Workers, Workplaces and Working Hours

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ABSTRACT

Under plausible assumptions about firm preferences over the working time of their employees, the number of hours worked is likely to depend on firm, as well as individual, characteristics. I use the WERS98 employer-employee matched dataset to analyse the role played by differences between firms on the one hand, and between individuals on the other, in the observed variation in hours of work. I analyse whether and how hours vary within firms according to individual characteristics, and evaluate the degree to which individuals are sorted into different firms based on their human capital characteristics and working time preferences. Overall, I find substantial roles for both firm-level differences in technology and individual characteristics. A large share of hours variation is also due to the sorting of individuals into firms based on human capital characteristics. By contrast, there is less evidence of sorting on labour supply preference characteristics like marital status and parenthood, despite differing working hours across firms. Within firms, after controlling for the effects of human capital on hours, preference characteristics have a statistically and economically significant effect on hours of work.

NON-TECHNICAL SUMMARY

This paper analyses the relative importance of differences between firms, as opposed to differences between individuals, in determining working hours. Are hours determined by who you are, where you work or both? The paper takes a snapshot of working hours in Britain from the 1998 Workplace Employee Relations Survey (WERS98). This survey took a nationally representative sample of British workplaces, obtaining information about each firm as well as up to 25 of its employees.

Differences between firms can explain about a third of the analysed variance of hours. This means that equivalent individuals – that is people with the same occupation, qualifications, age, family characteristics and the like – who work in different firms, can be working very different hours. After accounting for these individual characteristics, there is still a gap of over six hours per week between the quarter of firms working the longest hours, and the quarter working the shortest hours.

Another third of the analysed variation in hours is systematically associated with differences between individuals' characteristics, after netting out firm effects. 'Productivity'-related characteristics like occupation, an employee's age, their job tenure, educational qualifications, permanent or non-permanent job contract and whether they have had recent training, all affect hours. Family characteristics also play a role: within firms, married men work for longer (by about half an hour) and married women work shorter hours (by about an hour). But the largest effects are associated with women who have children. On average, a woman with a child under 12 years works about six hours less per week than a similar woman (same occupation, education etc) in the same firm but without children. These effects may suggest that hours within firms respond, at least in part, to individual preferences.

The final third of the analysed variation in hours can be explained by the combined influence of individual and firm characteristics, that is 'long-hours' workers tend to work in 'long-hours' firms and vice-versa. This effect is particularly strong for the 'productivity' characteristics: for example, women in occupations with longer hours tend to work in firms whose average hours (across all employees) are also longer. There is less evidence, though, that women with children sort into firms with shorter working hours, despite the marked differences in hours across firms.

The results are consistent with a labour market where there is competition, so that to some extent employers offer different working hours to employees with different preferences. But the evidence also suggests that competition is imperfect: there are barriers to mobility which prevent the complete 'matching' of workers to firms which one would associate with a perfectly competitive labour market.

1. Introduction

In the simplest version of the standard labour supply model, workers can choose to work any number of weekly hours at a fixed hourly rate of pay determined by the supply of and demand for their particular skills. The model assumes either (1) that hours are fully flexible within jobs, in the sense that employers are willing to pay the same hourly rate for any number of hours, or (2) that there is a range of jobs in the market (with costless mobility between them) offering different hours but at the same hourly rate. In both cases, workers are price takers and face a horizontal demand curve for their hours of labour. Although, in the second case, hours do vary across firms, they can still be explained by the wage and individual preferences only. Analysis of individual labour supply loses nothing by ignoring firm characteristics.

For a variety of reasons, however, it is likely that (1) a given employer's marginal willingness to pay for hours will depend on the number of hours already worked, (2) that the distribution of employer preferences in the market will give rise to different equilibrium wages at different hours levels and (3) that mobility is costly. Thus individuals may not be able to choose any number of hours at a constant hourly rate. A body of literature has done a good job of mapping the determinants of supply when individuals are subject to market constraints of this type (see, among others, Moffit, 1984; Biddle and Zarkin, 1989; and Tummers and Woittiez, 1991). But with relatively poor information on firm characteristics, this work has not produced a good picture of firm demand for hours and how it interacts with individual supply. In this paper, I use employer-employee matched data to derive new facts about the relative importance of differences between firms on the one hand, and between individuals on the other, in the observed variation in hours of work. I analyse whether and how hours vary within firms according to individual characteristics, and I evaluate the degree to which individuals are sorted into different firms based on their working time preferences.

The results show that nearly a fifth of the variation in weekly hours of work can be ascribed to firm-level differences in technology ('demand'); a fifth can be attributed to the effect of individual characteristics alone; and a further fifth is due to these factors acting together – in particular, the effects of human capital characteristics on hours worked are correlated with the firm-level determinants, so there is a sorting process of individuals to firms. Within firms, after controlling for the effects of human capital on hours, there remain effects due to characteristics (marital status and presence of children) which can be presumed primarily to reflect workers' preferences.[1] The observed variation in hours can be interpreted as firm responses to these preferences. By contrast there is much less evidence that workers sort between firms on the basis of these preferences, despite differences in working hours across firms. This result does not appear consistent with a simple model of a labour market where firms with different preferences compete with one another for workers.

The analysis is relevant to the ongoing policy debate about work-life balance, much of which presumes that supply side pressure is not stimulating appropriate responses on the demand side. Government initiatives in this area seem to be focused on trying to relieve these demand side blockages, by persuading employers to offer work schedules which are tailored to individual employees' requirements.[2]

To introduce the analysis, Section 2 of this paper briefly reviews the factors underlying the hours preferences which workers express through their labour market

[1] As discussed below, my definition of preferences includes supply-side constraints on the amount of time workers have available for market work.
[2] See the Department of Trade and Industry's Work-Life Balance website http://www.dti.gov.uk/work-lifebalance/.

behaviour. It then explains why, at the firm level, there may be also preferences over hours worked by employees. Section 3 considers how individuals interact with firms, and how the outcomes depend on market structure. A simple theoretical framework is presented to illustrate the process, and the implications for the allocation of individuals to firms are brought out. In Section 4, after introducing the data, I analyse how much of the variation in working hours and other characteristics is within firms and how much is between firms. These decompositions give an idea of the amount of sorting of individuals to firms and the importance of firm preferences. Section 5 then describes multivariate decompositions which partition the explained variance into components due to firm-level effects, human capital characteristics and preference characteristics, as well as joint effects. In Section 6, I focus on a within-firm analysis of the effects of human capital and preference characteristics, and also evaluate the evidence for sorting across firms based on these characteristics. Section 7 presents a brief analysis of the determinants of the estimated firm level effects. Finally, section 8 discusses and concludes.

2. Preferences and technology

The measure of working time studied in this paper is total weekly hours. Clearly, there are other dimensions to the working time of participants, such as daily start and finish times, and the possibility of weekend working. But weekly hours are perhaps a natural yardstick of "how much we work". They are also the focus of much of the huge existing labour supply literature, where the influence of individual preferences on weekly hours is well documented. This is therefore an obvious place to start when building in explicit consideration of firm preferences. I now turn to a discussion of preferences on each side of the market.

2.1. Individual preferences

Suppose there are two individuals with identical earning capacity. Differences between them in their observed hours of work are then presumed to reflect their differing trade-offs between domestic and market time. But while the value of market time is a straightforward concept, the value of domestic time is likely to be determined by a mix of "genuine" tastes for domestic work and leisure versus market work, domestic productivity, ingrained social norms over the domestic and gender division of labour, domestic bargaining power, and constraints on the substitution of domestic for market services (e.g. limited childcare facilities). Since my focus is on the worker-firm nexus in the labour market, rather than the domestic decision-making process, I use the shorthand *preferences* to cover the net effect of all these factors. They are preferences in the sense of being revealed in the labour market by individuals interacting with firms. It should be emphasised that this does not deny the existence of 'supply side constraints', where an individual wishes to change their working hours but is prevented from doing so by domestic obligations. Indeed, these constraints may be an important component of revealed preferences, but they are not the focus of the paper. As I discuss later in the empirical analysis, household characteristics, in particular marital and parental status, are used to capture preference effects.

2.2. Technology or firm preferences

Firms, like individuals, will have preferences over weekly hours if – for reasons discussed below – all hours are not equally productive (Barzel, 1973). Then the firm's marginal willingness to pay for the 45th hour supplied by a worker may not be the same as the 5th hour supplied. Moreover, the difference may depend on the number of other workers employed, their hours, their skills (human capital) and the amount of physical capital used. Consider a general production function for the output Y of a firm which employs a number of workers together with some capital. The value of output is given by:

$$pY = pF(h_1, k_1, h_2, k_2, \ldots, h_n, k_n, K)$$

where p is the price of output, h_i is the number of weekly hours of individual $i = 1, \ldots, n$, k_i is human capital and K is physical capital. The value to the firm of an extra hour worked by worker $i = 1$, say, is $pF_{h1}(h_1, k_1, h_2, k_2, \ldots, h_n, k_n, K)$, where $F_x(.)$ is the partial derivative of $F(.)$ with respect to argument x. So it potentially varies with number of other workers employed, their skills, the number of hours they do, and the amount of capital employed.

By what channels do these variables affect the value of the marginal product of hours? Most obviously, there are the 'physical' or technological constraints of the job. Setting up for the task in hand takes time, and the first few hours may not be very productive. After this start-up phase production then increases at a faster rate, before levelling off at higher hours levels as fatigue sets in. Fatigue may be more pronounced in manual or physically demanding jobs (requiring less human capital, k?) It may also be related to the amount of (labour saving?) physical capital, K, which is employed. In general, hours may be substitutes or complements to human and physical capital in the production function.

A second technological factor is that at some level of disaggregation, tasks become indivisible between individuals, e.g. typing a document; delivering a small parcel; installing a software package A task may require the undivided attention of a single person and could not be shared between two people, each working half the time on it. This introduces a non-convexity with respect to the individual workers' inputs to the production function.

Third, in some jobs there will be clear and sometimes very large benefits to coordinating the working times of different individuals even if the underlying technology is fairly 'neutral', e.g. on a production line. A worker's productivity depends immediately and directly on the outputs of other workers (see Siow, 1990, and Weiss, 1996).

A firm's actual demand for hours will depend not only on its willingness to pay but also on the cost of working hours. Let the total cost of h hours per person with human capital k be $c(h, k)$. For simplicity, $c(h, k)$ can be thought of as the wage payment to the worker, although part of it may actually cover the administrative charges of employment. For now, assume that c is determined as a competitive equilibrium and is exogenous to the firm; in the imperfectly competitive model developed below, I allow c to be jointly determined with hours at the firm level.

The $c(h, k)$ schedule will be non-linear in hours insofar as some charges and forms of compensation do not vary with hours (or vary non-linearly). For example, there are likely to be fixed administrative costs involved in keeping tax and national / social insurance records for each worker (though possibly also economies of scale if the personnel office can spread some of the costs over the workforce). Some social insurance charges may be subject to earning floors or ceilings or explicit hours thresholds (e.g. 16 hours). Payments for sick leave may be a fixed minimum unrelated to total hours usually worked (e.g. not varying with overtime). In many cases there will be a non-linearity in the wage schedule introduced directly as a result of an overtime premium paid for hours worked in excess of the standard full-time working week.

Other per-worker fixed costs will be related to provisions in the (implicit) contract between the individual and the firm, for example receipt of firm-financed training, and the part-payment of compensation as fringe benefits like a company car or private health insurance. The cost of paid holidays may also be non-linearly related to total hours usually worked, if, say, usual paid overtime were not included in holiday pay.[3] For a typology of these different costs, see Hamermesh (1993, p. 47). Finally, insofar as units of capital are tied to individuals, capital-intensive jobs may also have higher per-worker fixed costs.

All these factors mean that hours are not perfect substitutes for one another. From a firm's point of view, two part-time jobs may not be equal to one full-time job. Its optimal choice will maximise profits, given by:

$$\Pi = pF(h_1, k_1, h_2, k_2, \ldots, h_n, k_n, K) - \Sigma\, c(h_i, k_i) - rK$$

where r is the rental price of capital. The choice of h_1, say, must satisfy the first-order condition, that the net marginal benefit of changing h_1 is zero:

$$F_{h1}\,(h_1, k_1, h_2, k_2, \ldots, h_n, k_n, K) - c_{h1}(h_1, k_1) = 0$$

If all workers are identically productive, so $k_i = k_j$ for all i, j, then the first-order condition for each h is the same. If the profit function is concave in hours, the firm will optimally choose a single level of hours for all workers of a given labour quality. Notice that this implicitly assumes a perfectly elastic labour supply to the firm – in other words, a perfectly competitive labour market – so that the firm can always find a worker willing to supply h hours at wage

[3] The cost of some benefits, such as pensions, will increase more or less in proportion to the number of hours, if

$c(h, k)$. If there are imperfections in the labour market – for example, a finite supply of labour to the firm, and differing worker preferences over hours – it may be optimal for firms to employ identically productive workers at different hours levels. In Section 3 I formalise this possibility in a simple model.

Although, in the empirical analysis, I do find strong evidence of differing hours for otherwise identical workers, it is instructive to follow the general model through under the assumption that the firm does chose a single hours level for each worker. Then we can rewrite the profit function as:

$$\Pi = pF(n, h, k, K) - nc(h, k) - rK$$

where n is the number of workers employed. A commonly studied relationship is the trade-off between employment n and hours h. From the first-order conditions for h and n:

$$F_n(n, h, k, K) \,/\, F_h(n, h, k, K) = c(h, k) \,/\, n\, c_h(h, k)$$

It is clear that the trade-off depends, in the general case, on both human (k) and physical capital (K), i.e. hours and employment are not separable from the two types of capital. A priori it is difficult to say what the effect of K and k on the hours-employment trade off might be. As already suggested, high physical and human capital jobs might be less tiring, in which case hours might be longer. Insofar as units of physical capital are tied to individuals (as is human capital by definition), these jobs may also have higher per-worker fixed costs. Capital intensive jobs may also involve quite closely coordinated worked schedules, if complex equipment requires a team to operate it. These priors perhaps fit in with the empirical

they are paid as a proportion of the wage bill, and there is a fixed wage rate per hour.

findings, reported later in this paper, showing that average hours are higher and less variable in the manufactured goods sector than in public or private services.[4]

If capital is not separable from hours and employment, then unfortunately it becomes much more difficult to predict what will happen to hours as the parameters of the production and cost functions change. A shift of costs which would produce a move from hours to workers may also involve a change in capital which affects the marginal productivity of hours and workers differently (Hamermesh, 1993). A simplifying assumption is to rewrite the production function in terms of total labour input L and capital (k and K), and then to express L in a convenient form, such as $L = nf(h)$, where the sub-production function $f(h)$ captures the relationship for each worker between hours worked and effective labour input:

$$F = F(L, K, k) = F(nf(h), K, k)$$

From the first-order conditions for h and n:

$$f(h, k) \,/\, f'\,(h, k) = c(h, k) \,/\, c_h\,(h, k)$$

The choice of optimal hours and employment is defined implicitly by the levels that equate the ratio of their marginal products to the ratio of their marginal costs, and is independent of K and k. This simplification leads to some clear predictions based on what we can reasonably assume about how productivity and costs vary with hours (Hamermesh (1993)). Hours and employment are imperfect substitutes. For example, increased fixed per-person costs will raise the marginal cost of workers $c(h, k)$ relative to $c_h(h, k)$ and result in a substitution of hours (reducing $f'(h, k)$) for workers (raising $f(h, k)$). On the other hand, fatigue effects leading to a reduction of $f'(h, k)$ at long hours will producing a compensating increase in employment, which lowers the marginal product of workers $f(h, k)$.

[4] There is no specific measure of capital in my dataset.

In sum, this section has shown that firms will care about work hours if there are significant non-linearities with respect to hours in the production function or wage schedule. Interactions with physical and human capital may be important. In the next section, I consider the interaction of individuals and firms in the determination of hours and wages, and the conditions under which hours will not only differ across firms, but within firms.

3. Worker-firm interaction

How do firms and individuals interact? To set the scene for the empirical analysis, I set up a simple framework of imperfect labour market competition (oligopsony), where both firm and individuals have hours preferences. In the general case, both hours and earnings are jointly determined at the firm level. In common with other oligopsonistic models, this framework nests the polar cases of perfect competition and monopsony. This simple model suggests that hours will be determined by both individual and firm preferences. There will be a sorting process, more intense with increasing labour market competition, which will match individuals with firms that have preferences relatively close to there own. Under perfect labour market competition sorting will be perfect, that is identically productive individuals with different tastes will choose different firms. But under oligopsony, there will be some variation of hours within firms, reflecting individual and firm preferences as well as outside opportunities.

