic, but

positive: suggesting that we are still seeking to work more, with increased earnings, rather than less. Their findings also suggest that labour supply elasticities may vary considerably depending on gender and on personal circumstances, for example, whether or not one is married. Such micro-demographic considerations are taken up in this paper. More broadly in relation to total hours worked, in a comprehensive analysis on work patterns in OECD countries Faggio and Nickell (2007) argue that there has been a shift in the pattern of work in a number of countries over the last forty years. Specifically, there have been changes in the labour input due to the changes in the gender role, role of the unions particularly in Scandinavia and female participation, as well as taxes. Nevertheless, Faggio and Nickell (2007) emphasised that the shift in work patterns in the OECD should be seen in the context of country-specific factors as their results showed a significant difference between US and Europe as well as among European countries. Their assertion provides the rationale for our focus on the UK labour market.

A key aspect of labour supply, in relation to hours worked, is the role of flexibility working. Hesselink and Van Vuuren (1999) emphasise the importance of the flexibility of labour supply in allowing individuals the ability to work less (or longer) should they wish to. To what extent workers are able to do so is an interesting empirical question in itself, and something to which we return in this study. In principle, under the terms of the Employment Rights Act 1996 (section 80F) employees have the legal right to request flexible working and may make reasonable requests to employers. This builds in a systematic aspect of flexibility. Added to this is the emergence, during the period of the study, of flexible patterns of employment and flexible employment contracts. Bewley et al (2014) evidence the following prevalent aspects of flexible employment in the UK (see Table 8 p52): part-time working; self-employment; temporary, casual, agency and seasonal work based on a fixed-period contracts; homeworking; agreed work arrangements including flexitime, annual-hours contract, term time contract, job sharing, zero-hours contract, on-call working; own work scheduling. Whilst these arrangements exist, we must also acknowledge that institutional factors and constraints may still impede optimal choice of working hours. At one extreme, the demands of the job may mean working more hours than one would necessarily choose (formally measured as overemployment). At the other extreme, the lack of availability of extra hours may mean that individuals work less than they might choose (formally measured as underemployment). According to Walling and Clancy (2010) both overemployment and underemployment approximate to approximately 1 in 10 workers in the UK; approximately 8 in 10 workers report that they are neither want to work more nor less than their current hours.

This paper utilises UK Labour Force Survey (LFS) microdata to examine decisions regarding the response of hours worked to changes in earnings[1]. As well as providing a range of indicators of individual characteristics, the survey provides variables in relation to a range of labour market indicators, including occupation, training, hours of work and earnings (after 1994), which are utilised in this study. The UK LFS has been widely utilised to study aspects of labour market behaviour pertinent to this study. These include: extensive and intensive margins of labour supply (see Blundell, Bozio & Laroque, 2013); employment versus non-employment (see Moffat & Yoo, 2015); under- and over-employment based on choice of hours worked (see: Bell & Blanchflower, 2013; Bell & Blanchflower, 2014; Cam, 2014; and Walling & Clancy, 2010); as well as demographic and lifecycle aspects of employment emphasised here, including employment choices of younger and older workers. In relation to the former see: Berrington, Stone & Falkingham (2010) and Sissons, & Jones (2012). In relation to the latter, a long list includes: Banks, Emmerson & Tetlow (2020); Bell & Rutherford (2013); George et al (2015); Lain (2012) and Nunez (2010).

Labour supply decisions aside, the UK LFS data has also been widely used in relation to a broad range of labour topics of contemporary interest. A short and non-exhaustive list includes: the Great Recession (for example see Singleton, 2018); immigration (for example see Wadsworth, 2018); gender pay gap (for example see Azmat, 2015); ethnic pay gap (for example see Brynin & Güveli, 2012); returns to education (for example see Devereux & Fan, 2011); occupational and social mobility (for example see Laurison & Friedman, 2015); trade unions (for example see Beynon, Davies & Davies, 2012); employment polarisation (for example see Holmes & Mayhew, 2015); job quality (for example see Jones & Green, 2009); sickness and workplace injury (for example see Davies, Jones & Nuñez, 2009); happiness and wellbeing (for example see Fujiwara & Lawton, 2016).

This paper utilises the (LFS from 1994q2 to 2015q2 to examine labour supply decisions with respect to earnings and consider whether we are willing or indeed able to work less. We specifically focused on the three points of time (cross-sections) i.e. beginning of sample 1994q2, Pre Global financial Crisis 2007q2; and latest point of analysis post-Global Financial Crisis 2015q2. Our key results suggest that we are far from income-satiated. The elasticity of hours worked with respect to earnings is stubbornly inelastic and for some demographic cohorts positive, implying the desire to work more. We find that job flexibility matters in facilitating reduced hours of work, but that jobs are not becoming more flexible. We do see a secular reduction in hours worked, accompanied by a shift to working later in life, but these appear to be down to factors other than higher wages.

[11] The LFS (now combined with the UK Annual Population Survey, APS) is a large scale survey available from the UK Data Service. LFS data can be accessed at the following link: https://www.ukdataservice.ac.uk/

The rest of the paper proceeds as follows: In § 2 we shed light on the trends in Aggregate Hours Worked in the UK, § 3 elaborates on the empirical approach. The findings are presented in § 4 and § 5 will discuss the aspects of changing real wages and job flexibility and if we are working less, lastly, § 6 lead us to the conclusion.

2. Are We Working Less: Trends in Hours Worked in the UK

2.1 Aggregate data

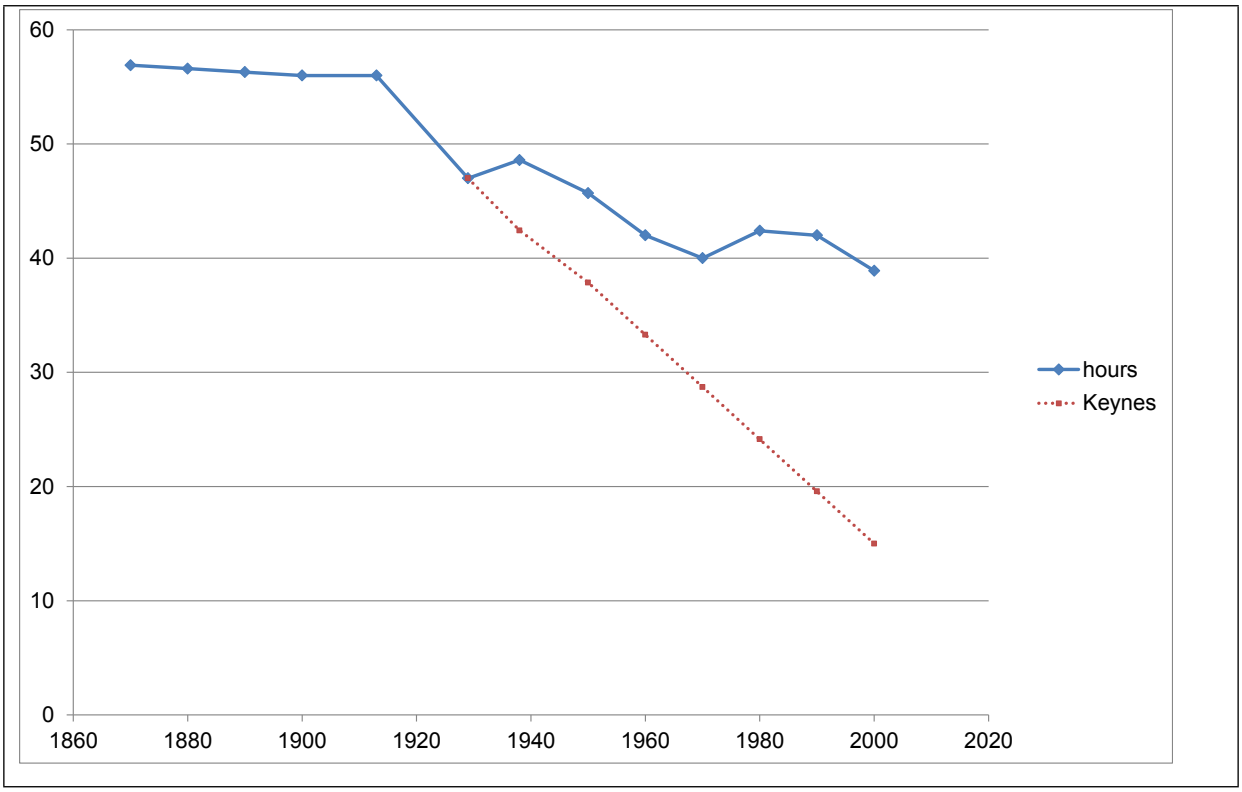
Let us consider the trends in aggregate data before turning our attention later to the analysis of more detailed microdata. The longest historical time series data on hours worked for the UK, which we are aware of, comes from Huberman and Minns (2007) which documents estimated average hours worked in the UK since 1860, at irregular intervals. This is contrasted against Keynes prediction of a 15-hour week by the millennium in Figure 1. What is striking from this picture is that although average hours of work have fallen gradually since the turn of the previous century, progress has been slow in this regard, contradicting the optimism of Keynes. Entering the 21st century, average hours worked are still stubbornly at or near the 40-hour per week mark.

Bringing the picture up to date, aggregate data on hours worked in the UK is available from the Office for National Statistics via the Annual Survey of Hours and Earnings (ASHE). This provides information about hours worked for employees since 1997, based on a one percent sample of all employee jobs taken from HM Revenue & Customs (HMRC) PAYE records. Note that ASHE does not cover the self-employed, nor does it cover employees not paid during the reference period. Figure 2 shows the trend in average full-time weekly paid hours to 2015. Note at this point that how hours are defined (e.g. full time versus part-time or employees versus self-employed) matters considerably, so the chart is best interpreted based on a trend pattern rather than on the precise number of hours worked per week. We also note that ASHE employs a different methodology to Huberman and Minns (2007), so that the estimates are not strictly comparable.

