Wages, Hours and Human Capital over the Life Cycle

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ABSTRACT

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We investigate wage-hours contracts within a four-period rent sharing model that incorporates asymmetric information. Distinctions are made among (a) an investment period, (b) a period in which the parties may separate (quits or layoffs) or continue rent accumulation and sharing, (c) a post investment period and, (d) retirement. We establish that increases in both wage rates and hours of work in the post-investment period serve to minimise sub-optimal separations and, moreover that both wage and hours schedules are concave. The model is tested with the British Household Panel Survey (1991-1997) and with the British Labour Force Survey (1993/4).

JEL Classification: J41, J33

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1. Introduction

This paper develops a life cycle wage-hours contract model. It adopts a human capital approach in which the worker and the firm seek to share rent optimally when faced with the problem of asymmetric information.[1] It is a four-period model, covering initial investment, post-investment, pre-retirement and retirement periods. The contract is specified in relation to wage earnings - i.e. the hourly wage rate multiplied by weekly hours - and not simply the hourly wage rate. The fact the parties bargain over both the wage rate and working hours is well understood in the firm-union bargaining literature (Pencavel, 1991; Trejo, 1993). Far less recognition has been given to the broader role of working time within rent sharing contracts. From a policy perspective, our model allows us to investigate an important, yet under-researched, aspect of working time over the life cycle. Thus, while numerous papers have been devoted to the reasons for and the consequences of retirement decisions, relatively few studies have investigated wage-hours decisions as retirement approaches. A notable exception is the paper by Gustman and Steinmeier (1986) who are also interested in hours of work within an optimal labour supply life cycle model.[2]

Human capital returns to acquired work skills and organisational know-how have implications for both extensive and intensive labour margins (Hart and Ma, 1999). The first of these, and the one most researched in the literature, is the length of job tenure. Given rent sharing agreements, higher investments may be expected, *ceteris paribus*, to induce longer tenure. Preventing losses of positive joint rents through sub-

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[1]Malcomson (1999) provides a review of this class of rent sharing model, including a comparative evaluation with other rent sharing approaches.

[2] However, unlike here, the Gustman and Steinmeier paper ignores problems of uncertainty.

optimal quits and layoffs is the extensive margin goal of the wage contract. To the

extent that investments involve firm-specific skills, then quits and layoffs also

influence returns in subsequent jobs. The intensive margin concerns the worker's per-

period utilisation, measured in terms of daily or weekly average hours of work.[3] In

this case, higher investments would be expected, *ceteris paribus*, to induce longer

average hours.[4] The degree of investment amortisation is dependent *both* on length

of tenure and on intensity of work per-period. If the wage rate is set to minimise

separations for given hours, the contract solution will not be fully efficient if hours are

themselves not optimal.

The four-period approach allows us to move beyond establishing that wages rise with

work experience since it discriminates between wage rises in the early and later years

of tenure. A particularly important generalisation is that we are able to move away

from a simple dichotomy between initial and post-investment periods. In our

framework, investment within the firm may be undertaken in periods 1 and 2. This

allows us to produce results about relative investment intensities in the early and later

stages of on-the-job experience and, therefore, to investigate the curvature of wage

profile over the life cycle. It is shown that hours also rise with work experience and,

as with the wage-rate, we are able to evaluate likely hours profiles with respect to

early and later years of tenure. We are also concerned with the inter-relatedness of

wage and hours decisions. Thus, we investigate relative income effects between

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[3] It might also involve effort per unit of time. However, this dimension of the intensive margin is ignored here.

[4] The link between investments and average hours goes back to the early labour demand work of Brechling (1965), Rosen (1968) and Ehrenberg (1971).

wages and working time, again differentiating between early and later years of tenure. This dimension of our work underlines the fact that modelling the intensive margin of the firm's operation would appear to be an essential requirement in the evolution of compensation over the life cycle. We might expect, for example, that income effects are significantly different during the pre-retirement period compared to early years of job tenure.

On the empirical side, we estimate separate wage rate and hours growth equations using individual-level data from the British Household Panel Survey (BHPS), 1991-1997. In the Empirical Appendix we also provide cross-section individual-level estimates from the British Labour Force Survey (LFS). We simulate the combined wage-hour effects in order to examine decompositions of the related earnings-experience profiles. Further, in the light of theoretical derivations, we differentiate in both the BHPS and the LFS empirical work between workers whose last job change occurred a considerable time before the age of retirement and those who changed jobs nearer to retirement. Like the symmetric-information implicit risk-sharing model of Beaudry and DiNardo (1995), our model predicts that hours are influenced by wages through an income effect. Additionally, we predict that hours are determined by work experience. A key empirical finding is that the positive impact of rent sharing on hours more than offsets the negative income effect. Hours rise with experience over the life cycle.

We allow for both specific and general human capital investments. Conventionally, we treat specific capital as having zero-return in the alternative employment. Period 1 is the investment period when the worker is young. Period 2 then accommodates the possibilities that the worker stays with the firm or moves - through either a quit or a

layoff - to an alternative firm. If the worker stays, then the parties share the post-investment return to period 1 investments. They also undertake additional investment, the returns to which are realised in period 3. If the parties separate, then period 2 marks the investment period in the new firm. Period 3 is the post-investment period. Finally, the worker retires at the beginning of period 4. Moving from a three-period (e.g. Johnson, 1996) to a four-period modelling perspective adds considerably to modelling complexity, but permits richer insights into the evolutions of wages and hours profiles.

2. Background framework

The wage-hour contracts adopt the basic modelling approaches of Hashimoto (1979) and Carmichael (1983). The analysis is conducted in terms of the marginal worker whose initial wage earnings are determined on a perfectly competitive spot market. At the outset, the firm and the worker must 'take' the initial wage-hours combination determined in the market place. Subsequently, training endows the worker with firm-specific skills and so in the second period rent sharing arising from this accrued return allows the parties to deviate from spot earnings thereby producing potentially different wage-hours combinations.

The marginal worker receives contractual wage w_i in the i-th period. The worker's pre-entry endowment of general human capital is worth w_1 in the open market and this is not augmented within the firm. Both parties are risk neutral. The firm provides specific training at a cost, $C(M_i)$, where M_i is the (uncertain) amount of human capital in the i-th period. *Ex ante*, each party knows only the distributions of η_i (the disturbance on the post-training productivity in the i-th period) and θ_i (the post-training job satisfaction of the workers in the i-th period). The density functions

of η_i and θ_i are $f(\eta_i)$ and $q(\theta_i)$ with $E(\theta_i) = E(\eta_i) = Cov(\eta_i, \theta_i) = 0$. *Ex post*, information cannot be exchanged; separation decisions are made independently.

General and specific elements of human capital acquired within the firm are treated in the bulk of the existing literature as if it is possible, *a priori*, to demarcate strictly between them. This is highly unlikely in practice. Especially where jobs involve complex sets of functional and organisational requirements, it would be difficult to assess definitively which parts of skill acquisition and know-how are of potential use in alternative employment and which are not. Accordingly, we assume that the proportion of general human capital is a random variable ε with a distribution of $v(.)$. If the worker leaves the firm at the end of a period, we assume that the outside firm knows whether separation is due to the worker being fired or quitting voluntarily. If the worker is fired, this is regarded as a signal that skills have not been acquired to a satisfactory level. In this event, the worker does not gain any increase of general human capital. If the worker quits, his general human capital will increase by a

proportion, with $g = \int_{0}^{1} \varepsilon v(\varepsilon) d\varepsilon$, where $0 \leq g \leq 1$.