There is an established strand of literature in labour economics which models a firm's oligopsonistic power as stemming from individual (and possibly job specific) characteristics which are heterogeneous but unobserved by the firm (for example see Stevens, 1994 and Bhaskar and To, 2001).[5] Examples of these characteristics are mobility costs and preferences over working conditions in the firm. Because the characteristics are unobserved, firms do not act as discriminating monopsonists, but instead they set an identical wage for all workers. Their market power arises because they can lower the wage and only some workers (those who like the job least compared to the alternatives) will quit to work elsewhere. The firm therefore faces an upward sloping labour supply curve.

[5] Another approach is to use models of job search. See Manning (2003) for extensive discussion.

This modelling approach seems less appropriate to the analysis of working time. Although it is possible that individual hours preferences – the heterogeneous characteristic considered – are not known or revealed to firms, the resulting number of hours is readily observable and in fact is a choice variable for the firm. It therefore seems more natural to think of a model where firms, knowing the individuals' hours preferences, compete by making different offers to workers with different hours preferences.

3.1 A simple model of worker-firm interaction

Suppose the labour market is limited in effective size by commuting costs. This means that for practical purposes there is a finite number of individuals who interact with a finite, though much smaller, number of firms (I assume all individuals face the same commuting costs). This labour market would be perfectly competitive if commuting costs were trivially low, as then the effective size of the market, in numbers of individuals and firms, would grow very large. Conversely, it would be a monopsony if commuting costs were so high that individuals could only work at their nearest firm (the stylised 'company town').

I consider a simple example intended to capture the existence of both firm and individual heterogeneity. Assume there are two firms (i.e. a duopsony) which have different hours preferences. There is no free entry or exit of firms. There are two types of individual, and n individuals in total. A number n_1 of the individuals would prefer a low hours job (e.g. a part-time job) all else equal, and n_2 individuals would like to work high hours (e.g. a full-time job). Their preferences over consumption c and hours of market work h are represented as $U_i = U_i(c, h)$, where $i = 1$ (low hours individual) or 2 (high hours individual).

To make the exposition more concrete I use specific functional forms for firm and individual preferences. And to focus on choice at the hours margin and simplify the analysis, I assume constant returns to employment. The general production function $F(h_1, k_1, h_2, k_2, \ldots, h_n, k_n, K)$ of the previous section is rewritten (for firm j) as $F_j = \Sigma_i\, G(h_i, k_i, K_j)$. $= \Sigma_i\, f_j(h_i, k_i)$, where h_i is the number of weekly hours worked by individual i with human capital k_i, and K_j is the firm's physical capital. The form of $f_j(h_i, k_i)$ captures the effect of physical capital in that firm. In the following model, I also assume all individuals have the same level of human capital, dropping the k argument for brevity. Introducing variation in human capital would change the marginal value of hours and imply different equilibrium hours for individuals of different skills levels in the same firm. In the empirical analysis though, I do allow for both variation in K (using firm identity and economic sector) and in k (using measures of education, experience and occupation).

The use of specific functional forms clearly implies restrictions which may not exist in reality. Furthermore, starting from simple and tractable objective functions does not guarantee the resulting conditional supply or demand expressions will also be simple and tractable. These problems confront more or less all studies of labour supply (see the examples in Stern, 1986).

3.2 Technology

From the above production function, it follows that each firm's profits consist of separate contributions from each type of worker, as follows:

$$\begin{aligned} \Pi_1 &= pn_{11}f_1(h_{11}) - n_{11}c_{11} + pn_{21}f_1(h_{21}) - n_{21}c_{21} \\ &= pn_{11}\,(a_1h_{11}^{\alpha} - b_1) - n_{11}c_{11} + pn_{21}\,(a_1h_{21}^{\alpha} - b_1) - n_{21}c_{21} \end{aligned} \tag{1}$$

and

$$\begin{aligned} \Pi_2 &= pn_{12}f_2(h_{12}) - n_{12}c_{12} + pn_{22}f_2(h_{22}) - n_{22}c_{22} \\ &= pn_{12}\,(a_2h_{12}^{\alpha} - b_2) - n_{12}c_{12} + pn_{22}\,(a_2h_{22}^{\alpha} - b_2) - n_{22}c_{22} \end{aligned} \tag{2}$$

where the subscripts ij denote individual type i in firm j. Parameter b_j is the fixed cost (in units of output) per person, $0<\alpha<1$ (so that h_j^{α} is concave), and c_{ij} is the wage payment to each individual of type i in firm j. The two firms are distinguished by the technology parameters a_j and b_j. For simplicity a_1 is normalised to unity. Firm 2 has $a_2 > 1$ and $b_2 > b_1$, which imply higher fixed costs, but also a greater return to hours worked. As will be seen below, this will increase its attractiveness to high hours individuals; equivalently firm 2 will be able to employ these individuals at lower cost.

3.3 Preferences

Now consider the preferences of the two types of individual. For simplicity and to concentrate on the substitution effects between hours of work and consumption, I specify a quasi-linear utility function:

$$U_1 = c - d_1 h^{\beta} \qquad (3)$$

for individual type 1, and

$$U_2 = c - d_2 h^{\beta} \qquad (4)$$

for individual type 2, where $\beta > 1$ (to ensure increasing marginal disutility from hours of work), d_2 is normalised to unity and $d_1 > 1$, so that type 1 has a greater distaste for work than type 2. The quasi-linear form removes the income effect (the marginal rate of substitution between hours and consumption does not depend on consumption) and has the advantage that utility is expressed in monetary units, which is useful in analy sing the sharing of the surplus between workers and firms.

3.4 Interaction

The interaction between workers and firms can be shown using diagrams representing the loci of (c, h) combinations over which workers and firms are indifferent. Figure 1, with c on the vertical axis and h on the horizontal axis, plots the (c, h) combinations for each firm which lead to zero profits. It also shows, for each individual type, combinations yielding identical utility, i.e. the two individual types' indifference curves. They have been drawn at the utility level which makes them tangential to the zero-profit curves. From (1) and (2), the firms' zero-profit curves are given by the expressions:

$$c_1 = p(a_1 h_1^{\alpha} - b_1) \tag{5}$$

and

$$c_2 = p(a_2 h_2^{\alpha} - b_2) \tag{6}$$

and show how individual production depends on hours. The zero-profit curves cross the h axis at $h_j = (b_j/a_j)^{1/\alpha}$ (i.e. an individual must work at least this number of hours before any net value is produced). The intercept on the horizontal axis for firms 2 must be to the right of firm 1 intercept for this model to make economic sense: otherwise both types of individual would prefer firm 2. This condition implies $b_2/ b_1 > a_2$.[6]

[Insert figure 1 about here]

If each individual received their full marginal product, they would choose optimal hours-consumption combinations at the tangencies of their indifference curves and the highest zero profit curve, as shown in Figure 1. Some working yields the solution (denoted by $^+$) to this maximisation problem for individual type i in firm j:

[6] The two c-h loci cross at $h_1 = h_2 = (b_2 - b_1/a_2 - a_1)^{1/\alpha}$. If $a_1 = 1$, this is to the right of firm 2's zero crossing ($=(b_2/a_2)^{1/\alpha}$) if $b_2/b_1 > a_2$.

$$U^{+}_{ij} = p\,[a_j(h_{ij}^{+})^{\alpha} - b_j] - d_i(h_{ij}^{+})^{\beta} \tag{7}$$
$$= p\,[\,a_j(p\alpha a_j\,/\,\beta d_i)^{\alpha/\beta-\alpha} - b_j] - d_i(p\alpha a_j\,/\,\beta d_i)^{\beta/\beta-\alpha}$$

For low hours individuals (type 1), the difference in maximum utility between firm 2 and firm 1 is then:

$$U^{+}_{12} - U^{+}_{11} = d_1^{-\alpha/\beta-\alpha}\ A - (b_2 - b_1)p \tag{8}$$

where $A = (a_2^{\ \beta/\beta-\alpha} - a_1^{\ \beta/\beta-\alpha})p^{\beta/\beta-\alpha}[(\alpha/\beta)^{\alpha/\beta-\alpha} - (\alpha/\beta)^{\beta/\beta-\alpha}]$, which is a positive constant since $a_2 > a_1$ (= 1) and $\alpha < \beta$. For high hours individuals (type 2) the difference is:

$$U^{+}_{22} - U^{+}_{21} = A - (b_2 - b_1)p \tag{9}$$

Since $d_1 > 1$, the factor $d_1^{-\alpha/\beta-\alpha}$ is positive but less than 1. If the fixed costs of the two firms are almost identical, i.e. $(b_2 - b_1) \approx 0$, then both types prefer firm 2, as its production function then lies everywhere above that of firm 1, due to the higher return to hours worked. On the other hand, if $(b_2 - b_1)$ is very large then both types will prefer firm 1, which has substantially lower fixed costs. But there is a range of fixed costs, characterised by $d_1^{-\alpha/\beta-\alpha} A/p < (b_2 - b_1) < A/p$, where type-1 individuals prefer firm 1 and type-2 individuals prefer firm 2, and it is this sorting which is of interest.

Whilst Figure 1 gives a good feel for the shape of the production function, and the way firms care about hours, the sorting process can perhaps be better represented with the hourly wage (c/h) on the vertical axis, retaining hours on the horizontal axis. The zero profit curves are then given by:

$$c_1/h_1 = p(a_1 h_1^{\alpha-1} - b_1/h_1) \tag{10}$$

and

$$c_2/h_2 = p(a_2h_2^{\alpha-1} - b_2/h_2) \tag{11}$$

and these curves are represented in Figure 2. For simplicity the figures are drawn such that the maximum hourly wage for zero profit is about the same for each firm: there are plausible parameter values which would make this so. Again the indifference curves of the two individual types are shown, implying the outcomes which are optimal from their point of view: at the tangency of their indifference curves and the respective zero profit curves.

[Insert figure 2 about here]

The actual outcomes, however, will differ since each firm has market power over the individuals who prefer it to the other firm. Each firm can increase its profits (from zero) by lowering the utility of the wage-hours package which it offers employees. As long as utility is higher than the other firm would be willing to offer then individuals will stay with their 'optimal' firm.

Take the example of type-1 individuals in firm 1. From their point of view, the best wage-hours combination which firm 2 would be willing to offer (the outside option of type-1 individuals) is implied by the tangency of the lower indifference curve, shown dotted, with firm 2's zero profit curve (or with a curve corresponding to some very small positive profit). This is precisely the utility level U_{12} given by equation (7) above:

$$U^{+}_{12} = pf_2(h_{12}^{+}) - d_1(h_{12}^{+})^{\beta} = p\,[a_2(h_{12}^{+})^{\alpha} - b_2] - d_1(h_{12}^{+})^{\beta} \tag{12}$$

There is now a Bertrand competition between the two firms. The firm offering the higher utility takes all n_1 type-1 workers, and as long as one firm can still make positive profits it will outbid the other. In equilibrium, firm 2 will offer U_{12}^{+} and firm 1 will offer a trivially higher utility. Subject to this utility constraint it chooses a wage and hours to maximise profits from the type-1 workers. Formally this means maximising the Lagrangean:

$$\begin{aligned} & pn_1 f_1(h_{11}) - n_1 c_{11} + \lambda\, n_1(U_{11} - U_{12}^{+}) \\ &= pn_1\,(a_1 h_{11}^{\alpha} - b_1) - n_1 c_{11} + \lambda\, n_1(c_{11} - d_1 h_{11}^{\beta} - U_{12}^{+}) \end{aligned} \tag{13}$$

The first-order conditions are:

$$-1 + \lambda = 0 \tag{14}$$

$$p\alpha\, a_1 h_{11}^{\alpha-1} - \lambda\, d_1\, \beta h_{11}^{\beta-1} = 0 \tag{15}$$

$$c_{11} - d_1 h_{11}^{\beta} - U_{12}^{+} = 0 \tag{16}$$

the last following since the constraint binds. These yield optimal hours and consumption:

$$h_{11}^{*} = (a_1 p\alpha / d_1\beta)^{1/(\beta-\alpha)} \tag{17}$$

$$c_{11}^{*} = d_1 h_{11}^{*\,\beta} + U_{12}^{+} \tag{18}$$

and firm 1 makes profits:

$$\Pi_1^{*} = p\; n_1 f_1(h_{11}^{*}) - n_1(d_1 h_{11}^{*\,\beta} + U_{12}^{+}) \tag{19}$$

The corresponding outcomes of the n_2 type-2 individuals in firm 2 are:

$$h_{22}^{*} = (a_2\, p\alpha / d_2\beta)^{1/(\beta-\alpha)} \tag{20}$$

$$c_{22}^{*} = d_2 h_{22}^{*\,\beta} + U_{21}^{+} \tag{21}$$

$$\Pi_2^{*} = p\; n_2 f_2(h_{22}^{*}) - n_2(d_2 h_{22}^{*\,\beta} + U_{21}^{+}) \tag{22}$$

So type-1 individuals work fewer hours than type-2 individuals, both because they prefer fewer hours ($d_1 > 1 = d_2$) and because their firm prefers fewer hours ($a_1 = 1 < a_2$).

3.5 Implications of the model

This simple model serves to make some relevant points. First, there is a sorting process of individuals to firms which picks the worker-firm pairings generating the highest joint surplus. For different hours outcomes to be observed across firms, they must differ sufficiently in their productivity parameters as already noted. But individual heterogeneity is also important because if individuals are identical, they will all prefer one firm over the other (as is clear from equations (8) and (9)). This firm will therefore be able to attract all individuals, and the other firm cannot survive.

Second, from equations (17) and (20), the equilibrium number of hours depends on both worker and firm characteristics. Only if one side has no hours preferences, in the sense that their marginal willingness to 'pay' does not depend on the number of hours already traded, does the model reduce to a conventional labour supply or demand model. For example, if productivity rises linearly with hours and there are no fixed costs, i.e. $\alpha = 1$ and $b_j = 0$, then firms do not care about hours. For both firms to exist, they must be equally productive, since a less productive firm would never attract any workers. Thus $a_2 = 1$ ($= a_1$). Then the expressions for hours become $h_{1j}^* = (p/d_1\beta)^{1/(\beta-1)}$ and $h_{2j}^* = (p\, d_2/\beta)^{1/(\beta-1)}$, which is the same for each $j = 1, 2$, as there is now nothing to choose between the two firms. Hours depend only on individual preferences and the underlying productivity of labour (reflected in the product price p, which because of competition is received in full as wages), as in the standard labour supply model.

If, on the other hand, consumption and hours are perfect substitutes from the individual's point of view, then $\beta = 1$, and the hours expressions reduce to $h_{i1}^* = (a_1 p\alpha/d_i)^{1/(1-\alpha)}$ and $h_{i2}^* = (a_2 p\alpha/d_i)^{1/(1-\alpha)}$. Hours depend on firm characteristics together with the amount of hourly compensation required for individuals' underlying disamenity of work (which is d_i). Suppressing the subscripts, we can write first-order condition (15) generically as:

$$pf'(h) = -U_h / U_c \tag{23}$$

If firms have no hours preferences, then the left-hand side is a constant, as in the standard labour supply model, where the constant is the hourly wage. If individuals have no preferences, the right-hand side is a constant: the hourly wage in an hours demand model.

Equations (19) and (22) for the firms' profits in equilibrium show how their market power enables them to appropriate a share of the surplus. Firm 1's profit per worker is $pf_1(h_{11}^*) - d_1 h_{11}^{*\beta} - U_{12}^+$. Since U_{12}^+ is the utility actually obtained by each type-1 individual and $pf_1(h_{11}^*) - d_1 h_{11}^{*\beta}$ is the utility they would have had if they received their full value of marginal product, there is a transfer from the worker to the firm of some of the surplus produced. This is clear in this example since utility is expressed in monetary units. However, with this particular functional form for utility, the outcome is nevertheless efficient. The same number of hours would be chosen even if workers received their full value of marginal product. The reason is that, although duopsony lowers workers' incomes, there is no income effect because preferences are quasi-linear. If, more plausibly, leisure were a normal good, then duopsony power would cause hours to exceed the level that is efficient from the workers' point of view.