The pattern of working hours from 1997 to 2015 presented in the above Figure 2 suggests that the average working hours have been declining throughout the period, from 40 to 39 hours per week, but with the rate of decline being steady rather than dramatic. We also note from the chart distinct cross sectional differences by gender, with men working longer full-time hours than women, on average. More detail regarding cross sectional differences in employment is available from the ASHE data. Table 1 below shows differences in hours worked (for 1997, 2007 and 2015) by age category, as well as large variations in the distribution of hours worked by percentile. It is noted, in particular, that in terms of patterns by age, the data reveals a sharp drop in hours worked amongst young people (aged 16-21)

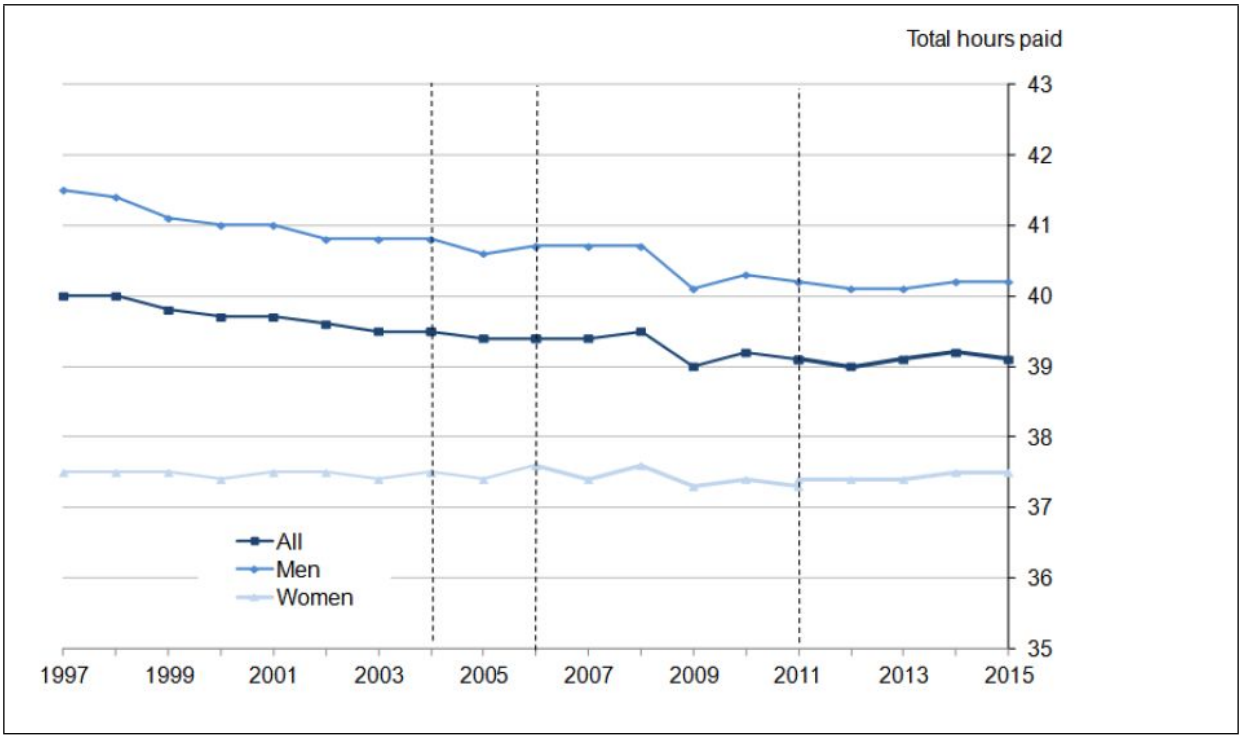
which could be associated with more young people entering the labour market at latter stages. On the other hand, the category with higher age groups 50+ showed a relatively smaller decline, suggesting heterogeneity across age groups.

Figure 1: Estimated average hourly length of the working week, 1870 - 2000



Source: Huberman and Minns (2007)

Figure 2: Average full-time weekly paid hours of work (including overtime), UK, April 1997 to 2015



Source: Annual Survey of Hours and Earnings (ASHE, 2015)

Note: Dashed lines represent discontinuities in ASHE estimates.

Table 1: Hours Worked, Employees by age catgory; 1997, 2007 and 2015

Hours worked: total: employee jobs; 1997							
				Percentiles			
Age	**Employees (millions)**	**Median**	**Mean**	**p10**	**p25**	**p75**	**p90**
18-21	1.24	37.0	31.6	10.0	20.0	40.0	44.0
22-29	3.94	37.0	36.9	24.0	35.0	40.0	46.1
30-39	5.75	37.5	35.8	19.1	35.0	40.0	46.8
40-49	5.32	37.5	35.1	19.0	31.3	40.0	46.0
50+	4.47	37.0	34.0	16.0	27.5	40.0	46.3
All	20.86	37.0	35.1	18.0	32.3	40.0	46.1
Hours worked: total: employee jobs; 2007							
				Percentiles			
Age	**Employees (millions)**	**Median**	**Mean**	**p10**	**p25**	**p75**	**p90**
18-21	1.52	35.0	29.4	8.8	17.0	39.3	43.4
22-29	4.03	37.5	35.5	20.0	34.9	40.0	44.8
30-39	5.89	37.0	35.0	18.9	32.5	40.0	45.0
40-49	6.55	37.0	34.6	18.5	30.5	40.0	45.0
50-59	4.70	37.0	33.8	17.5	29.5	39.5	44.0
60+	1.53	35.0	29.7	9.5	18.5	39.0	44.7
All	24.49	37.0	33.9	16.0	29.9	40.0	44.8
Hours worked: total: employee jobs; 2015							
				Percentiles			
Age	**Employees (millions)**	**Median**	**Mean**	**p10**	**p25**	**p75**	**p90**
18-21	1.25	29.5	26.6	6.8	13.5	38.0	42.3
22-29	4.40	37.5	34.8	18.5	32.5	40.0	44.3
30-39	5.84	37.0	34.6	19.0	32.2	40.0	43.9
40-49	6.43	37.0	34.1	17.9	30.0	40.0	44.0
50-59	5.37	37.0	33.6	17.0	29.4	39.1	43.4
60+	1.93	33.9	29.0	9.2	18.0	38.0	42.2
All	25.46	37.0	33.0	15.5	28.0	39.9	43.7

Source: Annual Survey of Hours and Earnings (ASHE, 2015)

2.2 UK labour force survey microdata estimates

This study utilises microdata from the UK Labour Force Survey (LFS) regarding individual hours worked in three separate survey periods: 1994q2, 2007q2 and 2015q2. Details of the data and modelling exercise are presented in the next section of the paper. Before we do this it is useful to provide some simple descriptive analysis of actual average hours worked, as reported in the LFS in each period. Table 2 analyses actual hours worked in each period, according to aspects later used in the modelling exercise. These are: employment status (employee, self-employed and total workforce) and demographic cohort, that is: *(a)* whether individuals are male or female combined with *(b)* whether they have dependent children. The results reveal interesting insights. Firstly, we can see that reported hours worked are consistently greater for self-employed workers than for employees in, especially so in 1994, and especially so for men rather than women. Secondly, between 1994 and 2007 there was a significant decrease in hours worked for all cohorts, for employees and more so for self-employed workers. The change in hours worked is partly continued into the latter period for those in self-employment, but not employees.

Table 2: Trends in average total hours worked, 1994 – 2015 by Employment type

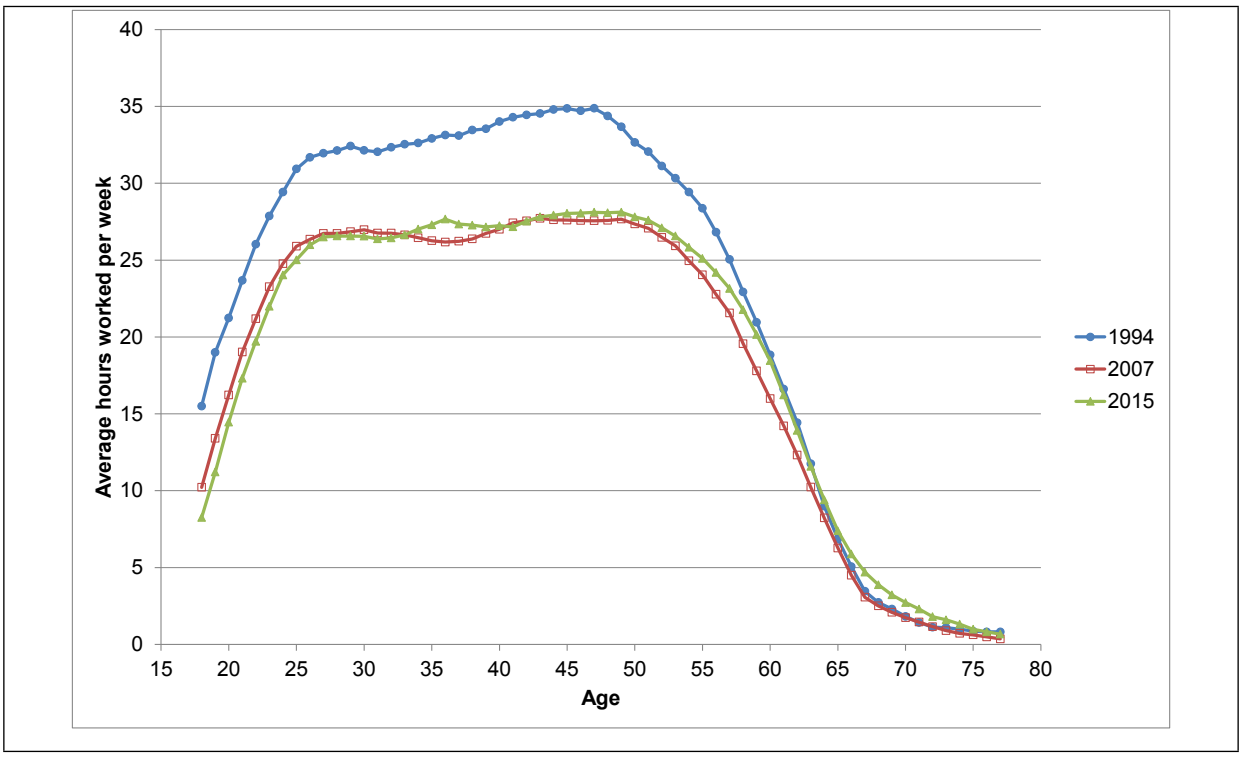
Employees					
				Change	
Cohort	**1994**	**2007**	**2015**	**1994-2007**	**2007-2015**
Male; no children	39.87	35.81	35.79	-10.2%	-0.1%
Male; with children	43.54	38.63	38.78	-11.3%	0.4%
Female; no children	31.20	29.01	29.44	-7.0%	1.5%
Female; with children	24.85	22.88	23.36	-7.9%	2.1%
All	*35.42*	*31.92*	*32.10*	*-9.9%*	*0.6%*
Self Employed					
				Change	
Cohort	**1994**	**2007**	**2015**	**1994-2007**	**2007-2015**
Male; no children	45.42	36.93	36.60	-18.7%	-0.9%
Male; with children	49.91	41.87	39.70	-16.1%	-5.2%
Female; no children	34.67	27.74	26.91	-20.0%	-3.0%
Female; with children	29.72	22.99	23.39	-22.6%	1.7%
All	*43.41*	*35.22*	*33.79*	*-18.9%*	*-4.1%*
Total Workforce					
				Change	
Cohort	**1994**	**2007**	**2015**	**1994-2007**	**2007-2015**
Male; no children	40.74	35.93	35.88	-11.8%	-0.2%
Male; with children	44.79	39.24	38.94	-12.4%	-0.8%
Female; no children	31.31	28.86	29.15	-7.8%	1.0%
Female; with children	25.20	22.81	23.32	-9.5%	2.2%
All	*36.39*	*32.27*	*32.29*	*-11.3%*	*0.0%*