The probability of a worker deciding to quit at the end of period i-1 is

$$Q_i = Q(\theta_i^*) = \int_{-\infty}^{\theta_i^*} q(\theta_i) d\theta_i \qquad (1)$$

while the probability of the firm wanting to fire a worker at the end of period i-1 is

$$F_i = F(\eta_i^*) = \int_{-\infty}^{\eta_i^*} f(\theta_i) d\eta_i \qquad (2)$$

where θ_i^* is the level of job satisfaction that leaves the worker indifferent about leaving and η_i^* is the level of productivity that leaves the firm indifferent over

employing the worker. In period i-1, specific training $C(M_i)$ is expected to raise

hourly productivity in the subsequent period by $M_i + \eta_i$, where η_i is revealed to the

firm at the end period i-1. Over the time, the human capital is assumed to appreciate

at the rate of δ. The worker's job satisfaction θ_i is revealed to the worker at the end of

period i-1. Without loss of generality, the discount rate is set to zero. Hours in period

i is denoted by h_i with the worker's associated disutilities represented by $D(h_i)$. In

period 1, h_1 and w_1 are determined on the open competitive market.

3. Joint wealth maximisation with a retirement constraint

The expected joint wealth V is the sum of the wealth over three periods that the

worker is in the labour force:

$$V = V_1 + V_2 + V_3. \tag{3}$$

We begin, in sub-sections (a) and (b), by detailing the compositions of the constituent

parts of V in (3). Table 1 provides a comprehensive summary of this discussion.

(a) Periods 1 and 2

A two-period time line of quasi rent is illustrated in Figure 1. Since returns to training

investments are not realised until period 2, wealth in period 1 consists of wage

earnings net of specific training cost and the disutility of working; thus

$$V_1 = w_1.h_1 - C(M_2) - D(h_1). \tag{4}$$

Combining periods 1 and 2, the parties' joint wealth consists of the returns arising

from three mutually exclusive and exhaustive events, weighted by the probability of

their occurrence. The worker may be fired or not-fired at the end of period 1. In the

event of the worker not being fired, separation may occur due to a quit decision or the

employment relationship may continue. In all three outcomes the first period rent

consists of wage compensation net of training cost and work disutility ($w_1.h - C - D(h)$). If the worker is fired or voluntarily quits, the firm itself cannot obtain second

period rent. If the worker remains with the firm, second period rent differs from the

first period due enhanced productivity and job satisfaction as well as to the fact that

second-period hours may differ from those in the first period.

Figure 1: Time line of quasi-rent

Period 1   **Period 2**

$$(1-\delta).w_1.h_{2f} - C_f - D(h_{2f})$$ **Fired** [prob. F_2]

$w_1.h_1 - C(M_2) - D(h_1)$ $[(1-\delta).w_1 + g.M_2].h_{2q} - C_q - D(h_{2q})$ **Quit** [prob. $(1-F_2).Q_2$]

$[(1-\delta).w_1 + M_2 + E(\eta_2|\eta_2 > \eta_2^*) + E(\theta_2|\theta_2 > \theta_2^*)].h_2 - C(M_3) - D(h_2)$ **Stay** [prob. $(1-F_2).(1-Q_2)$]

If the worker leaves the firm at the end of period 1, it is either through quitting or

being fired. To avoid excessive complexity, we make the reasonable assumption that,

if either type of separation occurs, the worker will not subsequently rejoin the firm. [5]

For subsequent wages, hours and costs, we assign subscripts 'q' and 'f' to denote,

respectively, quit and firing decisions. We assume that if the worker is fired then this

is regarded by potential employers as a signal that skills have not been acquired to a

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[5] Notice the case we are describing here differs from that in the literature of lay-off and re-employment involving relatively short spans of time. Our life cycle model deals with much longer time horizon in which case re-employment probabilities would be expected to be lower.

satisfactory level. In this event, he will not receive a higher return based on acquired human capital in firm 1. General human capital, after allowing depreciation, is $(1-\delta).w_1$ with expected working hours h_{2f}. The worker will also incur training costs, C_f. If the worker quits the firm, he will obtain a proportion of human capital, $g.M_2$, which is useful for the outside job. His general human capital is $(1-\delta).w_1 + g.M_2$, expected working hours is h_{2q} and training cost is C_q. Finally, if he stays in the current firm, he will gain the full amount of the increase of human capital, M_2.

Taken together, these three possibilities at the end of the initial training period lead to V_2 being expressed as the sum of returns of three mutually exclusive and exhaustive events:

$$V_2 = F_2.[(1-\delta).w_1.h_{2f} - C_f - D(h_{2f})] \qquad \text{(the worker is fired at the end of period 1)}$$

$$+(1-F_2).Q_2.\{[(1-\delta).w_1 + g.M_2].h_{2q} - C_q - D(h_{2q})\} \quad \text{(the worker quits at the end of period 1)}$$

$$+(1-F_2).(1-Q_2).\{[(1-\delta).w_1 + M_2 + E(\eta_2|\eta_2 > \eta_2^*) + E(\theta_2|\theta_2 > \theta_2^*)].h_2 - C(M_3) - D(h_2)\}$$

$$\text{(the worker stays at the end of period 1)} \qquad (5)$$

where $D(.)$ is the disutility of working.

(b)   Period 3

In period 3, the pre-retirement period, the worker reaches an age where no further training takes place. The wealth of period 3, V_3, is conditional on whether, at the end of period 1, the worker was either fired (V_f), or quit the firm (V_q) or stayed with the firm (V_S), i.e. $V_3 = V_f + V_q + V_s$ (see Table 1). Recall that if separation takes place (quit or layoff) then the worker will not return to the firm. We discuss each possibility in turn.

(i) The worker is fired at the end of period 1

The expected period 3 income from an outside job is given by

$$V_f = w_{3f}.h_{3ff} - D(h_{3ff}) \tag{6}$$

where (w_{3f}, h_{3ff}) is the expected wage-hour contract with $w_{3f} = w_1.(1-\delta)^2 + M_{3f}$,

where M_{3f} is the expected increase of human capital stemming from period 2 training.

(ii) The worker quits at the end of period 1

The expected outside job income is given by

$$V_q = (1-F_2).Q_2.\{[(w_1.(1-\delta) + g.M_2).(1-\delta) + M_{3q}].h_{3qq} - D(h_{3qq})\} \tag{7}$$

where $[(w_1.(1-\delta) + g.M_2).(1-\delta) + M_{3q}]$ is the expected contract wage, h_{3qq} is the

expected hours of work and M_{3q} is the expected increase of human capital.

(iii) The worker stays at the end of period 1

In this event, V_S is expressed further as the sum of returns of three mutually exclusive

and exhaustive events similar to V_2 (see Table 1)

$$V_S = (1-F_2).(1-Q_2).F_3.[(1-\delta).w_1.+g.M_2).(1-\delta).h_{3f} -D(h_{3f})]$$

(the worker is fired at the end of period 2)

$$+(1-F_2).(1-Q_2).(1-F_3).Q_3.\{[(w_1.(1-\delta) + g.M_2).(1-\delta)+g.M_3].h_{3q}- D(h_{3q})\}$$

(the worker quits at the end of period 2)

$$+(1-F_2).(1-Q_2).(1-F_3).(1-Q_3).\{[(w_1.(1-\delta) + M_2).(1-\delta)+ M_3 + E(\eta_3|\eta_3>\eta_3^*)$$

$$+E(\theta_3|\theta_3>\theta_3^*)].h_3 - D(h_3) \} \text{ (the worker stays at the end of period 2)} \tag{8}$$

where h_{3f} and h_{3q} are the expected hours outside the firm if the worker is fired or quits, respectively.

