Working Time Regulation in a Search Economy with Worker Moral Hazard*

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Abstract

This paper analyzes the consequences of a working time reduction within an integrated shirking-matching model. Under "laissez faire", workers and employers bargain over wages and working hours. When unemployment is high, the no-shirking condition is binding and the number of working hours is lower than the level that would be negotiated in the absence of unobservable shirking. In this case, a work-sharing policy increases aggregate employment. At the opposite, for low unemployment countries, the no-shirking condition does not bind and a working time regulation always worsens the labour market situation.

Keywords: working time; unemployment; matching; shirking.
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1 Introduction

Following a judgment from the European Court in 1996 asking Britain to comply with European Union rules on working hours, prime minister John Major just replied that "*there is no need to regulate working hours*".[1] The comparatively strong performance of the British labour market and the fact that the UK has the longest average working week among EU countries, with little regulation of working time (Roche *et alii*, 1996), seem to support this point of view. The UK example notwithstanding, other EU countries (Belgium, France, Germany, Italy) have seriously considered the regulation of working time as a policy to enhance employment. Is there a theory able to conciliate these views by showing that while a cut in working hours hurts low unemployment countries, it may promote job creation in high unemployment countries?

To address this issue, our paper analyzes the consequences of working time regulation policies within a search-matching model of the labour market that incorporates efficiency wage considerations. Our proposed synthesis of the matching and the shirking approaches provides a framework for assessing the effects of an economic policy on wages and employment. The model predicts that work sharing without full wage compensation can promote job creation if the level of the unemployment rate is above some threshold. In contrast, low unemployment countries gain nothing from regulating working time. The origin of this result lies in the wage formation which is endogenously modified above a certain threshold of the unemployment rate.

In contrast to the previous literature, this paper takes into account several aspects of the wage formation within an uniform set-up. Workers have some bargaining power allowing them to ask for a fraction of the recruiting costs borne by firms (an insider-outsider approach), and employers' information about workers' effort is imperfect (an efficiency wage approach). Consequently, the wage can take two forms depending on whether efficiency wage considerations matter or not.

We assume that under *laissez faire* workers and employers bargain over wages and working time. In the *regulated* equilibrium, the government intervenes by laying down a statutory level of working hours, so that workers and firms can only bargain over wages. Following the methodology proposed by Marimon and Zilibotti (2000), a work-sharing policy is said to be successful if the unemployment rate after the government's intervention is lower than that of the laissez-faire equilibrium.

[1] See The Economist (11/16/1996).

The main results of our analysis are as follows. The effectiveness of working time regulation depends on whether the no-shirking condition (NSC) is binding or not under laissez-faire. If it is binding, a reduction in working hours increases the employment level. This arises because each employer does not internalize the effects of a change in working hours on the efficiency wage paid by all other firms. Conversely, if the NSC is not binding cutting hours depresses job creation.

We demonstrate that the NSC is binding if the unemployment rate is above some threshold. This happens in our model at high levels of taxes and unemployment benefits. Consequently, our model predicts that reducing the number of working hours in high unemployment countries can reduce the unemployment rate, whereas the same policy in low unemployment countries has negative effect on the employment level. Nonetheless, our paper does not imply that regulating working hours is the most efficient policy to reduce unemployment. For instance, a government can achieve a better result by lowering taxes and unemployment benefits, which are at the origin of the high unemployment problem in our model.

We also demonstrate that the laissez-faire working time when the NSC is binding is lower than the one that would be obtained in the same economy without unobservable shirking. Hence, if efficiency wage considerations matter, workers and firm agree to reduce the working time without outside intervention. Nonetheless, a further reduction of the working time imposed by the government is employment creating. Finally, we find a negative correlation between the unemployment rate and the laissez-faire working time.

The welfare outcome of a small reduction of the working time when the NSC is binding depends on the extent of search externalities, i.e., the effects of firms' entry decisions on the vacancy filling rate and the exit rate out of unemployment. If these externalities are internalized, workers' wellbeing is reduced whereas firms' profits increase. In contrast, if workers' bargaining power is sufficiently high, a reduction in working hours may be Pareto improving. Finally, if the NSC is not binding any working time regulation generates a Pareto-dominated equilibrium.

An interesting outcome of the model is that, for some parameter values, the level of the unemployment-minimizing working time differs from the level predicted by a standard matching model without unobservable shirking and by a matching model with unobservable shirking but where workers have no bargaining power (i.e., an efficiency wage model). This feature of the model arises because a mandatory reduction of the working time can modify the determinants of the wage formation and generate a transition from one regime to another. To neglect this aspect might lead to inappropriate policy recommendations.

A simple calibration of the model reveals that a cut in working hours may increase the flow of job creation in economies that have an unemployment rate above 7.5%. For instance, it suggests that an economy with an unemployment rate of 12% and a laissez-faire working week of 40 hours should institute the 35 hour week: this would generate a fall of the unemployment rate from 12% to 10%. However, this would also imply a substantial drop in output.

A point that deserves some emphasis is that a reduction in working hours is always accompanied by a fall in wage income. Consequently, our model does not predict that a work-sharing policy with full wage compensation can be successful. Indeed, if the wage income is held constant, the flow of profits generated by a filled job decreases whereas the recruiting costs remain constant: this unambiguously leads to a reduction in the flow of job creation.

Our paper has been motivated by two recent theoretical papers studying the consequences of a working time reduction on both employment and wages. The first one by Moselle (1996) resorts to a shirking model, whereas the second one by Marimon and Zilibotti (2000) uses a matching model. Our paper offers a set-up which is consistent with those two approaches. In contrast to Marimon and Zilibotti who consider various functional forms for production and utility, we assume a constant returns to scale (with respect to the number of workers) production technology and quasi-linear utility. These simplifications allow us to combine the matching and the shirking approaches. Our shirking-matching framework determines the realm of validity of the shirking and matching approaches and offers predictions that differ from these two standard models.

Let us discuss briefly other theoretical papers related to our analysis. There are several efficiency wage models studying working time issues: Granier (1997), Hoel and Vale (1986), Moselle (1996), Rebitzer and Taylor (1995), Schmidt-Sorensen (1991).[2] In contrast to our analysis, they do not introduce search frictions and workers' bargaining power. Whereas Booth and Schiantarelli (1987), Booth and Ravallion (1993) and Calmfors (1985) consider an unionized economy, negotiations in our model are decentralized. Finally, an opposite approach to ours is taken by Brunello (1989) who assumes that information is perfect and that monitoring and turnover costs are small. A recent review of theories about working time regulation is offered by Contensou and Vranceanu (2000).

Our model is also related to Mortensen (1989), Mortensen and Pissarides (1999), and Larsen and Malcomson (1999) who study the unemployment effects of alternative wage determination mechanisms within a search equilibrium framework. In the same spirit,

[2] Hoel and Vale (1986) use the turnover version of the efficiency wage model, where the quit rate depends on the wage policy of the firm. Granier (1997), Moselle (1996) and Rebitzer and Taylor (1995) adopt the shirking model and Schimdt-Sorensen (1991) a general version of the efficiency wage model.

Ellingsen and Rosen (1997) endogenize the choice of a wage policy in a search model where wages are either posted by firms or negotiated individually with each applicant.

Finally, there is an empirical literature assessing the consequences of working time regulation policies. Experiences in Germany, France and the USA are studied by Hunt (1998). The German case is detailed in Bosch (1990) and Hunt (1999). Jacobson and Ohlsson (1996) focus on the Swedish case. In general, the evidence in support of a positive impact of a reduction in working hours on the level of unemployment is mixed: if this effect exists, it is fairly small.

This paper is organized as follows. Section 2 presents the model and its main assumptions. The two types of steady state equilibria are presented in the third and fourth sections. Section 5 studies the occurrence of each regime and characterizes the unemployment-minimizing level of working hours. Section 6 offers a numerical illustration. Limitations of the model are discussed in section 7. Section 8 concludes.

2 The model

2.1 Main assumptions

Consider an economy composed of a continuum of infinitely-lived homogeneous workers with measure normalized to one and of a continuum of identical firms which are free to enter the market. Time, denoted by t, is continuous and the discount rate of both workers and firms is equal to $r \in \mathbb{R}^+$. A worker's total endowment of labour per unit of time is normalized to one.

Each worker has an instantaneous utility

$$\mathcal{U}(x,l) = x - e(l), \tag{1}$$

where x is his total income and $l \in [0,1]$ the fraction of time devoted to work. It is assumed that the work disutility $e(.)$ is increasing, strictly convex and that $e(0) = 0$. The discounted utility of an agent whose income and working time paths are $\{x(t); t \in \mathbb{R}^+\}$ and $\{l(t); t \in \mathbb{R}^+\}$ is:

$$\int_{\mathbb{R}^+} \exp(-rt)\mathcal{U}\left[x(t), l(t)\right]\, dt$$

Following Pissarides (2000), all firms are identical and hold at most one vacancy. The production flow of a job-worker match (the *effectiveness* function), denoted by $y(l)$, is a strictly concave function of hours worked. Indeed, the more an individual works, the more he gets tired.[3] Furthermore:

$$y(0) = 0, \quad y'(0) = +\infty, \quad y'(1) < e'(1), \text{ and } y'(0) > e'(0)$$

Restrictions about $y'(.)$ and $e'(.)$ imply that there is a $l \in]0,1[$ satisfying $y'(l) = e'(l)$. Furthermore, we assume that $y(1) < e(1)$: production net of work disutility is negative for a too long working day.

The labour market has matching frictions. The flow of hirings per unit of time is $m(u,v)$ where u is the number of unemployed, v the number of vacancies, and $m(.,.)$ exhibits constant returns to scale. Furthermore, $m(0,0) = 0$, $m(+\infty,.) = m(.,+\infty) = +\infty$. Both u and v are endogenous. To facilitate the resolution of the model, it is convenient to reason on the number of vacancies per unemployed. Hence, let θ be defined as v/u, which is commonly referred to as the labour market tightness. Further, if q denotes the rate at which a vacancy fills, it is given by

$$q = \frac{m(u,v)}{v} = m\left(\frac{1}{\theta}, 1\right) \tag{2}$$

Hence, $q = q(\theta)$ with $q'(.) < 0$, $q(0) = \infty$ and $q(\infty) = 0$. The elasticity of $q(.)$ with respect to θ is $\eta \equiv \frac{-q'(\theta)}{q(\theta)}\theta$. Because of the constant returns to scale assumption, $\eta \in [0,1]$. The exit rate out of unemployment is $m(u,v)/u$. It equals $\theta q(\theta)$, which is increasing in θ. Note that the elasticity of the exit rate out of unemployment with respect to θ is $1-\eta$.