2.3 Employment and the lifecycle

Finally, the analysis so far has looked at average hours worked for those in a job. To this end we have ignore the question of economic activity, i.e. to what extent people opt in or out employment. To complete the picture, we therefore analyse average hours worked based on all people, whether in work (thereby recording positive values of actual hours worked) or those not in work at the time of the survey (recording zero hours worked). Combining these two groups, we calculated the weighted average number of hours worked for the representative individual in the population. The analysis is presented in Figure 3 for each of the surveys 1994q2, 2007q2 and 2015q2. The data is analysed by age, to create a picture of working hours over the lifecycle for each of the three periods.

The results confirm the secular decline in hours between 1994 and 2007. This is particularly the case during early to middle part of the work lifecycle. Working hours per representative individual have indeed increased since 1994 during retirement years, i.e. after age of 65. Comparing 2007 to 2015, profiles cumulatively show similar profiles of hours worked over the lifecycle. However, it is notable that by 2015 younger people (under 30) are working less, whilst older people (over 40; and especially in retirement years) are working more. This is consistent with the stylised fact that people are entering in the labour market at a later stage, but continuing to work for longer.

Figure 3: Lifetime Analysis, hours worked at each age; whole population



Note: profiles are smoothed using a centred 5-year moving average calculation at each age

3. Model and change

3.1 Model

The analysis of hours worked presented in this paper is based on the following model. The purpose of the model is twofold. Firstly, the model captures the relationship between hours worked and real income, thus allowing us to predict likely leisure-for-work substitution effects over time as real incomes change. Secondly, the model incorporates a measure of job flexibility as a proxy for ease of leisure-for-work substitution, so that changes in this structural factor may also be considered over time.

The model is run first of all based on the **individual** decision. In order to make predictions about **aggregate** behaviour we then sum across individuals, by 'type'. The aggregate modelling exercise (details below) deliberately separates out responses according to individual circumstances. To this end, individuals are separated by type, *x*. Type captures the individual's demographic characteristics, i.e.: gender and whether they have dependent children, as *de facto* both variables play key roles in determining labour supply decisions. Interaction between these variables, the model incorporates 4 types, which are referred throughout the remainder of the paper as demographic cohorts. That is:

$$X=\begin{cases} 1: Male; No\ dependent\ children \\ 2: Male; with\ dependent\ children \\ 3: Female; No\ dependent\ children \\ 4: Female; with\ dependent\ children \end{cases}$$

The model is run using survey data (details below) which has a household as well as individual aspect. Having dependent children refers to a situation where the individual is head of the household or spouse/partner of the head of household *and* where there are dependent children in the household i.e. under the age of 16 years. Children in the household 16 years of age or older are not considered as dependent for the purpose of the model. It is noted that the number and definition of types is deliberately kept simple since results are presented for each type separately.

The model is estimated using the individual, *i*, as the unit of observation, where the individual belongs to demographic cohort (type) *x*. A separate model is run for each cohort, so that four separate models are estimated each time period. The individual labour supply decision is modelled as a quadratic function of wages using a log-log specification. i.e.

$$Ln(H_{i|x}) = \alpha_x A_{i|x} + \gamma_{0x} Ln(w_{i|x}) + \gamma_{1x}[Ln(w_{i|x})]^2$$

The parameters γ_{0x} and γ_{1x} capture the elasticity, at individual level, of hours worked with respect to changes in wages. The quadratic functional form allows these elasticity values to vary with wage level,

including encompassing the possibility of a backward-bending supply curve of labour with respect to wages. Since these parameter values depend crucially on ability to change hours worked as desired, we further model these parameter values as a function of flexibility of individuals to change their hours of work in job *j*, as captured by the variable, $f_{ji|x}$, so that:

$$\gamma_{0x} = \beta_{0x} + \phi_{0x} f_{ji|x}$$

$$\gamma_{1x} = \beta_{1x} + \phi_{1x} f_{ji|x}$$

In turn, this yields our model:

$$Ln(H_{i|x}) = \alpha_x A_{i|x} + \beta_{0x} Ln(w_{i|x}) + \phi_{0x} f_{ji|x} \cdot Ln(w_{i|x}) + \beta_{1x} [Ln(w_{i|x})]^2 + \phi_{1x} f_{ji|x} \cdot [Ln(w_{i|x})]^2$$

(1)

In this model, *H* represents the total numbers of hours worked per week; and *w* is the hourly wage rate. The Log of hours worked is dependent on the logarithm of wage, applying a linear and quadratic term. In the model, the flexibility of individuals to change their hours of work is captured by the variable, f_j, where f_j is measured in relation to individual's main occupation of employment (job, *j*). Specifically, f_j is defined as the coefficient of variation of hours observed within that particular occupation. It is noted here that occupations are defined based on 4-digit categories of the UK's Standard Occupational Classification (SOC), the highest level of disaggregation of occupation available in the UK Labour Force Survey. i.e.

$$f_j = \frac{sd(H_j)}{mean(H_j)}$$

Using this measure, higher values of f_j are indicative of jobs in which hours worked are more variable in relation to the norm, and therefore acts as a proxy for 'flexibility' with respect to the choice of hours. The flexibility term is interacted (in multiplicative form) with the log of wages and log of wages squared. In this way flexibility has a direct impact on elasticity of hours worked with respect to wages – a point we will return to in the next section. Each of β_{0x},ϕ_{0x},β_{1x}, ϕ_{1x} are parameter values of the model. Finally, a dummy variable $A_{i|x}$ is included in the model to capture the effect of age on labour supply, modelled separately by cohort. To this end, age is included as one of 11 dummy variables capturing age category. The age categories used are in five year intervals, as follows: age 16-19; 20-24; 25-29; 30-34; 35-39; 40-44; 45-49; 50-54; 55-59; 60-64; 65 and over.

Whilst the model is estimated at the individual level, we are able to readily arrive at predicted average aggregate numbers of hours worked, in a given week, per cohort by summing over the cohort population, whilst taking onto account the distribution of wages and job flexibility across individuals.

Applying a weighted average measure calculation, we can calculate, average aggregate numbers of hours worked for cohort *x*, $\overline{\overline{H}}_{x,t}$. i.e.

$$\overline{\overline{H}}_{x,t} = \sum_A \sum_j p_{x,t}(A) \cdot p_{x,t}(j) \cdot \hat{H}_{i|x,t} \quad (2)$$

In this calculation, $\hat{H}_{i|x,t}$ represents the predicted hours worked for individual *i* given her type (*x*), age (*A*) and job (*j*). Summing over the working population, $p_{x,t}(A)$ and $p_{x,t}(j)$ represent, in turn, the proportion of each age group (*A*) and occupation (*j*) in the population of cohort *x* at time *t*.

The individual labour supply decision, in equation (1), is estimated using an OLS regression model. This is referred to as the **individual model**. The summation process, in equation (2) which involves averaging over individuals with cohort, is referred to as the **aggregate model**. Note at this point that the structure of equation (1) is kept deliberately simple with aggregation in mind, i.e. only age and job flexibility inform individual labour supply responses to wages. The distribution of age and job flexibility across cohort populations are then taken into account when summing to aggregate level for each type, as described above (effectively creating two sub-dimensions of summation by type). Any additional variables included in equation (1) would inevitably be lost through averaging in the summation exercise. These are therefore left out and effectively form the error term at individual level[2].

3.2 Change

The purpose of the modelling exercise is to compare changes in hours worked, by cohort, over time. So, in the context of the model, why might average hours worked (across the working population) vary from one point in time to another? The model provides the following list of reasons:

(i) Real wages change;

(ii) Job flexibilities change;

[2] One difficulty and long-standing issue in the estimation of such models is endogeneity. In short, variables used to predict labour supply (wages in particular) may well be endogenous because unobservable affecting labour supply may well be correlated with unobservable affecting explanatory variables such as wages, given heterogeneous individuals. This issue is associated with a large literature following Heckman J. (1974), with excellent commentary on this issue provided by Blundell, MaCurdy & Meghir (2007) and Van der Klaauw (2014). We do not approach this issue directly here but acknowledge it as an aspect for further research. Nonetheless, the drawn inferences and underlying relationships identified can be treated correlational rather causational. The debate on correlation vs causation and causation vs occurrence is beyond the scope of this paper.

(iii) Other exogenous changes, relating to either: (a) changes in underlying labour supply parameters (α's; β's; and ϕ's) in the individual model; or (b) changes in composition of cohort population by age in the aggregate model.

These changes will be examined in the paper, with particular and separate focus on the role of wages and job flexibility. The final factor in this list is considered as a residual category.