(c) Model solutions

We deal first with periods 1 and 2. From the first-order conditions to the problem of maximising wealth in (5) - derived in Theory Appendix (a) – we obtain

$$w_2 = (1-\delta).w_1 + M_2 + E(\eta_2|\eta_2>\eta_2*) > w_1 \tag{9}$$

and

$$\alpha - Q_2.[\beta + \gamma.g.M_2] - (1-Q_2).[\ h_2.E(\theta_2|\theta_2>\theta_2*) - C(M_3) - D(h_2)$$

$$+ [\tau + g.M_2.(1-\delta).h_{3f}\ ] + w_2.h_2] = 0. \tag{10}$$

Derivations of (9) and (10) are given in Results Appendix (b).

Expression (9) provides the well known outcome, illustrated in Figure 1 (a), that the contractual wage rate rises with tenure, or $w_2* > w_1$. Similar to the proof in Hart and Ma (1999), we can also show that working hours allocated in the post-investment period, conditional on satisfying a marginal disutility constraint, also rise relative to period 1 hours, or $h_2* > h_1$. Thus, we have the hours profile illustrated in Figure 1(b).

An optimal solution to the problem of maximising wealth in (8) cannot be attained through the choice of a single hourly wage rate, however. The problem is that the parties are seeking to minimise sub-optimal quits and layoffs on two margins. In other words, they are attempting to set a wage rate with an eye towards the outside wage *as well as* seeking to attain optimal length of working hours. Intuitively, at least

Table 1   Expected life-time wealth

PERIOD 1 (V_1)	PERIOD 2 (V_2)		PERIOD 3 ($V_3 = V_f + V_q + V_s$)		PERIOD 4
Probability =1.0 $w_1.h_1 - C(M_2) - D(h_1)$	Fired: probability = F_2 $(1-\delta).w_1.h_{2f} - C_f - D(h_{2f})$		Probability = F_2 $w_{3f}.h_{3ff} - D(h_{3ff})$	V_f	Retirement
	Quits: probability = $(1-F_2).Q_2$		Probability = $(1-F_2).Q_2$	V_q	
	$[(1-\delta).w_1+g.M_2].h_{2q} - C_q - D(h_{2q})$		$[(w_1.(1-\delta)+ g.M_2).(1-\delta) + M_{3q}].h_{3qq} - D(h_{3qq})$		
	Stays: probability = $(1-F_2).(1-Q_2)$ $[(1-\delta).w_1+M_2+E(\eta_2\|\eta_2>\eta_2*) +E(\theta_2\|\theta_2>\theta_2*)].h_2 - C(M_3) - D(h_2)$	V_2	Fired: probability = $(1-F_2).(1-Q_2).F_3$ $[w_1.(1-\delta)+g.M_2].(1-\delta).h_{3f} - D(h_{3f})$	V_s	
			Quits: probability = $(1-F_2).(1-Q_2).(1-F_3).Q_3$		
			$[(w_1.(1-\delta) + g.M_2).(1-\delta)+g.M_3].h_{3q} - D(h_{3q})$		
			Stays: probability = $(1-F_2).(1-Q_2).(1-F_3).(1-Q_3)$		
			$[(w_1.(1-\delta) + M_2).(1-\delta)+ M_3 + E(\eta_3\|\eta_3>\eta_3*)+E(\theta_3\|\theta_3>\theta_3*)].h_3$ $- D(h_3)$		

two instruments are required in order to achieve these mutually supportive objectives.

Hart and Ma (1999) establish that if an "overtime" premium is paid then contract

efficiency is established. This does not rule out the use of other instruments, such as

bonus payments (Hashimoto, 1979) or fixed seniority promotion rules (Carmichael,

1981).

Figure 1: Periods 1 and 2 wage and hours profiles
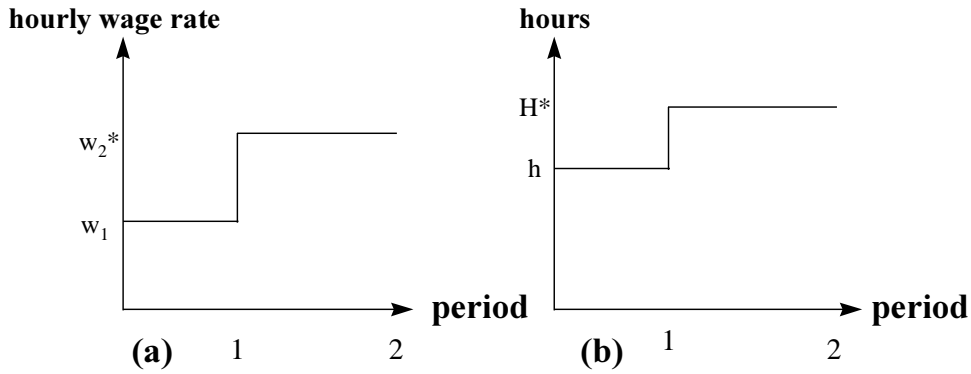
We now deal with the period 3. A summary of the expected lifetime wealth, together

with the first-order conditions (f.o.c's) for wealth maximisation are set out in the

Results Appendix (a). From the f.o.c's (A3) to (A6), it is easily established that

workers will quit whenever satisfaction is below θ_i^* ; that is,

$$\theta_2 < \theta_2^* = [\beta + \gamma.g.M_2]/ h_2 - [A/h_2 + E(\eta_2|\eta_2 > \eta_2^*)] \tag{11}$$

and

$$\theta_3 < \theta_3^* = [\mu + g.M_2.(1-\delta).h_{3q} + g.M_3.h_{3q}]/h_3 - [B/h_3 + E\eta_3|\eta_3 > \eta_3^*)]. \tag{12}$$

Further, the firm will fire the workers whenever productivity is below η_i^* ; that is

$$\eta_2 < \eta_2^* = \{\alpha - Q_2.[\beta + \gamma.g.M_2]\}/[h_2.(1-Q_2)] - [A/h_2 + E(\theta_2|\theta_2 > \theta_2^*)] \tag{13}$$

and

$$\eta_3 < \eta_3^* = \{[\tau + g.M_2.(1-\delta).h_{3f}] - Q_3.[\mu + g.M_2.(1-\delta).h_{3q} + g.M_3.h_{3q}] \}/$$

$$[h_3.(1-Q_3)] - [B/h_3 + E(\theta_2|\theta_2>\theta_2^*)] \tag{14}$$

These results state that the party wishing to separate must be made to internalise the entire expected losses from the separation at each period over the working life.

