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## Why Do Firms Pay an Overtime Premium?

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## **ABSTRACT**

### **Why Do Firms Pay an Overtime Premium?\***

We develop a rationale for the payment by firms of a wage premium on marginal, or overtime, weekly hours. We examine wage-hours contracts within the framework of a two-period specific human capital model with asymmetric information. The wage premium serves to achieve contract efficiency. For those weekly hours for which a premium is paid, worker compensation exceeds the value of marginal product. There is an optimal automatic compensatory differential rule between straight-time wages and the premium, and this provides new theoretical insights into recent empirical work in this area. Implications of imposing mandatory rules for premium pay and hours of work are also assessed.

JEL Classification: J41, J33

Keywords: Overtime premium, human capital, asymmetric information, mandatory overtime rules

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## 1. Introduction

Models based on agency (Lazear, 1981) and firm-specific human capital (Kahn and Lang, 1992) recognise that efficient long-term contracts must set hours as well as wages. Empirically, it is well recognised that unions bargain over both hourly wage rates and the length of working hours (Pencavel, 1991). The contract literature has stopped short, however, of providing explanations of why firms often pay for marginal daily or weekly hours at premium overtime rates. In any given week, roughly 25 percent of U.S. and 40 percent of U.K. male workers undertake paid overtime. Internationally, overtime hours are remunerated at a premium hourly rate, representing the straight time hourly rate plus an added percentage.<sup>1</sup> Why do firms pay this premium? This is clearly an important consideration in a country like the U.K. where the premium is set by collective agreement. But even in the US, where the government mandates a 50 percent premium for weekly hours in excess of 40, significant numbers of firms pay the premium for hours *less than* 40 (Trejo, 1993).

We develop a contract model that underpins the payment of a premium. It belongs to the class of contract models in which the parties have access to private information (Hashimoto, 1979; Carmichael, 1983; Malcomson, 1999). We show that a contract based solely on a straight-time wage does not achieve efficiency but that full efficiency can be achieved with the additional payment of an overtime premium. The intuition behind our key result is quite simple. In human capital models that concentrate only on the extensive margin, the parties set a higher wage-rate in the post-investment period in order to minimise sub-optimal (extensive margin)

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<sup>1</sup> See OECD Employment Outlook (1998) for international comparisons of average premium rates.

separations. With both extensive and intensive margins, the wage rate alone cannot be set to achieve *both* optimal separation and optimal worker utilisation. Providing that the value of an extra hour of leisure does not exceed the sum of the second period wage and expected job satisfaction, we demonstrate that the overtime premium provides an extra-required instrument that permits contract efficiency.

A rationale for exploring the overtime dimension in the wage-hours contract is provided by the U.S. study of Kahn and Lang (1992). They test the prediction from the agency approach that high tenured workers will want to work more hours than contracted. This arises because the firm and workers agree a second period optimal wage rate which is set above marginal product and designed to minimise worker malfeasance. Their PSID data reject this outcome. In the standard specific human capital model, by contrast, the optimal second period wage is set below marginal product. The firm would like the worker to supply more hours and it will restrict second period workers from working fewer-than-contracted hours. But their data also reject the prediction that second period workers will want to work fewer than contracted hours. Our model predicts that the straight-time wage is set below and the premium wage above marginal product. In effect, the premium acts optimally in the short-term to stimulate longer second period working hours within the human capital framework. Where overtime is worked, the marginal wage outcome runs parallel to the agency model of Lazear (1981) and the human capital model of Carmichael (1983) that establish a wage-in-excess-of-marginal-product for senior workers. However, our study provides both a long- and a short-run rationale for this phenomenon.

As a second area of interest, we consider the consequences for the model if the payment of a premium on marginal hours is subject to statutory rules. Typically, such legislation is intended to promote work sharing. The introduction of a high mandated overtime premium is directed towards increasing marginal cost on the intensive relative to the extensive margin and thereby encouraging a worker-hours substitution effect. The wage-hours contract developed here provides theoretical support for the view, tested by Trejo (1991), that firms will mitigate rises in mandatory premium payments by reducing straight-time hours.

## **2. Underlying framework**

Our wage-hours model differentiates between an initial period in which both work and specific training are undertaken and a post-investment period where the investment affects productivity. The analysis is conducted in terms of the marginal worker who initially receives spot market wage earnings in a perfectly competitive labour market. Thus, prior to specific training in the initial period, the particular wage-hours combination available to the worker is determined by the market. The training endows the worker with job-specific skills and so in the second period he is differentiated from other workers in the spot market. The generation of a surplus in the training period allows the parties to set a wage-hours combination in the second period that differs from the market-equivalents.

The worker's pre-entry endowment of general human capital is worth  $w_a$  in the spot market and this is not augmented within the firm. The firm provides specific training at a fixed (i.e. hours-independent) weekly cost,  $C$ . In period 1, the worker has hourly productivity  $MPL_1 = w_a - C/h$ , where  $h$  is first-period weekly hours. The expected

value per unit of specific human capital is  $M$  so that specific training is expected to raise hourly productivity to  $w_a + M$ .

The parties negotiate the contract at the beginning of period 1 and there is no subsequent renegotiation. The contract contains an agreed value of investment return  $M$ : it may be simple to verify some of the elements that signal the level of productivity – such as the state of current and future orders for the firm’s product. However, transaction costs of communicating and verifying information between the parties prevent agreement over the way in which random elements cause deviations from  $M$ . Such costs are represented by a random variable  $\eta$  which has density function  $f(\eta)$  and  $E(\eta) = 0$ . That is, the realised hourly productivity in period 2 is  $w_a + M + \eta$ . Due to lack of agreement over  $\eta$ , the firm responds unilaterally to the realised value of  $\eta$  at the end of period 1. The worker assesses the degree of job satisfaction  $\theta$  in the firm, relative to potential outside opportunities, at the end of period 1. Again, transaction costs prevent a mutually agreed value of  $\theta$  and only the worker responds to its realised value. The density function of  $\theta$  is  $q(\theta)$  with  $E(\theta) = 0$ . It is assumed that  $\text{Cov}(\eta, \theta) = 0$ . *Ex post*, information is private and cannot be exchanged and so separation decisions are made independently.

The probability of a worker deciding to quit is

$$Q = Q(\theta^*) = \int_{-\infty}^{\theta^*} q(\theta) d\theta \quad (1)$$

while the probability of the firm wanting to fire a worker is

$$F = F(\eta^*) = \int_{-\infty}^{\eta^*} f(\eta) d\eta \quad (2)$$

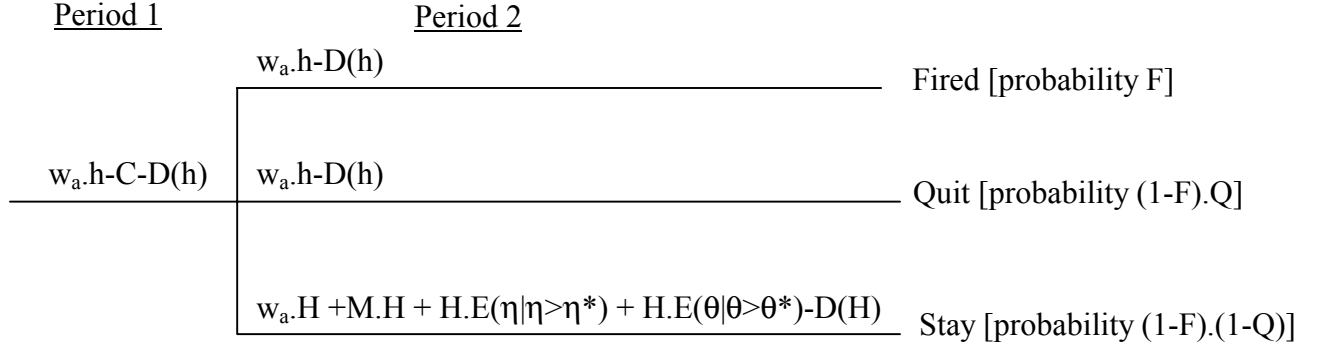


where  $\theta^*$  is the level of job satisfaction that leaves the worker indifferent about leaving and  $\eta^*$  is the level of productivity that leaves the firm indifferent over employing the worker. Without loss of generality, the discount rate is set to zero.