3.3 Estimation and data

The model is estimated using the UK Labour Force Survey (LFS). The LFS is a unique and rich source of microdata relating to individual's hours of work and earnings, together with a wide range of variables such as occupation and personal and household characteristics. Quarterly data is available from the LFS from 1992 onwards. Crucially, complete data on earnings (derived hourly rate of pay) and hours worked is available each quarter from 1994 onwards, thereby defining a starting point for our study. The study seeks to examine changes in hours worked over the longest possible period of time, with the latest available data at the time of writing being available for 2015. During the intervening period, the economic crisis (2008 onwards) may well have changed supply decisions and circumstances. We therefore choose to compare three points in time: 1994q2; 2007q2 (pre-crisis); and 2015q2 (post-crisis). The point 1994q2 is chosen because it is the start of the LFS sample period, whereas the 2007q2 and 2015q2 mark pre- and post-crisis points for comparison.

Of particular note in running the regression models are the following considerations. Firstly, LFS earnings (hourly pay) data is available only for **employees** (including those on government schemes) and not for self-employed workers. The model therefore represents supply decisions of employees only. Self-employed workers (which account for about 1 in 7 of the workforce) are not modelled explicitly. However, we presented figures on hours worked for self-employed workers for contrast with employees later in the paper. Secondly, note also at this point that information from the LFS on hours worked and hourly earnings is derived from **self-reported** data on hours worked in the previous week, usual hours worked and gross weekly pay. There is therefore an aspect of recall error in the data. Moreover, since hours worked (the denominator in hourly pay calculations) includes both paid and unpaid hours the effect of this is to understate the *paid* hourly rate. Thirdly, we note that so that regression results are comparable over time, monetary values are adjusted for inflation. To this end we use RPI data for the corresponding periods. LFS earnings in 2007q2 and 2015q2 are deflated to 1994-equivalent values. The analysis presented in this paper is undertaken at 1994 real wages. Finally, our dependent variable 'hours worked' is calculated based on total reported hours over all jobs, using

the variable TOTHRS in the LFS. This includes unpaid work and overtime working. The flexibility coefficient, f_j, which proxies for the individual's ability to vary their hours, uses the distribution (mean and standard deviation) of actual hours in main job (TTACHR) and is calculated for each occupation (j) and later applied to individual (i) depending on their main job. Note that the unit of measurement of flexibility is not important (our measure is essentially unit free), as we simulate high and low flexibility situations later in the paper.

4. Findings

4.1 Regression estimates

The model is estimated for three separate periods; 1994q2; 2007q2; and 2015q2, the results of which are shown in Tables 3, 4 and 5, respectively. Each table contains four separate regressions, by demographic cohort. All results are significant at 1% unless otherwise stated. It is noted that in all but one of the regressions (1994Q2) all coefficients reported are indeed significant. Moreover, the fit of the regressions is very strong with very high adjusted R-squared values and low model fit errors (RMSE) achieved on all regressions. In part these strong results reflect large sample sizes.

Table 3: Hours worked regression model; 1994Q2

	Male; no children		**Male; dependent**		**Female; no children**		**Female; Dependent children**	
	Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std.**	**Coef.**	**Std. Err.**
Ln(w)	0.493	0.051	0.070[n.s]	0.070	0.546	0.084	1.016	0.155
$[Ln(w)]^2$	-0.166	0.022	-0.002[n.s.]	0.024	-0.125	0.037	-0.204	0.065
Ln(w) * f	-1.821	0.127	0.013[n.s.]	0.136	-1.646	0.161	-1.791	0.233
$[Ln(w)]^2$ * f	0.565	0.064	-0.061[n.s.]	0.056	0.413	0.086	0.331	0.119
16-19	3.200	0.035	-	-	2.991	0.051	2.716	0.257
20-24	3.719	0.037	3.608	0.076	3.554	0.057	2.747	0.126
25-29	3.786	0.040	3.654	0.054	3.603	0.059	2.699	0.101
30-34	3.807	0.044	3.655	0.054	3.509	0.064	2.753	0.096
35-39	3.780	0.049	3.700	0.054	3.545	0.068	2.825	0.097
40-44	3.825	0.048	3.695	0.055	3.472	0.061	2.903	0.099
45-49	3.764	0.042	3.617	0.057	3.355	0.058	2.951	0.105
50-54	3.801	0.043	3.571	0.063	3.328	0.058	2.839	0.153
55-59	3.759	0.043	3.503	0.095	3.227	0.062	2.814	0.285
60-64	3.742	0.051	3.752	0.152	3.036	0.070	-	-
65+	2.901	0.074	-	-	2.886	0.089	-	-
N	2525		1379		2607		1328	
Adj R-sq	0.9856		0.9926		0.9769		0.9623	
RMSE	0.434		0.321		0.509		0.602	

Note: Coefficients significant at 1% unless otherwise stated. “n.s.” = not significant at the 5% error level.

Table 4: Hours worked regression model; 2007Q2

	Male; no children		Male; dependent		Female; no children		Female; dependent	
	Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Ln(w)	0.738	0.058	0.269	0.054	0.814	0.065	1.286	0.108
$[Ln(w)]^2$	-0.231	0.022	-0.080	0.022	-0.233	0.028	-0.285	0.041
Ln(w) * f	-1.816	0.145	-0.858	0.172	-2.164	0.156	-1.970	0.192
$[Ln(w)]^2$ * f	0.629	0.069	0.288	0.076	0.707	0.079	0.445	0.094
16-19	2.922	0.047	3.764	0.309	2.810	0.052	2.891	0.230
20-24	3.398	0.049	3.653	0.058	3.384	0.052	2.650	0.094
25-29	3.470	0.051	3.613	0.041	3.397	0.055	2.597	0.080
30-34	3.459	0.053	3.618	0.037	3.427	0.058	2.530	0.075
35-39	3.479	0.055	3.630	0.036	3.359	0.057	2.579	0.074
40-44	3.451	0.054	3.630	0.036	3.397	0.055	2.653	0.072
45-49	3.475	0.052	3.639	0.037	3.328	0.053	2.625	0.077
50-54	3.487	0.051	3.687	0.043	3.282	0.052	2.610	0.087
55-59	3.424	0.051	3.584	0.053	3.213	0.052	2.504	0.150
60-64	3.331	0.051	3.645	0.086	2.990	0.056	-	-
65+	2.929	0.059	-	-	2.734	0.069	-	-
N	3990		2170		4107		2236	
Adj R-sq	0.9868		0.9932		0.9802		0.9763	
RMSE	0.416		0.307		0.479		0.497	

Note: Coefficients significant at 1% unless otherwise stated

Table 5: Hours worked regression model; 2015Q2

	Male; no children		Male; dependent		Female; no children		Female; dependent	
	Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Ln(w)	0.429	0.056	0.677	0.066	0.779	0.070	0.778	0.103
$[Ln(w)]^2$	-0.131	0.022	-0.213	0.024	-0.184	0.029	-0.150	0.041
Ln(w) * f	-1.410	0.158	-1.483	0.168	-1.576	0.159	-1.786	0.239
$[Ln(w)]^2$ * f	0.461	0.073	0.585	0.071	0.352	0.075	0.404	0.111
16-19	2.924	0.049	3.790	0.316	2.712	0.046	2.443	0.337
20-24	3.507	0.045	3.342	0.071	3.285	0.047	3.135	0.097
25-29	3.618	0.048	3.418	0.047	3.409	0.050	3.027	0.081
30-34	3.643	0.051	3.393	0.044	3.372	0.053	2.987	0.078
35-39	3.572	0.054	3.417	0.043	3.372	0.057	3.010	0.079
40-44	3.624	0.052	3.391	0.044	3.328	0.052	3.001	0.080
45-49	3.618	0.050	3.403	0.045	3.289	0.047	2.987	0.082
50-54	3.640	0.049	3.347	0.047	3.233	0.046	3.071	0.086
55-59	3.633	0.048	3.389	0.058	3.152	0.046	3.078	0.142
60-64	3.488	0.049	3.220	0.101	3.008	0.049	3.448	0.340
65+	3.130	0.054	-	-	2.668	0.059	1.898	0.470
N	3020		1757		3137		1769	
Adj R-sq	0.9865		0.9928		0.9819		0.9799	
RMSE	0.418		0.314		0.460		0.465	

Note: Coefficients significant at 1% unless otherwise stated

With respect to the results presented in Tables 3, 4 and 5, coefficients of Ln(w) and $[Ln(w)]^2$ relate to the effect of wages on hours worked. The interpretation is made complex by both the quadratic form, so that elasticity of hours worked with respect to wages will vary with the wage rate rather than being a single value, and by the fact that there is an interaction between Ln(w) and the flexibility measure, so that elasticity of hours worked with respect to wages is also allowed to vary with job flexibility. A suggested intuitive insight into the results can be gained as follows.

If we suppose, as a starting point, that flexibility is zero (f=0) so that all job roles within an occupation offer the same hours with no variation then only the coefficients of Ln(w) and $[Ln(w)]^2$ matter in determining wage elasticity of labour supply (the top two rows of each table). In each period and for each cohort, the regression coefficients reveal a positive value on the linear term Ln(w) and negative value on the quadratic term $[Ln(w)]^2$. This may be interpreted as a *negative* quadratic profile of hours worked against wages, with a turning point at some threshold wage value (readily derived) after which we observed decreased hours and indeed a 'backward bending' labour supply curve. Note that these coefficients are significant in all but one case.

In reality, there will be variation of hours within jobs (more in some than in others) so that f will take a positive value (observed values of *f* can be found in Appendix 1). We must also consider the interaction terms f*Ln(w) and $f*[Ln(w)]^2$. These coefficients (3rd and 4th rows of each table) show, in all cases, have the opposite signs, a negative linear and positive quadratic effect once $f>0$. The significant effects on the interaction terms with job flexibility, for both the linear and the squared log wage term indicates that, in all but the one non-significant case, job flexibility does indeed play a role in determining how workers adjust their hours to changes in wage rates. The signs of the coefficients in this second case suggest a *positive* quadratic profile of hours worked against wages, with higher wages inducing ever increasing hours worked after a certain wage level.

These two competing effects are summed together. We can infer that in jobs that are more flexible (manifest higher values of *f*) this latter effect will eventually dominate after some threshold point on *f* , so that higher wages allow more hours worked rather than less, as we might have suspected following Keynes's original prediction. Given the squared and interacted terms it is hard to generalise beyond this. We therefore take two approaches to make the results meaningful. Firstly, we ask the simple question of whether the labour supply curve is 'backward bending' at reasonable values of the flexibility coefficient. This exercise is presented below. Secondly, we undertake a fuller simulation exercise to consider the shape of the supply curves under a range of parameterisations for the different demographic cohorts. The latter helps provide a visual understanding of the dynamics. This is presented in section 4.2.