Next we show that it is possible to formulate a wage-hour contract in terms of the parameters of η_i^* and θ_i^* to satisfy the first-order conditions (A3) to (A6). For period 3, there exists a wage-hour contract which can minimise the sub-optimal separation of the two parties, with (w_3^*, h_3^*), satisfying the following two equations:

$$w_3 = (1-\delta)^2.w_1 + M_2.(1-\delta) + M_3 + E(\eta_3|\eta_3>\eta_3^*) \tag{15}$$

and

$$[\tau+g.M_2.(1-\delta).h_{3f}] - Q_3.[\mu+ g.M_2.(1-\delta).h_{3q}+g.M_3.h_{3q}]$$
$$- (1-Q_3).[\,h_3.E(\theta_3|\theta_3>\theta_3^*) -D(h_3) + w_3.h_3] = 0 \tag{16}$$

Equations (15) and (16) are derived in Theory Appendix (c).

4 Life cycle changes in investments, wages and hours

The optimal wage-hour contract $(w_2^*, h_2^*, w_3^*, h_3^*)$ the level of human capital investments (M_2^*, M_3^*) are obtained by solving equations (9), (10), (15), (16), (A7) and (A8) simultaneously. In this section, we investigate four sets of questions that arise from these solutions. What are the implications of our model for

(a) the level of human capital investment over the life cycle;

(b) the level of hours over the life cycle;

(c) the income effect on hours in the post-investment period compared to the

previous period;

(d) the effects on wages and hours life-time schedules of separation before period 3?

(a) Human capital investments

We might expect that, given the retirement constraint, the optimal level of human capital produced by the training investments will rise initially and then fall as the worker becomes older. In effect, for given investments, the age of retirement serves to shorten the potential length of amortisation of period 2 compared to period 1 investments. We show formally in the Theory Appendix (d) that such an outcome is predicted by the model. Providing quit and layoff probabilities as well as the depreciation rate are small, we obtain the outcome

$$M_2 > M_3 > 0 \qquad\qquad (17)$$

that is, returns to human capital investments that are realised in period 3 are less than those realised in period 2. *Ceteris paribus*, our results suggest that wages and hours rise with experience due to rent sharing and, moreover, the two profiles are concave. In terms of the wage rate, the analysis provides a theoretical underpinning of the slope and shape of the Mincer-equation (Mincer, 1974).

(c) Hours

There are four explicit conditions and one implicit condition to guarantee that h_3 rises above h_2 (see Hart and Ma, 1999):

(i)   outside working hours are not far away from h_3;

(ii)   the quit probability Q_3 is not too high;

(iii)   the marginal disutility of work $D'(h_3)$ is not too large;

(iv) $D(0) = 0$, $D'(\cdot) > 0$ and $D''(\cdot) > 0$;

(v) $w_3 > w_2$.

Conditions (ii) and (iv) may well hold in period 3 as the worker is approaching retirement. However, (i) and (iii) may not hold. This implies hours may fall in the

pre-retirement period, *independent* of the wage. Furthermore, condition (v) may not hold in period 3 either.[6] This again implies that the hours may fall in period 3.

(d) Income effects on hours

In order to gain a deeper insight into period 3 relative to period 2 hours, we need to consider the income effect on hours. From equation (10) we have

$$\partial \log(h_2)/\partial \log(w_2) = -w_2/[\ w_2 + E(\theta_2 \,|\, \theta_2 > \theta_2^*) - D'(h_2)] \qquad (18)$$

While by equation (16) we have

$$\partial \log(h_3)/\partial \log(w_3) = -w_3/[\ w_3 + E(\theta_3 \,|\, \theta_3 > \theta_3^*) - D'(h_3)] \qquad (19)$$

Comparing (18) and (19), we can find that the following three factors increase the income effect of period 3, relative to that of period 2. These are:

(i) $w_3 < w_2$;

(ii) $\theta_3 < \theta_2$, i.e. job satisfaction may be lower when a worker gets older;

(iii) $D'(h_3) < D'(h_2)$ if $h_3 < h_2$. [7]

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[6] What can we say about the expected value of w_3 relative to w_2? Consider equation (15). It is clear that there are two influences on the value of w_3 that serve to render the outcome relative to w_2 as an open empirical question. From (15), if there were no human capital investment in period 2, with the result that $M_3 = 0$, then we would unequivocally obtain $w_3 < w_2$ due to the effect of the investment depreciation term, δ. But $M_3 > 0$ does not ensure the reverse wage inequality because we have established in (17) that human capital investment M_3 will be less than M_2. In other words, it would remain the case that $w_3 < w_2$ if the investment M_3 falls steeply enough so as not to offset the human capital depreciation. Therefore, relative sizes of w_3 and w_2 cannot be determined *a priori.*

[7] We note that factor (c) and inequality $w_3 < w_2$ reinforce one another.

(e) **Separation before period 3**

Suppose that we distinguish between two groups of workers. The first group consists of individuals who changed their last job relatively late in their working lifetime and who will have short expected tenure (SET). The second group's last job change is at an age that still leaves relatively long expected tenure (LET).

The wage profiles of these two groups are likely to differ. Consider first the implication for human capital investment in (a). We would expect in (17) that M_3 will fall relative to M_2 for the SET group considerably more than the LET group as approaching retirement will preclude significant period 2 investments. In relation to wage outcomes in (b), therefore, we would conclude that there is a far greater chance that $w_3 < w_2$ for the SET group compared to the LET group.

The hours profiles may also contrast between the two groups but in this case the picture is more complicated. Suppose, for example, that the conditions listed under the hours effect in (c) and under the income effect in (d) are small except for $w_3 < w_2$. This latter result would serve to depress hours but this would be counteracted by the income effect.

In the empirical estimation reported in Section 6, we examine the consequences of distinguishing between SET and LET groups.

5 Estimation

(a) *Wage and hours estimating equations*

We use BHPS data on males observed annually from 1991 to 1997. Table A2 in the Data Appendix defines all the variables used in our empirics. An advantage of using British data is that the labour market is more or less unregulated as far as working time is concerned. The

lengths of standard and total weekly hours are generally not subject to statutory interference.[8]

Table A1 in the Data Appendix defines all the variables used in our empirics.

We concentrate on the BHPS-related panel estimation here. From equation (9), we

predict that the wage rate rises with the acquisition of general and specific human

capital. We also predict (see discussion around (17)) that the profile will be concave.

We use work experience as a proxy for the combined returns to general and specific

investments. For J employed individuals (indexed by j = 1,…,I), we have

$$\log w_{jt} = x_{jt}\mathbf{a} + y_{jt}\mathbf{b} + \mu_j + e_{jt} \tag{20}$$

where w_{it} is the hourly straight-time wage rate[9] for individual i at time t, x is a vector

of the individual's human capital attributes (work experience) and y contains other

control variables (marital status, firm-size, industry); $\mathbf{a}$ and $\mathbf{b}$ are vectors of

parameters to be estimated; μ_i represents individual fixed effects and e_i is a zero-mean

random variable reflecting unobserved characteristics that affect the wage offer.

---

[8] Minimum hourly premiums for hours in excess of regular hours are also not subject
to legislation. Unfortunately, we have no direct information on premium rates for
individuals in BHPS or LFS and so they are not included in the analysis. Instead, we
focus our study on straight-time wage rates and total hours equations which, taken
jointly, provide lower bound estimates a earnings effects. A further advantage of
using British data is that the incidence of part-year working is extremely low and
problems associated with the endogenous choice of number of work weeks basically
do not arise.

[9] Paid-for basic hourly wage rates are not directly provided in the BHPS or the LFS
and they were derived on the following basis. Omitting cross-section subscripts, w =
[gross weekly earnings]/{basic weekly hours + [(overtime hours) × 1.25]}. The
overtime premium of 1.25 is based on estimates by Hart and Ruffell (1993) for males
in British production industries. These authors show that the premium remains
unaffected by variations in the length of weekly hours.