3.6 More types of individual

Suppose there is now a third type of individual, with utility function $U_3 = c - d_3 h^\beta$ where d_2=1<d_3<d_1. These individuals prefer more hours than type-1 individuals and fewer hours than type-2 individuals. Depending on the exact value of d_3, assume that they strictly prefer either be firm 1 or firm 2. Outcomes will be decided similarly to above, and the preferred firm will find it profitable to employ them in addition to its other type of individual, since once again it can exploit their relative preference for it. But their hours level will differ from that of the other type employed in the same firm.[7]

I have modelled the workforce here as atomised individuals, with all market power residing with firms. If workers were unionised, then they could presumably appropriate some of the surplus. Consumption would increase from its oligopsony levels, but again, with quasi-linear preferences, hours would not change. If leisure were a normal good however, hours would decrease. Depending on how responsive they were to individual member preferences, unions may also ‘compress’ within-firm outcomes. The empirical analysis below uses firm dummy variables to capture technology effects and this will also pick up any union effect on average outcomes in the firm. To allow for the compression effect, one could estimate separate union and non-union equations. In fact, I stratify the sample by industry sector, but this largely corresponds to the distribution of unions in Britain, that is they are concentrated in the public sector. It can also be noted that an analysis of the correlates of the firm effects (see Table 9, discussed below) does not suggest they are related to unions.

3.7 More types of firm

Suppose now that there is a third firm type, with production function $f_3(h_3) = a_3h_3^{\alpha} - k_3$, where $a_1=1<a_3<a_2$ and $k_1<k_3<k_2$, so that this firm sits between the other two in the hourly wage-hours space. Assuming only two types of individual and that type-1 individuals still prefer firm 1, its Bertrand competitor is now its ‘nearest neighbour’, i.e. firm 3. Firm 1 must offer them reservation utility:

[7] In reality there would be complications because it may be in individuals’ interests to hide their true preferences from the firm if they would prefer the wage-hours package of another preference type. In this simple model, though, I assume that the firm knows each individual’s preference type and so these signalling considerations do not apply.

$$U_{13}^{+} = pf_3(h_{13}^{+}) - h_{13}^{+\beta} \tag{24}$$

Equilibrium hours and consumption are then:

$$h_{11}^{*} = (a_1 p\alpha \,/\, d_1\beta)^{1/(\beta-\alpha)} \tag{25}$$

$$c_{11}^{*} = d_1 h_{11}^{*\beta} + U_{13}^{+} \tag{26}$$

$$= d_1\, h_{11}^{*\beta} + pf_3(h_{13}^{+}) - d_1\, (h_{13}^{+})^{\beta} \tag{27}$$

The market (from firm 1's point of view) becomes more and more competitive as firm 3 becomes more similar to firm 1, i.e. as $a_3 \rightarrow 1$ and $k_3 \rightarrow k_1$. Then $f_3(h) \rightarrow f_1(h)$ and $h_{13}^{+} \rightarrow h_{11}^{+}$, the hours which type-1 individuals would choose in firm 1 if they received their full marginal product. Also $U_{13}^{+} \rightarrow U_{11}^{+}$, implying $h_{11}^{*} \rightarrow h_{11}^{+}$.[8] Thus, from (27), $c_{11}^{*} \rightarrow pf_1(h_{11}^{+})$, which is the standard competitive outcome: workers receive their full value of marginal product.

3.8 Many individuals and firms

In a perfectly competitive labour market (a very large local labour market), there would be a continuum of individuals i and firm types j. Individuals would choose the combination (c_{ij}^{*}, h_{ij}^{*}), i.e. the firm, offering the highest utility, and they would receive their full value of marginal product. Observed outcomes would represent points on the envelope function of the individuals' utility. We would observe a continuous market locus, as depicted in Figure 3 (Kinoshita, 1987). The resulting sorting would be perfect, in that the equilibrium set of worker-firm pairings would maximise joint surplus, and therefore each firm would employ workers of a single preference type (if this were not so, and unless firm preferences were 'flat', workers of the other preference types could increase their utility by moving elsewhere).

[8] Because the quasi-linear utility function eliminates the income effect, h_{11}^{*} equals h_{11}^{+} whatever the degree of competition; only the wage payment c_{11}^{*} varies.

The next section draws out the empirical implications of the different market structures presented above.

4. Empirical implications and strategy

This framework leads to several empirical predictions:

(i) In a competitive labour market, there should be little within-firm variation in hours of work, among groups with the same productivity profile $f(h, k)$. In the empirical analysis, I control for differences in k using measures of education, labour market experience, tenure, training, type of contract and occupation. I variously refer to this set of characteristics as capturing human capital, labour quality and productivity.

(ii) In a competitive labour market there should be a high degree of sorting such that firm and worker preferences are well-matched. Individuals with characteristics associated with longer desired hours should be found in firms offering long work hours.

(iii) If, instead, the labour market is oligopsonistic, then there should be some within-firm variation in hours, even controlling for labour quality. One would also expect this within-firm variation to be explained quite well by observed labour supply characteristics, since firms should respond to workers' preferences when setting hours, by the process described in the previous section.

(iv) The effect of firm and individual characteristics on the chosen level of hours should vary according to the relative strength of the other side's preferences. For example, in firms which are quite flexible about working hours, then individual supply characteristics should have a larger effect on observed hours than in firms with rigid work schedules, where it is very costly to deviate from 'standard' hours. Firm preferences depend on the production technology, the benefits of workers synchronising their hours, and the productivity-hours profile of a given category of labour. All these factors may vary across different 'sectors' of the economy. On the supply side, individual preferences, as defined earlier, depend on the value of market work relative to domestic activity. These trade-offs may differ systematically across subgroups. It may be, for example, that the revealed preferences of men and women are different.[9] The effect of an extra child might have a larger effect on a woman's willingness to work more hours than a man's. Men and women may therefore constitute distinct supply types. The overall effects on observed hours will depend on the cross cutting of these demand and supply factors.

4.1 Economic sectors

The remainder of the paper evaluates these predictions against the data. Before detailing the statistical methods to be used, I discuss the definitions of the different sectors referred to in point (iv) above.

In defining sectors, one faces a trade-off between sample size and homogeneity. On the one hand, to identify labour supply effects, one would ideally like a sub-sample where firm preferences were held constant and one observed the outcomes of their interaction with a variety of different individual preferences; on the other hand, to identify demand effects, one would like an another sample containing closely matched individuals but working in a range of different firms.[10] Whilst it is possible to partition the sample quite finely, using observed characteristics, the number of observations within and across firms would be too small for reliable inferences to be made. The main analysis is therefore based on a broad partition of the sample into three economic sectors. Within each sector, different labour supply effects are allowed for by using gender interactions.

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[9] The analysis therefore abstracts from 'supply side constraints', that is where an individual wishes to change their working hours but is prevented from doing so due to domestic obligations, say. These constraints are not distinguished from supply preferences.

[10] There is a parallel in the labour supply literature where care is taken to ensure that the sample of individuals analysed are likely to be similar in their responses to changes in the wage. For example, analysis is often limited to male manual workers, or married women.

The three sectors are goods, private services and public services.[11] The groupings aim to reflect differences in intensities and use of both physical and human capital, for example the high capital investments and production line techniques in manufacturing, compared to labour intensive production in the service sectors. Public services may also differ in other respects. First, the sector might have other objectives than to maximise a financial surplus. In particular, it may want to (or want to be seen to) implement government objectives such as family-friendly working arrangements. Second, the public sector generally has a near monopoly in its product markets. By an argument related to Marshall's second law of derived demand, the demand for hours of work should be less sensitive to changes in the marginal cost of hours, since the costs can more easily be passed on to users (possibly in a non-monetary form, such as queues). Employer preferences, represented as isoprofit curves in hourly wage-hours space, will be flatter, and a dispersion of hours due to heterogeneous individual preferences will be more likel y.

4.2 Reduced-form equation

As stressed above, the assumption of particular functional forms for firm and worker preferences was a convenient way to present the factors underlying hours determination. Even so, it leads to a form of the reduced-form hours equation (17), which may be difficult to estimate and is itself highly specific. As an example, taking logs of the hours equation to change it to additive form, we get:

$$\begin{aligned} log(h_{ij}) &= log(p\alpha)/(\beta-\alpha) + log(a_j)/(\beta-\alpha) - log(d_i)/(\beta-\alpha) - log(\beta)/(\beta-\alpha) \\ &= \text{constant} - log(d_i)/(\beta-\alpha) + log(a_j)/(\beta-\alpha) \end{aligned}$$

[11] Goods comprises the Standard Industry Classifications 1992 (SIC 92) groups manufacturing, electricity, gas and water, and construction; private services consists of wholesale and retail, hotels and restaurants, transport and communications, financial services, other business services and private-sector firms in education, health and other community services; public services consists of public administration, and public-sector firms in education, health and other community services.

assuming a constant product price p, and that worker and firm heterogeneity is fully captured by d_i and a_i (so that α and β are constant, as in the model). The second term shows the effect of worker preferences, while the third shows that of firm preferences. If these two terms can be modelled as linear combinations of individual and firm characteristics, then one can estimate the equation by ordinary least squares (OLS), with stochastic terms added for unobserved worker and firm characteristics. This is broadly my approach, but recognising that it does rely on a set of assumptions about functional form, I specify, in turn, hours and the log of hours as the dependent variable to act a sensitivity check. I also estimate linear probability models to explain the dichotomous variable part-time (vs. full-time) incidence. As noted by Stewart and Swaffield (1999) for the case of a probit model, binary choice models are invariant to monotonic transformations of the underlying functional form, as long as one does not need to identify the constant term.

Consider the hours equation for individual i in firm j:

$$h_{ij} = z_j'\gamma + x_i'\beta + s_i'\delta + \eta_j + \upsilon_{ij} \tag{28}$$

where the vector z_j contains observed firm characteristics, x_i contains labour supply characteristics (for example, marital status and the presence of children) and s_i contains individual characteristics (such as education and occupation) which may affect the productivity-hours profile, and may also influence individual supply preferences.[12] The partitioning of individual variables into x_i and s_i is discussed below. The coefficient vectors associated with these characteristics are γ, β and δ; and η_j and υ_{ij} are unobserved characteristics at the firm and individual level. With the cross-sectional data which I shall use, it is not possible to identify a pure individual effect as individuals are not observed to move between firms. Instead η_j combines the "true" firm effect and the firm mean of individual unobserved characteristics, and υ_{ij} captures the deviation of the individual effect from this mean. For a more detailed discussed of these issues relating to matched employer-employee data, see Abowd and Kramarz (1999).

The sorting process described above implies that η_j will be correlated with x_i and s_i. The pure individual effect will also be correlated with z_j, and since η_j incorporates the mean individual effect at firm level, η_j will be correlated with z_j. This emphasises that estimation of (28) cannot be separated from consideration of these sorting effects. However, careful use of between- and within-estimation techniques can reveal the importance of the sorting effects and separate them from the effect of individual characteristics within firms. Replacing $z_j'\gamma + \eta_j$ with a vector of firm dummy variables D_j we arrive at a firm fixed-effects model:

$$h_{ij} = x_i'\beta + s_i'\delta + D_j'\alpha + \varepsilon_{ij} \qquad (29)$$

Sorting on unobservable individual characteristics and the effect of firm preferences are captured by the coefficient vector α. Together with estimates of β and δ, which are uncontaminated by sorting effects, we can then confront the hypotheses outlined above with evidence from the data.[13] A decomposition of the variance of h_{ij} into the components due to firm affiliation, and individual characteristics (x_i, s_i, and ε_{ij}) is then possible, and is described in the next section.

The vector s_i contains age and age squared (imputed from the midpoints of the questionnaire age bands), tenure (imputed from the midpoints of the questionnaire tenure bands), and dummies for highest educational qualification, receipt of training in the last 12 months, employment on fixed term or temporary contract, health problems affecting daily

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[12] Productivity characteristics were omitted from the model, which compared workers of identical productivity.

[13] Whilst the reduced-form hours equation could be specified as a random-effects model, the theoretical prediction that η_j is correlated with z_j, x_{ij} and s_{ij} suggests this would not be appropriate. Statistical tests discussed

activities, one-digit occupation and female gender.[14] The female dummy variable was also interacted with the age terms and the occupation dummies. This set of variables is intended to capture the effects of human capital on the marginal productivity of hours. The dummy variable for women and its interactions with age are included to control for any differences in the labour market position of women and men and in their accumulation of skills with age, in particular for women's more intermittent participation. The interactions with occupation control for any pattern of occupational segregation which is specific to women. For example, some 'women's jobs' may be inherently part-time.[15]

Whilst some of the s_i variables will also reflect supply differences (for example, age and occupation, insofar as occupational choice is a means of realising hours preferences), the aim is to purge the variation in hours of productivity effects as completely as possible. The characteristics in x_i are then allowed to explain the remainder. They are marital status and the presence of dependent children under 5 years, 5-11 years and 12-18 years, as well as interactions of the female dummy with these characteristics to allow different effects amongst men and women. I term these variables 'individual preference' or 'labour supply' characteristics on the assumption that their principal association is with the value of domestic time (i.e. domestic productivity) rather than with the value of market time. This seems a plausible idea – that characteristics associated with the domestic sphere should have their main effect there. Whilst family characteristics may also influence skills investment decisions and occupational choice, this is being controlled for by the extensive list of characteristics in s_i.

later support the fixed-effect specification.

[14] A quadratic term in tenure was excluded following a significance test.

[15] The results for public services show a much bigger gap between unskilled women and women managers than for their male counterparts (11.8 hours against 3.2 hours).

One can less confidently interpret the estimated β coefficients as the causal effects of family characteristics on hours, since labour supply and domestic decisions are probably taken jointly. But it seems rather unlikely that causality runs in one direction only, i.e. that the number of hours worked causes (in the short run) partnership formation and childbearing. It seems, instead, more plausible that the main causality is in the other direction. It could also be true that both labour supply and domestic outcomes are not directly linked but both caused by some independent factor. But then β still measures how tight is the connection within the firm between hours and domestic circumstances.

I now turn to discuss the method of decomposing the variation of hours worked. The aim of the decomposition is, in light of the theory, to evaluate the contribution to the observed variation in working time which can be assigned unambiguously to the separate individual and workplace level elements; and the part which cannot be assigned to any of these components alone, but which is a joint contribution, representing the sorting of workers to firms on observed characteristics.

4.3. Decomposition methods

Since the determination of working time is naturally expressed in the form of a regression equation, least squares decomposition is an obvious choice. To see the issues involved with the least squares method, consider the regression of a variable y on two scalar variables x and z:

$$y = \alpha + \beta x + \gamma z + \varepsilon \tag{30}$$

where ε has the usual 'classical' properties. One possible decomposition is suggested by writing down the variance of y:

$$V(y) = V(\beta x + \gamma z) + V(\varepsilon) \tag{31}$$
$$= \beta^2 V(x) + \gamma^2 V(z) + 2\,\beta\,\gamma\, cov(x, z) + V(\varepsilon) \tag{32}$$

The contribution of x to the variance is $\beta^2 V(x)$, that of y is $\gamma^2 V(z)$, whilst the joint contribution is $2\,\beta\gamma\, cov(x, z)$. There is a large literature on inequality decomposition in which one aim is to partition the variation according to different explanatory factors, dividing any joint contributions among the individual factors. An example which uses the least squares regression framework is Fields and Yoo (2000). They write $V(y)$ slightly differently as:

$$V(y) = cov(y, \beta x + \gamma z + \varepsilon)$$
$$= cov(\beta x, y) + cov(\gamma z, y) + V(\varepsilon)$$

Since $cov(\beta x, y) = \beta^2 V(x) + \beta\,\gamma\, cov(x, z)$, the joint contribution, which is distinct in equation (32), is shared equally between x and z. My approach differs, however, as I wish to account explicitly for sorting effects and so to separate the joint contribution from that due to the individual factors alone.