The standard 'backward bending' labour supply curve suggests that hours worked first increase at lowest wage rates and then decreasing beyond a threshold wage. Taking the second differential of equation (1) with respect to Ln(w), we can see that this applies when the $(\beta_{1x} + \phi_{1x} f_{ji|x})$ is negative. Taking $f_{ji|x}$ at its median value in each case, we can calculate the quadratic term. These are shown in Table 6, where negative coefficients of the quadratic term are shown where they apply, indicating the presence of a backward bending supply curve. Labour Supply curves are backward bending particularly during the latter two periods, and particularly for women rather than men.

Table 6: Quadratic term and backward bending supply curve

Demographic	1994	2007	2015
Male; no ch.	no	-0.053 Yes	no
Male; with ch.	n.s.	-0.003 Yes	-0.049 Yes
Female; no ch.	no	no	-0.058 Yes
Female; with ch.	-0.078 Yes	-0.121 Yes	-0.006 Yes

Note: "n.s." = Coefficients not significant at the 5% error level.

Finally, we note at this stage interesting labour supply differentials with respect to age and demographic type. Consistent across periods and by demographic type, we see hours worked steadily increasing with age, typically peaking at age 40-44 or 45-49 and then steadily declining. Youngest (16-19) and oldest (65 and over) age categories consistently work least number of hours. We also see consistent patterns for each period of men working more than women and those with children working less hours than those without dependent children. These results seem intuitively reasonable.

4.2 Labour Supply Curves

The results of the regression models may be illustrated diagrammatically in Figures 4 and 5 for men and women, respectively. The diagrams plot modelled hours worked against wage rates, for each period where 2007 and 2015 wages are deflated to 1994 (constant) levels. These effectively show labour supply curves but with axis reversed since we retain the dependent variable (hours worked) on the y-axis. Each cohort is shown separately. As noted, labour supply decision also depends, critically, on job flexibility, which is supported by a probability distribution for each cohort. For convenience we contrast "most flexible jobs" (taken at the 90th percentile of job flexibility, by cohort) with "least flexible jobs" (taken at the 10th percentile of job flexibility, by cohort). Note that labour supply depends on age. These curves shown for the age range 40-44, which is the age of peak labour supply. Other age groups will have curves with the same shape, but these will shift upwards/downwards, according to the constant term in the regression.

Supply curves vary considerably from cohort to cohort and over time. Amongst the notable features, three aspects are immediately striking. Firstly, there appear to be different trends amongst men and women. Crudely, men's hours worked have decreased over time since 1994, especially so during the period before the crisis, and especially at the bottom end of the earnings distribution. The decrease in hours worked for men shows a downward vertical shift (at all wages) for all but one cohort (males without dependent children in the most flexible jobs), where the highest paid have not decreased their labour supply. In contrast, women's hours worked have moved generally in the opposite direction - increasing - especially during the period before the crisis, but predominantly at the top end of the earnings distribution. The increase in women's hours worked here correlates with the background of increased female participation in the labour force, driven by exogenous socio-economic factors relating primarily to changing levels of education and fertility on which there is a large literature (see Vlasblom & Schippers, 2004).

Secondly, interesting changes in labour supply emerge, post-crisis. For males, the pattern is generally one of a partial reversal of the changes since 1994, with increased hours worked (at all wages). Men with children in particular are more willing to take advantage of higher wages to offer labour than previously. For women, a more complex pattern emerges. Women with dependent children show increased hours worked, compared to 2007, especially at high wage rates. Again, this illustrates emerging differences between gender groups at a time of shifting male versus female participation. In part the shift upwards between 2007 and 2015 in hours worked may also reflect the impact of the crisis on individuals/households with greater imperative to work post-recession.

Finally, it is noted that job flexibility does indeed make a big difference with respect to choice of hours worked: in particular for women with children, who work much lower hours in flexible jobs, but also for men without children, who work much more in least flexible jobs. Moreover, it is noted that job flexibility also plays a role in determining sensitivities of hours worked to changes in real wages, as seen in the slope of the supply curves. 'Backward bending' supply curves apply to least flexible jobs, whereas flexibility is associated with positive wage elasticities. Aspects of inflexiblility versus flexibility may indeed reflect deeper constraints on choice relating to job type and organisational structures therein.

Figure 4: Male Labour Supply by demographic cohort and time period

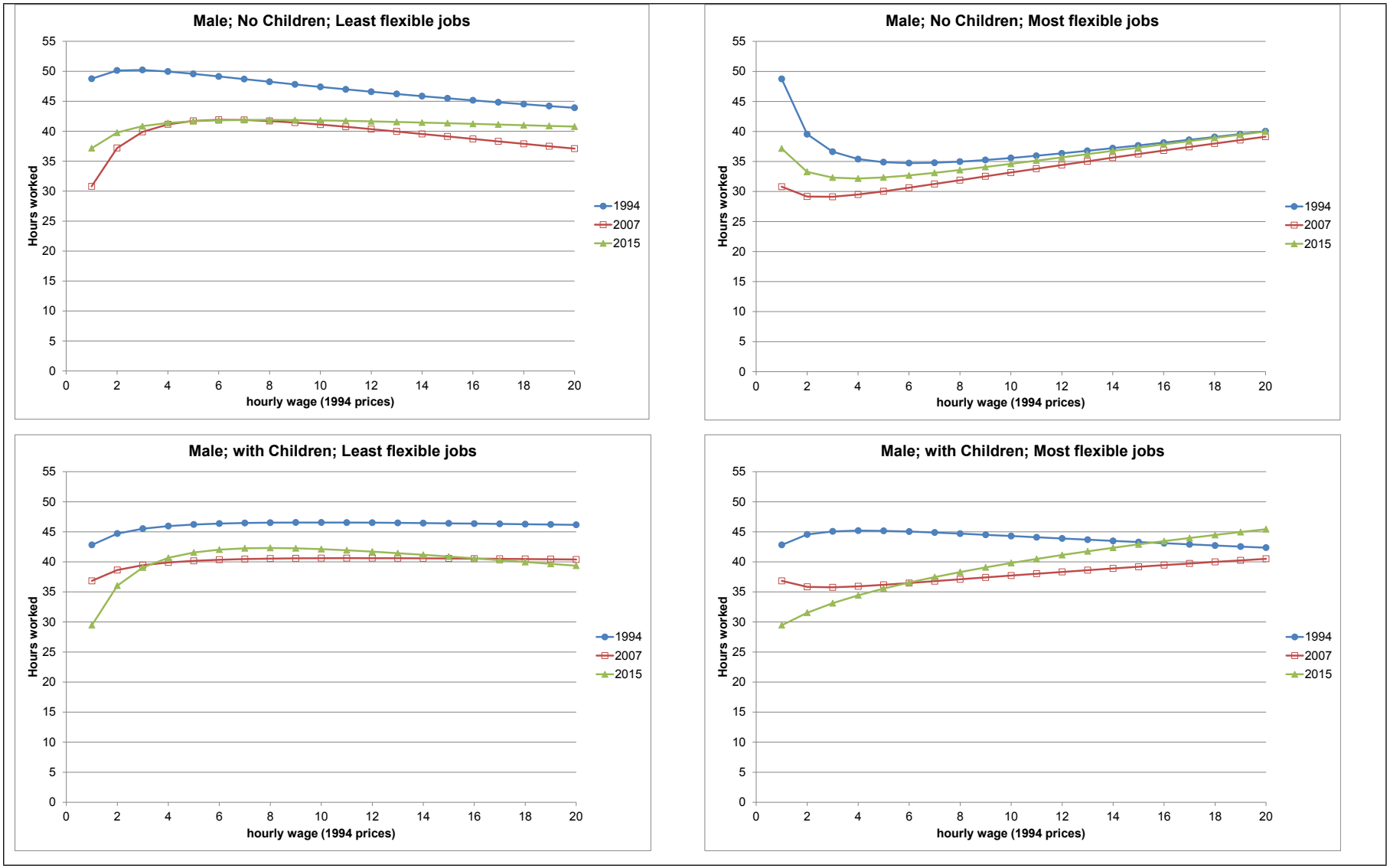
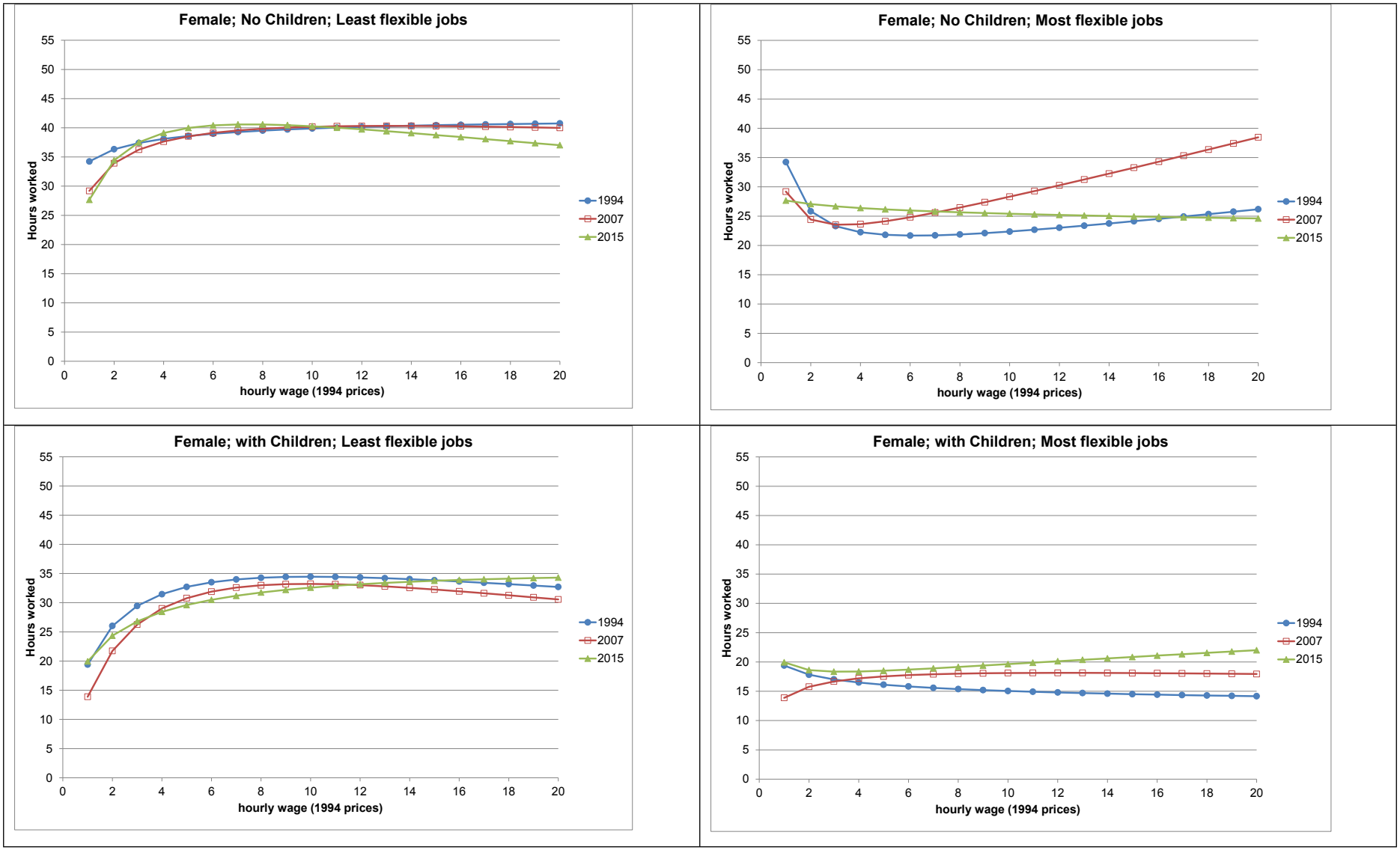