The worker works  $h$  and  $H$  weekly hours in periods 1 and 2 respectively, with the corresponding disutilities represented by  $D(h)$  and  $D(H)$ . If  $H > h$  then the question arises as to how the marginal increase in hours is to be compensated. We examine the consequences of introducing an overtime premium payment  $k \geq 1$  with respect to these hours.

### **3. The wage-hours model**

The parties' joint wealth consists of the returns arising from three mutually exclusive and exhaustive events, weighted by the probability of their occurrence. A two-period time line of worker and producer surplus is illustrated in Figure 1. The worker may be fired or not-fired at the end of the first period. 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 surplus consists of wage earnings net of training cost and work disutility ( $w_a \cdot h - C - D(h)$ ). If the worker is fired or voluntarily quits, the second period surplus to the worker is given by the market value  $w_a \cdot h - D(h)$ ; in these instances, the firm itself cannot obtain second period surplus. If the worker remains with the firm, second period surplus differs from the first period due to 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 worker and producer surplus**

Formally, the expected joint wealth  $W$  is expressed:

$$\begin{aligned}
W = & F \cdot [w_a \cdot h - C - D(h) + w_a \cdot h - D(h)] \quad (\text{the worker is fired}) \\
& + (1-F) \cdot Q \cdot [w_a \cdot h - C - D(h) + w_a \cdot h - D(h)] \quad (\text{the worker quits}) \\
& + (1-F) \cdot (1-Q) \cdot \{w_a \cdot h - C - D(h) + w_a \cdot H + M \cdot H + H \cdot E(\eta | \eta > \eta^*) + H \cdot E(\theta | \theta > \theta^*) - D(H)\} \\
& \quad \quad \quad (\text{the worker stays}). \quad (3)
\end{aligned}$$

Information concerning job satisfaction and productivity cannot be exchanged *ex post*.

To maximise (3), we follow the two-step approach of Carmichael (1983). First, we solve for the optimal  $\eta, \theta$  pair to maximise our objective function. Second, we assign second-period wages and hours to the first-order condition from step 1 to obtain the optimal wage-hour contract. From the Results Appendix (a) (see (A7) and (A8)), we establish a necessary condition for achieving a constrained optimal contract under the assumption that both parties are risk neutral. The contract is offered to ensure that workers will quit whenever job satisfaction is too low; i.e.

$$\theta < \theta^* = -\{M + E(\eta | \eta > \eta^*) - w_a h / H + w_a + [D(h) - D(H)] / H\} . \quad (4)$$

Equivalently, the firm will fire the workers whenever productivity is too low; i.e.

$$\eta < \eta^* = -\{M + E(\theta | \theta > \theta^*) - w_a h/H + w_a + [D(h) - D(H)]/H\} . \quad (5)$$

These conditions imply that the party wishing to separate must be made to internalise the entire expected losses from the separation.<sup>2</sup>

#### 4. Marginal hours compensated at the straight-time wage rate

Assume the earnings structure in period 2 is given as follows:

$$\text{Earnings (period 2)} = w_2 \cdot h + k \cdot w_2 \cdot (H - h) \quad (6)$$

where  $w_2$  is the straight-time wage in period 2 and  $k (\geq 1)$  is the overtime premium.

In this section, we consider the case of  $k = 1$ , or overtime hours do not incur a wage premium. In establishing an optimal wage-hours contract, the objective of the parties is two-fold. First, they seek to protect positive worker/producer surplus on the extensive margin by minimising sub-optimal separations. Second, since the size of the surplus is in part dependent on hours worked per-period, they wish to attain optimal second-period working time. These two objectives are not independent. Both the wage rate and hours affect productivity and so the process of minimising separations is dependent on is predicated on achieving optimal values of *both*  $w_2$  and  $H$ . It seems to be intuitively clear that  $w_2$  cannot be used as a single instrument to achieve optimality with respect to both labour margins.<sup>3</sup> In fact, this is demonstrated

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<sup>2</sup> In this Section, our wage-hours results run parallel to those obtained by Carmichael (1983) for the wage-rate alone. This can be checked by noting that the wage outcomes converge with Carmichael's for  $h = H$ .

<sup>3</sup> In similar fashion in the efficiency wage literature, the wage rate cannot achieve market clearing and optimal per-period worker effort.

formally below. Nonetheless, there are gains in carrying out the steps involving  $k = 1$  because several key intermediate results from this simpler case are relevant to the case  $k > 1$  which is discussed in the next section.

From the first-order conditions for maximising joint wealth in (3), derived in Results Appendix (a) (see (A12) and (A14)), we obtain

$$-\{E(\theta|\theta > \theta^*) - w_a h/H + [D(h) - D(H)/H]\} = w_2 \quad (7)$$

and

$$w_2 = w_a + M + E(\eta|\eta > \eta^*) > w_a. \quad (8)$$

As illustrated in Figure 2 (a), equation (8) produces the result familiar to earlier comparable models that the contractual wage rate rises with tenure.

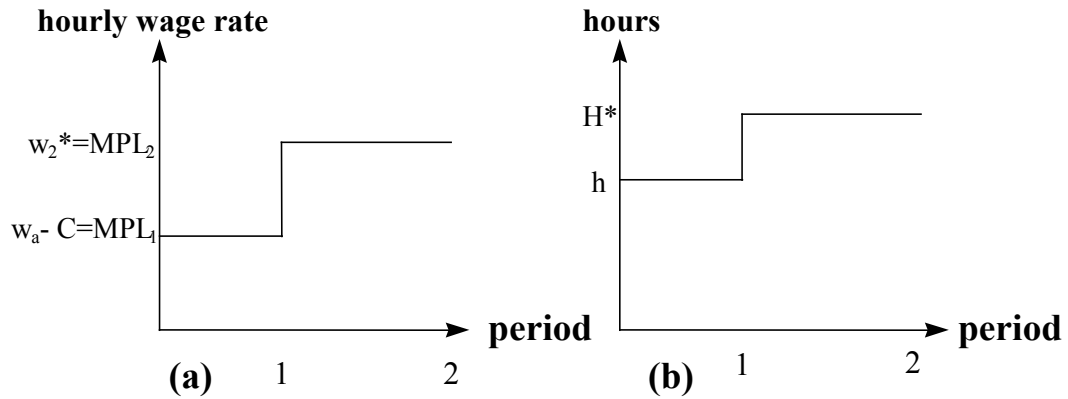
From the Results Appendix (a) (see (A17) and (A19)) we find, providing the marginal disutility of working  $D'(H)$  is less than the sum of the second period wage rate and the expected job satisfaction, that