Each filled job is destroyed according to a Poisson process with the arrival rate $\delta \in \mathbb{R}^+$. As the flow out of unemployment is $m(u,v) = u\theta q(\theta)$, while the flow in is $\delta(1-u)$, the steady state (which requires these two flows are equal) is characterized by an unemployment rate equal to:

$$u = \frac{\delta}{\delta + \theta q(\theta)}. \tag{3}$$

The equilibrium unemployment rate is decreasing in θ.

A moral hazard problem is introduced by assuming that the number of effective hours worked may be different from the number of paid hours, denoted by h, and that employers cannot observe accurately their employee behavior. For simplicity, we adopt the assumption that the leisure the shirker gets out of idleness is as much as the leisure that he gets from not going to work. Finally, the shirking rate is defined by $s = (h-l)/h$.

[3] According to Hart (1987), this fatigue effect is dominant for long durations of work. However, a recent study on a panel of French firms indicates that reducing working time would not have a significant positive impact on the productivity per man hour (Gianella and Lagarde, 1999). Note that our results would not be affected if we have assumed that $y(.)$ was linear instead of strictly concave, as long as $e(.)$ is strictly convex.

Faced with this moral hazard problem, employers set up an incentive device. Following Shapiro and Stiglitz (1984), inspections occur according to a Poisson process with arrival rate $\lambda \in \mathbb{R}^+$. To prevent shirking, the firm fires any individual who is caught working less than the number of paid hours ($s > 0$). Obviously, the optimal strategy for a worker consists in either not shirking ($s = 0$) or not working at all ($s = 1$).

2.2 The value functions

The value function of an employed worker, denoted by $\mathcal{V}_E(w,h)$, satisfies the following "asset pricing" equation:

$$r\mathcal{V}_E(w,h) = \max_{s\in[0,1]} \left\{ w - e((1-s)h) + \left(\lambda 1_{]0,1]}(s) + \delta\right)(\mathcal{V}_U - \mathcal{V}_E(w,h)) \right\}, \qquad (4)$$

where $\mathcal{V}_U$ is the expected utility of an unemployed worker, w is the real wage income of employed workers (which is assumed to be stationary), and $1_{]0,1]}(.)$ is an indicator function, which is equal to unity when its argument is strictly positive and zero otherwise. According to (4), an employed worker receives wage income w and suffers work disutility $e((1-s)h)$. He becomes unemployed if the job is destroyed, with an instantaneous probability $\delta \in \mathbb{R}^+$, or if he is dismissed, with an instantaneous probability λ if $s > 0$ and 0 otherwise. As demonstrated in the appendix A1, the worker's optimal strategy is to choose $s = 0$ if and only if:

$$\mathcal{V}_E(w,h) - \mathcal{V}_U \geq \frac{e(h)}{\lambda} \qquad (5)$$

Inequality (5) is the *no-shirking condition* (NSC). To prevent shirking, an employed worker must get a rent at least as equal to $e(h)/\lambda$. Indeed, a shirker saves the work disutility $e(h)$ but bears a capital loss $\mathcal{V}_E(w,h) - \mathcal{V}_U$ if he is dismissed (an event which occurs with an instantaneous probability λ).

Similarly, the value function of the unemployed ($\mathcal{V}_U$) is given by:

$$r\mathcal{V}_U = b + \theta q(\theta) \left\{\mathcal{V}_E(w,h) - \mathcal{V}_U\right\}, \qquad (6)$$

where $b \in \mathbb{R}^+$ is the unemployment benefit and $\theta q(\theta)$ the exit rate out of unemployment. If $\mathcal{V}_U$ represents the "asset" value of search activity, eq. (6) simply states that the opportunity cost of holding it, $r\mathcal{V}_U$, is equal to the current income flow b plus the expected capital gain flow.

Let us turn to the determination of firms' value functions. The expected profit of a filled job, denoted by $\mathcal{V}_J(w)$, satisfies the following "asset pricing" equation:

$$r\mathcal{V}_J(w,h) = y(h) - w - \tau + \delta \left\{\mathcal{V}_V - \mathcal{V}_J(w,h)\right\}, \qquad (7)$$

where $\tau \in \mathbb{R}$ is the tax/subsidy level per filled job. The value of a vacancy, $\mathcal{V}_V$, solves the following Bellman equation:

$$r\mathcal{V}_V = -\gamma + q(\theta)\left\{\mathcal{V}_J(w,h) - \mathcal{V}_V\right\}, \tag{8}$$

where γ is the instantaneous advertising cost and $q(\theta)$ the filling rate of vacancies. Vacancies are created until their value is zero. Hence, eq. (8) yields:

$$\mathcal{V}_V = 0 \Rightarrow \mathcal{V}_J = \frac{\gamma}{q(\theta)} \tag{9}$$

In equilibrium, the value of a filled job must be equal to the average recruiting cost. By substituting this expression into (7), we obtain θ as a decreasing function of workers' real income and taxes.

$$y(h) - w - \tau = (r+\delta)\frac{\gamma}{q(\theta)}. \tag{10}$$

From eq. (10), one can see that a reduction in the number of working hours with full wage compensation increases the equilibrium unemployment rate. Indeed, cutting working hours while maintaining w constant decreases the instantaneous profits of firms (the LHS of eq. (10)) and reduces firms' incentive to open vacancies.

2.3 The bargaining

In the laissez-faire equilibrium, both wages and working time are determined by bilateral bargainings between workers and firms. For simplicity, the set of contracts is restricted to stationary wages and stationary working hours.

Our analysis departs from Pissarides (2000) and Marimon and Zilibotti (2000) by assuming that the bargaining process is subjected to the NSC. This constraint determines the minimum wage that must be paid for any level of working hours to prevent his worker from shirking. The outcome of the negotiation cannot violate the NSC otherwise the surplus of the firm would be negative. The outcome of the bargaining process matches the asymmetric Nash solution with threat points equal to the employer's and worker's respective values of continued search. A firm's threat point is zero because of the free-entry condition. A worker's threat point is $\mathcal{V}_U$ and workers' bargaining power is $\beta \in (0,1)$. Accordingly, the Nash program is:

$$\max_{\substack{w\in[0,y(h)-\tau]\\ h\in[0,1]}} \left[\mathcal{V}_E(w,h) - \mathcal{V}_U\right]^{\beta} \left[\mathcal{V}_J(w,h)\right]^{1-\beta}$$

subject to (5)

By virtue of eqs. (4) and (6), the NSC (5) can be rewritten as follows:

$$w \geq (r+\delta)\frac{e(h)}{\lambda} + e(h) + r\mathcal{V}_U \tag{11}$$

A necessary and sufficient condition for the formation of a match under transferable utility is that there exists $h \in (0,1)$ such that

$$\mathcal{V}_E(w,h) - \mathcal{V}_U + \mathcal{V}_J(w,h) = \frac{y(h) - e(h) - \tau - r\mathcal{V}_U}{r+\delta} \geq \frac{e(h)}{\lambda} \tag{12}$$

Condition (12) requires that

$$\frac{y(\widehat{h}) - e(\widehat{h}) - \tau - r\mathcal{V}_U}{r+\delta} \geq \frac{e(\widehat{h})}{\lambda} \tag{13}$$

where $\widehat{h}$ satisfies

$$y'(\widehat{h}) = \left(\frac{r+\delta}{\lambda} + 1\right) e'(\widehat{h}) \tag{14}$$

Throughout the paper, it is assumed that condition (13) holds.

— Insert fig. 1 —

The outcome of the bargaining is represented in fig. 1. The Nash solution (point A) is given by the tangency point between the Pareto frontier of the bargaining set and the highest Nash product curve.[4] When the NSC (5) is not binding the Pareto frontier is linear and the total surplus of the match is

$$\mathcal{S}^* = \frac{y(h^*) - e(h^*) - \tau - r\mathcal{V}_U}{r+\delta} \tag{15}$$

where h^* satisfies $y'(h^*) = e'(h^*)$. When the NSC (5) is binding the Pareto frontier is concave and is situated below the $\mathcal{S}^*\mathcal{S}^*$ line. In fig. 1 it is assumed that the NSC is binding. Point B will be discussed latter on.

Let us determine analytically the bargaining solution. By multiplying by $(r+\delta)$ each term of the Nash product, and by using (4) and (7), the first order conditions of this constrained program give:

$$\beta\left(\frac{y(h) - w - \tau}{w - e(h) - r\mathcal{V}_U}\right)^{1-\beta} - (1-\beta)\left(\frac{w - e(h) - r\mathcal{V}_U}{y(h) - w - \tau}\right)^{\beta} + \xi = 0, \tag{16}$$

[4]See the appendix A2 for a formal derivation of the Pareto frontier.

$$-e'(h)\beta\left(\frac{y(h)-w-\tau}{w-e(h)-r\mathcal{V}_U}\right)^{1-\beta}+y'(h)(1-\beta)\left(\frac{w-e(h)-r\mathcal{V}_U}{y(h)-w-\tau}\right)^{\beta}+$$

$$-e'(h)\xi\left(1+\frac{r+\delta}{\lambda}\right)=0, \tag{17}$$

where $\xi \in \mathbb{R}$ is the Lagrangian multiplier associated with the NSC (11).

$$\xi\left(w-(r+\delta)\frac{e(h)}{\lambda}+e(h)+r\mathcal{V}_U\right)=0 \tag{18}$$

Eq. (18) is the Kuhn-Tucker condition for the NSC (11).

Let us turn next to the equilibrium concept we use in this model.

Definition 1 *A steady state* ***laissez-faire equilibrium*** *is a 8-uplet* ($\mathcal{V}_E$, $\mathcal{V}_U$, $\mathcal{V}_J$, u, θ, w, ξ, h) *satisfying (3), (4), (6), (7), (10), (16), (17) and (18).*

In a regulated equilibrium, the government intervenes by laying down a statutory level of working hours. Consequently, workers and firms can only bargain over wages, and the outcome of the bargaining is given by (16) and (18).

Definition 2 *A steady state* ***regulated equilibrium*** *is 7-uplet* ($\mathcal{V}_E$, $\mathcal{V}_U$, $\mathcal{V}_J$, u, θ, w, ξ) *satisfying (3), (4), (6), (7), (10), (16) and (18).*

The rest of the paper proceeds as follows. We characterize the laissez-faire equilibrium in the case where the NSC is not binding and in the case where it is binding. For each case, we study the regulated equilibrium in the neighborhood of the laissez-faire. Then, we determine the complete solution of the model by specifying in which type of equilibrium the economy settles down according to the parameters values.