Figure 5: Female Labour Supply by demographic cohort and time period



5. Changing real wages and job flexibility

As highlighted in section 3 of this paper, changing labour supply decisions depend crucially on real wages, as individuals may be induced to work less as their real incomes increase over time (or conversely so when real wages fall); and on job flexibility, as individuals are more able to vary their hours worked in responses to changes in real wages. How these two factors have changed over the periods 1994-2007-2015 is the focus of this section of the paper. Note that descriptive statistics in relation to measures of job flexibility by cohort and by period are presented in Appendix 1.

5.1 Sensitivity to changes in real wages

Between 1994q2, 2007q2 and 2015q2, based on LFS calculations, mean nominal average hourly earnings increased from £6.99 to £11.78 to £14.29. Adjusting for RPI this corresponds with an 18.0% increase in real wages between and 1994-2007; followed by a 3.6% decrease in real wages between 2007-2015, following the economic crisis. The impact of changes in real wages on hours worked will depend on change in wages experienced by each demographic type and according to individuals' relative position on the earnings distribution.

One way of summarising the effect of changes in real earnings on hours worked is to calculate the elasticity of hours worked with respect to earnings, ϵ. Within the context of this model, following the standard result, this is equal to the differential of log of hours work with respect to log earnings. Taking the first derivative of equation (1), we obtain the following:

$$\epsilon = \frac{dLn(H_{i|x})}{dLn(w_{i|x})} = \beta_{0x} + \phi_{0x} f_{ji|x} + 2(\beta_{1x} + \phi_{1x} f_{ji|x}) Ln(w_{i|x}) \quad (3)$$

From this we can see that the elasticity of labour supply with respect to changes in real wages will depend, at individual level, on demographic type, job flexibility and current earnings. Therefore a complex picture emerges, with a range of supply responses by cohort.

To consider sensitivities to real wage changes at each point in time, we employ the following approach. Using the estimated model for individual *i* of cohort *x* at each period in time (e.g. 1994), we consider: according to the model what will be the change in labour supply if real wages were to change from $w_{i|x}$ to $w_{i|x}^{(1)}$? Employing the model, we can predict the new level of hours worked as follows:

$$Ln(\hat{H}_{i|x}) = \alpha_x A_{i|x} + \beta_{0x} Ln(w_{i|x}^{(1)}) + \phi_{0x} f_{ji|x} \cdot Ln(w_{i|x}^{(1)}) + \beta_{1x} Ln(w_{i|x}^{(1)})^2 + \phi_{1x} f_{ji|x} \cdot Ln(w_{i|x}^{(1)})^2$$

In undertaking this modelling exercise we estimate a base period model (e.g. in 1994) and then impose wage levels which manifest themselves in the next period (e.g. 2007) for $w_{i|x}^{(1)}$, in this way we can

predict how changes in real wages are likely to have changed labour supply between the two periods (i.e. 1994-2007), *ceteris paribus*. To consider the effect for the whole cohort we aggregate up responses across the earnings distribution, employing the aggregate model. This modelling exercise is done, per cohort, using the 1994 model, imposing 2007 new wages; and in turn for the 2007 model, imposing 2015 new wages. The results are displayed in Table 7 for the period 1994-2007 and similarly in Table 8 for the period 2007-2015, for a range of scenarios. We consider the change for the cohort over all (mean value), and for the median employee within the cohort, i.e. earning median wages and with median job flexibility. As well as this we test the sensitivity of the results for individuals at the high and low end (10^{th} and 90^{th} percentile) of the wage distribution, assuming median flexibility; and for individuals at the high and low end (10^{th} and 90^{th} percentile) of the job flexibility distribution, assuming median wages.

For the period 1994-2007, real incomes increase across the distribution of earnings, and particularly so for women. All employees benefit, creating incentives for employees to change their labour supply. We see a contrast by gender, whereby men will respond to these incentives by reducing hours worked, whereas women will work more, especially those with dependent children. We note in this case that elasticities of labour supply for men are negative, but positive for women. For the period 2007-2015, there is a reversal of fortunes with real incomes decreasing. According to the estimates, employees will respond to these changes in income by decreasing hours worked. In this case, we see predominantly positive elasticities, and especially so for women.

Two general remarks are worth making at this point. Firstly, the results show that employees are apparently not ready to reduce hours of work as wages increase. This applies across the various scenarios estimated here. Women in particular show willingness to increase hours of work with higher wages. The apparent willingness to reduce hours worked following the onset of the economic crisis (2007-2015) comes only as a response to lower real wages – the opposite to what we would expect given satiated behaviour. Secondly, we observe that the response of hours worked to reasonably large changes in real wages is in fact quite muted. Elasticity values are small, according to our estimates, and strongly inelastic, whether positive or negative. These results are not inconsistent with the previous literature. Whilst our elasticity estimates are close to zero (median wage elasticity ranging from -0.04 to +0.06 in the first period, and +0.02 to +0.14 in the second period), previous studies have similarly reported inelastic labour supply functions. Estimates for the UK by Blundell et al. (2000) report wage elasticity values in the range (-0.17 to +0.11). Extensive surveys of labour supply by Bargain et al (2011) and Evers, De Mooij & Van Vuuren (2008) report generally weak inelastic responses of hours worked to changes in wages across a number of studies in Europe and the US.

Table 7: Effect of real wage changes on hours worked, 1994-2007

Male, no children					
	Change in real wage	**1994 Hours worked**	**Predicted @ 2007 real**	**Change in hours**	**Elasticity**
Mean	15.2%	39.86	39.57	-0.7%	-0.05
Median f, w	13.4%	40.80	40.58	-0.5%	-0.04
f_{med} ; $w_{0.1}$	27.8%	42.09	41.64	-1.1%	-0.04
f_{med} ; $w_{0.9}$	14.2%	39.53	39.33	-0.5%	-0.04
$f_{0.1}$; w_{med}	13.4%	45.09	44.75	-0.8%	-0.06
$f_{0.9}$; w_{med}	13.4%	31.75	31.77	0.1%	0.01
Male, with dependent children					
	Change in real wage	**1994 Hours worked**	**Predicted @ 2007 real**	**Change in hours**	**Elasticity**
Mean	16.5%	43.54	43.42	-0.3%	-0.02
Median f, w	9.7%	43.88	43.85	-0.1%	-0.01
f_{med} ; $w_{0.1}$	7.4%	43.68	43.74	0.1%	0.01
f_{med} ; $w_{0.9}$	26.0%	43.35	42.99	-0.8%	-0.03
$f_{0.1}$; w_{med}	9.7%	44.54	44.58	0.1%	0.01
$f_{0.9}$; w_{med}	9.7%	42.69	42.55	-0.3%	-0.03
Female, no children					
	Change in real wage	**1994 Hours worked**	**Predicted @ 2007 real**	**Change in hours**	**Elasticity**
Mean	19.8%	31.20	31.30	0.3%	0.02
Median f, w	16.2%	32.63	32.78	0.5%	0.03
f_{med} ; $w_{0.1}$	26.9%	32.46	32.46	0.0%	0.00
f_{med} ; $w_{0.9}$	24.0%	33.66	34.17	1.5%	0.06
$f_{0.1}$; w_{med}	16.2%	37.80	38.11	0.8%	0.05
$f_{0.9}$; w_{med}	16.2%	21.44	21.31	-0.6%	-0.04
Female, with dependent children					
	Change in real wage	**1994 Hours worked**	**Predicted @ 2007 real**	**Change in hours**	**Elasticity**
Mean	20.1%	24.85	25.14	1.2%	0.06
Median f, w	25.4%	27.55	27.99	1.6%	0.06
f_{med} ; $w_{0.1}$	28.9%	25.70	26.71	3.9%	0.13
f_{med} ; $w_{0.9}$	19.9%	28.10	27.84	-0.9%	-0.05
$f_{0.1}$; w_{med}	25.4%	33.18	34.18	3.0%	0.12
$f_{0.9}$; w_{med}	25.4%	16.47	16.10	-2.2%	-0.09