$$\partial\theta^*/\partial H < 0. \quad (9)$$

and

$$\partial\eta^*/\partial H < 0. \quad (10)$$

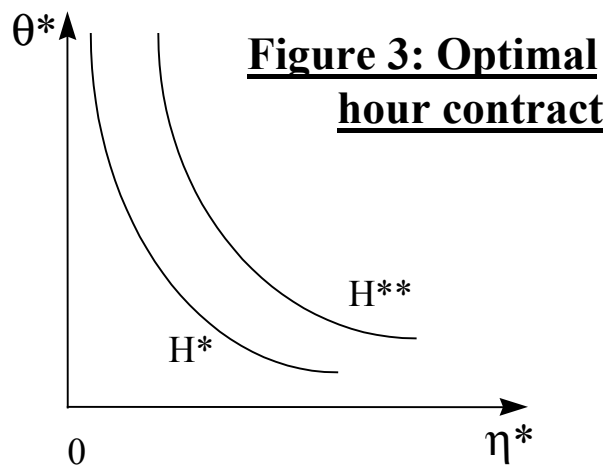
Within the marginal disutility constraints, equations (9) and (10) state that an increase in hours in the post-investment period will reduce the probability of separation. For a given wage rate, a rise in  $H$  increases the size of the surplus that in turn is distributed in higher profits and wage earnings.

**Figure 2: Wage and hours profiles**

From Results Appendix (b), we know that there are two solutions to (7) - i.e.  $H^*$  and  $H^{**}$  - which satisfy  $H^{**} < h < H^*$ . However, (9) and (10) imply that  $H^{**}$  is not the preferred option in period 2, in which case we have

$$H^* > h. \quad (11)$$

Such a result is illustrated in Figure 3 by the move  $H = H^{**}$  to  $H = H^*$ . Thus, we have the hours profile illustrated in Figure 2(b), showing that hours also rise with tenure.



As it stands, however, this particular wage-hours contract does not produce efficiency on either of the labour margins. Through (8),  $w_2 = w_a + M + E(\eta|\eta > \eta^*)$ ; that is the worker is paid his expected productivity. The worker is fired by the firm if the wage is greater than actual productivity, that is  $w_2 > w_a + M + \eta$ . Thus, the critical value of  $\eta$  at which the worker is fired is  $\eta^* = w_2 - M - w_a$ . But substituting for  $w_2$  from (8) implies that  $\eta^* = E(\eta|\eta > \eta^*)$  which only occurs when  $\eta^*$  is the upper bound of  $\eta$  or when almost all workers are fired. On the other hand, using (4) and (8), the critical value of  $\theta$  at which the worker quits is  $\theta^* = w_a h/H - w_2 - [D(h) - D(H)]/H$ . Combining this quit rule with (7) gives  $\theta^* = E(\theta|\theta > \theta^*)$  which occurs when almost all workers quit. In essence, the contract with  $k = 1$  is roughly equivalent to a spot market solution since almost all workers will quit/be fired before the second period, effectively resulting in no training taking place.

### 5. Marginal hours compensated at a premium wage rate

We now consider the payment of a wage premium which renders pay on marginal hours to be greater than hourly straight-time pay; that is  $k > 1$  in (6). We begin by establishing that this serves to counter the contract inefficiency outlined above.

With  $k > 1$ , the solutions which maximise joint wealth in (3) - equivalent to (7) and (8) for the case where  $k = 1$  - are given by (A20) of Results Appendix (a):

$$-\{M + E(\theta|\theta > \theta^*) + w_a - w_a \cdot h/H + [D(h) - D(H)]/H\} = -[w_a + M - k \cdot w_2] \quad (12)$$

and, using (A22) from Results Appendix (a),

$$-[M + E(\eta|\eta > \eta^*)] = -[w_2 \cdot (\gamma + 1) - w_a] \quad (13)$$

where  $\gamma = (k-1) \cdot (1 - h/H) > 0$ .

If the firm solves (12) and (13) simultaneously, it will attain an optimal wage-hours  $(w_2^*, H^*)$  contract, conditional on the level of premium,  $k$ . In order to see how the inefficient quit rule of the previous section (i.e. for  $k = 1$ ) has been overcome, we combine (12) with the quit rule  $\theta^* = w_a h/H - w_2 - [D(h) - D(H)]/H$  to obtain  $\theta^* = E(\theta|\theta > \theta^*) - w_2 \cdot (k-1) \cdot h/H$ . Note that in the previous model formulation (i.e. with  $k = 1$ ) the critical value of  $\theta$  at which the worker quits is given by  $\theta^* = E(\theta|\theta > \theta^*)$  which occurs when almost all workers quit. In the new equivalent result, the overtime premium provides a wedge that serves to satisfy the necessary condition for *ex ante* joint wealth maximisation. The introduction of the premium allows the attainment of a similar optimal solution with respect to firing: combining (13) with the fire rule  $\eta^* = w_2 - M - w_a$  we obtain  $\eta^* = E(\eta|\eta > \eta^*) - \gamma \cdot w_2$ .

Before we look more closely at the implications of (13), we need to tackle the question of whether there exists a  $k$  that maintains (i)  $w_2^* > w_a$  and (ii)  $H^* > h$ . We find that the answer is yes. From (8), we know that if  $k=1$  then

$$w_2^* > w_a. \tag{14}$$

By assuming continuity, there exists a  $k_{\max_1} > 1$  such that if  $k \in [1, k_{\max_1}]$  then  $w_2^* > w_a$  from (13). So the well-known result that the contractual wage rate increases with tenure is retained. Similarly, we also know that if  $k=1$  then  $\partial\theta^*/\partial H < 0$  and  $\partial\eta^*/\partial H < 0$  from (9) and (10). By the continuity assumption, there exists a  $k_{\max_2} > 1$  such that if  $k \in [1, k_{\max_2}]$  then  $\partial\theta^*/\partial H \leq 0$  and  $\partial\eta^*/\partial H \leq 0$ . That is, the working hours allocated to the trained workers can induce efficient turnover. The implied premium profile is shown in Figure 3. Parallel to the developments in the previous section, it can be shown that

$$H^* > h \tag{15}$$

for any  $k$  if  $1 < k \leq \min [k_{\max_1}, k_{\max_2}]$ .

From (13), it can be shown that

$$k \cdot w_2 > \text{MPL}_2 = w_a + M + E(\eta | \eta > \eta^*) > w_2 \quad (16)$$

or premium pay is higher than the expected marginal product of labour in period 2 ( $\text{MPL}_2$ ), while the straight-time wage is lower than  $\text{MPL}_2$ .