3 Freely-negotiated wage (FNW) equilibria

The easiest case to start is one in which the NSC is not binding. Such an equilibrium is called a FNW equilibrium.

3.1 The wage/hours choice

The NSC is not binding, $\xi = 0$. After some calculation, eqs. (16) and (17) yield:

$$w = \beta\left[y(h)-\tau\right]+(1-\beta)\left[r\mathcal{V}_U+e(h)\right], \tag{19}$$

$$y'(h) = e'(h) \tag{20}$$

Like in Pissarides (2000) who assumes the absence of unobservable shirking, the wage income is a weighted mean of worker's productivity net of taxes and worker's reservation wage.[5] The level of working hours h^* satisfying (20) is efficient in the sense that the marginal product of labour is equal to its marginal disutility. Because $y'(0) > e'(0)$ and $y'(1) < e'(1)$ then $0 < h^* < 1$. A critical feature of eq. (20) is that the length of a working day is independent of the workers' bargaining power. With two instruments in the bargaining, one (namely, h) is used to maximize the total surplus regardless of the bargaining strengths of the two players, whereas the other (namely, w) splits this surplus between the worker and the firm.

3.2 The labour market tightness

By virtue of eq. (16), the surplus of an employed worker is equal to $\beta/(1-\beta)$ times the value of a filled job, that is:

$$\mathcal{V}_E - \mathcal{V}_U = \frac{\beta}{1-\beta}\mathcal{V}_J = \frac{\beta}{1-\beta}\frac{\gamma}{q(\theta)}. \tag{21}$$

In the FNW regime, the NSC is not binding and the following inequality is satisfied:

$$\frac{\beta}{1-\beta}\frac{\gamma}{q(\theta)} \geq \frac{e(h^*)}{\lambda}, \tag{22}$$

Substitution of (21) into (6) yields the permanent income of an unemployed:

$$r\mathcal{V}_U = b + \frac{\beta}{1-\beta}\gamma\theta. \tag{23}$$

To obtain the wage income, we substitute $r\mathcal{V}_U$ given by (23) into (19).

$$w = \beta\left[y(h) - \tau + \theta\gamma\right] + (1-\beta)\left[b + e(h)\right]. \tag{24}$$

In keeping with the insider-outsider approach, each worker receives a fraction β of the average recruiting costs per unemployed ($v\gamma/u$).

Finally, the labour market tightness in the laissez faire equilibrium is obtained from the free-entry condition (10) and eq. (24):

$$(r+\delta)\frac{\gamma}{q(\theta)} = (1-\beta)\left[y(h) - \tau - e(h) - b\right] - \beta\theta\gamma, \tag{25}$$

[5] The worker's reservation wage is equal to the permanent income of the unemployed plus the work disutility.

The working time h is equal to h^* under laissez-faire, and is exogenous in case of a working time regulation. An increase in the worker's bargaining power reduces the vacancy supply per unemployed (θ) but does not modify the laissez-faire working time.[6]

In fig. 2 (a), eq. (25) is represented by a curve labelled $\widetilde{VS}$ which is $\cap$-shaped. The working time schedule given by (20) is labelled $\widetilde{WT}$ and is vertical at $h = h^*$.

Proposition 1 *Consider a laissez-faire equilibrium and assume that the NSC is not binding. Then, any small change in the working time results in an increase in the equilibrium unemployment rate.*

Proof. According to (25), the labour market tightness is an increasing function of productivity net of work disutility: it reaches a maximum in $h = h^*$. See fig. 2 (a). ■

Proposition 1 is only true for small changes in the number of working hours because we have not considered yet the possibility that the NSC may bind for larger changes in the working time. In section 5, we will show that the result of Proposition 1 holds in fact for any working time regulation.

— **Insert fig. 2** —

3.3 Welfare

The next proposition evaluates the consequences of a working time regulation on employed workers', unemployed workers', and firms' wellbeings.

Proposition 2 *Assume that the NSC is not binding under laissez-faire. Then, any regulated equilibrium in the FNW regime is Pareto dominated by the laissez faire equilibrium.*

Proof. See appendix. ■

Propositions 1 and 2 state that lowering the number of working hours raises the unemployment level and generates a Pareto dominated equilibrium.[7]

4 Efficiency wage (EW) equilibria

Let us turn to the shirking part of the model.

[6] As it has previously been mentioned, the worker's bargaining power only acts upon the splitting of the match surplus. However, under a CES specification for the utility function, Marimon and Zilibotti (2000) indicate that the worker's bargaining power influences the working time.

[7] This result is contingent upon the assumption of constant returns to scale of the production technology with respect to the number of workers (see Marimon and Zilibotti, 2000, Proposition 1).

4.1 The wage/hours choice

The NSC (5) is binding, $\xi \neq 0$. From (18), the expression of the wage income is given by:

$$w = (r+\delta)\frac{e(h)}{\lambda} + e(h) + r\mathcal{V}_U. \tag{26}$$

The efficiency wage is independent of both the worker's productivity and the worker's bargaining power. The first term on the RHS of (26) is the income flow generated by the worker moral hazard problem. The sum of the two last terms of RHS is the worker's reservation wage. Eqs (16), (17), and (26) yield the level of working hours resulting from the bargaining:

$$e(h)\,(1-\beta)\left(\frac{y'(h)}{e'(h)} - 1\right) = \left(\frac{r+\delta}{\lambda}\right)e(h) + \beta\left[e(h) + r\mathcal{V}_U + \tau - y(h)\right]. \tag{27}$$

Proposition 3 *Consider a laissez-faire equilibrium and assume that the NSC is binding. Then, the working time is smaller than the level that would prevail in the absence of unobservable shirking (i.e., $h < h^*$).*

Proof. See appendix. ■

Proposition 3 suggests that, when efficiency wage considerations matter, the worker and the firm agree to reduce the working time below the value that would prevail in the FNW regime.

The reader who has in mind that the total surplus of a match is maximized when $h = h^*$ may be puzzled by proposition 3. To see this point, remember that in the FNW regime workers and firms have two instruments in the bargaining: they use working time to maximize the surplus of the match, and the wage to split this surplus. In contrast, in the EW regime, wage is given by (26) so that there is only h left in the bargaining. Consequently, firms disagree to the splitting of the surplus imposed by the NSC if the working time is equal to h^*. This argument is illustrated in fig. 1 which represents the outcome of the bargaining when the NSC is binding. Point A represents the Nash solution and point B the surpluses of the two players if they choose the level of working hours h^* that maximizes the total surplus of the match. One can see that the Nash product is higher at point A than it is at point B.

In standard shirking models, workers have no bargaining power. If $\beta = 0$, the level of working hours chosen by employers is $\widehat{h}$ that maximizes the expected profits of a firm for given $r\mathcal{V}_U$. According to eq. (27), $\widehat{h}$ satisfies:

$$y'(\widehat{h}) = e'(\widehat{h})\left(1 + \frac{r+\delta}{\lambda}\right). \tag{28}$$

On the contrary, if workers have some bargaining power ($\beta > 0$) the laissez-faire working time in the EW regime is greater than $\widehat{h}$. Indeed, an infinitesimal increase in the working time from $h = \widehat{h}$ raises the worker's rent ($\frac{e(h)}{\lambda}$) with only a second order effect on the employer's rent. Consequently, if $h = \widehat{h}$, the Nash product can be increased by raising the working time above $\widehat{h}$.

4.2 The labour market tightness

When the NSC is binding, the rent of an employed worker is $e(h)/\lambda$. Thus, according to (6), the permanent income of unemployed workers satisfies

$$r\mathcal{V}_U = b + \theta q(\theta)\frac{e(h)}{\lambda}. \tag{29}$$

Substitution of (29) into (26) gives the implied non-shirking wage:

$$w = e(h) + b + (r+\delta)\frac{e(h)}{\lambda} + \theta q(\theta)\frac{e(h)}{\lambda}. \tag{30}$$

Wages depend positively on work disutility and the exit rate out of unemployment. From (10) and (30), we obtain the value of θ in equilibrium.

$$(r+\delta)\frac{\gamma}{q(\theta)} = y(h) - \tau - e(h) - b - (r+\delta)\frac{e(h)}{\lambda} - \theta q(\theta)\frac{e(h)}{\lambda}. \tag{31}$$

Finally, by substituting $r\mathcal{V}_U$ by its expression given by (29) into (27), and from (31), we get h in the laissez faire equilibrium as an implicit function of θ.

$$e(h)\left\{\frac{y'(h)}{e'(h)} - 1\right\} = (r+\delta)\left\{\frac{e(h)}{\lambda} - \frac{\beta}{1-\beta}\frac{\gamma}{q(\theta)}\right\}. \tag{32}$$

In the EW regime, the *laissez-faire equilibrium* pair (h, θ) satisfies (31) and (32). In a *regulated equilibrium*, the labour market tightness is characterized by (31) only, where h is chosen by the government.

Eq. (32) and proposition 3 imply:

$$\frac{\beta}{1-\beta}\frac{\gamma}{q(\theta)} < \mathcal{V}_E(w,h) - \mathcal{V}_U = \frac{e(h)}{\lambda} < \frac{e(h^*)}{\lambda}, \tag{33}$$

In the EW regime, the EW rent $\left(\text{i.e., } \frac{e(h)}{\lambda}\right)$ is larger than the FNW rent $\left(\text{i.e., } \frac{\beta\gamma}{(1-\beta)q(\theta)}\right)$ and the working time is smaller than the efficient level h^*.

In fig. 2 (b), the vacancy supply condition (31) and the working time condition (32) are represented by two curves labelled $\widehat{VS}$ and $\widehat{WT}$.

Lemma 1 $\widehat{VS}$ *is* $\cap$*-shaped and* $\widehat{WT}$ *is upward sloping. The curve* $\widehat{WT}$ *cuts* $\widehat{VS}$ *in its downward sloping part.*

Proof. See appendix. ■

The shapes of $\widehat{VS}$ and $\widetilde{VS}$ are similar: the value of a match is increasing in h when the number of working hours is low (because the marginal productivity of working hours is high) and decreasing in h otherwise. The reason why $\widehat{WT}$ is upward-sloping is rather intuitive. If a filled job is very valuable, then firms open a large number of vacancies and the labour market becomes tight (θ is high). But according to the Nash bargaining solution, if the value of a filled job is high, the worker's rent $e(h)/\lambda$ must also be high which implies a long working day. Note that the positive slope of the working time schedule suggests that a high unemployment economy should have a low working time under laissez-faire.