Table 8: Effect of real wage changes on hours worked, 2007-2015

Male, no children

	Change in real wage	2007 Hours worked	Predicted @ 2015 real	Change in hours	Elasticity
Mean	-4.3%	35.81	35.69	-0.3%	0.07
Median f, w	-5.2%	37.27	37.23	-0.1%	0.02
f_{med} ; $w_{0.1}$	-9.5%	36.07	35.74	-0.9%	0.09
f_{med} ; $w_{0.9}$	-3.5%	36.72	36.80	0.2%	-0.06
$f_{0.1}$; w_{med}	-5.2%	40.04	40.06	0.0%	0.00
$f_{0.9}$; w_{med}	-5.2%	29.75	29.54	-0.7%	0.13
Male, with dependent children					
	Change in real wage	**2007 Hours worked**	**Predicted @ 2015 real**	**Change in hours**	**Elasticity**
Mean	-6.2%	38.62	38.54	-0.2%	0.03
Median f, w	-4.3%	38.91	38.86	-0.1%	0.02
f_{med} ; $w_{0.1}$	-10.9%	38.15	38.02	-0.3%	0.03
f_{med} ; $w_{0.9}$	-5.9%	39.72	39.66	-0.2%	0.03
$f_{0.1}$; w_{med}	-4.3%	39.90	39.89	0.0%	0.00
$f_{0.9}$; w_{med}	-4.3%	36.63	36.52	-0.3%	0.07
Female, no children					
	Change in real wage	**2007 Hours worked**	**Predicted @ 2015 real**	**Change in hours**	**Elasticity**
Mean	-3.8%	29.01	28.83	-0.6%	0.16
Median f, w	-4.3%	29.04	28.90	-0.5%	0.12
f_{med} ; $w_{0.1}$	-7.7%	27.63	27.43	-0.7%	0.09
f_{med} ; $w_{0.9}$	-6.5%	32.00	31.69	-1.0%	0.15
$f_{0.1}$; w_{med}	-4.3%	33.99	33.87	-0.4%	0.09
$f_{0.9}$; w_{med}	-4.3%	21.46	21.31	-0.7%	0.16
Female, with dependent children					
	Change in real wage	**2007 Hours worked**	**Predicted @ 2015 real**	**Change in hours**	**Elasticity**
Mean	0.9%	22.88	22.68	-0.9%	-1.00
Median f, w	-4.4%	23.44	23.30	-0.6%	0.14
f_{med} ; $w_{0.1}$	-6.9%	21.33	20.94	-1.8%	0.26
f_{med} ; $w_{0.9}$	-1.5%	24.00	24.02	0.1%	-0.07
$f_{0.1}$; w_{med}	-4.4%	29.14	28.92	-0.8%	0.18
$f_{0.9}$; w_{med}	-4.4%	16.20	16.15	-0.3%	0.07

Finally, to complete the picture, we may consider elasticity of labour supply in 2015. We do this by considering the effect of a hypothetical increase in wages for all cohorts, uniformly applied across the distribution to represent a reversal of the decline in real wages moving forward, post crisis. The choice of value is +3.6% increase in real wages which is equal in magnitude to the average decline in real wages between 2007-2015. (The arbitrary choice of hypothetical scenario is not critical in calculating elasticities). The results of this exercise are shown in Table 9.

The results show predominantly negative responses – decrease in hours worked in response to wage increases – for three of the four cohorts, i.e. excluding women without children. For the latter group, we see, on average, a marginal desire to increase hours worked, especially at highest earnings and job flexibility. The predominantly negative results demonstrate a willingness to decrease hours worked with higher incomes, post crisis, in contrast with earlier periods. However, as previously, elasticities are very small and so responses are muted.

5.2 Job flexibility

The regression results presented in the previous section reveal that job flexibility is an important determinant of hours worked. The intuition behind this is that greater job flexibility facilitates the ease with which workers are able to increase/reduce their hours worked, should they wish to do so, for example in response to changes in income. The exact response of hours worked to changes in job flexibility can be obtained by differentiating equation (1), as follows.

$$\frac{dLn(H_{i|x})}{df_{ji|x}} = \phi_{0x} Ln(w_{i|x}) + \phi_{1x}[Ln(w_{i|x})]^2 \qquad (4)$$

The size of this effect depends at individual level on both parameters of the model and on wages. However, this result is not intuitive primarily because change in flexibility has no natural unit of comparison. To provide transparency, we therefore consider the effect of job flexibility on labour supply based on a simple hypothetical experiment, as follows. There is a distribution of job flexibilities. Suppose for now that the least flexible jobs (lower half of the distribution) became more flexible so that they all are assigned flexibility values at the median; with the most flexible jobs (upper half of the distribution) left unchanged. What is the effect on hours worked? Table 10 shows the results of this exercise for each cohort for each of the three time periods.

Table 9: Effect of a hypothetical increase in real wage changes after 2015

Male, no children					
	Change in real wage	**2015 Hours worked**	**Predicted**	**Change in hours**	**Elasticity**
Mean	+3.6%	35.79	35.90	-0.3%	-0.09
Median f, w	+3.6%	36.38	36.45	-0.2%	-0.05
f_{med} ; $w_{0.1}$	+3.6%	35.68	35.73	-0.1%	-0.04
f_{med} ; $w_{0.9}$	+3.6%	37.40	37.53	-0.3%	-0.10
$f_{0.1}$; w_{med}	+3.6%	39.11	39.13	-0.1%	-0.01
$f_{0.9}$; w_{med}	+3.6%	30.71	30.89	-0.6%	-0.16
Male, with dependent children					
	Change in real wage	**2015 Hours worked**	**Predicted**	**Change in hours**	**Elasticity**
Mean	+3.6%	38.78	38.95	-0.4%	-0.12
Median f, w	+3.6%	39.58	39.73	-0.4%	-0.10
f_{med} ; $w_{0.1}$	+3.6%	37.02	37.24	-0.6%	-0.16
f_{med} ; $w_{0.9}$	+3.6%	40.10	39.99	0.3%	0.08
$f_{0.1}$; w_{med}	+3.6%	40.92	40.89	0.1%	0.02
$f_{0.9}$; w_{med}	+3.6%	37.09	37.57	-1.3%	-0.35
Female, no children					
	Change in real wage	**2015 Hours worked**	**Predicted**	**Change in hours**	**Elasticity**
Mean	+3.6%	29.45	29.43	0.1%	0.02
Median f, w	+3.6%	29.96	29.98	-0.1%	-0.02
f_{med} ; $w_{0.1}$	+3.6%	29.18	29.28	-0.3%	-0.09
f_{med} ; $w_{0.9}$	+3.6%	29.41	29.22	0.7%	0.18
$f_{0.1}$; w_{med}	+3.6%	35.69	35.80	-0.3%	-0.09
$f_{0.9}$; w_{med}	+3.6%	23.11	23.06	0.2%	0.06
Female, with dependent children					
	Change in real wage	**2015 Hours worked**	**Predicted**	**Change in hours**	**Elasticity**
Mean	+3.6%	23.36	23.54	-0.8%	-0.21
Median f, w	+3.6%	23.22	23.40	-0.8%	-0.21
f_{med} ; $w_{0.1}$	+3.6%	21.74	21.86	-0.5%	-0.15
f_{med} ; $w_{0.9}$	+3.6%	25.45	25.71	-1.0%	-0.28
$f_{0.1}$; w_{med}	+3.6%	28.12	28.39	-1.0%	-0.26
$f_{0.9}$; w_{med}	+3.6%	17.28	17.36	-0.5%	-0.13

Table 10: Responsiveness of hours worked to hypothetical increases in job flexibility

Male, no children			
	Standard Model	**Predicted @ increased flexibility**	**Implied change**
1994	39.86	38.65	-3.0%
2007	35.81	35.09	-2.0%
2015	35.79	35.07	-2.0%
Male, with dependent children			
	Standard Model	**Predicted @ increased flexibility**	**Implied Change**
1994	43.54	43.33	-0.5%
2007	38.62	38.37	-0.6%
2015	38.78	38.51	-0.7%
Female, no children			
	Standard Model	**Predicted @ increased flexibility**	**Implied Change**
1994	31.20	29.78	-4.5%
2007	29.01	27.67	-4.6%
2015	29.45	27.77	-5.7%
Female, with dependent children			
	Standard Model	**Predicted @ increased flexibility**	**Implied change**
1994	24.85	23.39	-5.9%
2007	22.88	21.24	-7.2%
2015	23.36	21.88	-6.3%

These results show that increased flexibility for least flexible jobs indeed has a notable impact on labour supply. Whilst men with dependent children show low sensitivity to increased job flexibility (although willing to reduce hours marginally), results for other cohorts show that increases in job flexibility will facilitate substantial decreases in hours worked. This is more so the case for women, and especially women with children. Results of this exercise are consistent each of the three time periods.

The question that naturally follows is: how have changes in flexibility over time affected supply decisions. To this end we undertake a similar forecasting exercise to previously. That is, predicted changes in hours worked due to changes in job flexibility can be obtained from the regression model, by cohort, based on the aggregated model. This is done by imposing new job flexibility parameters (i.e. those observed at $t = 1$) onto the regression model run in the initial period. In this case, predicted 'new' hours worked are given by the equation below. These can be readily compared to existing hours.

$$Ln(H_{i|x}) = \alpha_x A_{i|x} + \beta_{0x} Ln(w_{i|x}) + \phi_{0x}\left[f_{ji|x}^{(1)} Ln(w_{i|x})\right] + \beta_{1x}\left[Ln(w_{i|x})\right]^2 + \phi_{1x}\left[f_{ji|x}^{(1)} Ln(w_{i|x})^2\right]$$

Table 11 shows anticipated changes in hours worked due to changes in job flexibility for 1994-2007, by cohort, after imposing the 2007 distribution of job flexibility onto the 1994 model. Table 12 repeats this exercise for the period 2007-2015, imposing the 2015 distribution of job flexibility onto the 2007 model. The tables show mean changes for each cohort, based on the aggregate model, as well as the for median worker (i.e. median wage and job flexibilities). As previously we consider sensitivity of these results at the 10^{th} and 90^{th} percentile.

Results for the period 1994-2007 show that employees are likely to react to changes in job flexibility over this period by increasing hours worked, which is the opposite to what we might have anticipated based on changes hypothesised in Table 10. Decreases in job flexibility at the top of the flexibility distribution have the effect of increasing hours worked in these (most flexible) jobs, even though from a lower hours worked base. These effects are smallest for men with dependent children, whose sensitivity to changes in job flexibility are small, and greatest for women, especially those with dependent children, where sensitivity to changes in job flexibility are greatest. The magnitude of changes in *mean* hours worked due to these effects vary from an anticipated increase in hours from 0.3% to 11.6%. It is noted that the magnitude of these effects are generally much larger than those predicted due to changes in real wages; see the previous section.