Consider an example with three covariates, where we wish to partition the explained variance between one pair of variables, on the one hand, and the remaining variable on the other hand:

$$y = \alpha + \beta x + \gamma z + \delta w + \varepsilon$$
$$V(y) = \beta^2 V(x) + \gamma^2 V(z) + \delta^2 V(\mathrm{w})$$
$$+ 2\,\beta\,\gamma\, cov(x, z) + 2\,\beta\,\delta\, cov(x, w) + 2\,\gamma\,\delta\, cov(z, w) + V(\varepsilon)$$

The total contribution due to x and z is $\beta^2 V(x) + \gamma^2 V(z) + 2\,\beta\,\gamma\, cov(x, z)$, whilst the contribution due to w is $\delta^2 V(w)$. The sum of the remaining two components is the variance due to w co-varying with x and z. By an extension of this idea, any number of variables can included in the regression and the variance partitioned amongst single variables or blocks of variables, as desired. Consider the general case:

$$y_i = x_i'\beta + \varepsilon_i$$

where x_i now denotes a vector of k variables, including a constant term, associated with parameter vector β, and i indexes observations 1, .., n. Assuming β and ε were known, we could calculate the sample analogue of the variance decomposition as:

$$\frac{\sum_i (y_i - \bar{y}_i)^2}{n-1} = \frac{\sum_i ((x_i - \bar{x})'\beta)^2}{n-1} + \frac{\sum_i \varepsilon_i^{\,2}}{n-1}$$

with an expansion of the first term on the right-hand side giving the variance components due to each variable. Since β and ε are not known it is natural instead to partition the sample variance as:

$$\frac{\sum_i (y_i - \bar{y}_i)^2}{n-1} = \frac{\sum_i ((x_i - \bar{x})'b)^2}{n-1} + \frac{\sum_i e_i^{\,2}}{n-1}$$

$$\text{i.e.} \frac{TSS}{n-1} = \frac{ESS}{n-1} + \frac{RSS}{n-1}$$

where b is the estimate of β, and e is the residual. We know that the left-hand side term is an unbiased estimate of $V(y_i)$. But, because b is estimated with error, the two right-hand side terms are biased estimates of $V(x_i'\beta)$ and $V(\varepsilon_i)$ (= σ^2). The estimate of σ^2 is easy to correct by applying the standard result:

$$E\left(\frac{\sum e^2}{n-1}\right) = \frac{n-k}{n-1}\sigma^2$$

which is the basis of the R^2 adjusted for degrees of freedom[16], defined as:

$$\bar{R}^2 = 1 - \frac{\sum e^2/(n-k)}{\sum (y-\bar{y})^2/(n-1)}$$

Since the estimate of $V(\varepsilon_i)$ is biased downward by $\sigma^2(k-1)/(n-1)$, the estimate of $V(x_i'\beta)$ is biased upward by the same amount. If k is small relative to n then the bias is very small, but with a large number of covariates (e.g. many firm dummies) it can be big. In the analysis below, $(k-1)/(n-1)$ approaches 0.1 in some cases. This total bias is partitioned amongst the different components of explained variance, so that individual component estimates may in fact suffer much larger proportionate bias. I now demonstrate how corrections can be applied to these estimates.

4.3.1. Degrees of freedom correction

We want to know the expectation of the sample sum of squared deviations. There are now two stochastic elements, the vector x_i and the error term ε_i which affects b. By the law of iterated expectations, and substitution of the standard expression for b:

$$E\left[\sum_i \left((x_i-\bar{x})'b\right)^2\right] = E_X\left(E\left[\sum_i \left((x_i-\bar{x})'b\right)^2 \middle| X\right]\right)$$
$$= E_X\left(E\left[\sum_i \left((x_i-\bar{x})'(\beta+(X'X)^{-1}X'\varepsilon)\right)^2 \middle| X\right]\right)$$

where $E_X(.)$ denotes the expectation over X, the n x k data matrix formed by stacking row vectors x_i', and ε is a vector of error terms. Expansion of the squared term gives:

[16] Note that, although the estimates of $V(\varepsilon_i)$ and $V(y_i)$ are unbiased, the adjusted R^2 is not an unbiased estimate of the true coefficient of determination in the population. It is, however, less biased than the unadjusted R^2. The distributions of both estimates are intractable in the general case that the true coefficient of determination is non-zero (see Kennedy, 1998, p.91).

$$
\begin{aligned}
&E\left[\sum_i \left((x_i - \bar{x})'b\right)^2\right] \\
&= E_X\left(E\left[\sum_i \left\{\left((x_i - \bar{x})'\beta\right)^2 + \left((x_i - \bar{x})'(X'X)^{-1}X'\varepsilon\right)^2 + 2(x_i - \bar{x})'\beta[(X'X)^{-1}X'\varepsilon]'(x_i - \bar{x})\right\}\middle|X\right]\right) \\
&= E_X\left(E\left[\sum_i \left\{\left((x_i - \bar{x})'\beta\right)^2 + \left((x_i - \bar{x})'(X'X)^{-1}X'\varepsilon\right)^2\right\}X\right]\right), \text{since } E\left[(X'X)^{-1}X'\varepsilon\middle|X\right] = 0 \\
&= E_X\left(\sum_i \left((x_i - \bar{x})'\beta\right)^2\right) + E_x\left(E\left[\sum_i \left((x_i - \bar{x})'(X'X)^{-1}X'\varepsilon\right)^2\middle|X\right]\right)
\end{aligned}
$$

The first term is the desired quantity, the expectation of the sum of squared deviations due to the underlying model, whilst the second term is the bias. Some matrix transposition of this second term leads to:

$$
\begin{aligned}
&E_X\left(E\left[\sum_i \left((x_i - \bar{x})'(X'X)^{-1}X'\varepsilon\right)^2\middle|x\right]\right) \\
&= E_X\left(E\left[\sum_i (x_i - \bar{x})'(X'X)^{-1}X'\varepsilon\varepsilon'X(X'X)^{-1}(x_i - \bar{x})\middle|X\right]\right) \\
&= E_X\left(\sum_i (x_i - \bar{x})'(X'X)^{-1}X'\sigma^2 IX(X'X)^{-1}(x_i - \bar{x})\right), \text{since, by assumption, } E\left[\varepsilon\varepsilon'\middle|X\right] = \sigma^2 I \\
&= \sigma^2 E_X\left(\sum_i (x_i - \bar{x})'(X'X)^{-1}(x_i - \bar{x})\right)
\end{aligned}
$$

where I is the n-dimensional identity matrix. It is easily shown that the term inside the large brackets evaluates to k–1, so the total bias is $(k-1)\sigma^2$, as noted above for the estimate of σ^2. But the matrix form of this term shows how the bias is apportioned amongst the different elements of the decomposition. To see this more clearly, consider the sum of the products of deviations which one would use to calculate the covariance component corresponding to two individual elements of x_i, say x_{ij} and x_{ik}:

$$\frac{\sum_i (\tilde{x}_i - \bar{\bar{x}})'b \cdot (\hat{x}_i - \bar{\bar{x}})'b}{n-1}$$

where $\tilde{x}_i$ is vector x_i with all elements set to zero except x_{ij}, and $\hat{x}_i$ is vector x_i with all elements set to zero except x_{ik}. By working similar to that above, we arrive at an expression for the bias:

$$\text{Bias} = \frac{\sigma^2}{n-1} E_X\left(\sum_i (\tilde{x}_i - \bar{\bar{x}})'(X'X)^{-1}(\hat{x}_i - \bar{\bar{x}}) \right)$$
$$= \frac{\sigma^2}{n-1} E_X\left(m_{jk} \sum_i (x_{ij} - \bar{x}_j)(x_{ik} - \bar{x}_k) \right)$$

where m_{jk} is the corresponding element of $(X'X)^{-1}$. For large n, this expression evaluates to the covariance of x_{ij} and x_{ik} multiplied by $\sigma^2 E(m_{jk})$. So an estimate of the bias associated with the two elements x_{ij} and x_{ik} is simply their sample covariance, weighted by the corresponding element of $\sigma^2(X'X)^{-1}$, which is of course the covariance matrix of the coefficient vector b.

In this way, it is straightforward to calculate unbiased estimates of all the variance components. I partition the variance explained by the reduced form hours equation into the components due to (i) human capital characteristics, (ii) preference characteristics, (iii) firm effects, and (iv) joint effects.

4.4 Equations estimated

The empirical analysis proceeds in five steps, and I now explain each one in turn.

First, I summarise the raw data by estimating OLS equations of the form:

$$y_{ij} = D_j'\alpha + e_{ij} \qquad (33)$$

where y_{ij} may be one of three measures of working time (total hours, the log of total hours, incidence of part-time working) as well as related variables such as personal characteristics, and D_j is a vector of firm dummies. This is the simplest application of the decomposition described above – a variable regressed on the set of firm dummies – and the adjusted R^2 is a convenient measure of the proportion of the variance of y_{ij} accounted for by firm affiliation. It is instructive to calculate this simple association both for the hours measures and for other personal characteristics. If there is strong sorting of individuals to firms of the basis of hours preferences, this proportion should be high for the hours measures and typical labour supply characteristics like marital status and the presence of children. On the other hand, if sorting is weak, the adjusted R^2 should be low.

Where y_{ij} is binary/dichotomous (33) becomes a linear probability model; nevertheless the adjusted R^2 can still be interpreted as a measure of the importance of the regressors (in this case firm affiliation) is explaining the outcome. For example, this same method has been used to derive measures of skills segregation across firms (Kremer and Maskin, 1996). Gronau (1998) showed that the R^2 from a linear probability model equals the difference between the average predicted probability of the group with $y_{ij} = 1$ and the group with $y_{ij} = 0$. This would be zero if $\alpha = 0$ and thus it represents the improvement in the fit due to the regressors.

The next step is to estimate reduced-form equations of the form:

$$h_{ij} = x_i'\beta + s_i'\delta + D_j'\alpha + \varepsilon_{ij} \tag{34}$$

with individual characteristics x_i and s_i added as explanatory variables, and to evaluate the contributions to the variance as discussed above. These shares provide more descriptive evidence of the relative importance of the different factors.

In the third step I examine more formally the evidence for sorting. To test for sorting, I estimate:

$$h_{ij} = x_i'\beta + s_i'\delta + \overline{x}_j'\kappa + \overline{s}_j'\lambda + \mu_j + \varepsilon_{ij} \tag{35}$$

where a bar and subscript j indicate the firm mean calculated over observed workers belonging to each firm. The error component μ_j is the part of the firm effect not explained by the linear combination of means $\overline{x}_j'\kappa + \overline{s}_j'\lambda$, and is assumed random and uncorrelated with the regressors. The model follows Mundlak (1978), who showed that for a balanced panel, the generalised least squares (GLS) estimates of β and δ are identical to the within-firm estimates from a model omitting the workplace means. The κ and λ estimates are the difference between the within-firm estimates and the between-firm estimates that would be obtained by regressing the firm means of hours on the firm means of the other characteristics. A test of the joint significance of the estimates of κ and λ is a test of whether the firm effect is correlated with individual characteristics, i.e. whether there is sorting on observed characteristics into firms. The individual coefficients and their statistical significance can reveal the importance of different individual characteristics in the allocation of workers to firms.

I then discuss the within-firm estimates of the human capital and preference coefficients in more detail, contrasting the effects by gender and across the three sectors.

Finally, I regress the firm effects estimated from the fixed effects model on a set of observed firm, industry and area-level characteristics to see the associations between these characteristics and firm-level hours.

5. The Data

I now briefly present the data used and discuss the available measures of working time. The data are from the 1998 Workplace Employee Relations Survey (WERS 98), a nationally representative cross-sectional survey of workplaces with ten or more employees.[17] The sample of workplaces was obtained through a process of stratified random sampling, with over-representation of larger workplaces and some industries (see Forth and Kirby, 2000, for details).[18] This non-random selection of workplaces potentially complicates the analysis and this issue is returned to below. I treat the workplace as the empirical equivalent of the theoretical concept of the firm. Whilst many workplaces are just one part of a larger organisation, the considerations of the interactions between hours and physical and human capital should still apply.

WERS98 was innovative because information was collected from up to 25 individuals in each workplace.[19] The main workplace level component of the survey was a face-to-face interview with the most senior workplace manager responsible for personnel or employee relations (see Cully et al, 1999). Interviews were conducted in 2191 workplaces over the period October 1997 to June 1998, with a response rate of 80.4%. The Survey of Employees was then conducted using a self-completion questionnaire distributed to 25 randomly selected employees at each workplace (or all employees in smaller workplaces). The questionnaire was distributed to the 1880 workplaces where management permitted it, with a response rate of 64% (28,215 employees).[20]

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[17] The survey covered both public and private sectors, but excluded agriculture, fishing, mining, private households with employed persons, and extra-territorial organisations.
[18] The oversampled industries are the SIC 92 major groups covering electricity, gas and water, construction, hotels, financial services, and other community services.
[19] Previous surveys in the same series were only carried out at the workplace level.
[20] A third component of the survey, not used in this study, was the worker representative questionnaire. Where relevant and permitted by management, interviews were carried out with worker representatives. This occurred in some 43% of workplaces and the interviewee was usually a trade union representative.

[Insert Table 1 around here]

As shown in Table 1, usable responses were obtained in 1782 workplaces from 28215 individuals, which represents an average of 15.8 individuals per workplace. After dropping cases with invalid data on hours and other variables to be used in the analysis there were 21833 individuals in 1740 workplaces, a mean of 12.5 per workplace. The median is slightly higher at 14, so the distribution of individuals is slightly left skewed.[21]

The idea that working time may depend on both the workplace and the individual is embedded in the WERS98 questionnaire, as both the employer and employee components include questions on working time. Unfortunately, the employer questions typically only cover certain segments of the labour force, for example workers in the largest occupational group in the establishment, and so cannot be used as the basis for the main analysis. But to get a flavour for the data and to assess how compatible the two sets of responses are, it is instructive to compare briefly the management and employee-reported measures.

5.1. Total usual full-time working hours

There are two measures of usual full-time hours including overtime. The first is the average number of hours usually worked by employees in the largest one-digit occupational group of the workplace, and is the management representative's response to the following question:

> "What is the average duration of the normal working week for full-time [employees in the largest occupational group], including any overtime hours?"

[21] The largest group of cases dropped, 2314, was because the number of overtime hours was missing. Inspection of WERS variable A5, which indicates the means of compensation of any overtime, suggests that these individuals did sometimes work overtime, e.g. 39% said they were normally paid for overtime. Therefore it did not seem reasonable to set these missing cases to zero and include them in the sample. I also dropped cases where reported usual hours were more than 80 (37 observations) or where usual overtime hours were reported as greater than usual total hours (49 observations).

The second measure is variable A4 from the employee questionnaire, in response to:

> "How many hours do you usually work each week, including any overtime or extra hours?"

This second measure is the key working time variable used in the main analysis. I computed the workplace mean of this variable for those full-time individuals in each workplace whose reported one-digit occupation matched the biggest occupational group given by the manager. Graph 1 plots the individual measure against the management measure for the 1394 workplaces with valid data on both.[22]

If individuals worked the average hours level stated by management, and if they reported their hours accurately, the points of the graph should be clustered around the 45 degree ray from the origin. In fact there is wide dispersion, so there is either some genuine divergence of individual hours from management-declared levels or hours are reported with error.[23] The graph also shows a line fitted through the data by the uncentred regression of the individual variable on the management variable. The slope is very precisely estimated at 1.03 (the 95% confidence intervals are 1.027 and 1.039), so there is a systematic discrepancy between management and individual reported hours, with individuals reporting 3% more

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[22] The standard definition of full-time working is 30 or more hours per week including overtime. On average there were 4.3 full-time individuals in the largest occupational group per workplace. In 292 workplaces there were no observations on full-time individuals in the largest occupational group, and there was no valid management response in 33 workplaces. There were also 56 workplaces where management reported mean full-time hours of less than 30 hours per week (only 34 of them had valid figures for mean individual hours, often because no full-time employees were observed). Inspection of their industrial and occupational characteristics suggested that these workplaces made extensive use of atypical working patterns with employees concentrated at the two ends of the occupational range: for example, part-time teachers at one end, and security attendants or cleaners at the other. About half were educational establishments, and the most common largest occupational groups were professionals (in the educational establishments), personal and protective services and other occupations. The 56 workplaces also stood out as significant employers of part timers (mean proportion of part time workers given by management was 0.55 compared to 0.25 in the other workplaces). The management respondent may have had some difficulty defining the length of the normal full-time working week. These workplaces were excluded from the comparison.

[23] The actual dispersion observed on the graph will also reflect the number of individuals observed in each workplace, since each point is a mean. The regressions reported below are weighted to account for this.

hours than management on average. The standard error of the regression is 4.9 hours, again indicating the wide dispersion.