The payment of a wage premium  $k > 1$  for hours  $(H - h)$  allows the parties to achieve an optimal wage-hours contract that consists of second-period wages and hours that are higher than their first-period equivalent values. By contrast, there are inefficient quits and layoffs if the premium is set to unity, that is if a single wage is paid in the second period. This would seem to imply that an increase in  $k$  is associated with reductions in separations. This is confirmed formally in Results Appendix (a) (see (A24) and (A25)). It is shown that there exists a  $k_{\max_3} > 1$  such that if  $k \in (1, k_{\max_3}]$  then

$$\partial \theta^* / \partial k < 0 \quad (17)$$

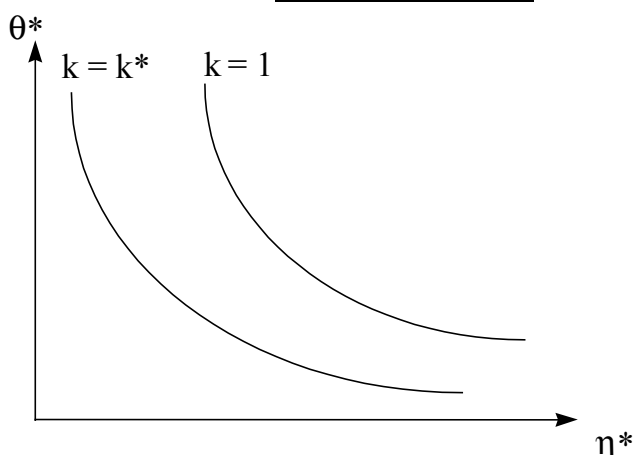
and

$$\partial \eta^* / \partial k < 0 . \quad (18)$$

Figure 4 illustrates the effect of an increased  $k$  on the quit/layoff decisions.



**Figure 4: Premium payments and efficient turnover**



On the worker's side, the results in (17) are quite straightforward. Since overtime is remunerated at a premium rate in excess of marginal product, it is unsurprising that a rise in  $k$  will lead to a higher  $H$  and a lower quit probability. But these outcomes appear to fall short of providing contract optimality from the firm's viewpoint (see (18)). While  $k > 1$  provides a desirable instrument towards achieving a contractual solution on the two margins, the firm would be reluctant to raise the proportion of premium payments within total labour costs in the absence of offsetting cost reductions. In other words, this would act merely to raise the worker's surplus. However, the optimal wage-hours contract contains an in-built compensating differential. We find from (13) that

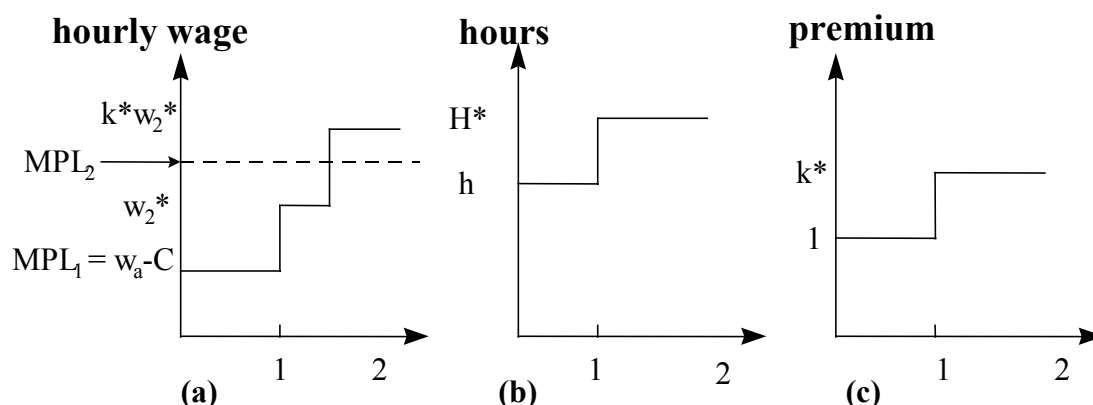
$$\frac{\partial w_2}{\partial k} < 0$$

or there is an inverse relationship between the contractual wage and the overtime premium. Therefore, there exists an "optimal automatic compensating differential rule". A compensating differential reaction in the straight-time wage to an increase in  $k$  is embedded in the contract solution and therefore (18) holds.

The full solution to the contract is as follows. Let  $k^* = \min\{k_{\max_1}, k_{\max_2}, k_{\max_3}\}$ . Then (9), (10), (14), (15), (17) and (18) will all hold. Given  $k^*$ , solving (12) and (13) simultaneously gives us  $w^*$  and  $H^*$ . And then  $(w_2^*, H^*, k^*)$  forms the efficient contract. The solutions are illustrated graphically in Figure 5.

To the extent that these overtime outcomes are feasible, the model predicts that, as with straight-time hourly wages, hours should rise with job tenure. Hart and Ma (2000) provide strong empirical support for this contention. We note that the life cycle models of Ghez and Becker (1975) predict that hours supplied to the market place would be positively related to the price of time over the life cycle. Consistent with this approach is the expectation that workers would contribute their highest average hours when they are most productive, that is in the middle years of their work experience.

As illustrated in Figure 5 (a), the payment of an hours premium in order to effect efficient turnover produces the result that the worker is paid more than marginal product in period 2. Suppose that weekly compensation is based on  $x$  number of straight time hours and  $y$  number of overtime hours. The optimal payments configuration is to pay the former hours at below and the latter hours above their respective marginal products.

**Figure 5: Wage, hours, and premium profiles**

In Lazear (1981), the wage mark-up is paid in later years of job tenure and is interpreted as a long-run incentive-compatible form of compensation. The equivalent long-term explanation in the present paper relates to wage premiums designed to encourage longer working time given specific human capital accumulation over the length of job experience. In Carmichael (1983), the central argument is also a long-term one; wages above marginal product result from seniority-based promotions. However, a comparative advantage of the wage-hours model is that it also encompasses a *short-term* rationale. For *given* levels of human capital, it may pay the firm to offer an incentive to work longer hours in order to protect reduce sub-optimal separations.

## 6. Effects of statutory overtime regulations

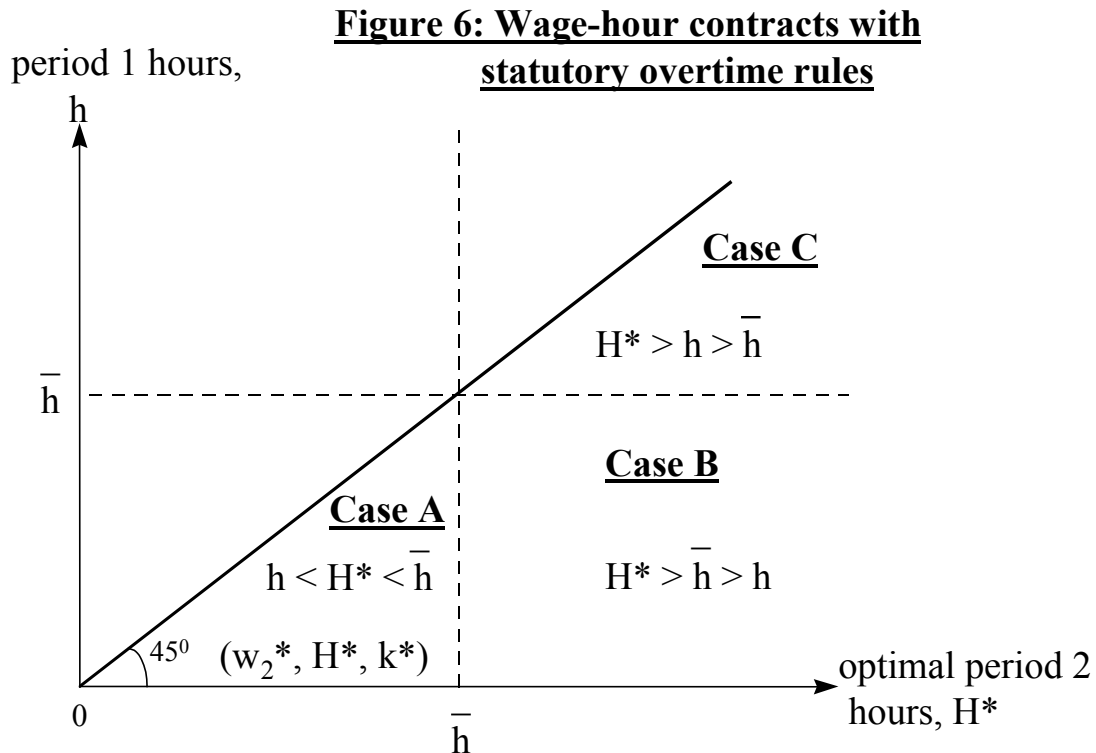
The wage-hours contract developed in the previous section involves the parties reaching agreement on optimal values of the straight-time wage, the overtime premium and the length of per-period hours. In several OECD economies, statutory overtime pay restrictions limit negotiated degrees of freedom as far as setting the premium is concerned (OECD Employment Outlook, 1998). As mentioned in the