From equation (10), we establish that hours also rise with work experience. Longer hours are consistent with greater turnover efficiency in the face of sunk investments. The hours-equivalent equation to (20) is expressed:

$$\log h_{jt} = z_{jt}\mathbf{c} + y_{jt}\mathbf{d} + \upsilon_j + u_{jt} \tag{21}$$

where h is weekly hours for individual; $\mathbf{z}$ represents the work experience and - as dictated by equation (10) - the straight-time wage; y are the same controls as in (20); $\mathbf{c}$ and $\mathbf{d}$ are vectors of parameters; υ represents fixed effects; u is the error term.

Our data sets contain both employed and unemployed persons. Given the potential for sample selection bias, we adopt Heckman's two-step procedure. The probability of being unemployed is estimated on an auxiliary probit regression where the sample of both employed and unemployed is included. The explanatory variables in the probit consisted of the individual's age, marital status and category of child dependency. From the probit, we obtained an estimate of the inverse Mills ratio which is added as an additional variable in the wage and hours specification, (20) and (21).

(b) *Simulations*

In order to evaluate the contributions of total experience on the wage rate and hours profiles, as well as on wage earnings (i.e. the wage rate times hours), we carried out a simple simulation exercise. Suppose a worker enters a firm immediately after schooling and remains in the firm, without unemployment spells or other major non-vacation breaks, until the age of retirement. How much would wage rates, weekly hours and wage earnings rise with accumulated years of tenure (= experience)? Based on our estimates of equation (20), let $\hat{a}_1$ be the estimated coefficient on the

experience variable, EXP and $\hat{a}_2$ the coefficient on EXP^2 within the **a** vector. Then, we can evaluate

$$\frac{\partial(\log w_j)}{\partial(EXP)} = \hat{a}_1 + 2\hat{a}_2.(EXP). \tag{22}$$

In the estimated hours equation (21), let $\hat{b}_1$ be the estimated coefficient on EXP, $\hat{b}_2$ on EXP^2, and $\hat{b}_3$ the coefficient on the wage in the **b** vector. Then, we have

$$\frac{\partial(\log h_j)}{\partial(EXP)} = \hat{b}_1 + 2\hat{b}_2.(EXP) + \hat{b}_3.\left[\frac{\partial(\log w_j)}{\partial(EXP)}\right]. \tag{23}$$

Combining these wage rate and hours simulations allows us to evaluate the growth rates of wage earnings that are attributable to work experience. Note, however, that these are *lower bound* earnings estimates because we are assuming implicitly that all weekly hours are compensated at the straight-time wage rate, w_t. For many workers, marginal weekly hours are paid at an overtime premium. Our construction assumes that this premium rate is 1 which clearly underestimates the true figure. Elsewhere, we establish theoretically that the overtime premium itself will relate to human capital investments (Hart and Ma, 1999).[10]

(c) *SET and LET dichotomies*

Following the discussion in Section 3 (e), we differentiated between individuals with short expected tenure (SET) and those with long expected tenure (LET). We argued that our theoretical developments would lead us to expect to observe different wage and hours returns to experience for the two groups as well as different income effects. Dividing individuals into SET and LET groups is, of necessity, a somewhat arbitrary process. We adopted a simple heuristic approach. We experimented with ages within

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[10] We establish that the premium itself may serve to reduce sub-optimal separations given sunk investments.

middle age (between 40 and 55) and to find an 'optimum' dividing age. The optimum age was simply the choice that maximised the estimated differences in experience and hours-wage coefficients. It turned out that the age was 43 using the BHPS data and 49 using the LFS data. A SET individual changed jobs after that age, while a LET individual last changed jobs before that age.

Letting D be a dichotomous variable that represents the dividing age, our modified versions of (20) and (21) are given by

$$\log w_{jt} = x_{jt}\mathbf{a_1} + D.x_{jt}\mathbf{a_2} + y_{jt}\mathbf{b} + \mu_j + e_{jt} \tag{24}$$

and

$$\log h_{jt} = z_{jt}\mathbf{c_1} + D.z_{jt}\mathbf{c_2} + y_{jt}\mathbf{d} + \upsilon_j + u_{jt} \,. \tag{25}$$

6 Results

The estimates in Table 2 establish, in line with our theory, that *both* wage rates and weekly hours rise with work experience. Moreover, both components of earnings exhibit concave profiles. These findings are corroborated in our cross sectional LFS estimates shown in the Empirical Appendix, Table A1. The hours' results contain two particularly interesting findings. As in many previous supply-side and wage contract models, we obtain a negative income effect in respect of the straight-time wage. But, as we will see in the following simulations, this effect *is more than offset* by the positive hours-experience relationship. Hours rise over the life cycle with the result that wage earnings (i.e. wages-times-hours) rise more than wage rates.

From Table 2 and Figure 2, we find from the simulations - i.e. equations (22) and (23) - that a worker receives 35.8 growth in hourly wage rates by the fifth year of experience. By 30 years of experience, growth reaches 204 per cent. But hours also rise over the life cycle: the experience effect is greater than the income effect. After 5 years, hours grow 2.3 per cent due to experience and by year 25 hours growth peaks at 5.5 per cent. Combining the two simulations in order to establish the earnings-experience profile, increase the wage-rate growth from 35.8 to 38.7 after 5 years and from 175 to 189.4 per cent after 25 years. The comparable LFS simulations in Table A1 reveal somewhat greater hours' growth - due to a significantly lower estimated income effect - and considerably lower wage rate growth. The net effect is to produce a greater hours' contribution to the growth of wage earnings in the latter case.[11]

We suggested in Section 3 (e) that sharper evidence in relation to our theoretical predictions may be derived by separating individuals into those with short expected tenure (SET) and long expected tenure (LET). We dichotomised between SET and LET groups in the following manner. The 'optimum' age for separating SET and LET workers - based on the heuristic approach of maximising significant differences between experience and wage coefficients - turned out to be 43 years with our BHPS panel estimates and 49 years with the LFS.

We first predicted in respect of wage rates that returns to experience within the SET group would be expected to be less than within the LET group. The BHPS results in

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[11] The LFS estimates with respect to the wage rate are reasonably similar to the cross-sectional U.S. findings (for small, medium and large firms) of Hashimoto and Raisian (1985) based on the 1979 Current Population Survey. Taking medium firms as "representative", they find that hourly wage earning peak at 30 years with 99 per cent

Table 2 and the LFS results in Table A1 both support this expectation. The shift dummies indicate higher absolute wages for the SET group because this consists, on average, of older workers. When interacted with the experience, however, the SET group displays a significantly lower experience effect on wage growth than its LET equivalent. In the hours' equations, in Tables 2 and A1, the shift dummy is also positive; on average, the SET group is older and works longer hours. As far as the slope dummies are concerned, there is one similarity and one difference in the estimates as between the two data sets. Both sets of results indicate that the income effect is stronger in the SET compared to the LET group. We set out the conditions in Section 3 (d) that combine to bring about this outcome. As for the effect of experience on hours, the BHPS panel estimates in Table 2 indicate lower hours' response among SET compared to LET workers. In the cross section data, the position is reversed: relatively high positive experience effects among SET workers compare to insignificant coefficients for LET workers.