Predicted changes for the period 2007-2015 due to changes in job flexibility are more muted, with mean changes in hours worked by cohort due job flexibility effects varying from -1.1% to +2.4%, by cohort. Underlying changes in flexibility during this period is small. Men's jobs become on average slightly more flexible during this period, allowing them to work less, whereas women's jobs become on average slightly less flexible during this period, resulting in desire to work more. Again we see the strongest predicted increases in hours worked at the top end of the flexibility distribution (i.e. in the most flexible jobs).

Table 11: Effect of changes in job flexibility on hours worked, 1994-2007

Male, no children			
	1994	**Predicted 1994 @ 2007 flexibility**	**Implied change**
Mean	39.86	40.28	1.1%
Median f, w	40.80	41.60	2.0%
f_{med} ; $w_{0.1}$	42.09	42.84	1.8%
f_{med} ; $w_{0.9}$	39.53	40.04	1.3%
$f_{0.1}$; w_{med}	45.09	45.47	0.8%
$f_{0.9}$; w_{med}	31.75	31.45	-0.9%
Male, with dependent children			
	1994	**Predicted 1994 @ 2007 flexibility**	**Implied change**
Mean	43.54	43.65	0.3%
Median f, w	43.88	44.05	0.4%
f_{med} ; $w_{0.1}$	43.68	43.76	0.2%
f_{med} ; $w_{0.9}$	43.35	43.65	0.7%
$f_{0.1}$; w_{med}	44.54	44.54	0.0%
$f_{0.9}$; w_{med}	42.69	42.91	0.5%
Female, no children			
	1994	**Predicted 1994 @ 2007 flexibility**	**Implied change**
Mean	31.20	33.01	5.8%
Median f, w	32.63	33.25	1.9%
f_{med} ; $w_{0.1}$	32.46	32.94	1.5%
f_{med} ; $w_{0.9}$	33.66	34.31	1.9%
$f_{0.1}$; w_{med}	37.80	38.74	2.5%
$f_{0.9}$; w_{med}	21.44	24.78	15.6%
Female, with dependent children			
	1994	**Predicted 1994 @ 2007 flexibility**	**Implied change**
Mean	24.85	27.73	11.6%
Median f, w	27.55	28.26	2.6%
f_{med} ; $w_{0.1}$	25.70	26.19	1.9%
f_{med} ; $w_{0.9}$	28.10	28.97	3.1%
$f_{0.1}$; w_{med}	33.18	34.76	4.8%
$f_{0.9}$; w_{med}	16.47	19.89	20.8%

Table 12: Effect of changes in job flexibility on hours worked, 2007-2015

Male, no children			
	2007	**Predicted 2007 @ 2015 flexibility**	**Implied change**
Mean	35.81	35.74	-0.2%
Median f, w	37.27	36.95	-0.9%
f_{med} ; $w_{0.1}$	36.07	35.71	-1.0%
f_{med} ; $w_{0.9}$	36.72	36.64	-0.2%
$f_{0.1}$; w_{med}	40.04	40.12	0.2%
$f_{0.9}$; w_{med}	29.75	30.46	2.4%
Male, with dependent children			
	2007	**Predicted 2007 @ 2015 flexibility**	**Implied change**
Mean	38.62	38.43	-0.5%
Median f, w	38.91	38.65	-0.7%
f_{med} ; $w_{0.1}$	38.15	37.85	-0.8%
f_{med} ; $w_{0.9}$	39.72	39.70	-0.1%
$f_{0.1}$; w_{med}	39.90	39.89	0.0%
$f_{0.9}$; w_{med}	36.63	36.36	-0.7%
Female, no children			
	2007	**Predicted 2007 @ 2015 flexibility**	**Implied change**
Mean	29.01	29.33	1.1%
Median f, w	29.04	29.04	0.0%
f_{med} ; $w_{0.1}$	27.63	27.62	0.0%
f_{med} ; $w_{0.9}$	32.00	31.99	0.0%
$f_{0.1}$; w_{med}	33.99	34.43	1.3%
$f_{0.9}$; w_{med}	21.46	22.55	5.1%
Female, with dependent children			
	2007	**Predicted 2007 @ 2015 flexibility**	**Implied change**
Mean	22.88	23.46	2.5%
Median f, w	23.44	24.00	2.4%
f_{med} ; $w_{0.1}$	21.33	21.76	2.0%
f_{med} ; $w_{0.9}$	24.00	24.58	2.4%
$f_{0.1}$; w_{med}	29.14	29.70	1.9%
$f_{0.9}$; w_{med}	16.20	17.28	6.7%

6. Conclusion

The substantive contribution of this paper has been the application of a model of hours worked based on UK micro-data at different time intervals since the early 1990s. We consider aspects of the changing labour supply decision during a period of increasing real incomes pre-crisis (1994-2007) and decreasing real incomes post-crisis (2007-2015). We also consider the role of individual demographics in influencing these decisions. This updates recent UK empirical work by Blundell et al (2013). The paper considers two key aspects of changing patterns of hours worked in the UK. Firstly, are we willing to work less? That is, are individuals displaying negative elasticity of labour supply with respect to wages, such that hours worked will be reduced as real wages increase? Secondly, are people able to work less, with respect to their flexibility to vary their working hours, should they wish to do so. Finally, we consider the role of the crisis in affecting changing behaviour over time.

With respect to the first question: are we willing to work less? The short answer is: perhaps not. The results of this study reveal generally positive (but small) elasticity of hours worked with respect to wages in 1994 and 2007, although this varies by cohort. The increase in real wages between 1994-2007 has generally increased the appetite for work, especially so amongst women, and decreased real incomes between 2007-2015 have generally decreased the appetitive for work. These results go against Becker's notion of earnings-satiation and Keynes' prediction. Looking at the most recent data (2015) we see a glimmer of light in this respect. We predict that an increase in real wages, moving forward, to reverse the effects of the economic crisis and applied equally to all employees will act to reduce hours worked, but only slightly. Over all three periods, our elasticity estimates are very close to zero, confirming the results of Blundell et al (2000), and suggesting that wage changes have little impact on labour supply decision. This throws a dampener over the satiation hypothesis, generally. In this sense the paper reports negative evidence.

With respect to the second question: are we able to work less? The short answer is: no. The regression findings presented in this paper suggest that job flexibility, as we measure it, does indeed matter (significantly so) in determining the labour supply elasticity. Moreover, we demonstrate that hypothetical increases in job flexibility, as we measure it, are able to generate reductions in hours worked much larger than those that come from wage effects. However, our results suggest that job flexibility has decreased slightly over time, with the effect *ceteris paribus* of increasing rather than decreasing hours worked. If we interpret our job flexibility measure as the ability to vary hours worked, within an occupation, then it may be that individuals are not able to reduce hours due to constraints on decision making which *de facto* have not changed over time. We note at this point that the job flexibility may well have its roots in deeper structural factors in the labour market and in organisations.

The measure applied here is simply intended to capture the empirical aspect of available choice. However “least flexible” and “most flexible” jobs may have stronger overtones in terms of constraints placed on individuals by organisations, including aspects of internal hierarchy, wage-seniority and tournament structures, such as those highlighted by Lazear & Rosen (1981). The precise role of flexibility and its implications for choice of hours worked opens possibilities for further research.

Finally, we do see a substantial decrease in average hours worked between 1994-2007, for those in work and for some demographic cohorts, although it appears that this has halted since the crisis. This change represents an exogenous shift in the context of this paper, in that it is not a response to changes in real income nor job flexibility. Instead, it represents, in terms of the labour supply curve, a downward shift in hours worked at all wages. The source of this change therefore remains an empirical puzzle and a direction for future research. At this juncture, one more crucial aspect for the UK labour market is Brexit and potential restrictions on the movement of labour. On this aspect, a recent study by Wadsworth (2018) argued that although the effects of UK immigration on labour market is not huge at an aggregate level, any reduction in the EU immigration would make it difficult for exchequer to balance the books as EU migrants pay more in taxes than they receive in benefits and public services, though the net payments are not very high. It is worth acknowledging that the restrictions on the EU migrants would affect the flow of future EU migrants to the UK, rather than the current stock on EU migrants in the UK. In relation to labour labour-leisure choice, decreased immigration from EU would imply increased demand of domestic workers which may lead to either increase in wages or loss or destruction of industry and sector which would not be able to cope with such a shift. There could also be sector wise differences in the effects of Brexit, mainly on low-pay and high-turnover, for instance, seasonal employment sectors. This requires further research as well as consideration by the British government while formulating its immigration policy.

Appendix 1

Job Flexibility

The following table shows descriptive statistics in relation to job flexibility by demographic cohort in each period. Job Flexibility, f_j is defined as the coefficient of variation of hours observed within job j. i.e.

$$f_j = \frac{sd(H_j)}{mean(H_j)}$$

The statistics presented below show the distribution of f_j across all 4-digit occupations. The table contrasts 10th percentile (taken as synonymous with "least flexible" in the paper), median (50th percentile) and 90th percentile (taken as synonymous with "most flexible" in the paper),

Distribution of Job Flexibility (f_j) by demographic cohort and period

Male; no children			
Percentile	**1994**	**2007**	**2015**
10%	0.258	0.238	0.240
50%	0.311	0.296	0.319
90%	0.558	0.461	0.505
Male; with children			
Percentile	**1994**	**2007**	**2015**
10%	0.249	0.233	0.240
50%	0.303	0.286	0.310
90%	0.427	0.409	0.435
Female; no children			
Percentile	**1994**	**2007**	**2015**
10%	0.297	0.273	0.268
50%	0.403	0.396	0.370
90%	0.651	0.550	0.526
Female; with children			
Percentile	**1994**	**2007**	**2015**
10%	0.310	0.280	0.270
50%	0.408	0.385	0.365
90%	0.657	0.550	0.521

conflicts of interest

Conflict of Interest: The authors hereby declare that they have no conflict of interest.

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