introduction, the usual policy objective behind overtime legislation is to encourage employment expansion by raising marginal cost on the intensive relative to the extensive labour margin. Among the most stringent, comprehensively binding, and simplest sets of legislative measures is the US Fair Labor Standards Act (FLSA). Under FLSA rules, covered workers must be paid an overtime wage of at least one and one-half times the straight-time wage for weekly hours in excess of 40. Let these hours and premium constraints be denoted, respectively, by  $\bar{h}$  and  $\bar{k}$  (i.e.  $\bar{h} = 40$ ,  $\bar{k} = 1.5$ ). Here, we discuss several implications of our model in relation to this Act.

If we rule out short-time working, Figure 6 illustrates three cases between actual straight-time hours worked in period 1 ( $h$ ), maximum permitted straight-time hours before a premium must be paid ( $\bar{h}$ ), and optimal second period hours ( $H^*$ ). All period 2 contracts under the legislation - indicated as either Case A or Case B or Case C - occur at or below the  $45^\circ$  line given that period 2 hours are greater than period 1 hours. Here, we present a non-exhaustive discussion different possible contracts.

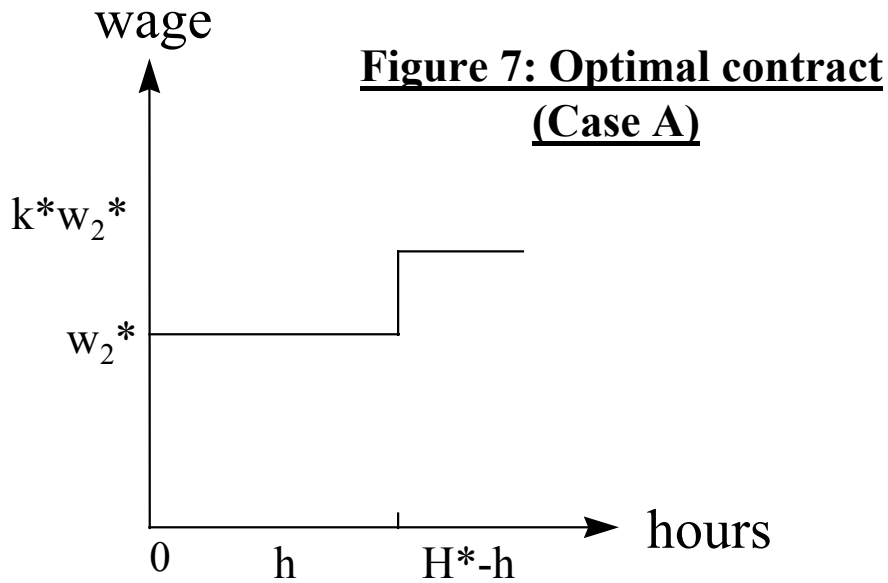
### **Case A**

The simplest case in terms of the previous analysis concerns the outcome  $h < H^* \leq \bar{h}$ . Period 2 hours are above those in period 1 but below the mandatory maximum that trigger overtime regulations. As illustrated in Figure 7, the optimal contract would be one whereby the internal premium  $k^*$  is paid on hours  $H^*-h$ . The implication is that it



would be optimal to pay a premium on marginal hours (i.e.  $H^*-h$ ) despite no compulsion so to do. This outcome is consistent with the interesting observation that a significant proportion of US firms pays an overtime premium even when weekly hours are *below* the statutory minimum set under FLSA rules. Trejo (1993) presents 1985 Current Population Survey data which reveal that over 20 per cent of workers sampled receive premium pay for hours less than the 40 hour limit; in fact, for 10 per cent of workers, the premium started at 34 hours or less.<sup>4</sup> Moreover, both union and non-union workers display similar percentages in these respects.

<sup>4</sup> Although due to (an under-recorded) anomaly resulting from the fact that some workers receive overtime pay according to a daily standard, Trejo reports that the figures may exaggerate the frequency with which workweek standards other than the 40-hour standard may occur.

**Case B**

A commonly occurring case is that of  $H^* > \bar{h} \geq h$  and  $\bar{k} > k^*$ .<sup>5</sup> These relative outcomes fit with the work-sharing policy-logic discussed above. Two related labour market issues arise.

**(i) Compensating differentials**

Trejo (1991) presents U.S. empirical evidence that firms mitigate rises in mandatory premium payments by reducing straight-time wages. This response accords with the so-called 'fixed-job' model whereby firms and workers adhere to agreed compensation packages by lowering straight-time wages in response to increases in overtime premium pay or overtime eligibility. Our model provides theoretical justification for such behaviour by the two parties. Equation (15) in the previous section shows that an automatic compensating differential rule is integral to the optimising behaviour suggested by the wage-hours model. A rise in  $k$  due to

<sup>5</sup> If  $k^* \geq \bar{k}$ , then the analysis is effectively the same as under Case A.

legislation will result in an agreed offsetting lowering of  $w_2$ . Worker compensation and the outside opportunity will be left unaffected with no incentive to expand employment.

### **(ii) Non-compliance**

Based on late-1970s data, Ehrenberg and Schumann (1982, Ch. 5) indicate that a 10 percentage rate of non-compliance with the FLSA regulations would constitute a conservative estimate (see also Trejo, 1993). If the parties seek this illegal strategy, what type of non-compliance might appear to be most mutually advantageous? The firm and its workers may reach an implicit agreement at the beginning of period 1 to work “unpaid” hours in period 2 to the extent that the value of  $k$ , averaged over paid and unpaid overtime hours, is equal to  $k^*$ .<sup>6</sup> One such agreement along these lines is illustrated in Figure 8 (a). Here, the parties agree to work paid and unpaid hours in period 2 that solves

$$k^*.w_2^*. (H^*-h) = (\bar{h} - h).k^*.w_2^* + \bar{k} H_p + 0.H_u$$

where, in period 2,  $H_p$  is paid-for and  $H_u$  is unpaid-for hours. Under this arrangement, the firm pays for hours in excess of period 1 straight-time hours and up to  $\bar{h}$  at the optimal premium rate and tackles the problem of  $\bar{k} > k^*$  by manipulation of the length of unpaid overtime. This latter exercise determines  $H_p$  and  $H_u$  as

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<sup>6</sup> Unpaid overtime is quantitatively very significant in the U.K. While there are no national-level overtime regulations in this economy, premium pay and the maximum level of straight-time pay may be set at industry-level - such as in the engineering industry - and effectively act as mandatory rules for relevant firms. The mandatory overtime-related reason for working unpaid hours could be one of several explanations of this phenomenon, as discussed by Bell and Hart (1999).

$$H_p = \frac{k^*}{\bar{k}}(H^* - h)$$

and

$$H_u = \left| 1 - \frac{k^*}{\bar{k}} \right| (H^* - h).$$

As with Case A, the firm pays a premium before mandatory hours,  $\bar{h}$ , are reached. An alternative strategy to achieve  $k^*$  is to agree to commence paying the premium  $k = \bar{k}$  for hours above  $h$ .<sup>7</sup>

In the absence of a downward adjustment of  $w_2$ , or some form of non-compliance,  $\bar{k} > k^*$  implies that either  $\bar{h}$  or  $\bar{k}$  become binding. The former outcome is illustrated in Figure 8 (b) where no overtime would be undertaken.