[Insert Table 2 around here]

Graph 2 partitions the sample into the nine largest occupational groups; the plots are truncated at 60 hours for clarity. If the variation around management-reported hours represents noise, one would not expect it to differ significantly across occupations. A finding that the variation did differ across occupation would support the view that it is at least partly due to genuine variation in individual hours. The plots suggest that the dispersion does indeed vary substantially across occupations. Table 2 reports details of the accompanying regressions, which have been weighted by the number of observations used to calculate each workplace mean. The number of observations differs systematically by occupation (see the last column of Table 2) and could give rise to different estimated dispersions if it were not controlled for. However, the pattern of dispersion according to the regression standard errors turns out to be very similar to the graphs. If we ignore managers, as there were only 14 workplaces where they were the biggest occupation, we see that professionals had the highest dispersion (a standard error of 7.57 hours) and clerical workers the lowest (2.30 hours).

These large differences suggest that the observed dispersion of hours is not just noise. Simple F-tests of the equality of pairwise variances confirm that these differences are statistically significant in many cases. For example, a test that the variance for professionals equals that for clerical workers gives a statistic of $7.57^2/2.30^2 = 10.8$, distributed as $F(221,299)$, for which the 5% critical value is approximately 1.3.[24]

[24] This point is confirmed by the results of a similar regression (not reported) with all occupations combined but including occupation specific dummies and allowing the variance of the error term to differ by occupation. In 5 occupations, dispersion differed significantly from the base case of 'other occupations'.

5.2. The incidence of part-time work

The management questionnaire also asked for a breakdown of employee numbers by part/full-time status (and gender). Table 3 compares the total proportion of part-time employees given by management with the proportion of part-timers derived from the individual responses. Both measures are expressed in bands and the shaded cells are the modes of the individual-based measure for each band of the management measure. The table shows there is quite a strong association between the two variables, though with frequent off-diagonal entries which can reflect individual sampling error.

[Insert Table 3 around here]

6. Results

6.1. Between and within workplace variation of individual level variables

I now turn to look at how selected personal characteristics are distributed across and within workplaces (Table 4), using simple regressions on a vector of workplace dummies and calculation of the adjusted R^2, as described above.

The data are also weighted to take account of the non-random selection of workplaces due to the survey design (larger workplaces and some industries are over represented) and to correct for individual non-response within workplaces. The WERS98 data set is supplied with both workplace-level and individual-level weights for this purpose. I have used the individual-level weights (which account for workplace and individual-level selection) since this is the level of my analysis. It is clearly important to weight raw data if one wants to draw inferences about the population. For example, the overall incidence of part-time work is 25% in Table 4 (which is close to the population estimates from other surveys[25]); whereas the unweighted figure is 19%. Similarly, unweighted estimates of the proportion of variance that is between workplaces are likely to be biased if, for example, the effect of workplace affiliation differs in larger workplaces.[26]

[Insert Table 4 near here]

The top row of Table 4 reports that mean total hours across the whole sample of individuals are 36.03, with a variance of 171.1 (so the standard deviation is 13.1 hours). The decomposition shows that 41% of this variation can be attributed to workplace affiliation. The remainder is due to individual characteristics, observed and unobserved, and to

[25] For example, Labour Force Survey data on the usual weekly hours of employees in 1998 show that 25% of employees worked 30 hours or less per week.

[26] It turns out that weighting does have a substantial effect on the estimates: the shares of the variance due to workplace affiliation are higher by about 7–8 percentage points with the weights.

measurement error. The second row shows an identical result (to 2 decimal places) when the log of total hours is used as the measure; and the third row reports that 38% of variation in part-time incidence can be explained by workplace. These three figures imply that, consistent with the theoretical framework laid out above, the weekly hours worked by an individual are strongly associated with the workplace they belong to.[27]

The next panel of Table 4 reports the adjusted R^2 for some measures of human capital: education (degree level), three broad occupational groups, age, and tenure. Gender is also listed. All the estimates imply that these characteristics are not randomly distributed across workplaces. Instead, their incidence is relatively well explained by workplace affiliation. For example, the occupation proportions vary from 28% to 43%. The variable with the lowest share is age (15%).

The final panel of the table shows the shares for worker preference characteristics: marital status and the presence of children in three age bands. In contrast with the other characteristics, little of the variation can be attributed to workplace affiliation. The highest estimate is 8% for marital status and the highest estimate for the children dummies is 5% for children aged 12–18 years. At face value, these figures suggest that there is not much sorting into workplaces based on worker characteristics expected to influence labour supply.

6.2. Multivariate decompositions

The results of the decompositions are presented in Table 5. Column (4) reports the R^2, while column (5) shows the R^2 adjusted for degrees of freedom. The difference between them is the sum of the proportionate corrections applied to the individual variance components. Columns

[27] All of the estimates in Table 5 are statistically significant: in the regression framework, the workplace dummy coefficients are jointly significantly different from zero.

(6)–(11) show the corrected estimates, as a proportion of total variance, which therefore sum to the adjusted R^2. The figures in italic are the contribution of each component as a percentage of the explained variance. All the vectors of coefficients corresponding to the blocks of characteristics considered are significant at the 1% level at least.

[Insert Table 5 near here]

Consider the first row, for total hours of work. From the adjusted R^2 in column (5), about 57% of the total variance of 171.6 hours squared can be attributed to the combined effects of personal characteristics and workplace affiliation (recall that the share when only workplace dummies were included was 41%). This is about 3 percentage points less than the R^2 in column (4), and this difference is the total proportionate correction, distributed among the individual variance component estimates. The remaining unexplained proportion (44%, column (12)) may simply be due to random measurement error, but it seems likely that are also unobserved individual productivity and preference characteristics at work. The calculated variance contributions may therefore underestimate the true values to some degree.

What share of the total variation can be attributed solely to workplace affiliation (including the effects of sorting on unobservable characteristics)? The answer (column (8)) is 18%, or 18/57 = 32% (reported in italics) of the explained variation. This points to a substantial role for firm-level 'demand' characteristics in the determination of total working hours. This share is slightly bigger than any of the other components of the decomposition to be discussed, although slightly smaller than all personal characteristics combined. The uncorrected estimate was 21% (not reported in the table), and in fact it turns out that almost all of the total correction (of about 3 percentage points) can be assigned to the workplace component. This is intuitively reasonable since it is primarily the workplace dummy variables which are 'using up' degrees of freedom. It shows the importance of correcting each variance component separately.

How much variation can be attributed to the individual variables defined as human capital characteristics? With the caveat that these variables will also, to some extent, capture individual preferences, column (6) shows that 16% of total variation (and 28% of explained variation) is due to these labour quality factors, including occupation. So these characteristics also seem important in hours determination.

The next column (7) shows the proportion of variation due to characteristics which I have argued should primarily influence work preferences, after controlling for other productivity characteristics. These variables are marital/cohabiting status and the presence of children of less than 5 years, 5-11 years and 12-18 years. The theory predicted that in a highly competitive labour market, these variables should contribute very little to explaining hours variations after controlling for workplace affiliation and labour quality. This is because workers of given productivity should sort into firms with preferences matching their own.[28] According to the decomposition, 4% of total variation (7% of explained variation) is due to preference characteristics. As noted above, the coefficients are jointly significant. This provides some evidence of a within-workplace effect, and that preferences affect hours other than through sorting; it is, however, small (though the choice of preference variables was deliberately restrictive). In the next section I consider the size and individual significance of these within-workplace effects.

Do the results provide any evidence of sorting? The covariances reported in columns (9)–(11) do suggest some positive sorting based on human capital and preference

[28] In fact, with perfect sorting the vector of preference characteristics should be highly collinear with the workplace dummies. This is not what is found.

characteristics, with the larger contribution coming from human capital variables (11% against 4% for joint preference-workplace effects). About 4% of the variance is also explain by the positive co-movement of human capital and preference characteristics, i.e. individuals who have human capital characteristics which raise their hours of work also tend to have characteristics which make them want to work more. Workplace sorting effects are investigated in more detail in the Section 6.3.1.

To check robustness to a different functional form, the second row of Table 5 reports the results when the log of hours is used as the dependent variable. They are similar to those of the first row. The third row shows the estimates when a dummy variable for part-time work is used. Again they are reasonably similar, so the decomposition results do not appear to be an artefact of the functional form assumed for the hours relationship.

Because the results do seem robust to different measures of weekly hours, I focus hereafter on the measure of total hours in levels. The lower panel of Table 5 repeats the decompositions, but partitions according to the sectors defined earlier. In section 4.1, it was argued that differences of capital intensity and usage, and product market structure, would be likely to change the relative importance of workplace and individual characteristics.

6.2.1 Economic sectors

Consider the three economic sectors, goods, private services and public services. The means in column (1) show that work hours are the highest on average in goods (42.2 hours) and substantially lower in the other two sectors (33.3 in private services and 34.3 in public services). More detailed analysis (not reported) shows that the figures largely reflect a much lower prevalence of part-time work in goods (only 5% of goods workers are part-time, compared to around a third in the other two sectors). But median hours are higher in goods than in the other two sectors (40 compared to 37 hours), and the upper quartiles are 47 hours in goods, 42 hours in private services and 40 hours in the public sector, so there is a higher incidence of long hours in the goods sector. Consistent with the prevalence of part-time working, overall there is more variability of hours in private and public services as compared to the goods sector. The standard deviations of hours (column (2)) are 14.3 in private services and 12.8 in public services, but only 8.6 in goods.

Firstly, consider the decompositions within each sector. The results show that in the goods sector, workplace effects account for 16% of variation (column (8)), which is lower than their 22% contribution in private services, but higher than their 9% share in the public sector. However, given the much lower unconditional variance of hours in the goods sector, it may be that a higher proportion of this variance is due to measurement error. In this case, the contribution of workplace effects may be understated. So it perhaps makes more sense to compare the contributions across sectors as a percentage of explained variance. The figures in italics in column (8) show that 50% of explained variance in the goods sector is accounted for by workplace effects, compared to 36% in private services and 19% in the public sector. This indicates that workplace effects are very important in the goods sector, which is consistent with there being large benefits to hours coordination due to production line techniques. Workplace effects, as measured by the shares of both total and explained variance, are also important in private services, but much less important in public services.

What role do human capital characteristics play? In the goods sector, they account for 9% of total variance (or 29% of explained variance, column (6)). The corresponding figures in private services and the public sector are 15% (26%) and 22% (46%). Taken together, these estimates suggest that human capital characteristics are particularly important for hours in the public sector relative to the other two sectors. But column (9) indicates there is strong sorting on human capital (14% of total variance and 29% of explained variance) in private services, and that this does not exist in either of the other sectors (the figures are –1% (–4%) in goods and 3% (6%) in public services). So there is evidence that human capital is important for hours in both the service sectors relative to the goods sector. The mechanisms differ though: in private services, workers with similar human capital are sorted into workplaces with similar hours, while in public services the effect is at the individual level.

Turning to look at preference characteristics (column (7)), we see that they play a bigger role in public services than in the other two sectors (6% of total variation compared to 3% in the other two). The contributions as a percentage of explained variance also suggest that preferences are more important in public services (13% compared to 5% in private services and 9% in goods). Column (10) provides some evidence of sorting on preferences, particularly in private and public sectors. This is tested more formally in the next section.

Another way to examine the evidence across sectors is to express the variance contributions in absolute terms (i.e. multiply the shares by the variance of hours in that sector). Then one can make direct comparisons of the roles played by different characteristics. These absolute contributions are reported in Table 6. Comparing private services to the goods sector, we see that the variance due to each of the three components, human capital characteristics, preference characteristics and workplace effects, is about 3–4 times greater in private services than the corresponding contributions in the goods sector (columns (4)–(6)). So private services are more heterogeneous along all three dimensions. By comparison, in the public services, there is much less variation due to workplace effects (14.9 hours squared compared to 44.8 hours squared in private services and only 12.0 hours squared in the goods sector). But there is more variation than in the other sectors due to both human capital characteristics and due to preference characteristics.

[Insert Table 6 near here]

The overall picture, then, is of a goods sector with relatively tightly bunched hours, and where workplace affiliation plays an important role in hours determination; a private service sector with wide variation in hours, in part due to widely differing workplaces but also where human capital characteristics are very important, and where individuals with similar human capital characteristics tend to be clustered into the same firms. Finally, in the public sector, hours are also quite variable, but relative to private services, a much larger share of variation, and a slightly larger absolute contributions, is associated with both human capital and preference characteristics. Workplace effects are relatively unimportant.

6.3 Regression results

The results for each economic sector of the basic regression containing individual characteristics and their workplace means (equation (35)), instead of workplace dummy variables, are presented in Table 7. Unlike the regressions in the previous section, where the use of weights was necessary to obtain representative variance shares, these regressions were not weighted. This is because their purpose is to estimate marginal effects, conditioning on firm and individual characteristics. Since these are also the characteristics which influence sample selection, one is implicitly controlling for non-random sampling. The regressions in Table 7 also contain a more parsimonious specification of the preference variables than the previous regressions. Tests of equality of coefficients indicated that children in all three age bands had the same effect on men's hours, so these dummies were combined. For women, children of less than 5 years and from 5-11 years had the same effect on their hours, and these dummies were also combined.

The coefficients on the preference characteristics are reported in the top part of the table, followed by those on the human capital characteristics. The bottom panel of the table contains some test statistics of whether or not the included individual characteristics are correlated with the workplace effects, i.e. whether or not there is sorting on personal characteristics.

[Insert Table 7 near here]

6.3.1. Evidence of sorting

The overall joint (Wald) test statistics imply a strong rejection of the hypothesis of no sorting on individual characteristics taken as a whole, in all three sectors. Separate Hausman tests (not reported) also produced the same result. Econometrically, therefore, a fixed effects model is preferred to one where the workplace effects are assumed to be random.[29]

Joint tests of the significance of the coefficients on the workplace means of the preference characteristics suggest that there is no sorting on these characteristics in the goods sector, but there is some evidence of sorting in the two service sectors, mainly for women. The individual coefficients and their *t*-ratios, at the top of the table, indicate that married men in the public sector (and possibly also in private services) tend to sort into workplaces with longer hours, and women with children tend to sort into workplaces with shorter hours in the private and public service sectors. But these effects, individually, are typically only (just) significant at the 5% level.

The coefficients can be interpreted as the marginal association between the workplace component of individual hours and a shift in the proportion of individuals with the particular characteristic. For example, take the coefficient of 5.3 on the workplace mean of married men in the public sector. The standard deviation of this variable is 0.26, so in a workplace with a one standard deviation higher proportion of married men, working hours would be 5.3 x 0.26

[29] A test of whether the three subsamples could be pooled in the estimation of the FE model rejected the hypothesis ($F(72, 19917) = 12.87$, critical value at 5% = 1.32). This test allowed the variance of the error term to differ across sectors.

= 1.4 hours longer, *ceteris paribus*. As another example, consider the coefficient of –3.3 on the workplace mean of women with children under 12 in private services. The standard deviation of this variable is 0.16, giving a difference in working hours associated with a one standard deviation difference in the proportion of women with children under 12 of –3.3 x 0.16 = –0.52 hours. Below, these estimates are compared to the magnitudes of the individual effects of these variables.

The estimates associated with the workplace means of the human capital characteristics suggest a large role in sorting. The tests of joint significance, reported at the bottom of Table 7, all strongly reject the hypothesis of no sorting. Perhaps not surprisingly, the allocation process of workers to workplaces based on productivity seem to differ substantially between sectors. For example, in public services, the within-workplace age profile in hours, which peaks at around 40, is magnified when one looks across workplaces: the average age of the workforce has an additional effect on hours. In the two service sectors, there does not seem to be sorting on age; but workplaces with more stable workforces (longer average tenure) work fewer hours on average. This effect actually counteracts the within-workplace effect of tenure, particularly in private services, which is positive.[30] Other variables associated with hours differences at workplace level are education in the goods sectors (workplaces with moderately skilled workforces work fewer hours), temporary contract status in private services (fewer hours) and occupation in the public sector.