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growth over the base starting year. For all firms in the LFS, the hourly wage growth peaks at 28 years with 71 per cent growth.

Table 2: Wage and hours fixed effects regressions and simulations (BHPS: 1991-7)

	Basic wage (ln w)		Hours (ln h)	
Experience	0.055	0.070	0.013	0.016
	(0.003)	(0.004)	(0.001)	(0.002)
Experience^2/100	-0.063	-0.117	-0.019	-0.030
	(0.007)	(0.012)	(0.003)	(0.006)
Wage	-		-0.163	-0.159
			(0.001)	(0.008)
Mills	0.240	0.216	0.078	0.090
	(0.066)	(0.066)	(0.032)	(0.032)
D		0.616		0.189
		(0.162)		(0.083)
D.Experience		-0.051		-0.009
		(0.011)		(0.005)
D.(Experience^2/100)		0.113		0.023
		(0.020)		(0.010)
D.Wage		-		-0.036
				(0.011)
Sample size	7628		7628	

Notes: These regressions include controls for 2-digit industries, firm size (1-24 workers, 25-49, and over 50), whether living with partner, number of children. The dummy variable D takes the value of 1 for those workers who changed job after the age of 43.

Percentage growth in wage rates, weekly hours and wage earnings attributable to work experience			
Experience (years)	Wage rates (w_t)	Weekly hours (h_t)	Wage earnings ($w_t.h_t$)
5	35.8	2.3	38.7
10	69.5	3.8	75.6
15	105.3	4.8	114.7
20	141.3	5.4	153.6
25	175.0	5.5	189.4
30	204.1	5.1	218.9

Notes: These figures show the percentage differences between the current values of wages, hours and earnings and their respective starting values due to total experience.

Figure 2: Wage Hours Experience Profiles (BHPS)
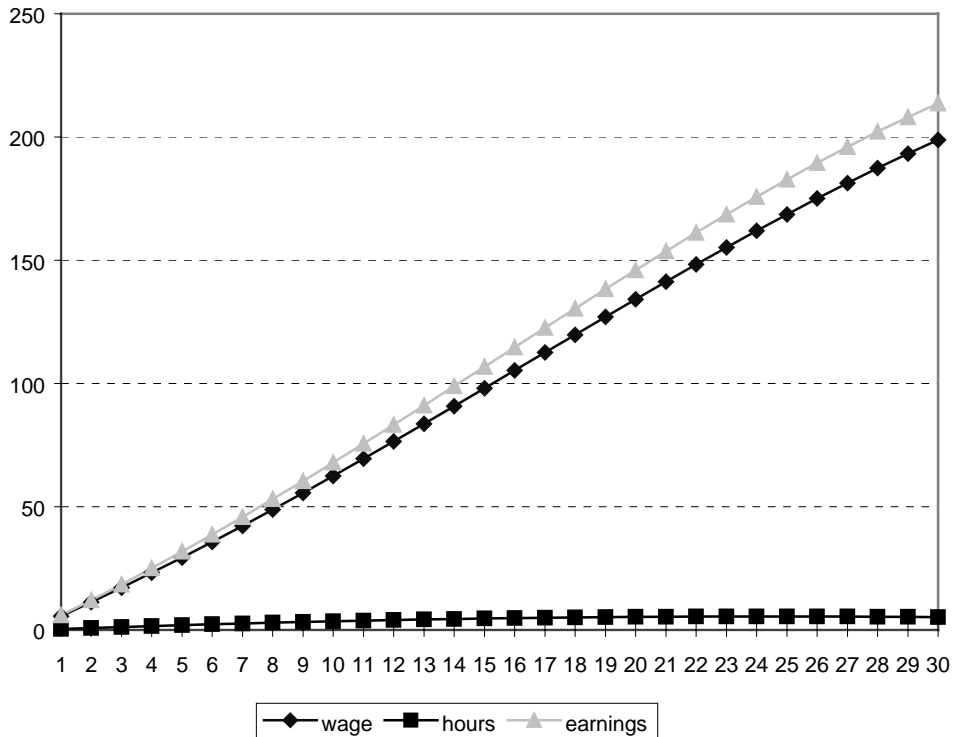
6 Concluding remarks

Investments in general and specific human capital earn an expected rent in the post-investment period. The rent payment to workers has two dimensions. It can be paid in the form of (a) a wage rate increment that applies to (b) longer per-period hours. We show that, under reasonable conditions, both modes of payment serve to improve contract efficiency in terms of minimising sub-optimal separations in the face of informational asymmetries. Empirical support is obtained from related Mincer equations estimated on data relating to British male workers. Over the working life cycle, the positive effect of rent sharing on hours growth is estimated to be larger than the countervailing negative income effect. This is an important finding in relation to previous empirical literature on hours of work.

There is an obvious empirical extension to this work. Data limitations have prevented us from integrating the role of premium pay into our empirics. Accordingly, our resulting wage earnings growth profiles are lower bounds. Some part of the hours growth due to human capital investments will involve payment of an overtime premium. Elsewhere, we have shown that payment of a premium on marginal per-period hours worked serves as a device that helps to further to reduce sub-optimal separations by the two parties. As and when data sets become available that allow researchers to measure marginal premium rates of pay, along with work experience, then estimates of wage earnings returns to human capital investments may be further refined.

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Theory Appendix

(a)   Wealth maximisation: first-order conditions

To summarise, we have (where t_i means the end of period i):

$V = V_1 + V_2 + V_3 = V_1 + V_2 + V_f + V_q + V_s$:

$= w_1.h_1 - C(M_2) - D(h_1)$ (wealth in period 1)

$+ F_2.[(1-\delta).w_1.h_{2f} - C_f - D(h_{2f})] + w_{3f}.h_{3ff} - D(h_{3ff})$ (fired at t_1)

$+(1-F_2).Q_2.\{[(1-\delta).w_1 + g.M_2].h_{2q} - C_q - D(h_{2q})$

$+ [(w_1.(1-\delta) + g.M_2).(1-\delta) + M_{3q}].h_{3qq} - D(h_{3qq})\}$

   (quits at t_1)

$+(1-F_2).(1-Q_2).\{[(1-\delta).w_1 + M_2 + E(\eta_2|\eta_2>\eta_2^*) + E(\theta_2|\theta_2>\theta_2^*)].h_2 - C(M_3) - D(h_2)\}$

   (stays at t_1)

$+ (1-F_2).(1-Q_2).\{ F_3.[(w_1.(1-\delta)+g.M_2).(1-\delta).h_{3f} - D(h_{3f})]$ (fired at t_2)

$+ (1-F_3).Q_3.\{[(w_1.(1-\delta) + g.M_2).(1-\delta)+g.M_3].h_{3q} - D(h_{3q})\}$ (quits at t_2)

$+ (1-F_3).(1-Q_3).\{[(w_1.(1-\delta) + M_2).(1-\delta)+ M_3 + E(\eta_3|\eta_3>\eta_3^*)$

$+E(\theta_3|\theta_3>\theta_3^*)].h_3 - D(h_3)\}\}$

   (stays at t_2)

                                                                                                 (A1)

where w_1, w_{3f}, h_1, h_{2f}, h_{2q}, h_{3f}, h_{3ff}, h_{3q} and M_{3q} are exogenously determined constants.