### **Case C**

An analysis parallel to Case B applies here; for example, non-compliance incentives are again relevant.

## **7. Conclusions and future developments**

Overtime premium payments are an important variable in labour market economics and macroeconomics because, in many instances, they represent the marginal cost of labour input. Earlier explanations as to why firms operate overtime schedules include the need to provide extra compensation in order to cover rush orders, high seasonal

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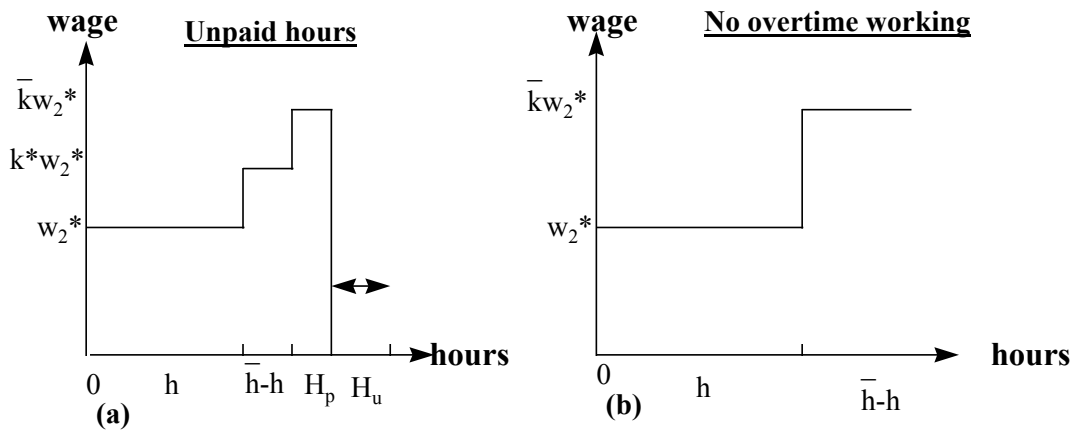
<sup>7</sup> Under this agreement,  $k^*.w_2^*. (H^* - h) = (\bar{h} - h). w_2^* + \bar{k}. H_p. w_2^* + 0.H_u$ , in which case  $H_p = [h - \bar{h} + k^*(H^* - h)] / \bar{k}$  and  $H_u = H^* - [h - \bar{h} + k^*(H^* - h)] / \bar{k}$ .



demand, and work scheduling involving irregular or abnormal hours requirements.

These reasons may be important but they tend to be derived *either* from purely

**Figure 8: Case B contracts**



supply-side arguments *or*, more usually, from *ad hoc* economic reasoning. Here, we offer a new approach to understanding the use of premium payments based on a more general wage contract formulation. Our model allows for changes in labour inputs on the extensive (workers) and intensive (working hours) margins. It also incorporates information asymmetries between workers and firms. We show that it is in the interest of the firm and its workforce to increase *both* wages and hours once investments have been sunk. However, the payment of a wage premium for additional hours is required in order to achieve an optimal wage-hours contract. Our results are consistent with a number of recent important empirical findings concerning the operation of overtime working.

This modelling framework could no doubt benefit from further modifications and refinements. One particular area is worthy of future research. Unlike the treatment of productivity and job satisfaction, we assume that the parties can agree with certainty over the length of job-task completion times. In other words, hours of work are not

subject to randomness and problems of asymmetric information. In important instances, however, the firm and its workers may be uncertain over the completion times of given tasks, especially in jobs requiring significant degrees of independent worker decision making and initiative. Management and professional occupations would be particularly relevant in this respect. Integrating this possibility could clearly lead to modifications of results and conclusions.

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## Results Appendix

### (a) Joint wealth maximisation

In order to illustrate the optimisation with respect to the joint wealth defined in (3) in the main text, we begin by presenting a number of useful lemmas.

#### Lemma 1

$$\frac{d}{du} \int_{a(u)}^{b(u)} g(x,u) dx = \int_{a(u)}^{b(u)} \frac{\partial g}{\partial u} dx + g(b,u)b' - g(a,u)a'$$

#### Lemma 2

$$dQ/d\theta^* = q(\theta^*) \quad \text{and} \quad dF/d\eta^* = f(\eta^*)$$

**Proof.** From (1), (2) and lemma 1.

**QED.**

#### Lemma 3

$$1 - Q = \int_{\theta^*}^{\infty} q(\theta) d\theta \quad \text{and} \quad 1 - F = \int_{\eta^*}^{\infty} f(\eta) d\eta$$

#### Lemma 4

$$E(\theta | \theta > \theta^*) = \frac{1}{1 - Q} \int_{\theta^*}^{\infty} \theta q(\theta) d\theta$$

$$E(\eta | \eta > \eta^*) = \frac{1}{1 - F} \int_{\eta^*}^{\infty} \eta f(\eta) d\eta$$

#### Lemma 5

$$\frac{dE(\theta | \theta > \theta^*)}{d\theta^*} > 0 \quad \text{and} \quad \frac{dE(\eta | \eta > \eta^*)}{d\eta^*} > 0$$

#### Proof

$$\frac{dE(\theta|\theta > \theta^*)}{d\theta^*} = -\frac{\theta^* q(\theta^*)}{1-Q} + \frac{q(\theta^*) \int_{\theta^*}^{\infty} \theta q(\theta) d\theta}{(1-Q)^2} = \frac{q(\theta^*)}{(1-Q)^2} \int_{\theta^*}^{\infty} (\theta - \theta^*) q(\theta) d\theta > 0$$

Similar proof applies to  $dE(\eta|\eta > \eta^*)/d\eta^*$ .