6.3.2. Within-workplace effect of human capital characteristics

Now consider the coefficients on the individual characteristics themselves. There are some common patterns across sectors of the effect of personal characteristics on hours (although,

[30] Contract models like the specific capital and agency models predict that tenure will have an effect on hours, but of course this would only apply within the firm. So it is not necessarily a puzzle that the within effect opposes the between effect.

as already mentioned, statistical tests indicate the data should not be pooled). For example, there is an inverted U shaped age profile, peaking at around or just below 40 years. As predicted by theoretical considerations of fixed costs per person, the hours of trained workers tend to be higher, though the coefficient is not significant in the goods sector. Workers employed on fixed and temporary term contracts also work fewer hours, consistent with theory. Occupation has an important effect, which differs substantially by gender in the public sector.

6.3.3. Within-workplace effect of preference characteristics

I now focus on the estimates associated with the individual preference characteristics. Unlike the human capital coefficients, which may pick up the effects of preferences (operating, for example, through occupational choice) as well as productivity effects, I have argued that these coefficients should primarily reflect individual preferences. Since, statistically, a fixed effects model is preferred over a random effects specification, I formally re-ran the regressions using the within estimator. The coefficients are identical to the individual coefficients of Table 7, and the *t*-ratios almost identical. For clarity, only the preference coefficients are presented in Table 8. For each coefficient, the final column reports a Wald statistic to test the hypothesis of joint equality across the three sectors. Under this null hypothesis, the statistic is distributed as $\chi^2(2)$, with a critical value at the 5% confidence level of 5.99.[31]

[Insert Table 8 near here]

The first row of the table provides some evidence that married men work longer weekly hours, by around an hour, than single men, after controlling for productivity and

[31] The test assumes that the three subsamples are independent, so the three coefficient estimates have zero covariance.

workplace affiliation. The estimate is the largest (1.2 hours) and is precisely estimated (t=4.0) in the goods sector. In private services, the estimate is smaller (0.6 hours) and only significant at the 20% level, and in the public sector, the coefficient is negative but insignificant. However, the joint equality of the coefficients cannot be rejected. The second row of the table provides no evidence that the presence of children affects men's working hours.

The following three rows show the effect of marital status and the presence of children on women's hours. As for men's characteristics, the hypothesis of joint equality across sectors cannot be rejected for any of the three coefficients. The results show that, compared to a similar single woman, we would expect a married woman to work up to about 2 hours less per week, although the coefficient is only significant in the public sector.

The presence of children is associated with a large and highly significant reduction in women's hours. Whereas children make no difference to men's working hours, on average, children younger than 12 years decrease women's hours by about 4.5-6.5 hours per week. Children between 12 and 18 years have a smaller, but statistically significant, effect in all three sectors, lowering working time by about 1–2 hours.

How do these individual within-workplace effects compare with the sorting effects discussed above? Where they are strong – for example, the individual effects associated with women having children under 12 – they dwarf the sorting effects. Recall that a one standard deviation difference in the proportion of women with children under 12 in a workplace in private services was associated with a half hour difference in hours at the workplace level. This compares to a 6.4 hours difference within a workplace between two comparable women, one with a child under 12 and one without any children. For other characteristics, though, like men's marital status in the public sector, the sorting effect (a 1.4 hour difference for a one standard deviation difference) seems stronger compared to a weak within-workplace effect. There is also some evidence in Table 7 that women with older children sort into workplaces with shorter hours.

7. Correlates of workplace effects

This section briefly analyses the workplace effects (i.e. the coefficients on the workplace dummies, D_j) estimated from the fixed-effects model of Table 8. Their distributions are shown in graph 3, where the large differences at workplace level in the private services sector are once again apparent. By contrast, the distributions for the goods and public services sector are much narrower, though there is some evidence of a lower tail in public services.

Although, from the previous results, the workplace effects seem to be strongly correlated with individual characteristics, one might wonder whether they are associated with the various observable workplace, industry and regional effects. The results of OLS regressions of the effects on these characteristics are presented in Table 9. The model in each sector is significant, though the adjusted R^2 figures are low: 6% in goods, 15% in private services and 17% in public services. This can partly reflect sampling error, since only about 12 individuals are observed on average in each workplace. But the reminder will be workplace heterogeneity which cannot be explained by measured characteristics.

[Insert Table 9 near here]

For each sector, the industry dummy variables are jointly highly significant, and typically have quite large effects, of several hours. There is only limited evidence of regional effects, in private services: workplaces in London and the South East work about 2 extra hours on average. In the other two sectors the regional dummies are jointly insignificant. In public services, medium and large workplaces work 1.5-2 hours more than small ones, all else equal.

8. Discussion

8.1. Summary

Nearly a fifth of the variation in total weekly hours of work can be attributed to workplace-level effects, which can be interpreted as a combination of firm-specific technology effects and sorting based on unobserved human capital and preference characteristics. It is difficult to establish the relative importance of each type of sorting but one might suspect that sorting on unobserved human capital is not too important, since a large set of observed productivity characteristics was included in the regressions. Since preferences are less easy to measure, might there be sorting on unobserved preferences? Possibly, but this can actually be seen as reflecting technology in the sense that individuals sort into firms whose preferences match their own. However, as discussed below, the results do not provide very strong evidence of sorting on observed preference characteristics (marital status and presence of children). Therefore one might conclude there is unlikely to be sorting on unobserved preferences. Whatever the case, it would seem reasonable to interpret the estimated workplace effects as technology or 'demand' factors.

The absolute comparisons across economic sectors showed that the extent of workplace heterogeneity varies substantially. The private services sector stands out as having widely differing workplaces, whereas the workplace components of hours in the goods and public sectors are more closely bunched together. If the products offered by private service companies are more closely tied to customers' time schedules than those of the other two sectors, this result is not surprising.

Overall, about 16% of the variation in hours of work can be attributed to human capital characteristics acting independently of workplace effects. The breakdown by sector shows that these individual productivity characteristics are over four times as important (in absolute variance) in the two service sectors as in the goods sector. This is consistent with the returns to hours being more closely related to human capital than physical capital in services as compared to goods.

There is strong evidence that workers are allocated or sort into workplaces on the basis of human capital characteristics. That is, workers with productivity characteristics which raise their hours tend to be located in workplaces with high hours. This is particularly true in private services, where it accounts for 14% of variation in hours, and emphasises the importance of human capital.

Preference characteristics do affect hours of work, even after controlling for workplace effects and individual level productivity characteristics. Being married or cohabiting raises a man's working time by about an hour per week, and having young children reduces women's hours by about 5 per week. These effects, interpreted as the interaction of differing worker supply preferences with firm demand preferences, are remarkably similar across the three sectors. The variation due to preference characteristics does vary across sectors, though, because of the higher concentration of women in the service sectors.

Unlike the strong evidence for sorting on human capital, there is weaker evidence for sorting by observed preference characteristics, despite the substantial differences in hours across workplaces. First, unlike human capital characteristics, preference characteristics are not strongly associated with firm affiliation in the raw data. Second, statistical tests only strongly reject the hypothesis of sorting on preference characteristics for women in the two service sectors. But the magnitude of these between-workplace effects was not very great. Typically, an increase of one standard deviation in the proportion of women workers with children had less than one tenth the effect on hours which would be induced by an individual woman having a child.

The combination of within-firm preference effects and the relatively weak evidence for sorting do not support a simple model of perfect labour market competition (with firm preferences) where workers move between firms to achieve their desired hours. But they are consistent with an oligopsonistic model where firms do accommodate worker preferences to some degree, but where employer preferences also count.

The stability of the within-workplace preference effects across the three sectors is not in line with the hypothesised differences in employer preferences due to capital use and product market structure. One explanation would be that changes in hours of work cause changes in family characteristics, and the coefficients are simply picking up behavioural responses unconnected with firm demand. But I have already argued that the more plausible chain of causality is in the other direction. This stability therefore remains something of a puzzle.

8.2. Other literature

The results presented here complement a small number of previous papers which have analysed changes in the working hours of individuals, comparing people who stay in the same job and those who move jobs. Altonji and Paxson (1986) found that the variance of hours changes for individuals who moved jobs was typically two to four times greater than the variance of hours changes for individuals who remained in the same job. Altonji and Paxson (1992) found that (among married women) hours were more sensitive to changes in hours preference variables (like number of children) when the job changed than when it did not. Other studies have examined in more detail the effect of stated labour supply preferences on future changes in hours (Euwals et al, 1998; Euwals, 2001; and Böheim and Taylor, 2004). They have also found that hours changes across jobs are larger than within jobs, and that they are more responsive to reported preferences.

How do these results fit in with mine? The result in the literature that hours change more across jobs than within jobs is to be expected from the wide distribution of firm-specific hours effects that I have found. But the other studies also found that hours changes across jobs were particularly responsive to labour supply preferences, implying a fairly vigorous sorting process. My evidence for sorting is more nuanced: the differences in hours across firms that are associated with preference variables are not that much bigger than the within-firm differences. Perhaps the answer is that, while studies of changes measure the effects for those who do change jobs, in fact most people do not move jobs very often. In the WERS98 data, 16% of workers had been in the job for less than a year, while nearly half had been in the job for more than 5 years.[32] Therefore a cross-sectional snapshot may not show much influence from sorting. Instead it will be a picture of overall disequilibrium, revealing the relative impact of firms and workers on working hours at any one time. An analysis of changes, on the other hand, directly shows the dynamics of sorting and the movement towards equilibrium, while necessarily neglecting the importance of stability.

An obvious extension for future research would be to combine the cross-sectional and longitudinal analyses, using suitable panel data on matched workers and firms. This would require very good data, ideally with information on desired hours, together with sophisticated econometric techniques.

[32] There is also evidence from Euwals (2001) and Böheim and Taylor (2004) that hours preferences are not the primary cause of job changes.

8.3. Conclusions

Firm characteristics, worker characteristics and the combined influence of the two (sorting) account for roughly equal shares of weekly working hours variation in Britain. The findings are consistent with a labour market where there is competition, but also where there are barriers to mobility which prevent the complete sorting one would associate with a perfectly competitive labour market. This result pinpoints changes within the firm as a key part of labour market adjustment. A policy aimed at encouraging more diverse working arrangements therefore does well to promote within-firm flexibility.

References

Abowd, John M. and Francis Kramarz. 1999. “The Analysis of Labor Markets Using Matched Employer-Employee Data”, in Ashenfelter, Orley and David Card (eds.), *Handbook of Labor Economics*, Volume 3, Amsterdam: Elsevier Science.

Altonji J. G. and Paxson C. H. (1986), “Job Characteristics and Hours of Work”, *Research in Labor Economics*, vol. 8, part A, 1-55.

Altonji J.G. and Paxson C.H. (1992), “Labor Supply, Hours Constraints and Job Mobility”, *Journal of Human Resources*, 27, 2 , 256-278.

Barzel Yoram (1973), “The Determination of Daily Hours and Wages”, *Quarterly Journal of Economics*, Vol. 87, No. 2, 220-238

Bhaskar V. and Ted To (2001), “Oligopsony and the Distribution of Wages”, forthcoming *The European Economic Review*.

Biddle J. E. and Zarkin G. A. (1989), "Choice Among Wage-Hours Packages: an Empirical Investigation of Male Labor Supply", *Journal of Labor Economics*, vol. 7, no. 4, 415-437.

Böheim René and Mark P. Taylor (2004), “Actual and Preferred Working Hours”, *British Journal of Industrial Relations*, 42(1), 149-167.

Euwals Rob (2001), “Female Labour Supply, Flexibility of Working Hours, and Job Mobility”, *Economic Journal*, 111, C120-C134.

Euwals Rob, Melenberg Bertrand and Van Soest Arthur (1998), “Testing the Predictive Value of Subjective Labour Supply Data”, *Journal of Applied Econometrics*, 13, 567-585.

Fields Gary S. and Yoo Gyeongjoon (2000), “Falling Labor Income Inequality in Korea’s Economic Growth: Patterns and Underlying Causes”, *Review of Income and Wealth*, Series 46, Number 2, June, 139-159.

Forth, John and Kirby, Simon (2000), *Guide to the Analysis of the Workplace Employee Relations Survey 1998*, London: NIESR, WERS98 Data Dissemination Service (http://www.niesr.ac.uk/niesr/wers98).

Gronau Reuben (1998), “A Useful Interpretation of R in Binary Choice Models (Or, Have We Dismissed the Good Old R Prematurely)”, Working Paper no. 397, Industrial Relations Section, Princeton University.

Hamermesh Daniel (1993), *Labour Demand*, Princeton: Princeton University Press.

Kennedy Peter (1998), *A Guide to Econometrics*, 4th edition, Oxford: Blackwell Publishers Ltd.

Kinoshita T. (1987), ‘Working Hours and Hedonic Wages in the Market Equilibrium’, *Journal of Political Economy*, vol. 95, no. 6, 1262-1277.

Kremer Michael and Maskin Eric (1996), “Wage Inequality and Segregation by Skill”, NBER Working Paper no. 5718.

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

Moffit R. (1984), "The Estimation of a Joint Wage-Hours Labor Supply Model", *Journal of Labor Economics*, vol. 2, no.4, 550-566.

Mundlak, Y. (1978). 'On the Pooling of Time Series and Cross Section Data', *Econometrica*, 46, 69-86.

Siow A (1990), "The Use of Wages in Coordinating Hours of Work", mimeo, University of Toronto.

Stevens, Margaret (1994) "A Theoretical Model of On-the-job Training with Imperfect Competition", *Oxford Economic Papers*, 46, pp. 537-562.

Stewart M. B. and Swaffield J. K. (1999), "Low Pay Dynamics and Transition Probabilities", *Economica*, 66, 23-42.

Stern, N. (1986), "On the Specification of Labour Supply Functions", in Blundell R. and I. Walker (eds), *Unemployment, Search and Labour Supply*, pp. 143-189. Cambridge: Cambridge University Press.

Tummers M.P. and Woittiez I. (1991), "A Simultaneous Wage and Labor Supply Model with Hours Restrictions", *Journal of Human Resources*, 26, 3, 393-423.

Weiss Y (1996), "Synchronization of Work Schedules", *International Economic Review*, 37, no.1, 167-179.