Proposition 4 *Consider a laissez-faire equilibrium and assume that the NSC is binding.*

(i) A small reduction of the working time results in a lower equilibrium unemployment rate.

(ii) A reduction of the worker's bargaining power (β) leads to a decrease in both the equilibrium unemployment rate and the working time.

Proof. (i) Consequence from lemma 1 and eq. (3).

(ii) In the (h, θ) space, the working time schedule ($\widehat{WT}$) given by (32) moves upward when β decreases. The vacancy supply schedule ($\widehat{VS}$), given by (31), which is downward sloping in the neighborhood of the laissez faire equilibrium is not affected by a modification of β. ■

As previously indicated by proposition 3, when the NSC is binding, firms and workers agree to reduce the working time below the level h^* that would prevail in the absence of worker moral hazard. Indeed, by decreasing the disutility of work, a cut in working hours lowers the incentives to shirk and so the non-shirking wage. Nonetheless, proposition 4 states that a further reduction of the working time imposed by the government can improve the labour market situation. Hence, this result shows that Moselle's (1996) prediction is robust to the introduction of both search externalities and worker's bargaining power.

One of the key result of the paper is that the consequences of a reduction in the working time depend on whether the NSC is binding or not (See propositions 1 and 4). In the FNW regime, a compulsory change in the level of working hours increases the unemployment rate. In the EW regime, the government can enhance employment by reducing the working time. Hence, when promoting working time regulation it is crucial to identify whether the NSC is binding or not.

The second part of the proposition is more puzzling. It indicates that employed workers oppose to a working time reduction, even if this policy increases employment. Employed workers (insiders) negotiate the wage and the working time without taking into account the situation of the unemployed; the exit rate out of unemployment is taken as given. Furthermore, the rent they obtain when the NSC is binding is proportional to the disutility of work which is increasing with the number of working hours. So, preventing employers from reducing working time is a way to preserve a high rent and a high wage.[8]

Even in the case where wages are set unilaterally by firms ($\beta = 0$), as it is assumed in efficiency wage models, a reduction in the working time results in a lower unemployment rate. Indeed, for any given level of the labour market tightness, employers fail to internalize the effect of an increase in the number of working hours on the permanent income of the unemployed workers ($r\mathcal{V}_U$). According to (29), a decrease in the working time, for a given θ, reduces $r\mathcal{V}_U$ and, consequently, the non-shirking wage that must be paid by firms. Since employers ignore this effect, they choose a too high level of working hours.[9] This externality is the origin of the employment improving role of working time regulation. Formally, the level of working time chosen by employers, i.e. $\widehat{h}$ given by (28), is superior to h^{**} that maximizes θ in the EW regime. According to (31), h^{**} satisfies:

$$y'(h^{**}) - e'(h^{**}) - \{(r+\delta) + \theta q(\theta)\} \frac{e'(h^{**})}{\lambda} = 0 \tag{34}$$

Finally, note that this externality is not present in the FNW regime because, according to (23), the permanent income of unemployed workers does not depend directly on the level of working hours.

4.3 Welfare

In proposition 5 we compare the situation of workers and firms before and after a cut in working hours.[10] For simplicity, we restrict our attention to Cobb-Douglas matching functions: hence, η is constant.

[8] An analogous argument is mentioned by Schmidt-Sorensen (1991) in his concluding remarks. He indicates that employed workers get incentives to counteract the expected increase in productivity from lower working hours, to the detriment of unemployed, because such an increase would imply a decrease in the efficiency wage.

[9] A related externality is pointed out by Shapiro and Stiglitz (1984, p.440): according to them, when a firm hires one more worker, it fails to take into account the effect this has on $\mathcal{V}_U$.

[10] In our model, there is no transitional path for the value functions. Following a change in the working time, $\mathcal{V}_U$ and $\mathcal{V}_E$ immediatly jump to their new steady state value.

Proposition 5 *Consider a laissez-faire equilibrium and assume that the NSC is binding. A small reduction of the working time leads to:*

- *an improvement in the firm's situation,*
- *an improvement in the unemployed worker's situation if and only if $\beta > \eta$.*
- *an improvement in the employed worker's situation if and only if $\beta > \bar{\beta} \in [\eta, 1]$*

Proof. See appendix. ■

In contrast to Moselle (1996), a work-sharing policy does not necessarily imply a distributional effect which is detrimental to workers. Particularly, if the workers' bargaining power is high enough, a working time reduction improves the situation of both the employed and the unemployed. To see this, note that the lifetime utility of unemployed workers ($\mathcal{V}_U$) in the neighborhood of the laissez-faire equilibrium is increasing with the number of working hours if $\beta < \eta$ and is decreasing with the number of working hours if $\beta > \eta$. Furthermore, the lifetime utility of an employed worker ($\mathcal{V}_E$) is the sum of two terms: the EW-rent $e(h)/\lambda$ and the lifetime utility of unemployed ($\mathcal{V}_U$). If $\beta > \eta$, a reduction in the length of the working day from the laissez-faire equilibrium reduces the first term but increases the second term. The effect on the second term dominates for sufficiently high value of workers' bargaining power. As a consequence, in economies where workers are strong in the bargaining, there may be an unanimous agreement for a *coordinated reduction* in the working time.

An important case to discuss is when search externalities are shut off, which means that the wage is at the level which gives the right incentive to firms to open vacancies.[11] According to the Hosios-Pissarides' condition, this happens if $\beta = \eta$. Then, the value to be unemployed ($\mathcal{V}_U$) is maximum in the laissez faire and a working time reduction necessarily worsens the workers' situation (see Appendix A6).[12] Hence, in this case, there is a conflict

[11] Search externalities arise because the firms' entry decision affects the vacancy filling rate (a congestion effect) and the exit rate of unemployment (a thin market externality). More precisely, the vacancy filling rate, $m(u, v)/v$, is increasing with v whereas the exit rate out of unemployment, $m(u, v)/v$, is decreasing with v. These externalities just offset one another when β is equal to the elasticity of the matching function with respect to unemployment. See Hosios (1990) and Pissarides (1990). The efficient case is of particular interest because Mortensen and Wright (1997) have demonstrated that such an outcome can be sustained by a *competitive search equilibrium* where there is a competition among market makers.

[12] A similar result is found in the shirking model of Moselle (1996) and in matching model of Pissarides (2000) if $\beta = \eta$. Furthermore, it can be demonstrated that if the Hosios-Pissarides' condition for efficiency holds (i.e. $\beta = \eta$) then the elasticity of the exit rate out of unemployment with respect to the number of working hours is equal to the elasticity of the work disutility with respect to the number of working hours.

$$\frac{-\mathrm{d}\theta q(\theta)}{\mathrm{d}h}\frac{h}{\theta q(\theta)} = \frac{\mathrm{d}e}{\mathrm{d}h}\frac{h}{e}$$

of interest between workers and firms.

5 The complete solution

The preceding section characterized the steady state equilibria. It has been shown that the effects of working time regulation on equilibrium unemployment depends on whether the NSC is binding or not in the initial laissez-faire equilibrium. If it is not binding, any change in working hours increases unemployment; if it is binding, a small reduction in working time reduces unemployment. In this section, we determine conditions that identify the relevant wage formation (EW or FNW) of the economy. We also characterize the level of working time which minimizes the equilibrium unemployment rate. Beforehand, we prove the existence and uniqueness of the equilibrium.[13]

5.1 The separation locus

In this subsection we introduce a *separation locus* that allows us to distinguish the EW and the FNW regimes. This separation locus is the set of points where $\widehat{VS}$ cuts $\widetilde{VS}$. From (25) and (31), it is characterized by the following equation:

$$\frac{e(h)}{\lambda} = \frac{\beta}{1-\beta}\frac{\gamma}{q(\theta)}. \tag{35}$$

In (h, θ)-space, the separation locus (see the dotted curve labelled SL in fig. 3) is upward-sloping. For each pair (h, θ) situated on the right of this separation locus, the EW is larger than the FNW, i.e., the FNW does not satisfy the NSC. This region is tainted in grey in fig. 3. Conversely, for each pair (h, θ) situated on the left of the separation locus, the economy is in the FNW regime.

In fig. 3 we introduce $\overline{\theta}$, the labour market tightness such that the EW is just equal to the FNW if $h = h^*$. Hence, the pair $\left(h^*, \overline{\theta}\right)$ is on the separation locus. From (3), the equilibrium unemployment rate associated with $\overline{\theta}$ is $\overline{u} = \delta / \left[\delta + \overline{\theta} q(\overline{\theta})\right]$. According to (22), if $\theta \geq \overline{\theta}$ and $u \leq \overline{u}$, the NSC is not binding and the equilibrium wage is a FNW. On the contrary, according to (33), if $\theta < \overline{\theta}$ and $u > \overline{u}$, the NSC is binding and the equilibrium wage is an efficiency wage.

The following lemma rules-out multiple laissez-faire equilibria by showing that the FNW equilibrium and the EW equilibrium cannot coexist for the same values of the parameters.

[13] If the incidence of unemployment (δ) was endogenous, an EW mechanism could generate multiple equilibria. See Mortensen and Pissarides (1999).

Lemma 2 *The points of intersection* $\widetilde{VS} \cap \widetilde{WT}$ *and* $\widehat{VS} \cap \widehat{WT}$ *are located on the same side of the separation locus.*

Proof. See appendix. ■

To understand this lemma, remember that a laissez-faire equilibrium is determined at the intersection of a vacancy supply curve (VS) and a working time schedule (WT). Because the two candidates for an equilibrium, i.e., $\widetilde{VS} \cap \widetilde{WT}$ and $\widehat{VS} \cap \widehat{WT}$, are situated on the same side of the separation locus, one of them can be eliminated.

— Insert fig. 3 —

Lemma 2 is illustrated in fig. 3. The upper part of fig. 3 depicts the case where $\widetilde{VS} \cap \widetilde{WT}$ and $\widehat{VS} \cap \widehat{WT}$ are located on the right of the separation locus whereas the lower part of fig. 3 depicts the case where $\widetilde{VS} \cap \widetilde{WT}$ and $\widehat{VS} \cap \widehat{WT}$ are located on the left of the separation locus.[14] The $\widehat{WT}$-curve is below the separation locus when $h < h^*$ and above when $h > h^*$. Furthermore, condition (22) for a FNW equilibrium is fulfilled above the separation locus, and condition (33) for an EW equilibrium is satisfied below the separation locus (the grey region). This makes multiple equilibria impossible.