**QED.**

To maximise  $W$  defined in (3) in the main text, we first collect the item

$[wa.h - C - D(h)]$  in  $W$ :

$$\begin{aligned} W &= [wa.h - C - D(h)] && \text{(defined as X)} \\ &+ [F + (1-F)Q][wa.h - D(h)] && \text{(defined as Y)} \\ &+ (1-F)(1-Q)\{wa.H + H.M + H.E(\eta|\eta > \eta^*) + H.E(\theta|\theta > \theta^*) - D(H)\} && \text{(defined as Z)} \\ &= X + Y + Z && \text{(A1)} \end{aligned}$$

The first order conditions to max  $W$  in (A1) are:

$$\partial W / \partial \theta^* = 0 \quad \text{and} \quad \partial W / \partial \eta^* = 0$$

To derive  $\partial W / \partial \theta^* = 0$  firstly:

$$\partial X / \partial \theta^* = 0 \tag{A2}$$

$$\partial Y / \partial \theta^* = (1-F) \cdot [dQ/d\theta^*] \cdot [wa.h - D(h)] = (1-F) \cdot q(\theta^*) \cdot [wa.h - D(h)] \tag{A3}$$

(from lemma 2)

Rewrite  $Z$  into:

$$Z = (1-F)(1-Q) \left| wa.H + M.H + \frac{\int_{-\infty}^{\theta^*} \eta f(\eta) d\eta}{1-F} H + \frac{\int_{-\infty}^{\theta^*} \theta q(\theta) d\theta}{1-Q} H - D(H) \right| \tag{A4}$$

(from lemma 4)

Substituting (1) and (2) from the main text into (A4), we have:

$$Z = \int_{\theta^*}^{\infty} \int_{\eta^*}^{\infty} [w_a.H + M.H + \eta.H + \theta.H - D(H)]q(\theta)f(\eta)d\theta d\eta \quad (\text{A5})$$

Differentiating (A5) with respect to  $\theta^*$ , we have:

$$\begin{aligned} \frac{\partial Z}{\partial \theta^*} &= - \int_{\eta^*}^{\infty} [w_a.H + M.H + \eta.H + \theta.H - D(H)]q(\theta^*)f(\eta)d\eta \\ &= - (1-F).q(\theta^*). \{w_a.H + M.H + H.\theta^* + H.E(\eta|\eta > \eta^*) - D(H)\} \end{aligned} \quad (\text{A6})$$

Therefore,

$$\begin{aligned} \partial W / \partial \theta^* &= \partial X / \partial \theta^* + \partial Y / \partial \theta^* + \partial Z / \partial \theta^* \\ &= - [-w_a.h + D(h) + w_a.H + M.H + H.\theta^* + H.E(\eta|\eta > \eta^*) - D(H)].(1-F).q(\theta^*) = 0 \end{aligned} \quad (\text{A7})$$

By symmetry,

$$\partial W / \partial \eta^* = - [-w_a.h + D(h) + w_a.H + M.H + H.\eta^* + H.E(\theta|\theta > \theta^*) - D(H)].(1-F).f(\eta^*) = 0$$

(A8)

Information concerning job satisfaction and productivity cannot be exchanged *ex post*.

A necessary condition for achieving a constrained optimal contract derives from (A7)

and (A8). The contract is offered to ensure that workers will quit whenever job

satisfaction is too low, i.e.

$$\theta < \theta^* = - \{M + E(\eta|\eta > \eta^*) - w_a.h / H + w_a + [D(h) - D(H)] / H\} . \quad (\text{A9})$$

(from (A7))

Equivalently, the firm will fire the workers whenever productivity is too low, i.e.

$$\eta < \eta^* = - \{M + E(\theta|\theta > \theta^*) - w_a.h / H + w_a + [D(h) - D(H)] / H\} . \quad (\text{A10})$$

(from (A8))

[Equations (A9) and A(10) are (4) and (5) in the main text, respectively.]

These conditions imply that the party wishing to separate must be made to internalise the entire expected losses from the separation.

Next we show that it is possible to formulate a wage-hour contract in terms of the parameters of  $\eta^*$  and  $\theta^*$  to satisfy (A9) and (A10).

The firm will fire the worker if return is below the second period wage, that is if

$$w_a + M + \eta < w_2$$

or

$$\eta < \eta^* = -(w_a + M - w_2) \quad (\text{A11})$$

Substituting (A10) into (A11) gives:

$$-\{M + E(\theta|\theta > \theta^*) - w_a \cdot h / H + w_a + [D(h) - D(H)] / H\} = -(w_a + M - w_2)$$

or

$$-\{E(\theta|\theta > \theta^*) - w_a h / H + [D(h) - D(H) / H]\} = w_2 . \quad (\text{A12})$$

(This is equation (7) in the main text.)

The worker will quit if second period return is less than the outside opportunity, that is if

$$H \cdot w_2 + H \cdot \theta - D(H) < w_a \cdot h - D(h)$$

or

$$\theta < \theta^* = w_a \cdot h / H - w_2 - [D(h) - D(H)] / H . \quad (\text{A13})$$

Substituting (A9) into (A13) gives:

$$w_2 = w_a + M + E(\eta|\eta > \eta^*) = \text{MPL}_2 \quad (\text{A14})$$

where  $\text{MPL}_2$  is the expected productivity of the worker.

[(A14) is equation (8) in the main text.]

If the firm solves (A12) and (A14) simultaneously, it will achieve an optimal wage-hour  $(w_2^*, H^*)$  contract.

Can working hours allocated in the post-investment period serve to induce efficient turnover? That is, do we obtain  $\partial\theta^*/\partial H < 0$  and  $\partial\eta^*/\partial H < 0$ ? Substituting (A14) into (A12) and multiplying H on both sides produces

$$-H.E(\theta|\theta>\theta^*) + w_a \cdot h - D(h) + D(H) = w_a \cdot H + M \cdot H + H.E(\eta|\eta>\eta^*) . \quad (\text{A15})$$

Given  $\eta^*$ , differentiating (A15) gives

$$\partial\theta^*/\partial H = - [E(\theta|\theta>\theta^*) - D'(H) + w_a + M + E(\eta|\eta>\eta^*)] / [H \cdot dE(\theta|\theta>\theta^*)/d\theta^*] . \quad (\text{A16})$$

If the marginal disutility of working  $D'(H)$  is less than the sum of the second period wage rate and the expected job satisfaction, then

$$\partial\theta^*/\partial H < 0 \quad (\text{A17})$$

(by Lemma 5).

By symmetry,

$$\partial\eta^*/\partial H = - [E(\theta|\theta>\theta^*) - D'(H) + w_a + M + E(\eta|\eta>\eta^*)] / [H \cdot dE(\eta|\eta>\eta^*)/d\eta^*] . \quad (\text{A18})$$

Again, if the marginal disutility of working  $D'(H)$  is less than the combined value of the second period wage and expected job satisfaction, then

$$\partial\eta^*/\partial H < 0 . \quad (\text{A19})$$

(by Lemma 5).

[Equations (A17) and (A19) are (9) and (10) in the main text respectively.]

Therefore, within the marginal disutility constraints, equations (A17) and (A19) state that an increase in hours in the post-investment period will reduce the probability of separation.



### An efficient contract with a marginal hours' premium

Now we consider that additional working hours are compensated at a premium,  $k$ , where  $k > 1$ .

Firstly, if the firm decides to fire a worker, then equations (A11) and (A12) should be modified as the marginal product is now  $k.w_2$ . Thus, (A12) becomes

$$-\{ M + E(\theta|\theta>\theta^*) + w_a - w_a.h/H + [D(h)-D(H)]/H \} = - [w_a + M - k.w_2 ]$$

(This is equation (12) in the main text)

or

$$-\{ E(\theta|\theta>\theta^*) - w_a.h/H + [D(h)-D(H)]/H \} = k.w_2 . \quad (A20)$$

The premium also alters the worker's decision to quit:

$$w_2.h + k.w_2.(H-h) + \theta.H - D(H) < w_a.h - D(h)$$

or

$$\theta < \theta^* = w_a.h/H - w_2.h/H - k.w_2.(1 - h/H) - [D(h) - D(H)]/H. \quad (A21)$$

Substituting (A9) into (A21) gives:

$$- [M + E(\eta|\eta>\eta^*)] = -[ w_2.(\gamma+1) - w_a ] \quad (A22)$$

where  $\gamma = (k-1).(1 - h/H) > 0$ .