To simplify the notation, let

$\varphi = w_1.h_1 - D(h_1)$

$\alpha = (1-\delta).w_1.h_{2f} - C_f - D(h_{2f}) + w_{3f}.h_{3ff} - D(h_{3ff})$

$\beta = (1-\delta).w_1.h_{2q} - C_q - D(h_{2q}) + [(1-\delta)^2.w_1 + M_{3q}].h_{3qq} - D(h_{3qq})$

$\gamma = h_{2q} + (1-\delta).h_{3qq}$

$\tau = (1-\delta)^2.w_1.h_{3f} - D(h_{3f})$

$\mu = w_1.(1-\delta)^2.h_{3q} - D(h_{3q})$

$B = [(w_1.(1-\delta) + M_2).(1-\delta) + M_3].h_3 - D(h_3)$

$A = [(1-\delta).w_1 + M_2].h_2 - C(M_3) - D(h_2) + F_3.[\tau + g.M_2.(1-\delta).h_{3f}]$

$\quad + (1-F_3).Q_3.[\mu + g.M_2.(1-\delta).h_{3q} + g.M_3.h_{3q}]$

$\quad + (1-F_3).(1-Q_3).\{B + [E(\eta_3|\eta_3 > \eta_3^*) + E(\theta_3|\theta_3 > \theta_3^*)].h_3\}$ (A2)

where φ, α, β, γ, τ, and μ are constants.

The first order conditions satisfying max V are $\partial V/\partial \theta_i^* = \partial V/\partial \eta_i^* = 0$ (i=2,3):

$\partial V/\partial \eta_2^* = f(\eta_2^*).\{\alpha - Q_2.[\beta + \gamma.g.M_2] - (1-Q_2).[A + h_2.E(\theta_2|\theta_2 > \theta_2^*)]$

$\quad - (1-Q_2).h_2.\eta_2^*\} = 0$ (A3)

$\partial V/\partial \theta_2^* = (1-F_2).q(\theta_2^*).\{[\beta + \gamma.g.M_2] - [A + h_2.E(\eta_2|\eta_2 > \eta_2^*)] - h_2.\theta_2^*\} = 0$ (A4)

and

$\partial V/\partial \eta_3^* = f(\eta_2^*).\{[\tau + g.M_2.(1-\delta).h_{3f}] - Q_3.[\mu + g.M_2.(1-\delta).h_{3q} + g.M_3.h_{3q}]$

$\quad -(1-Q_3).[B + h_2.E(\theta_2|\theta_2 > \theta_2^*)] - (1-Q_3).h_3.\eta_3^*\} = 0$ (A5)

$\partial V/\partial \theta_3^* = (1-F_3).q(\theta_3^*).\{[\mu + g.M_2.(1-\delta).h_{3q} + g.M_3.h_{3q}]$

$\quad - [B + h_3.E(\eta_3|\eta_3 > \eta_3^*)] - h_3.\theta_3^*\} = 0$ (A6)

(b) Period 2 wage-hour contract

The optimal period 2 wage-hour contract is obtained as follows. If the firm decides to fire a worker at the end of period 1, then

$$(1-\delta).w_1 + M_2 + \eta_2 < w_2$$

or

$$\eta_2 < \eta_2^* = w_2 - (1-\delta).w_1 - M_2 \tag{A7}$$

Substituting (A7) into f.o.c. (A3) gives (10).

On the other hand, the worker will quit at the end of period 1 if

$$h_2.w_2 + h_2.\theta_2 - D(h_2) - C(M_3) + V_s < \{[(1-\delta).w_1 + g.M_2].h_{2q} - C_q - D(h_{2q})$$

$$+ [(w_1.(1-\delta) + g.M_2).(1-\delta) + M_{3q}].h_{3qq} - D(h_{3qq})\} \tag{A8}$$

The worker is assumed to be forward looking. He therefore considers current returns, $[h_2.w_2 + h_2.\theta_2 - D(h_2) - C(M_3)]$, as well as future returns, V_s, if he stays with the firm at period 2 when he makes his decision. The right-hand-side of the above inequality is the sum of the wealth over periods 2 and 3 if the worker quits.

Rewrite (A8):

$$\theta_2 < \theta_2^* = - w_2 + [\beta + \gamma.g.M_2 + D(h_2) + C(M_3) - V_s]/h_2 \tag{A9}$$

Substituting (A9) into f.o.c. (A4) gives (9) if M_2 is sufficiently large or δ is relatively small.

(c) Period 3 wage-hour contract

If the firm decides to fire a worker at the end of period 2, then

$$(1-\delta)^2.w_1 + M_2.(1-\delta) + M_3 + \eta_3 < w_3$$

or

$$\eta_3 < \eta_3^* = - [(1-\delta)^2.w_1 + M_2.(1-\delta) + M_3 - w_3] \qquad (A10)$$

Substituting (A10) into (A5) gives (16).

On the other hand, the worker will quit at the end of period 2 if

$$h_3.w_3 + h_3.\theta_3 - D(h_3) < [\mu + g.M_2.(1-\delta).h_{3q} + g.M_3.h_{3q}]$$

or

$$\theta < \theta^* = - w_3 - \{D(h_3) - [\mu + g.M_2.(1-\delta).h_{3q} + g.M_3.h_{3q}]\}/h_3 \qquad (A11)$$

Substituting (A11) into (A6) gives (15).

(d) Human capital investment over the life cycle

The first-order conditions satisfying max V are $\partial V/\partial M_i = 0$ (i=2,3) are given by

$$\partial V/\partial M_2 = -C'(M_2) + (1-F_2).Q_2.\gamma.g + (1-F_2).(1-Q_2).[\, h_2 + g.F_3.(1-\delta).h_{3f}$$

$$+ g.(1-F_3).Q_3.(1-\delta).h_{3q} + (1-F_3).(1-Q_3).(1-\delta).h_3] = 0 \qquad (A12)$$

$$\partial V/\partial M_3 = (1-F_2).(1-Q_2).[\, -C'(M_3) + g.(1-F_3).Q_3.h_{3q} + (1-F_3).(1-Q_3).h_3] = 0. \qquad (A13)$$

Equations (A12) and (A13) imply that

$$C'(M_2) - C'(M_3) = (1-F_2).Q_2.\gamma.g + (1-F_2).(1-Q_2).[\ h_2 + g.F_3.(1-\delta).h_{3f}\ ]$$

$$- \delta(1-F_2).(1-Q_2).(1-F_3).[g.Q_3.h_{3q} + (1-Q_3).h_3]$$

$$- (F_3 + Q_3 - F_3.Q_3).(1-F_3).[g.Q_3.(1-\delta).h_{3q} + (1-Q_3).(1-\delta).h_3] > 0 \qquad (A14)$$

if F_i, Q_i (i=2,3) and δ are small. Therefore, we have

$$M_2 > M_3 > 0.$$

which is expression (17) in Section 4(a).

Empirical Appendix: Model estimates based on LFS data

In this Appendix we show results based on cross-sections of males taken from the second and third quarters of the British Labour Force Survey (LFS) in 1993 and 1994.[12] Results are shown in Table A1 and Figure A1. They are simply the cross-section equivalents of equations (20) and (21), together with the simulations generated by (22) and (23) as well as the SET/LET dichotomies in equations (24) and (25). Of course, fixed effects are now included, the principal of which are pre-work educational attainments.

We refer to our central findings in the main text. Of our controls, we show the education results in Table A1. Pre-work qualification levels in the wage equation are positively related to wage growth, with university-level education (Education1) showing by far the biggest gain, followed by reasonably similar estimated gains among the other educational levels (see Table A2 for definitions).