Proposition 6 *Under the following condition,*

$$y(\widehat{h}) - e(\widehat{h}) - \tau - b - \frac{(r+\delta)}{\lambda} e(\widehat{h}) > 0, \tag{36}$$

a laissez-faire equilibrium with both $\theta > 0$ *and* $h > 0$ *exists and is unique. If (36) is not satisfied, there is no active laissez-faire equilibrium.*

Proof. See appendix. ■

Condition (36) simply states that a necessary and sufficient condition for firms to open vacancies is that the expected profits of a filled job, in the absence of any congestion from other firms ($\theta = 0$), is positive. The LHS of (36) is the productivity of workers net of taxes minus the EW $\left(\text{i.e., } e(\widehat{h}) + b + \frac{(r+\delta)}{\lambda} e(\widehat{h})\right)$. Note that under inequality (36), the condition (13) for the formation of a match will be satisfied in equilibrium.

5.2 The employment-maximizing regulation of working time

This subsection characterizes the employment-maximizing working time regulation. First, we demonstrate that a working time regulation can decrease the equilibrium unemployment

[14] As shown in fig. 5b, $\widehat{VS}$ and $\widetilde{VS}$ can intersect the separation locus more than once.

rate only for countries with a depressed labour market. Second, we show that a reduction of the working time can trigger a transition from an EW equilibrium to a FNW equilibrium. The possibility of such a change must be taken into account when determining the employment-maximizing level of working hours.

Let us consider hypothetical economies which only differ by the extent of unemployment benefit (b) and tax/subsidy (τ) levels.[15] The unemployment rate increases with $z = b + \tau$ because an increase in the levels of taxes and unemployment benefits reduces the value of each match, and hence the incentive of firms to open vacancies. Indeed, according to (12), the total surplus of a match is $\frac{y(h)-e(h)-\tau-r\mathcal{V}_U}{r+\delta}$.

— Insert fig. 4 —

Fig. 4 depicts equilibria for different values of $z = b + \tau$. A laissez-faire equilibrium is represented by a dot in fig. 4; it lies at the unique intersection of a vacancy supply schedule ($\widetilde{VS}$ or $\widehat{VS}$) and a working time schedule ($\widetilde{WT}$ or $\widehat{WT}$). For instance, if $z = z_0$ the laissez-faire equilibrium is (h_0, θ_0) at the intersection of $\widehat{VS}(z_0)$ and $\widehat{WT}$. This equilibrium is located in the EW region tainted in grey in fig. 4. Note that the VS-schedules move upward as z decreases.

Proposition 7 *There is a critical value $\bar{z}$ such that:*

(i) For all $z \leq \bar{z}$, u is smaller than $\overline{u}$ and any modification of the working time from the laissez faire equilibrium increases unemployment.

(ii) For all $z > \bar{z}$, u is strictly larger than $\overline{u}$ and a small reduction of the working time from the laissez faire equilibrium decreases unemployment.

Proof. See appendix. ■

Proposition 7 establishes the circumstances under which a working time regulation decreases the equilibrium unemployment rate. A work-sharing policy turns out to be successful only for high unemployment countries ($u > \overline{u}$), i.e., countries with high unemployment benefits and tax levels. In contrast, by lowering the expected profits of filled jobs, a working time regulation in low unemployment countries ($u \leq \overline{u}$) depresses the flow of job creation.

The intuition of this result is the following. A country with high levels of taxes and unemployment benefits has a depressed labour market. There are few vacancies and recruiting costs are low. Consequently, if monitoring were perfect, workers would be in a

[15] According to Mortensen and Pissarides (1999), variations in the payroll tax and unemployment benefit levels can explain the differences in the unemployment rate among OECD countries.

weak position in the bargaining and could only obtain a low wage. However, in the presence of unobservable shirking, workers can threat to shirk, and this threat is credible when the unemployment rate is high because the rent generated by the presence of recruiting cost is low. Employers must then pay a non-shirking wage to their employees. Because there is an externality in the choice of the working time in the EW regime, workers and firms agree on a length of the working day which is larger than the employment-maximizing level.

This result highlights the importance of an accurate description of the wage formation when assessing the consequences of a work-sharing policy. With our specification for the production technology and the utility function, a standard matching model without unobservable shirking would not find any justification to a work-sharing policy, even for high unemployment countries.

Sections 3 and 4 have described the effects of small changes in the working time in the neighborhood of the laissez-faire equilibrium. It is now time to characterize the employment-maximizing regulation of the working time and its consequences on the wage formation. To do this, we take into account that a large reduction in the number of working hours may trigger a transition from one regime to another. Before turning to proposition 8, there are two benchmark cases that are worth mentioning. The first benchmark case is an economy without unobservable shirking ($\lambda \to +\infty$). In this economy, the wage is always a FNW and the level of working time that maximizes employment is h^*. The second benchmark case is an economy with unobservable shirking but without workers' bargaining power ($\beta = 0$). There, the NSC is always binding and the level of working hours that maximizes employment is h^{**} that satisfies (34).

Proposition 8 *Let $h_{\max}$ denote the level of working hours which maximizes aggregate employment. There is $z_C > \bar{z}$ such that*

(i) For all $z \leq \bar{z}$, $h_{\max}$ is equal to the unemployment-minimizing level of working hours in the absence of unobservable shirking ($h_{\max} = h^*$).

(ii) For all $z > z_C$, $h_{\max}$ is equal to the unemployment-minimizing level of working hours in the absence of worker's bargaining power ($h_{\max} = h^{**}$).

(iii) For all $z \in]\bar{z}, z_C[$, $h_{\max}$ is between h^{**} and h^* and is such that the EW is just equal to the FNW.

Proof. See appendix. ■

— Insert fig. 5 —

Proposition 8 implies the following. First, a government which regards unemployment reduction as its main objective must leave working time unchanged if the level of taxes and unemployment benefits is below the threshold $\bar{z}$. This result is in accordance with proposition 1. Second, if $z > z_C$, the government must choose h^{**} because reducing the working time from $h_{\text{laissez-faire}}$ to h^{**} does not modify the wage equation. This part of the proposition is illustrated in fig. 5(b). One can see that the whole downward-sloping part of the vacancy supply curve in the EW regime ($\widehat{VS}$) is situated on the right of the separation locus and that the new equilibrium of the economy corresponds to the maximum of $\widehat{VS}$.

Finally, for intermediate values of z, the government can promote job creation by cutting working hours but the unemployment-minimizing level of working hours is larger than h^{**}. This point is illustrated in fig. 5(a). A cut in working hours succeeds in reducing the unemployment rate as far as the NSC is binding. The optimal number of working hours is reached when the EW equals the FNW: the economy is on the separation locus. Reducing the working time below $h_{\max}$ would trigger a switch to the FNW regime (i.e., the economy would be situated on the left of the separation locus) and this would increase unemployment.

Proposition 8 emphasizes the need to introduce both informational problems and search frictions into the same set-up. In the absence of worker moral hazard problem, a standard matching model would predict $h_{\max} = h^*$. In the absence of worker's bargaining power, a shirking model would predict $h_{\max} = h^{**}$. First, our shirking-matching framework allows us to determine the set of parameters such that either h^* or h^{**} is the employment-maximizing level of working hours. Second, and more interestingly, it may happen that neither h^* nor h^{**} minimizes unemployment. This is due to the fact that a too large reduction of working hours may modify the wage formation mechanism and bring a change of regime. Consequently, the extent to which working time can be reduced in the EW regime to increase employment is lower than what is predicted by a shirking model.

Finally, even if a work-sharing policy may have positive effects on the employment level, one can show that a country with an unemployment rate above $\overline{u}$ under laissez faire cannot reach an equilibrium unemployment rate below $\overline{u}$ by reducing working time. That is, a government cannot fully offset the adverse effect of high taxes and high unemployment benefits simply by changing the number of working hours.

6 A numerical exercise/calibration

In this section, we analyze briefly the policy implications of the model. Our calibration relies on Marimon and Zilibotti (2000). A period of unit length is assumed to be a quarter.

The parameter values and the functional forms are reported in table 1.[16]

Table 1 : *Specification assumptions*

Work disutility	$e(l) = l^{1.7}/1.7$
Match productivity	$y(l) = Al^{0.65}/0.65$
Matching function	$m(u, v) = u^{0.5}v^{0.5}$
Discount rate	$r = 0.01$
Worker's share	$\beta = 0.5$
Incidence of unemployment	$\delta = 0.04$

Our benchmark case is an economy with no unemployment benefits, no taxes ($z = 0$), and perfect monitoring ($\lambda = +\infty$). The instantaneous advertising cost γ and the productivity parameter A are chosen so that the unemployment rate and the working time in the absence of government regulation are equal to 0.06 and 0.55. If $l = 1$ corresponds to 75 hours per week then the efficient working time is between 41 and 42 hours.

There is no empirical observation of the inspection rate; so, λ is calibrated to obtain a 12% unemployment rate economy with a 40 hours per week working time in the laissez faire. Let us call this hypothetical economy the H-economy. Because the working time is chosen to be smaller than its efficient level, the H-economy is in the EW regime, and hence, is able to carry out a work-sharing policy successfully. The inspection rate is slightly less than 0.6: on average, a shirker is fired after 5 months.

Next, we determine the optimal reduction in working hours that must be carried out in economies with different levels of taxes and unemployment benefits. For this, we increase z from 0 to 0.3. First, we calculate the unemployment rate and the working time of the economy in the laissez faire. Second, we determine the employment-maximizing level of the working time (in hours per week) and the corresponding unemployment rate. Results are reported in table 2.

Table 2 : *The employment-maximizing regulation of working time*

Laissez faire	u	6	7	8	9	10	11	12	13
equilibrium	h	41.2	41.2	41.0	40.7	40.4	40.2	40.0	39.8
Regulated	u	6	7	7.8	8.3	8.9	9.4	10	10.5
equilibrium	h	41.2	41.2	40.2	38.5	37.0	35.7	34.4	33.2

[16] The elasticity of the work disutility with respect to the number of working hours is set equal to 1.7 and the elasticity of the workers' productivity with respect to working hours is set equal to 0.65. The annual interest rate is 4.5%. The elasticity of the matching function with respect to the unemployment rate is equal to the worker's bargaining power. Hence, the Hosios-Pissarides condition for social efficiency is satisfied. The average duration of a job is 1/0.04=25 quarters, that is more than 6 years.