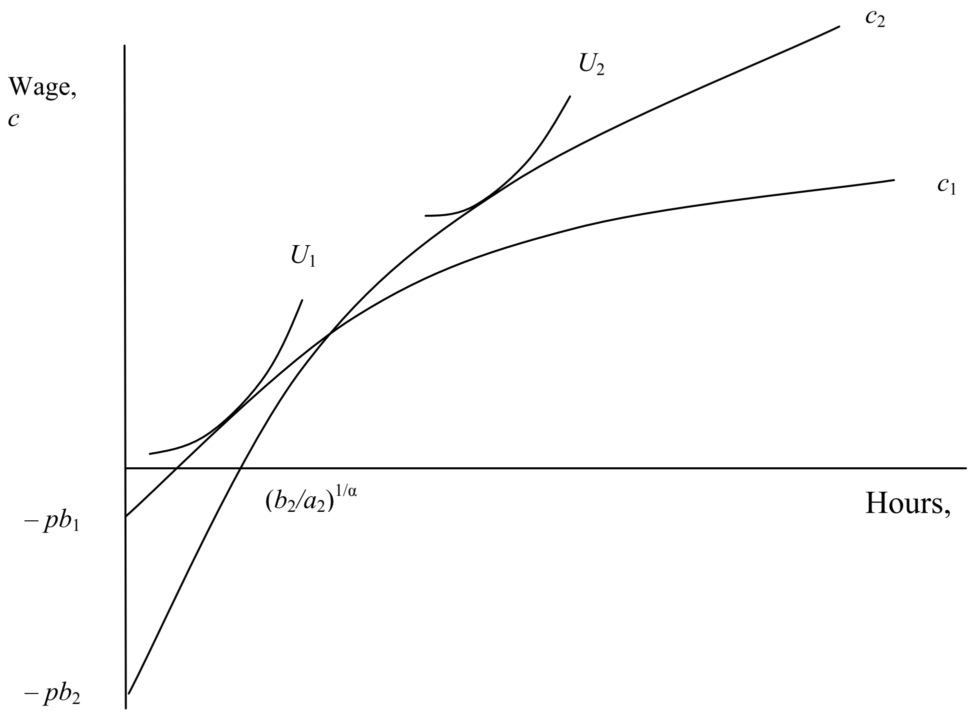


Figure 1

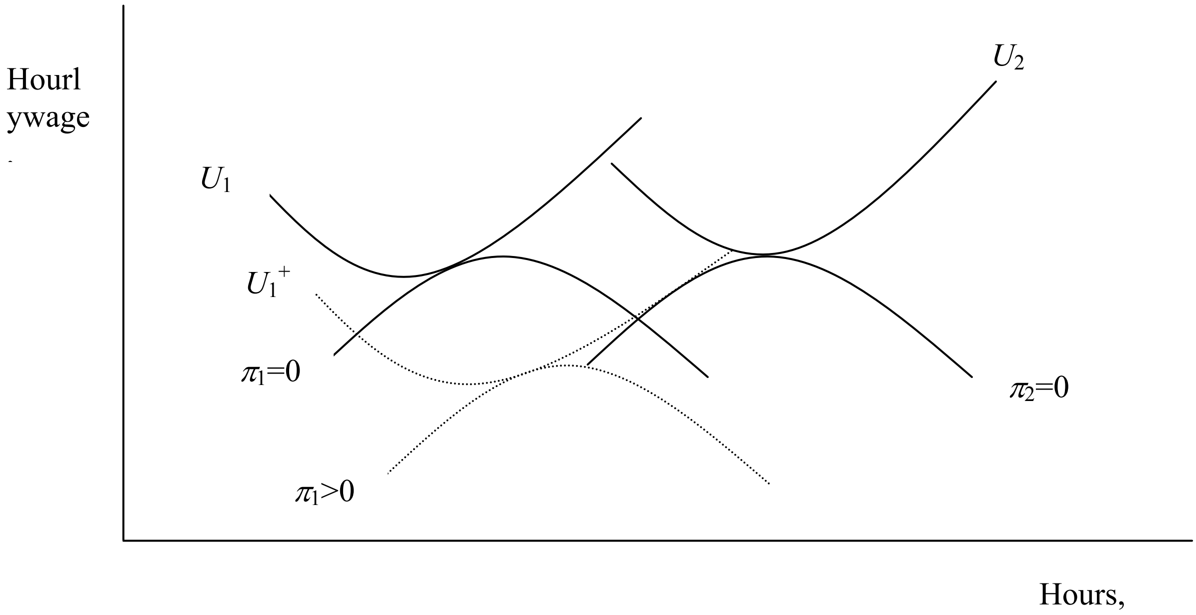


Figure 2

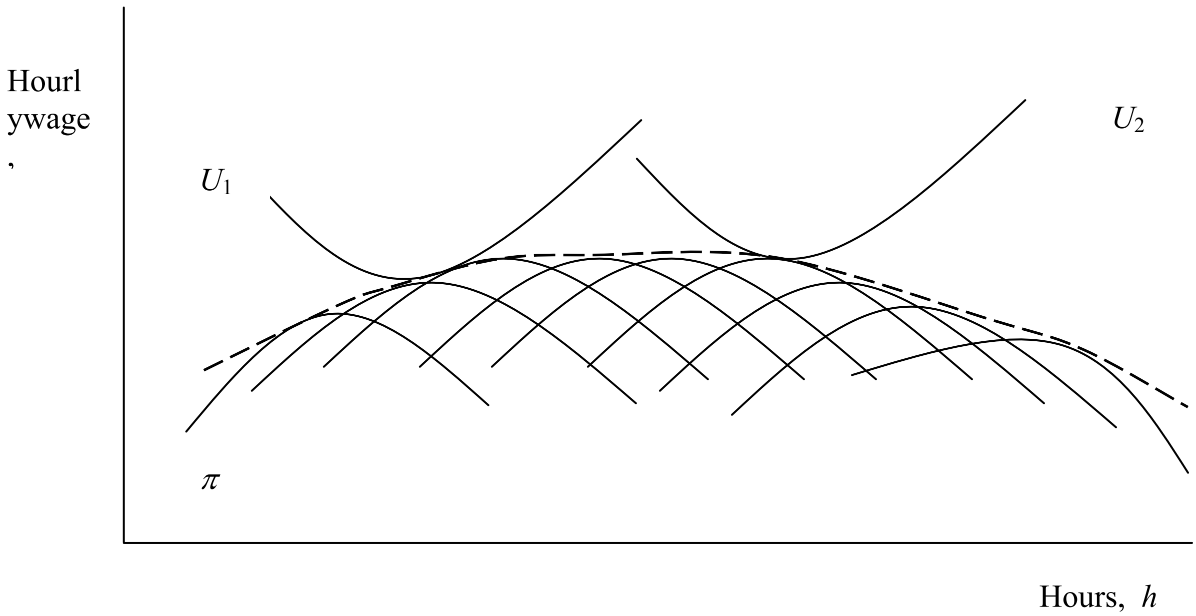
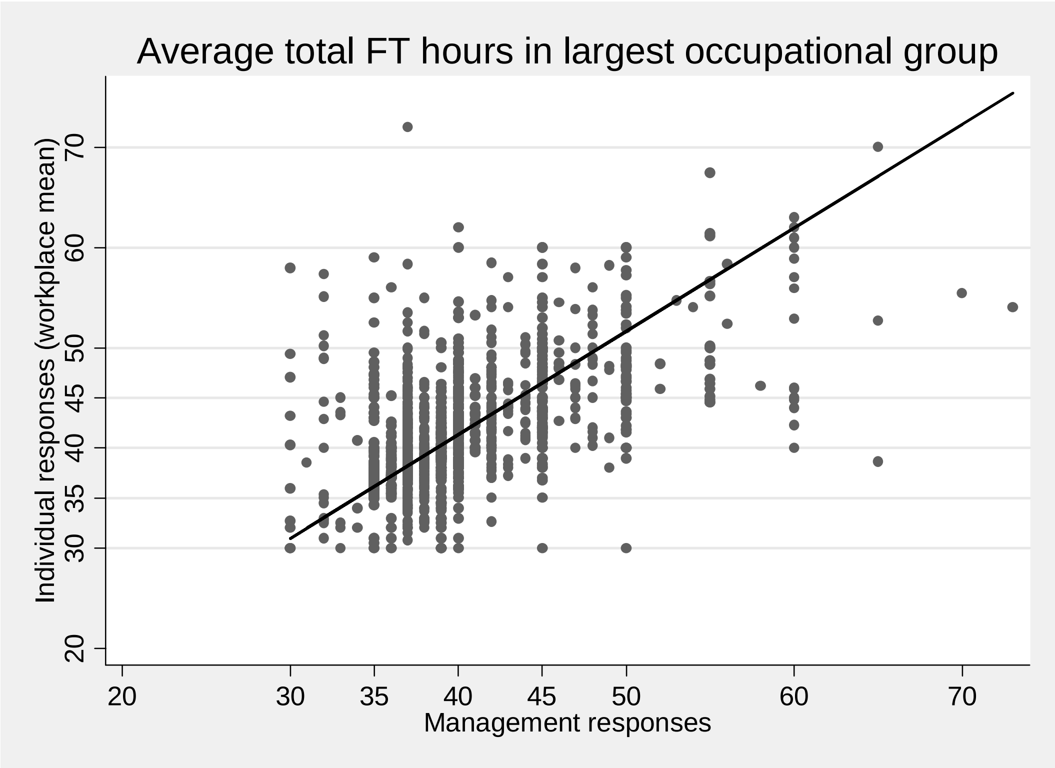
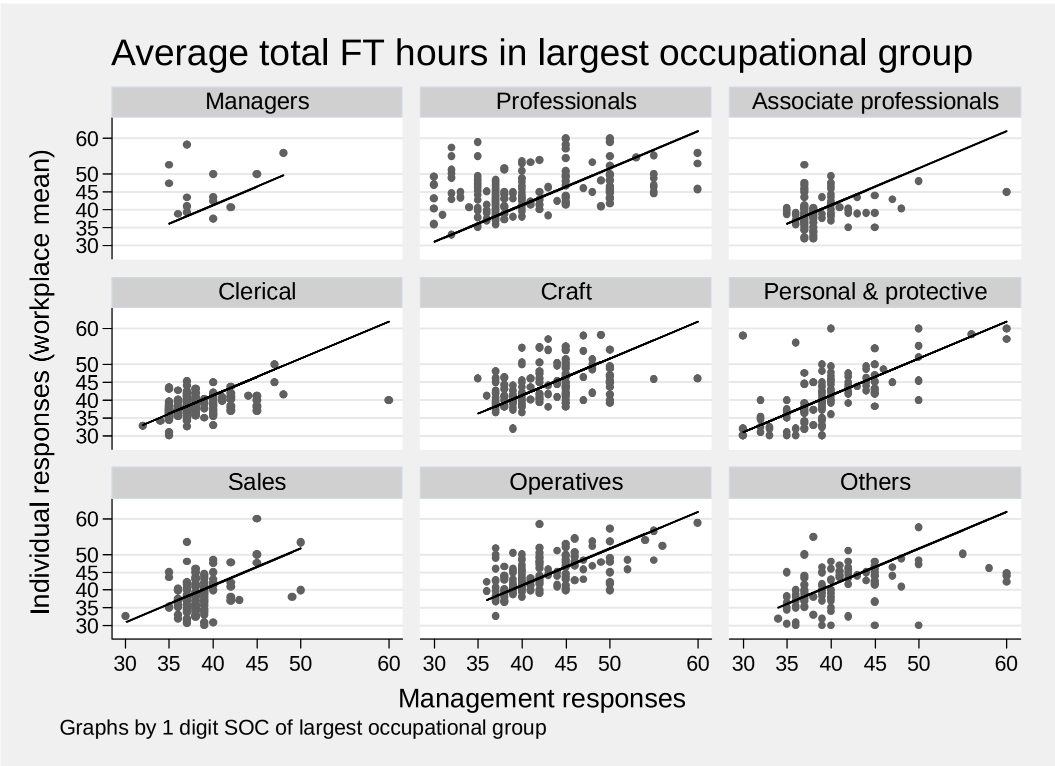


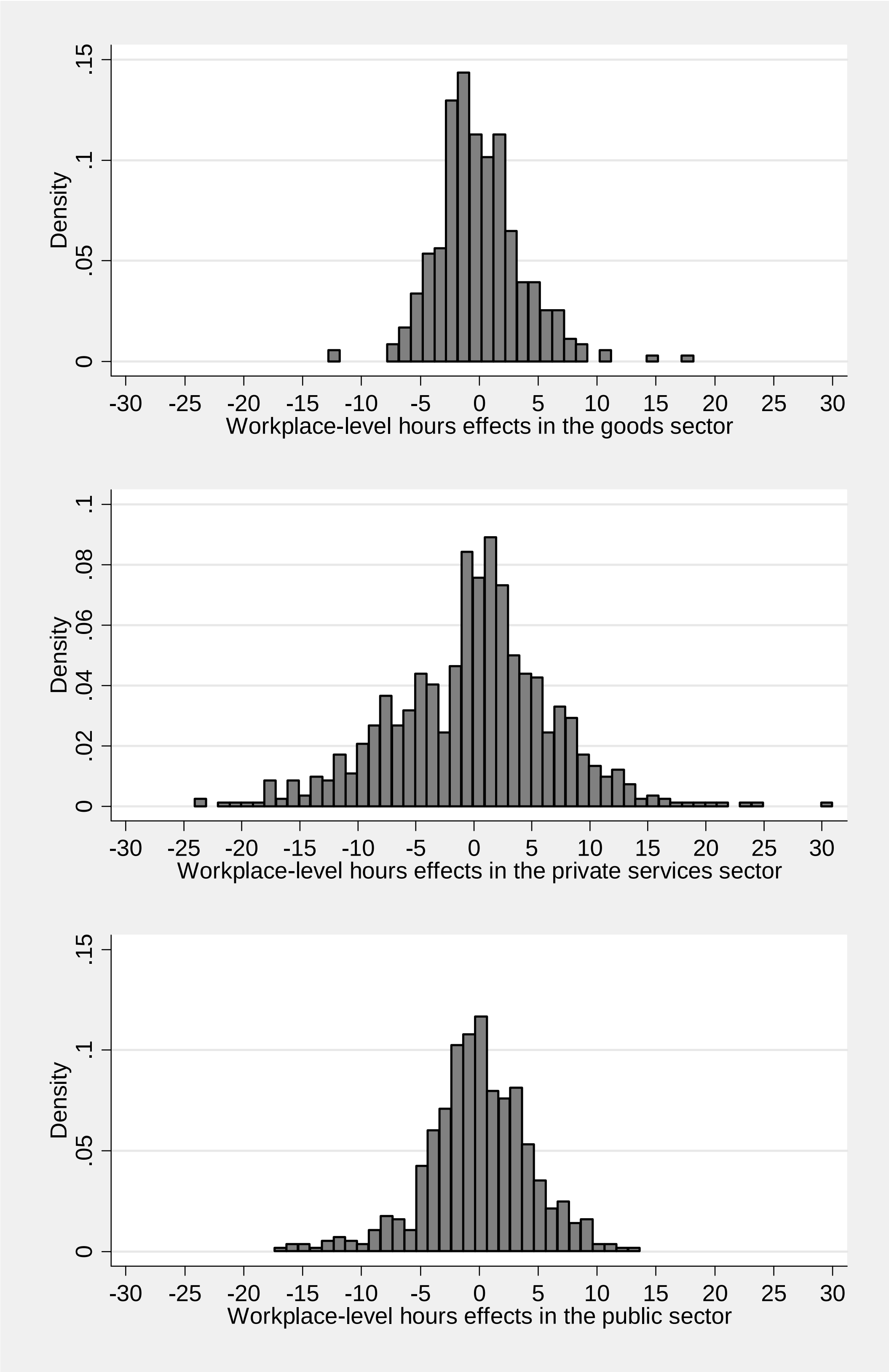
Figure 3



Graph 1



Graph 2



Graph 3: workplace hours effect

Table1
Numbers of workplace and individual observations

Sample	Number of workplaces (N_1)	Number of individuals (N_2)	Mean individuals per workplace (N_2/N_1)	Median individuals per workplace
Full	2191	-	-	-
With individual info	1782	28215	15.8	17
With valid data	1740	21833	12.5	13

Table 2
Regressions of mean individual reported hours on management reported hours

Occupation	Coefficient	Regression standard error	N (workplaces)	Mean individuals per workplace
Managers	1.149	5.88	14	4.1
Professionals	1.069	7.57	222	5.9
Assoc professionals	1.014	3.82	115	4.2
Clerical	1.020	2.30	300	6.1
Craft	1.008	4.80	163	5.5
Personal services	1.032	3.94	151	4.3
Sales	1.009	4.09	131	3.2
Operatives	1.053	3.86	184	6.6
Other	0.996	5.86	114	3.6

Note: Observations weighted by number of individuals per workplace.

Table 3
Proportion of individuals working part-time – individual and management responses

Management response	Proportion calculated from individual responses							
	0%	1-19%	20-39%	40-59%	60-79%	80-99%	100%	Total
0%	277 (87.9)	35 (11.1)	3 (1.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	315 (100.0)
1-19%	309 (46.8)	300 (45.5)	44 (6.7)	5 (0.8)	0 (0.0)	0 (0.0)	2 (0.3)	660 (100.0)
20-39%	30 (11.1)	83 (30.6)	117 (43.2)	37 (13.7)	3 (1.1)	0 (0.0)	1 (0.4)	271 (100.0)
40-59%	11 (5.8)	15 (7.9)	58 (30.4)	79 (41.4)	24 (12.6)	2 (1.1)	2 (1.1)	191 (100.0)
60-79%	8 (3.7)	4 (1.9)	30 (13.9)	71 (32.9)	69 (31.9)	18 (8.3)	16 (7.4)	216 (100.0)
80-99%	2 (2.4)	1 (1.2)	4 (4.7)	8 (9.4)	29 (34.1)	26 (30.6)	15 (17.7)	85 (100.0)
100%	0 (0.0)	0 (0.0)	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	2 (100.0)
Total	637 (36.6)	438 (25.2)	256 (14.7)	201 (11.6)	126 (7.2)	46 (2.6)	36 (2.1)	1,740 (100.0)

Note: (i) Cells show counts of workplaces (cell percentages in parentheses).
(ii) Shaded cells indicate the modal proportion based on individual responses for each management response band.