(This is equation (13) in the main text.)

That is:

$$w_2 = [ w_a + M + E(\eta|\eta>\eta^*) ] / (\gamma+1) < MPL_2 = w_a + M + E(\eta|\eta>\eta^*). \quad (A23)$$

If the firm solves (A20) and (A22) simultaneously, it will attain an optimal wage-hour  $(w_2^*, H^*)$  contract, conditional on the level of premium,  $k$ .

Now we turn to discuss the implications of this optimal contract.

First, as we discussed in the main text, we know that if  $k=1$  then  $\partial\theta^*/\partial H < 0$  and  $\partial\eta^*/\partial H < 0$  from (A17) and (A19). By the continuity assumption, there exists a  $k_{\max_2} > 1$  such that if  $k \in (1, k_{\max_2}]$  then  $\partial\theta^*/\partial H \leq 0$  and  $\partial\eta^*/\partial H \leq 0$ . That is, the working hours allocated to the trained workers can induce efficient turnover under the premium scheme.

Second is to establish that the premium can further induce efficient turnover; i.e.

$$\partial\theta^*/\partial k < 0 \quad (\text{A24})$$

and

$$\partial\eta^*/\partial k < 0. \quad (\text{A25})$$

Re-write (A24) and (A25) as:

$$\partial\theta^*/\partial k = (\partial\theta^*/\partial H) \cdot (\partial H/\partial k) \quad (\text{A26})$$

and

$$\partial\eta^*/\partial k = (\partial\eta^*/\partial H) \cdot (\partial H/\partial k). \quad (\text{A27})$$

We know that  $\partial\theta^*/\partial H < 0$  and  $\partial\eta^*/\partial H < 0$  for small  $k > 1$ . Hence to show (A24) and (A25) hold we need only to demonstrate that

$$\partial H/\partial k > 0 \quad (\text{A28})$$

for some  $k > 1$ . The logic is that if increasing  $k$  from  $k = 1$  would increase working hours  $H$  and increasing  $H$  will reduce sub-optimal separation, then a premium  $k > 1$  would improve efficiency.

In Results Appendix result (c) it is shown that if  $k=1$  then  $dH/dk > 0$ . Hence by the continuity assumption, there exists a  $k_{\max_3} > 1$  such that if  $k \in (1, k_{\max_3}]$  then  $dH/dk > 0$ . This establishes (A24) and (A25).

**(b) First- and second-period hours**

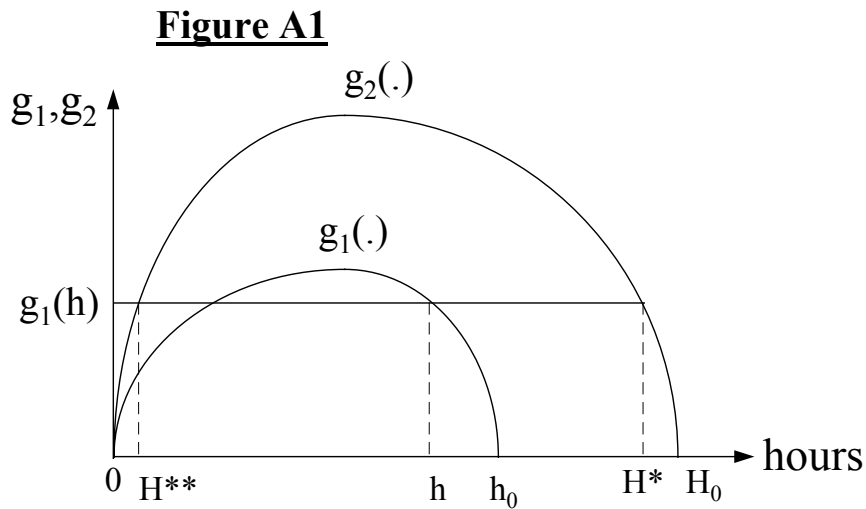
For any  $h \in (0, h_0)$  (where  $h_0$  satisfies  $w_a(h_0) - D(h_0) = 0$ ), equation (7) in the main text has two solutions  $H^*$  and  $H^{**}$  which satisfy  $0 < H^{**} < h < H^*$  if  $D(0) = 0$ ,  $D'(\cdot) > 0$  and  $D''(\cdot) < 0$ .

**Proof**

Equation (7) is the same as (A12) in Results Appendix (a). By substituting (A14) into (A12) we obtain (A15). Re-write equation (A15) as

$$w_a \cdot h - D(h) = H \cdot [w_a + M + E(\eta | \eta > \eta^*) + E(\theta | \theta > \theta^*)] - D(H)$$

Let  $w_b \equiv w_a + M + E(\cdot) + E(\cdot)$  and so we have  $w_b > w_a > 0$ . Define  $g_1(h) \equiv w_a \cdot h - D(h)$  and  $g_2(H) \equiv w_b \cdot H - D(H)$ . Since  $g_1''(h) = D''(h) < 0$  and  $g_2''(H) = D''(H) < 0$  both  $g_1(h)$  and  $g_2(H)$  are concave (see Figure A1). Also,  $g_2(x) - g_1(x) = (w_b - w_a)x > 0$  for any  $x > 0$ .



Hence  $H_0 > h_0 > 0$  where  $g_2(H_0) = g_1(h_0) = 0$ . From Figure A1, for any  $h \in (0, h_0)$  there are two solutions  $H^*$  and  $H^{**}$  for equation  $g_1(h) = g_2(H)$  and  $0 < H^{**} < h < H^*$ . **QED.**

**(c) The relation between second-period hours and the overtime premium**

We show here that (A28),  $\partial H/\partial k > 0$ , holds provided that  $k$  and the disutility of working are not too large.

Substituting (A23) into (A20) produces

$$(1+\gamma).[-E(\theta|\theta>\theta^*) + w_a.h/H - D(h)/H + D(H)]/H = k.[w_a + M + E(\eta|\eta>\eta^*)] \quad (C1)$$

where  $\gamma = (k-1).(1 - h/H) > 0$ .

Differentiating (C1) gives

$$A.[-h/H^2.dH + dk.(1-h/H) + (k.h/H^2).dH] + (1+\gamma).B.dH = G.dk \quad (C2)$$

where

$$A = -E(\theta|\theta>\theta^*) + w_a.h/H - D(h)/H + D(H)/H = k.w_2 > 0 \quad (C3)$$

$$B = w_a.h/H^2 + D(h)/H^2 + D'(H)/H - D(H)/H^2 > 0 \text{ (if } D(H) \text{ is not too large)} \quad (C4)$$

$$G = w_a + M + E(\eta|\eta>\eta^*) > 0 \quad (C5)$$

From (C2):

$$\frac{\partial H}{\partial k} = \frac{G - A \left| 1 - \frac{h}{H} \right|}{(1+\gamma).B + A \left( \frac{-h + kh}{H^2} \right)} > 0 \quad (C6)$$

where

$$G - A(1-h/H) = w_a.h/H + M + E(\eta|\eta>\eta^*) + E(\theta|\theta>\theta^*) + D(h)/H - D(H)/H > 0 \quad (C7)$$

if  $D(H)$  is not too large. Both (C4) and (C7) would be satisfied if marginal disutility is constant (i.e. a linear disutility function) or the increase in disutility from period 1 to period 2,  $D(H) - D(h)$ , is less than the wage earning of period 1,  $w_a.h$ .

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