Laissez faire	u	14	15	16	17	18	19	20
equilibrium	h	39.7	39.6	39.5	39.4	39.3	39.2	39.1
Regulated	u	11	11.7	12.3	13.2	14.1	15.3	16.4
equilibrium	h	32.0	30.9	27.8	28.5	27.8	28.4	29

Table 2 shows that there is a negative relationship between the unemployment rate and the working time in the laissez faire. Furthermore, the model predicts that the H-economy should cut its working hours by 5.6 hours to reach a 10% unemployment rate. Note that this improvement in the labour market is accompanied by a 7% drop of aggregate output.

In this example, the critical level of the unemployment rate which separates the EW regime and the FNW regime in the laissez faire is equal to 7.5%. As a consequence, economies with an unemployment rate above 7.5% can enhance employment by cutting hours. The relationship between the unemployment rate and the working time in the regulated equilibrium is U-shaped: the maximizing-employment working time is increasing with z for very high unemployment countries.

Finally, the maximizing-employment level of working hours for countries with an initial unemployment rate between 7.5% and 18% is such that the EW is just equal to the FNW: the regulated equilibrium is on the separation locus, at the frontier of the two regimes.

7 Limitations of the model

Our model has been kept as simple as possible. For this, we have used assumptions that warrant additional discussion. In this section we discuss briefly the following assumptions: taxes and unemployment benefits are exogenous; overtime and part-time work are absent from the model; wages and working hours are negotiated at a decentralized level; particular specifications apply to utility and production functions.

It is unrealistic to assume that the levels of taxes and unemployment benefits are exogenous and independent. In real economies both payroll taxes and unemployment benefits are proportional to wages. Furthermore, a policy that succeeds in decreasing the unemployment rate gives room for a decrease in taxes which may have cumulative effects. For the sake of simplicity this feed-back effect has been ignored. Indeed, as shown by Rocheteau (1999), endogenizing the level of tax under a balanced budget requirement could generate multiple equilibria.

The implementation of a working time policy can be more complex than in our model. We have assumed that the government could directly regulate the level of actual hours. However, most often it reduces the level of standard hours (See Hunt, 1999). In fact, as mentioned by Contensou and Vranceanu (2000, chapter 3), there are basically three different ways to regulate working time. The government can decide a statutory level of working hours, an overtime premium for hours above the statutory level and a quota on the overall working hours. Introducing these possibilities would complicate our analysis without changing our conclusions in any fundamental way. We have also ignored the existence of part-time jobs or more generally the possibility to regulate or deregulate the flexibility of working time. A case in point is the recent French experience where the reduction in working hours has been accompanied by more flexibility in workplace organization.[17]

The central element in our model is the description of the choice of wages and working hours by workers and employers. In many respects, this part of the model is not realistic because unions' role in negotiations of wages and working time is neglected. In particular, unions may partially internalize the consequences of their choices on the welfare of unemployed workers. Furthermore, employment is most often at stake in negotiations about working time. Finally, we have restricted the set of contracts (i.e., wages are stationary).

The most serious limitation of the model could be the lack of robustness of some of our results to alternative specifications of the production function and the utility function. Indeed, as shown by Marimon and Zilibotti (2000), other specifications would lead to a positive effect on employment of a working time reduction in the FNW regime. Nonetheless, the economy will still be characterized by two regimes with different expressions for the wage as long as efficiency wage considerations are taken into account along the lines proposed in our paper. Furthermore, we conjecture that our argument according to which efficiency wage considerations are more likely to matter in depressed labour markets is robust to these extensions.

8 Conclusion

In this paper, we have explored working time regulation within a search-matching model with worker moral hazard. The wage formation process depends on both the no-shirking condition, which may be binding or not, and on worker's bargaining power. Hence, our model exhibits two types of steady-state equilibria which have opposite consequences of a cut in working hours on unemployment.

A working time regulation is helpful in lowering unemployment in high unemployment countries. Indeed, according to our model, when the unemployment rate is above a certain threshold, wage formation is mainly influenced by the asymmetry of information which prevails between workers and employers. A mandatory reduction of working hours from the

[17] On this point, see Askenazy (2000).

laissez-faire equilibrium reduces work disutility and lowers the rent obtained by employed workers who threaten to shirk. However, the welfare consequences of such a move are ambiguous and depend on whether the search externalities generated by the entry decision of firms are internalized or not through the wage mechanism. If they are, a small reduction in working hours would be beneficial to firms but it would harm workers. Nonetheless, even in such a situation where a small cut in hours can reduce unemployment, a too large reduction in the working time would have the opposite effect.

Conversely, when the unemployment rate is low, a working time regulation can only depress the flow of job creation. Indeed, if the level of recruiting costs is high, employed workers (i.e. insiders) receive a fraction of these recruiting costs, and hence obtain a wage superior to the efficiency wage. Thus, the moral hazard problem is irrelevant and a change in working hours from the laissez faire only reduces the value of filled jobs. A working time regulation in this regime would decrease the welfare of both workers and firms.

Our results are consistent with those provided by the standard matching model of Marimon and Zilibotti (2000) and the shirking model of Moselle (1996). However, because with the specification we use the two models have opposite conclusions, our model indicates which prediction is more accurate for given values of the parameters. Furthermore, we show that a mandatory working time reduction can generate a change in the wage equation. This change must be taken into account when calculating the unemployment-minimizing level of working hours.

Working time regulation is a major political issue in several European countries. Because of this, it is important not to misuse the conclusions of our model. A crucial point is that the effects of a working time reduction are mainly based on a wage mechanism. If the working time reduction takes place with no wage loss, our model predicts a non-ambiguous increase in the equilibrium unemployment rate: our paper does not uncover a hidden free lunch. This qualification is important because most of the work-sharing policies that have been carried out in the past have been accompanied by full wage compensation (Hunt, 1999). Having this reservation and the several limitations of the model in mind, our model can be viewed as an attempt to formalize the working time regulation policies in France and Germany. Our regulated equilibrium where the cut in hours is at the initiative of the government would better fit the French case, whereas the laissez-faire equilibrium where a working-time reduction can be negotiated between workers and employers is more in accordance with the German experience.

Furthermore, even though a reduction in working hours can promote job creation in the EW regime, work-sharing is not the most efficient policy to reduce the unemployment rate. In our model, changing the level of taxes and unemployment benefits reduces the unemployment rate more strongly. To summarize, a working time regulation can enhance employment only when policy makers have adopted tax and unemployment benefit schemes that are inconsistent with low unemployment in the first place.

A natural extension of our analysis would be to introduce our description of the wage formation process in a more realistically calibrated paper. This could be achieved by adopting a similar methodology to that of Mortensen and Pissarides (1999) and Marimon and Zilibotti (2000). For theory, our shirking-matching framework should provide a useful tool to address other questions related to unemployment and wages.

Appendix

A 1: The No-Shirking Condition

The NSC holds if there is no gain for a worker to deviate from the no-shirking strategy even on a very short interval of time. The expected lifetime utility of a currently employed worker who chooses to shirk during a spell of length dt, denoted by $\mathcal{V}_E^S(w,h;dt)$ (S for *shirking*), satisfies:

$$\mathcal{V}_E^S(w,h;dt) = wdt + \exp(-rdt)\left\{\mathbb{P}\left[\min(t_\delta,t_\lambda)\leq dt\right]\mathcal{V}_U + \right.$$

$$\left. + \left(1-\mathbb{P}\left[\min(t_\delta,t_\lambda)\leq dt\right]\right)\mathcal{V}_E(w,h)\right\}, \tag{37}$$

where t_λ is the length of time until the next inspection (an exponential distribution of parameter $\lambda \in \mathbb{R}^+$) and t_δ the duration of a job (an exponential distribution of parameter $\delta \in \mathbb{R}^+$). The random variable $\min(t_\delta, t_\lambda)$ is characterized by an exponential distribution with parameter $\delta + \lambda$. According to (37), during the time interval of length dt, the worker receives the real wage wdt and suffers no disutility; he loses his job if he is caught shirking or if his job is destroyed by an idiosyncratic shock. If none of these two events occur, the employed worker starts working hard again: his expected discounted utility is equal to $\mathcal{V}_E(w,h)$. After some calculation, eq. (37) yields:

$$\begin{aligned}\mathcal{V}_E^S(w,h;dt) &= wdt + (1-rdt)\left\{(\delta+\lambda)dt\mathcal{V}_U + \left[1-(s+\lambda)dt\right]\mathcal{V}_E(w,h)\right\} + o(dt),\\ &= \mathcal{V}_E(w,h) + e(h)dt - (1-rdt)\lambda dt\left\{\mathcal{V}_E(w,h)-\mathcal{V}_U\right\} + o(dt),\end{aligned}$$

where $o(dt)$ is a remaining term that satisfies $\lim_{dt\to 0} o(dt)/dt = 0$. A worker who draws a benefit from cheating his employer over a period of time of length dt, chooses to shirk all the time. By taking the limit $dt \to 0$, it can be shown that the worker's optimal strategy is to shirk if and only if:

$$\lim_{dt\to 0}\left(\mathcal{V}_E^S(w,h;dt) - \mathcal{V}_E(w,h)\right) > 0 \Leftrightarrow \frac{e(h)}{\lambda} > \mathcal{V}_E(w,h) - \mathcal{V}_U.$$

A2. Derivation of Pareto frontier of the bargaining set

The Pareto frontier of the bargaining set is the set of pairs $(\mathcal{V}_E - \mathcal{V}_U, \mathcal{V}_J)$ such that it is not possible to increase $\mathcal{V}_E - \mathcal{V}_U$ without decreasing $\mathcal{V}_J$. Formally, the Pareto frontier is determined by the following program:

$$\max_{w,h} \mathcal{V}_E\left(w,h\right) - \mathcal{V}_U \tag{38}$$

$$\text{s.t. } \mathcal{V}_J\left(w,h\right) \geq \overline{\mathcal{V}}_J \text{ and } \mathcal{V}_E\left(w,h\right) - \mathcal{V}_U \geq \frac{e(h)}{\lambda}$$

The total surplus of a match is:

$$\mathcal{V}_E\left(w,h\right) - \mathcal{V}_U + \mathcal{V}_J\left(w,h\right) = \frac{y(h) - e(h) - \tau - r\mathcal{V}_U}{r+\delta}$$