Table 4
Share of variation in individual characteristics due to workplace affiliation

Individual variable	Mean	Variance	Proportion of variation due to workplace affiliation
Total hours	36.03	171.16	0.41
Log total hours	3.48	0.27	0.41
Part time incidence	0.25	-	0.38
Degree level qualification	0.21	-	0.25
High-skilled non-manual	0.31	-	0.28
Less-skilled non-manual	0.26	-	0.34
Manual	0.44	-	0.43
Age	39.70	146.38	0.15
Tenure (months)	88.1	6102.7	0.22
Female	0.48	-	0.32
Married or cohabiting	0.70	-	0.08
Children under 5	0.14	-	0.03
Children 5-11	0.20	-	0.04
Children 12-18	0.20	-	0.05

Notes: (a) The number of individuals is 21833 and the number of workplaces is 1740 (mean number of individuals per workplace is 12.5).
(b) The proportion of variation is the adjusted R^2 from a regression of the individual variable on the set of workplace dummies. Individual probability weights are used.

Table 5
Decomposition of working time measures into proportionate contributions due to individual and workplace characteristics

	Mean (1)	St dev (2)	Variance (3)	Total R^2 (4)	Total adjusted R^2 (5)	Share of variance due to: Human capital chars (6)	Preference chars (7)	Workplace effects (8)	Joint human cap-workplace (9)	Joint preference -workplace (10)	Joint human cap-preference (11)	Unobserved ind-level chars and meas error (12)
Total hours	36.03	13.08	171.16	0.601	0.565	0.161	0.039	0.178	0.112	0.037	0.039	0.435
					100.0	*28.4*	*6.9*	*31.5*	*19.7*	*6.6*	*6.8*	
Log total hours	3.48	0.52	0.27	0.574	0.536	0.144	0.033	0.192	0.112	0.032	0.022	0.464
					100.0	*26.9*	*6.2*	*35.8*	*20.9*	*6.0*	*4.2*	
Part time incidence	0.25	0.43	0.19	0.556	0.517	0.119	0.062	0.158	0.112	0.043	0.023	0.483
					100.0	*23.0*	*11.9*	*30.6*	*21.6*	*8.3*	*4.5*	
Total hours in:												
Goods	42.22	8.62	74.39	0.377	0.325	0.093	0.029	0.161	-0.011	0.009	0.042	0.675
					100.0	*28.8*	*8.9*	*49.8*	*-3.5*	*2.9*	*13.1*	
Private services	33.25	14.29	204.22	0.639	0.603	0.154	0.032	0.219	0.142	0.034	0.022	0.397
					100.0	*25.6*	*5.2*	*36.3*	*23.6*	*5.6*	*3.7*	
Public services	34.34	12.80	163.83	0.531	0.489	0.227	0.064	0.091	0.031	0.024	0.052	0.511
					100.0	*46.4*	*13.0*	*18.6*	*6.3*	*5.0*	*10.7*	

Note: (1)The decompositions are based on least squares regressions on the following variables: dummies for workplace affiliation; 'human capital' characteristics: age and age squared (calculated from midpoints of questionnaire age bands), tenure (calculated from midpoints of questionnaire tenure bands), dummies for highest educational qualification, receipt of training in the last 12 months, employment on fixed term or temporary contract, health problems affecting daily activities, 1 digit occupation, gender; 'preference' characteristics: marital status and presence of children less than 5, 12 and 19 years old. In addition, occupation, age, marital status and the children variables were interacted with gender.
(2) In the goods subsample, the personal and protective services and operative occupational categories were combined with the base category of routine unskilled workers to maintain reasonable cell sizes.
(3) In the public services subsample, the operative occupational category was combined with the base category of routine unskilled workers to maintain reasonable cell sizes. Sales and female craft workers (72 individuals) were excluded from the estimation.
(4) Figures in italic are percentage shares of total explained variance.
(5) Estimates are weighted using individual probability weights (variable EMPWT_NR).

Table 6
Decomposition of total weekly hours into absolute contributions due to individual and workplace characteristics

Subsample	Mean (1)	St dev (2)	Variance (3)	Variance component due to: Human capital chars (4)	Preference chars (5)	Workplace effects (6)	Joint human cap-workplace (7)	Joint preference -workplace (8)	Joint human cap-preference (9)	Unobserved ind-level chars and meas error (10)
Goods	42.22	8.62	74.39	6.94	2.13	11.99	-0.85	0.69	3.15	50.33
			100.0	*28.8*	*8.9*	*49.8*	*-3.5*	*2.9*	*13.1*	
Private services	33.25	14.29	204.22	31.53	6.47	44.75	29.10	6.88	4.51	81.00
			100.0	*25.6*	*5.2*	*36.3*	*23.6*	*5.6*	*3.7*	
Public services	34.34	12.80	163.83	37.19	10.46	14.92	5.05	4.01	8.54	83.65
			100.0	*46.4*	*13.0*	*18.6*	*6.3*	*5.0*	*10.7*	

Note: (1)The decompositions are based on least squares regressions on the following variables: dummies for workplace affiliation; 'human capital' characteristics: age and age squared (calculated from midpoints of questionnaire age bands), tenure (calculated from midpoints of questionnaire tenure bands), dummies for highest educational qualification, receipt of training in the last 12 months, employment on fixed term or temporary contract, health problems affecting daily activities, 1 digit occupation, gender; 'preference' characteristics: marital status and presence of children less than 5, 12 and 19 years old. In addition, occupation, age, marital status and the children variables were interacted with gender.
(2) In the goods subsample, the personal and protective services and operative occupational categories were combined with the base category of routine unskilled workers to maintain reasonable cell sizes.
(3) In the public services subsample, the operative occupational category was combined with the base category of routine unskilled workers to maintain reasonable cell sizes. Sales and female craft workers (72 individuals) were excluded from the estimation.
(4) Figures in italic are percentage shares of total explained variance.
(5) Estimates are weighted using individual probability weights (variable EMPWT_NR).

Table 7
Equations for total weekly hours including workplace-specific means, estimated by GLS

Variable	Goods Coefficient: Individual level	Goods Coefficient: W/place mean	Private services Coefficient: Individual level	Private services Coefficient: W/place mean	Public services Coefficient: Individual level	Public services Coefficient: W/place mean
Male * married	1.220***	1.025	0.590	3.978*	-0.387	5.352**
	(4.00)	(0.55)	(1.63)	(1.70)	(0.87)	(2.41)
Male * children <19	0.213	-1.876	0.141	0.433	0.196	-2.337
	(0.81)	(0.98)	(0.41)	(0.20)	(0.49)	(1.15)
Female * married	-0.585	2.462	-0.305	-2.298	-2.078***	0.828
	(1.33)	(0.80)	(0.99)	(1.33)	(5.92)	(0.49)
Female * child <12	-4.651***	-3.272	-6.403***	-3.273*	-6.167***	-3.530**
	(8.59)	(0.88)	(18.93)	(1.73)	(17.38)	(2.06)
Female*child 12-18	-1.151*	-1.767	-1.856***	-3.932*	-0.934**	-4.422***
	(1.82)	(0.46)	(4.96)	(1.80)	(2.56)	(2.63)
Age	0.362***	0.704*	0.902***	0.398	0.563***	1.556***
	(4.87)	(1.82)	(10.53)	(0.82)	(4.76)	(2.68)
Age sq	-0.005***	-0.008*	-0.011***	-0.005	-0.007***	-0.020***
	(5.28)	(1.66)	(10.77)	(0.85)	(4.86)	(2.94)
Female * age	-0.200	-0.950	-0.147	-0.072	-0.362**	-0.453
	(1.41)	(0.98)	(1.26)	(0.11)	(2.29)	(0.55)
Female * age sq	0.001	0.011	0.001	-0.001	0.003	0.006
	(0.72)	(0.88)	(0.64)	(0.14)	(1.54)	(0.61)
Tenure	0.002	-0.032***	0.009***	-0.016**	0.006***	0.003
	(1.36)	(5.44)	(5.60)	(2.41)	(3.74)	(0.55)
O level	-0.058	-4.585***	-0.595**	-3.043**	0.633*	1.251
	(0.22)	(2.84)	(2.22)	(2.00)	(1.82)	(0.74)
A level	0.155	-7.741***	-0.124	-2.543	1.017**	0.501
	(0.45)	(3.82)	(0.38)	(1.45)	(2.54)	(0.28)
Degree	0.664*	-3.570	0.507	-1.428	3.326***	1.257
	(1.78)	(1.59)	(1.42)	(0.87)	(8.11)	(0.75)
Vocational qual	0.065	-2.661**	0.886***	1.424	0.014	-2.088**
	(0.30)	(2.01)	(4.17)	(1.24)	(0.06)	(2.02)
Received training	0.188	-0.024	1.509***	-1.338	2.896***	-0.182
	(0.83)	(0.03)	(6.84)	(1.51)	(10.52)	(0.18)
Fixed term contract	-1.278	-3.304	-1.749***	-5.729*	-4.058***	4.670**
	(1.60)	(0.84)	(2.62)	(1.78)	(7.84)	(2.39)
Temp term contract	-3.071***	0.172	-7.849***	-8.870***	-5.436***	-1.724
	(4.38)	(0.04)	(14.11)	(3.19)	(9.93)	(0.84)
Health problems	-0.528	-0.930	-0.811*	-4.560*	-0.131	-0.053
	(1.27)	(0.31)	(1.80)	(1.83)	(0.28)	(0.02)
Manager	2.885***	2.542	8.831***	3.832	3.193***	-6.367**
	(6.69)	(1.05)	(14.46)	(1.31)	(3.91)	(2.06)
Professional	-0.763*	0.585	4.738***	-0.041	1.527**	-8.302***
	(1.67)	(0.26)	(7.11)	(0.01)	(2.05)	(3.77)
Associate prof	-1.699***	1.288	2.905***	-2.953	-0.625	-4.037
	(3.70)	(0.58)	(4.31)	(0.92)	(0.77)	(1.64)
Clerical	-3.262***	0.752	1.753**	-0.000	-1.449*	-5.551**
	(5.39)	(0.21)	(2.54)	(0.00)	(1.75)	(2.14)
Craft	0.203	1.855	4.479***	3.103	1.069	-4.970**
	(0.59)	(1.33)	(6.47)	(0.99)	(1.21)	(2.47)

Pers service			4.131***	3.911	-0.714	-1.519
			(4.43)	(1.17)	(0.81)	(0.84)
Sales	-2.633**	9.142*	1.081*	-2.430		
	(2.43)	(1.94)	(1.65)	(0.81)		
Operative			6.106***	3.016		
			(8.71)	(1.12)		
Female * manager	0.860	2.138	3.962***	5.969	11.704***	6.313
	(0.89)	(0.34)	(4.77)	(1.37)	(10.70)	(1.33)
Female * profess	0.853	2.959	4.958***	4.282	11.654***	4.516*
	(0.86)	(0.54)	(5.68)	(1.00)	(13.44)	(1.68)
Female * assoc prof	0.445	4.746	4.560***	6.461	9.691***	1.799
	(0.47)	(0.78)	(5.13)	(1.47)	(9.64)	(0.58)
Female * clerical	-0.099	7.906*	3.338***	3.920	10.429***	1.939
	(0.13)	(1.75)	(4.19)	(0.93)	(10.94)	(0.60)
Female * craft	0.402	-4.041	3.503**	-4.099		
	(0.42)	(1.22)	(2.35)	(0.56)		
Female*pers service			-0.166	-9.434**	3.826***	-3.234
			(0.15)	(2.16)	(3.62)	(1.15)
Female * sales	-2.200	-5.194	1.034	-2.368		
	(1.37)	(0.69)	(1.27)	(0.63)		
Female * operative			0.481	1.463		
			(0.37)	(0.31)		
Female	3.066	13.209	-1.717	2.963	-1.951	5.974
	(1.16)	(0.77)	(0.82)	(0.27)	(0.62)	(0.36)
Constant	28.458***		13.997*		0.355	
	(4.20)		(1.76)		(0.03)	
Number of individuals	5021		9462		7278	
Number of workplaces	356		818		565	
Tests of joint significance of workplace mean coefficients:						
All	χ^2(31) = 93.47***		χ^2 (35) = 366.03***		χ^2 (30) = 157.84***	
Human capital characs	χ^2(26) = 89.38***		χ^2 (30) = 156.15***		χ^2 (25) = 69.56***	
Preference characs	χ^2(5) = 2.37		χ^2(5) = 13.16**		χ^2(5) = 17.65***	
Men's pref characs	χ^2(2) = 1.03		χ^2(2) = 3.50		χ^2(2) = 5.84*	
Women's pref characs	χ^2(3) = 1.25		χ^2(3) = 9.83**		χ^2(3) = 11.64***	

Notes: (1) Absolute value of t statistics in parentheses
(2) * significant at 10%; ** significant at 5%; *** significant at 1%
(3) Estimates are unweighted.

Table 8
The effect of preference characteristics on total weekly hours – within workplace estimates

Variable	Goods	Private services	Public services	Joint test of equality, χ^2(2)
Male * married	1.220***	0.590	-0.387	1.03
	(4.00)	(1.62)	(0.87)	
Male * children <19	0.213	0.141	0.196	0.00
	(0.81)	(0.41)	(0.49)	
Female * married	-0.585	-0.305	-2.078***	0.57
	(1.33)	(0.99)	(5.92)	
Female * child <12	-4.651***	-6.403***	-6.167***	3.78
	(8.58)	(18.88)	(17.38)	
Female*child 12-18	-1.151*	-1.856***	-0.934**	0.17
	(1.82)	(4.95)	(2.56)	
Number of individuals	5021	9462	7278	
Number of workplaces	356	818	565	

Notes: (1) Absolute value of t statistics in parentheses
(2) * significant at 10%; ** significant at 5%; *** significant at 1%
(3) Estimates are unweighted.

Table 9
The correlates of workplace effects by sector, OLS estimates

	Goods	Private services	Public services
Trade union recognised	-0.772	-0.573	-0.915
	(1.49)	(0.97)	(1.18)
Electricity, gas, water (sic 2)	-0.938		
	(1.48)		
Construction (sic 3)	1.891***		
	(2.96)		
Hotels and restaurants (sic 5)		1.101	
		(1.38)	
Transport, storage and comms (sic 6)		5.639***	
		(6.56)	
Financial intermediation (sic 7)		2.161**	
		(2.49)	
Real estate, renting, business (sic 8)		3.535***	
		(4.87)	
Public administration and defence (sic 9)		2.545	-1.177**
		(0.39)	(2.04)
Education (sic 10)		0.060	-3.268***
		(0.05)	(5.41)
Health and social work (sic 11)		-2.212**	-3.313***
		(2.55)	(5.35)
Other social and pers services (sic 12)		-0.152	-6.307***
		(0.15)	(7.40)
W/place sz 50-499	0.061	0.620	1.479***
	(0.10)	(1.24)	(3.50)
W/place sz 500+	0.171	-1.040	1.838***
	(0.22)	(1.12)	(3.19)
Part of bigger UK org	0.670	1.060*	1.387**
	(1.22)	(1.75)	(1.97)
UK org 10k+	-0.311	-3.223***	-0.429
	(0.48)	(5.22)	(1.02)
UK org sz missing	1.277	-1.259	-0.530
	(0.92)	(1.22)	(1.00)
Few competitors	0.122	0.127	
	(0.27)	(0.23)	
Domestic market	-0.327	-0.263	
	(0.73)	(0.49)	
Tight labour market	0.260	0.214	0.242
	(0.47)	(0.34)	(0.52)
East Midlands	-1.148	0.668	-0.415
	(1.01)	(0.60)	(0.48)
London	0.835	2.343**	0.531
	(0.73)	(2.37)	(0.66)
North East	-1.596	-0.779	0.344
	(1.20)	(0.56)	(0.36)
North West	-0.382	0.380	-1.071
	(0.36)	(0.37)	(1.25)
Scotland	-2.211**	-0.933	-0.427
	(2.11)	(0.85)	(0.52)
South East	-0.734	1.856*	-0.603
	(0.72)	(1.94)	(0.78)

South West	-1.196	-0.804	-1.247
	(1.13)	(0.73)	(1.32)
Wales	-1.688	0.611	-0.001
	(1.29)	(0.42)	(0.00)
West Midlands	-0.258	-1.752	-0.229
	(0.24)	(1.56)	(0.26)
Yorkshire and Humberside	-1.043	-0.050	0.418
	(0.91)	(0.04)	(0.44)
Constant	0.583	-1.549	1.281
	(0.53)	(1.41)	(1.02)
Observations	356	818	565
Adjusted R^2	0.06	0.15	0.17

Notes: (1) Absolute value of t statistics in parentheses
(2) * significant at 10%; ** significant at 5%; *** significant at 1%
(3) Estimates are unweighted.