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[12] We confine attention to the second and fourth quarters because they allow us to control for regional differences.

Table A1: Wage and hours cross-section regressions and simulations (LFS: 1993/4)

	Basic wage (ln w)		Hours (ln h)	
Experience	0.037	0.035	0.009	0.0003
	(0.001)	(0.002)	(0.002)	((0.016)
Experience^2/100	-0.066	-0.058	-0.024	-0.027
	(0.003)	(0.003)	(0.003)	(0.033)
Wage	-	-	-0.078	-0.091
			(0.005)	(0.005)
Education 1	0.563	0.565	-0.047	-0.046
	(0.011)	(0.011)	(0.007)	(0.007)
Education 2	0.323	0.325	-0.041	-0.044
	(0.016)	(0.016)	(0.010)	(0.009)
Education 3	0.310	0.313	-0.103	-0.108
	(0.032)	(0.033)	(0.019)	(0.019)
Education 4	0.296	0.297	-0.053	-0.058
	(0.018)	(0.018)	(0.011)	(0.011)
Mills	-0.663	-0.674	-0.966	-0.911
	(0.045)	(0.045)	(0.111)	(0.110)
Constant	1.407	1.419	4.079	4.128
	(0.030)	(0.031)	(0.043)	(0.043)
D	-	1.203		-1.900
		(0.455)		(0.281)
D.Experience	-	-0.067		0.108
		(0.020)		(0.012)
D.(Experience^2/100)	-	0.079		-0.152
		(0.022)		(0.014)
D.Wage	-	-		-0.037
				(0.017)
Sample size	18057		14703	

Notes: These regressions include controls for 2-digit industries, regions, firm size (1-24 workers, 25-49, and over 50), whether living with partner, number of dependent children. The dummy variable D takes the value of 1 for those workers who changed job after the age of 49.

Percentage growth in wage rates, weekly hours and wage earnings attributable to work experience			
Experience (years)	Wage rates (w_t)	Weekly hours (h_t)	Wage earnings ($w_t.h_t$)
5	22.1	3.0	25.6
10	39.3	4.4	45.2
15	53.8	4.8	61.1
20	64.5	4.3	71.4
25	70.4	2.8	74.9
30	70.7	0.3	71.0
Peak	28	15	25

Notes: These figures show the percentage differences between the current values of wages, hours and earnings and their respective starting values due to total experience.

Figure A1: Wage Hours Exoerience Profiles (LFS)
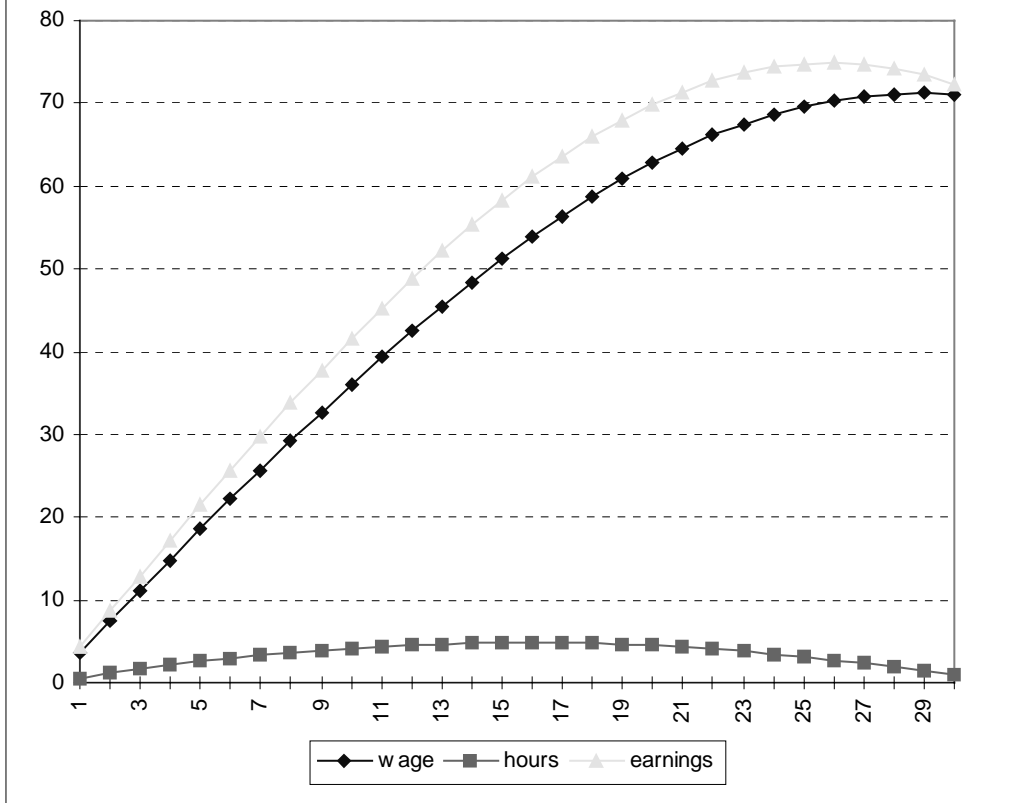
Data Appendix

The data were extracted from the Quarterly Labour Force Survey. Each household is
surveyed in five successive quarterly waves. Only in the final wave are questions
regarding earnings asked. Four quarters of responses from such "fifth wave"
households were combined in order to create an annual dataset for 1993.

Variable	Definition	Data source
Wage	straight-time hourly wage rate (see footnote 4)	BHPS/LFS
Hours	individual's total weekly paid-for hours	BHPS/LFS
Exp	age of individual minus age when completed full-time education	BHPS/LFS
Education 1	higher degree, degree, other degree level qualification	LFS
Education 2	diploma in higher education, Higher National Certificate, Higher National Diploma,	LFS
Education 3	teaching qualification, nursing or other medical qualification, other higher educational qualification below degree level	LFS
Education 4	Higher level school leaving certificate (A-level or equivalent)	LFS
Education 5*	none of the above	LFS
Ethnic	0 = white 1 = other	
Partner	0 = married or living together 1 = single, widowed, divorced, separated	BHPS/LFS
chil 0	no dependent children under 19	
chil 1*	youngest dependent child is between 0 and 3 (0 and 4)	BHPS (LFS)
chil 2	youngest dependent child is between 5 and 11 (4 and 11)	BHPS (LFS)
chil 3	youngest dependent child is between 12 and 18	BHPS/LFS
size 0*	1 - 24 employees at workplace	BHPS/LFS
size 1	25 - 49 employees at workplace	BHPS/LFS
size 2	50 or more employees at workplace	BHPS/LFS
ind 1	Agriculture, forestry & fishing	BHPS/LFS
ind 2	Energy & water supplies	BHPS/LFS
ind 3*	Mineral extraction metals & chemicals	BHPS/LFS
ind 4	Metal goods, engineering & vehicles	BHPS/LFS
ind 5	Other manufacturing	BHPS/LFS
ind 6	Construction	BHPS/LFS
ind 7	Distribution, hotels & catering	BHPS/LFS
ind 8	Transport & communication	BHPS/LFS
ind 9	Banking, finance, insurance, business services & leasing	BHPS/LFS
ind 10	Other services	BHPS/LFS

Note: * indicates the omitted variable in regression analyses. Additionally, the LFS regressions
include 28 regions which we do not list.

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