Note that the total surplus of the match does not depend on the choice of the wage income. Consequently, the program (38) can be rewritten as follows:

$$\max_h \frac{y(h) - e(h) - \tau - r\mathcal{V}_U}{r+\delta} - \overline{\mathcal{V}}_J \tag{39}$$

$$\text{s.t. } \frac{y(h) - e(h) - \tau - r\mathcal{V}_U}{r+\delta} - \overline{\mathcal{V}}_J \geq \frac{e(h)}{\lambda} \tag{40}$$

(i) The NSC is not binding

The FOC of program (39) gives:

$$h = h^*,$$

where h^* satisfies $y'(h^*) = e'(h^*)$. Hence, the equation of the Pareto frontier of the bargaining set is:

$$\mathcal{V}_E - \mathcal{V}_U + \mathcal{V}_J = \frac{y(h^*) - e(h^*) - \tau - r\mathcal{V}_U}{r+\delta} = \mathcal{S}^* \tag{41}$$

The condition that the NSC is not binding yields:

$$\mathcal{V}_E - \mathcal{V}_U \geq \frac{e(h^*)}{\lambda}$$

(ii) The NSC is binding

According to (40), the working time h satisfies:

$$\frac{y(h) - e(h) - \tau - r\mathcal{V}_U}{r+\delta} - \frac{e(h)}{\lambda} = \overline{\mathcal{V}}_J \tag{42}$$

Note that the LHS of eq. (42) is maximized when $h = \widehat{h}$. It can be verified that:

$$\frac{\mathrm{d}\mathcal{V}_J}{\mathrm{d}\left(\mathcal{V}_E - \mathcal{V}_U\right)} = \frac{\lambda}{r+\delta}\left(\frac{y'(h)}{e'(h)} - 1\right) - 1 \tag{43}$$

The RHS of eq. (43) is decreasing in h and $\mathcal{V}_E - \mathcal{V}_U$ is increasing in h. Hence, the Pareto frontier is concave.

A3. Proof of proposition 2

(i) The situation of firms

According to proposition 1, θ is maximum when $h = h^*$. Consequently, the value of a filled job, $\mathcal{V}_J = \gamma/q(\theta)$, and the number of filled jobs $(1-u)$ are at a maximum level when $h = h^*$, and firms are better off in the laissez faire equilibrium.

(ii) The situation of unemployed workers

The lifetime utility of an unemployed satisfies (23) and is increasing in the labour market tightness (θ). Hence, $\mathcal{V}_U$ is maximum for $h = h^*$.

(iii) The situation of employed workers

According to (21) the lifetime utility of an employed worker satisfies:

$$\mathcal{V}_E = \mathcal{V}_U + \frac{\beta}{1-\beta}\frac{\gamma}{q(\theta)}$$

Both $\mathcal{V}_U$ and $\frac{\gamma}{q(\theta)}$ reach a maximum for $h = h^*$. Consequently, employed workers are also better off in the laissez faire equilibrium.

Following a change in the number of working hours, all value functions jump to their steady state value (The only predetermined variable in the model is the unemployment rate). Hence, there is no transitional dynamics to study.

A 4. Proof of proposition 3

Eq. (16) can be rewritten as follows:

$$\tilde{\xi} = w - \beta\left[y(h) - \tau\right] - (1-\beta)\left[r\mathcal{V}_U + e(h)\right], \tag{44}$$

where

$$\tilde{\xi} = \xi\left\{y(h) - \tau - w\right\}^{\beta}\left\{w - e(h) - r\mathcal{V}_U\right\}^{1-\beta}.$$

Eq. (26) with (27) and (44) leads to:

$$\tilde{\xi}\left(\frac{r+\delta}{\lambda}\right) = (1-\beta)(r+\delta)\frac{e(h)}{\lambda}\left\{\frac{y'(h)}{e'(h)} - 1\right\}, \tag{45}$$

Let us assume that $h \geq h^*$. Then $y'(h) \leq e'(h)$ and, according to (45), $\tilde{\xi} \leq 0$. Furthermore, $\tilde{\xi} \neq 0$ because the NSC is binding. Eq. (44) implies then:

$$w < \beta\left[y(h) - \tau\right] + (1-\beta)\left[r\mathcal{V}_U + e(h)\right]. \tag{46}$$

The RHS is the FNW given by (19). Eq. (46) states that the wage is smaller than the FNW. This contradicts the assumption that the NSC is binding. Consequently, $h \geq h^*$ cannot be an outcome of the Nash bargaining.

A 5. proof of lemma 1

(i) The $\widehat{WT}$ curve.

Eq. (27) can be rewritten as:

$$\frac{(r+\delta)\beta}{(1-\beta)}\frac{\gamma}{q(\theta)} = e(h)\left\{1+\frac{r+\delta}{\lambda}-\frac{y'(h)}{e'(h)}\right\} \tag{47}$$

We restrict our attention to values of θ and h such that $\theta > 0$ and, consequently, $h > \widehat{h}$ where $\widehat{h}$ satisfies:

$$y'(\widehat{h}) = e'(\widehat{h})\left(1+\frac{r+\delta}{\lambda}\right)$$

The LHS is increasing in θ, while the RHS is the product of two positive functions that are increasing in h.

(ii) The $\widehat{VS}$ curve.

The differentiation of (31) gives:

$$\frac{\mathrm{d}\theta}{\mathrm{d}h} = \frac{y'(h)-e'(h)\left(\frac{r+\delta}{\lambda}+1+\frac{\theta q(\theta)}{\lambda}\right)}{(r+\delta)\frac{\gamma}{\theta q(\theta)}\eta+(1-\eta)\frac{e(h)}{\lambda}q(\theta)}, \tag{48}$$

where $\eta \equiv -q'\theta/q$ is the elasticity of q with respect to θ. Furthermore:

$$\left.\frac{\mathrm{d}^2\theta}{\mathrm{d}h^2}\right|_{\mathrm{d}\theta/\mathrm{d}h=0} = \frac{y''(h)-e''(h)\left[\frac{r+\delta}{\lambda}+1+\frac{\theta q(\theta)}{\lambda}\right]}{(r+\delta)\frac{\gamma}{\theta q(\theta)}\eta+(1-\eta)\frac{e(h)}{\lambda}q(\theta)} < 0.$$

The vacancy supply condition (labelled $\widehat{VS}$ in fig. 2 (b)) is concave when $d\theta/dh = 0$. Consequently, $\widehat{VS}$ is upward-sloping, reaches a maximum and then is downward sloping.

After some calculation, eqs (32) and (48) yield:

$$(1-\beta)\left.\frac{\mathrm{d}\theta}{\mathrm{d}h}\right|_{\text{laissez faire}} = \frac{-\frac{e'(h)}{e(h)}\left\{\beta(r+\delta)\frac{\gamma}{q(\theta)}+(1-\beta)\theta q(\theta)\frac{e(h)}{\lambda}\right\}}{(r+\delta)\frac{\gamma}{\theta q(\theta)}\eta+(1-\eta)\frac{e(h)}{\lambda}q(\theta)} < 0. \tag{49}$$

Thus, $\widehat{WT}$ cuts $\widehat{VS}$ in its downward sloping part.

A 6. proof of proposition 5

(i) The situation of firms

According to proposition 4 a small reduction in the working time raises θ, and hence the expected profits of a filled job, $\mathcal{V}_J = \gamma/q(\theta)$.

(ii) The situation of unemployed workers

Differentiating (29) yields:

$$\left.\frac{\mathrm{d}r\mathcal{V}_U}{\mathrm{d}h}\right|_{\text{laissez faire}} = \theta q(\theta)\frac{e'(h)}{\lambda} + q(\theta)(1-\eta)\left.\frac{e(h)}{\lambda}\frac{d\theta}{dh}\right|_{\text{laissez faire}}. \tag{50}$$

By virtue of eq. (49) and after some calculation, we get:

$$(1-\beta)\left.\frac{\mathrm{d}r\mathcal{V}_U}{\mathrm{d}h}\right|_{\text{laissez faire}} = \frac{(r+\delta)\gamma\frac{e'(h)}{\lambda}\left\{(1-\beta)\eta - \beta(1-\eta)\right\}}{(r+\delta)\frac{\gamma\eta}{\theta q(\theta)} + (1-\eta)\frac{e(h)}{\lambda}q(\theta)}. \tag{51}$$

If $\beta > \eta$ then $\mathrm{d}r\mathcal{V}_U/\mathrm{d}h\,|_{\text{laissez faire}} < 0$. Conversely, if $\beta < \eta$ then $\mathrm{d}r\mathcal{V}_U/\mathrm{d}h\,|_{\text{laissez faire}} > 0$.

To check that $r\mathcal{V}_U$ is maximized when the Hosios-Pissarides' condition ($\beta = \eta$) holds, we determine the level of working hours that maximizes $r\mathcal{V}_U$ given by (29) subject to the constraint that the labour market tightness obeys (31). The FOC is:

$$e(h)\left\{\frac{y'(h)}{e'(h)} - 1\right\} = (r+\delta)\left\{\frac{e(h)}{\lambda} - \frac{\eta}{1-\eta}\frac{\gamma}{q(\theta)}\right\} \tag{52}$$

Under Cobb-Douglas specification for the matching function, η is constant. Hence, eqs (31) and (52) give a unique pair (h, θ). It can be verified that $r\mathcal{V}_U$ is increasing for low values of h. Consequently, the unique point that satisfies the FOC (52) must be a maximum. When comparing (52) with the working time condition in laissez faire (32), it is immediately seen that both coincide when $\beta = \eta$.

(iii) The situation of employed workers

According to (4) and (30), the permanent income of employed workers satisfies:

$$r\mathcal{V}_E = b + [r + \theta q(\theta)]\frac{e(h)}{\lambda}. \tag{53}$$

From (49) we obtain:

$$(1-\beta)\left.\frac{\mathrm{d}r\mathcal{V}_E}{\mathrm{d}h}\right|_{\text{laissez faire}} = \frac{(r+\delta)\gamma\frac{e'(h)}{\lambda}}{(r+\delta)\frac{\gamma\eta}{\theta q(\theta)} + (1-\eta)\frac{e(h)}{\lambda}q(\theta)} \times$$

$$\left\{\frac{\eta}{\theta q(\theta)}r(1-\beta) + (1-\beta)\eta - \beta(1-\eta) + \frac{(1-\beta)r}{(r+\delta)}(1-\eta)\frac{e(h)}{\lambda}\frac{q(\theta)}{\gamma}\right\}. \tag{54}$$

Thus, the critical value of the worker's bargaining power $\bar{\beta}$ above which a cut in working hours improves the situation of employed workers is:

$$\bar{\beta} = \frac{\frac{\eta r}{\theta q(\theta)} + \eta + \frac{r}{(r+\delta)}(1-\eta)\frac{e(h)}{\lambda}\frac{q(\theta)}{\gamma}}{\frac{\eta r}{\theta q(\theta)} + 1 + \frac{r}{(r+\delta)}(1-\eta)\frac{e(h)}{\lambda}\frac{q(\theta)}{\gamma}} > \eta.$$

It is interesting to note that:

$$\lim_{r\to 0}\bar{\beta}=\eta,\qquad \lim_{r\to+\infty}\bar{\beta}=1$$

A 7. proof of lemma 2

The proof of lemma 2 exploits the properties of the curves $\widetilde{VS}$, $\widetilde{WT}$, $\widehat{VS}$, $\widehat{WT}$ and SL that are represented in fig. 3. It has been established that $\widetilde{VS}$ and $\widetilde{WT}$, on one side, and $\widehat{VS}$ and $\widehat{WT}$, on the other side, have a unique intersection. According to (32), $\widehat{WT}$ is situated below the separation locus when $h < h^*$ and above otherwise. According to (35), $\widetilde{WT}$ is situated below the separation locus when $\theta < \overline{\theta}$ and above otherwise.

Two cases can be distinguished.

(i) The intersection of $\widetilde{VS}$ and $\widetilde{WT}$ is located below the separation locus. See the upper part of fig. 3.

$\widetilde{VS}$ can only intersect the separation locus for values of h smaller than h^*. Suppose that $\widehat{VS}$ intersects $\widehat{WT}$ for some $h \geq h^*$. For all $h \geq h^*$, $\widehat{VS}$ is downward-sloping and $\widehat{WT}$ is situated above the separation locus. Furthermore, SL goes to infinity and $\widehat{VS}$ goes to 0 as $h \to +\infty$. As a consequence, $\widehat{VS}$ intersects the separation locus for some $h \geq h^*$ which is impossible according to our previous assertion. Hence, $\widehat{VS}$ intersects $\widehat{WT}$ for some $h < h^*$.

(ii) The intersection of $\widetilde{VS}$ and $\widetilde{WT}$ is located above the separation locus. See the lower part of fig. 3.

$\widehat{VS}$ and $\widetilde{VS}$ intersect the separation locus for some $h > h^*$. For all $h > h^*$, $\widehat{VS}$ is downward sloping and $\widehat{WT}$ is situated above the separation locus. Consequently, the intersection of $\widehat{VS}$ and $\widehat{WT}$ is also located above the separation locus.

A8. proof of proposition 6

(i) Existence.

Suppose that $\theta = 0$: there is no recruiting cost and eq. (33) is satisfied for all $h > 0$. Therefore, the NSC is binding and by virtue of eq. (32) $h = \widehat{h}$. According to condition (36), the instantaneous profits of a filled job (the productivity minus the wage income and taxes) is strictly positive. Thus, firms have an incentive to enter the market.

In fig. 2b, condition (36) implies that $\widehat{VS}$ intersects $\widehat{WT}$ for a positive value of θ. Hence, if (36) is not satisfied there is no EW equilibrium. Furthermore, by using arguments from Lemma 2, one can show that if there is no intersection between $\widehat{VS}$ and $\widehat{WT}$, then there is no FNW equilibrium satisfying the NSC.

(ii) Uniqueness.

Consequence of Lemma 2.

A9. Proof of proposition 7

Let us define $\bar{z} \in \mathbb{R}$ by the following equation:

$$(r+\delta)\frac{\gamma}{q(\bar{\theta})} = (1-\beta)\left\{y(h^*) - e(h^*) - \bar{z}\right\} - \beta\bar{\theta}\gamma, \tag{55}$$

Note that $(\overline{\theta}, \overline{z})$ also satisfies (31) when $h = h^*$.

(i) $z \leq \bar{z}$

According to (25), for all $z \leq \bar{z}$, $\theta \geq \bar{\theta}$ and $u \leq \overline{u}$: the NSC is not binding under laissez-faire. For given h, let $\widetilde{\theta}$ denote the value of the labour market tightness satisfying (25) and $\widehat{\theta}$ the value of the labour market tightness satisfying (31). As previously mentioned, for given h, the wage is the maximum of the FNW and the EW. Consequently, according to the vacancy supply condition (10), the value of θ for given h is $\min(\widetilde{\theta}, \widehat{\theta})$. Furthermore, $\widetilde{\theta}$ is maximum when $h = h^*$; thus, any modification of the working time leads to a decrease in the labour market tightness and an increase in the unemployment rate.

(ii) $z > \bar{z}$

According to (31) and (32), for all $z > \bar{z}$, $\theta < \bar{\theta}$ and $u > \overline{u}$; the NSC is binding in the laissez faire. From proposition 4, a small reduction of the working time decreases the unemployment rate.

A10. proof of proposition 8

Let (θ_C, h_C, z_C) denote the triplet (θ, h, z) which satisfies the following equations:

$$\frac{e(h)}{\lambda} = \frac{\beta}{1-\beta}\frac{\gamma}{q(\theta)}, \tag{56}$$

$$y'(h) = e'(h)\left\{1 + \frac{r+\delta}{\lambda} + \frac{\theta q(\theta)}{\lambda}\right\}, \tag{57}$$

$$(r+\delta)\frac{\gamma}{q(\theta)} = y(h) - e(h) - z - (r+\delta)\frac{e(h)}{\lambda} - \theta q(\theta)\frac{e(h)}{\lambda}. \tag{58}$$

Eq. (56) defines the separation locus. Eq. (57) defines h^{**}, i.e. the working time that maximizes the vacancy supply in the EW regime. Finally, eq. (58) is the vacancy supply condition in the EW regime.

The triplet (θ_C, h_C, z_C) exists and is unique. Indeed, it can be shown that there is a unique $(h, \theta) \in \left(\widehat{h}, h^*\right) \times \mathbb{R}^+$ that satisfies (56) and (57). For a given $(h, \theta) = (h_c, \theta_c)$ there is a unique $z \in \mathbb{R}$ that satisfies (58). According to (57), $h_C < h^*$. Thus, from (56) and (58), $\theta_C < \overline{\theta}$ and $z_C > \overline{z}$.

Next, the proof of the proposition proceeds as follows. For each value of z, we identify a candidate for the minimizing-unemployment level of working hours and we check whether this candidate satisfies the conditions for a minimum unemployment level.

Part (i) of the proposition is demonstrated above.

Part (ii) of the proposition: $z > z_C$ (see fig. 5b)

The candidate for the minimizing-unemployment level of working hours is h^{**} where (θ^{**}, h^{**}) is the pair of values determined by (57) and (58).

First, we verify that the condition for an EW equilibrium is satisfied. From eqs (57) and (58) one can show that $\theta^{**} < \theta_C$ and $h^{**} > h_C$. Consequently,

$$\frac{e(h^{**})}{\lambda} > \frac{\beta}{1-\beta}\frac{\gamma}{q(\theta^{**})}.$$

When $h = h^{**}$, the wage is an EW.

Second, we demonstrate that θ is maximum for $h = h^{**}$ and is equal to θ^{**}. For given h, the value of θ is $\min(\widetilde{\theta}, \widehat{\theta})$, where $\widetilde{\theta}$ obeys (25) and $\widehat{\theta}$ obeys (31). Since $\widehat{\theta}$ reaches a maximum in θ^{**} for $h = h^{**}$, the maximum for $\min(\widetilde{\theta}, \widehat{\theta})$ is θ^{**}, and h^{**} is the minimizing-unemployment level.

Part (iii) of the proposition: $\overline{z} < z < z_C$ (see fig. 5a)

The candidate for the minimizing-unemployment level of working hours is $h_{\max}$ where $(\theta_{\max}, h_{\max})$ is the pair (θ, h) satisfying (56) and (58).

First, we show that $h_{\max} > h^{**}$. Eq. (56) gives a positive relation between h and θ. Furthermore, according to (58), as z decreases θ increases. Thus, $\theta_{\max} > \theta_C$, $h_{\max} > h_C$ and $\partial h_{\max}/\partial z < 0$. Furthermore, given that $\partial h^{**}/\partial z > 0$ and that $h_{\max} = h_C = h^{**}$ when $z = z_C$, then $h_{\max} > h^{**}$. This implies that $\widehat{VS}$ is downward-sloping for all h larger than $h_{\max}$.

Second, we demonstrate that when $h = h_{\max}$ the labour market tightness is maximum. The value of θ when the government regulates the working time is $\min(\widetilde{\theta}, \widehat{\theta})$. When $h = h_{\max}$, $\widetilde{\theta} = \widehat{\theta}$ (the wage is both an EW and a FNW). For all $h < h_{\max}$, $\widetilde{\theta}$ is increasing with h whereas for all $h > h_{\max}$, $\widehat{\theta}$ is decreasing with h. Thus, $h_{\max}$ is the maximizing-employment working time.

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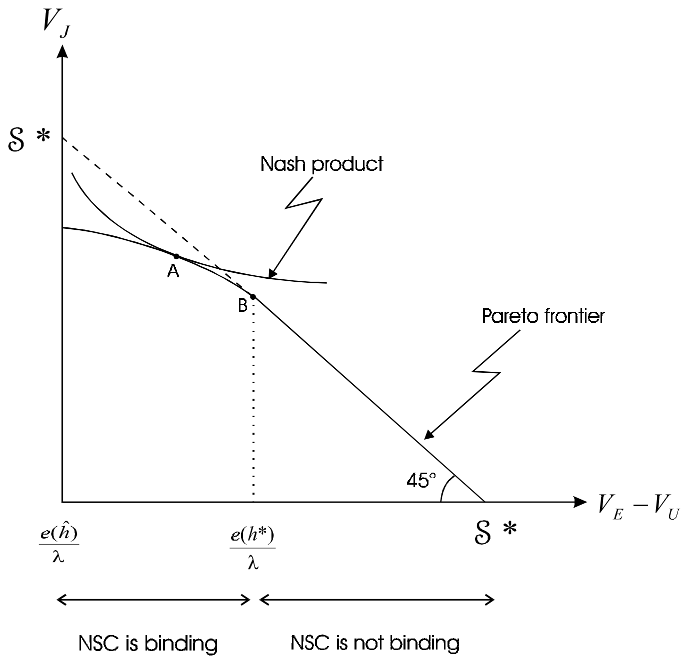

Fig. 1. The bargaining solution

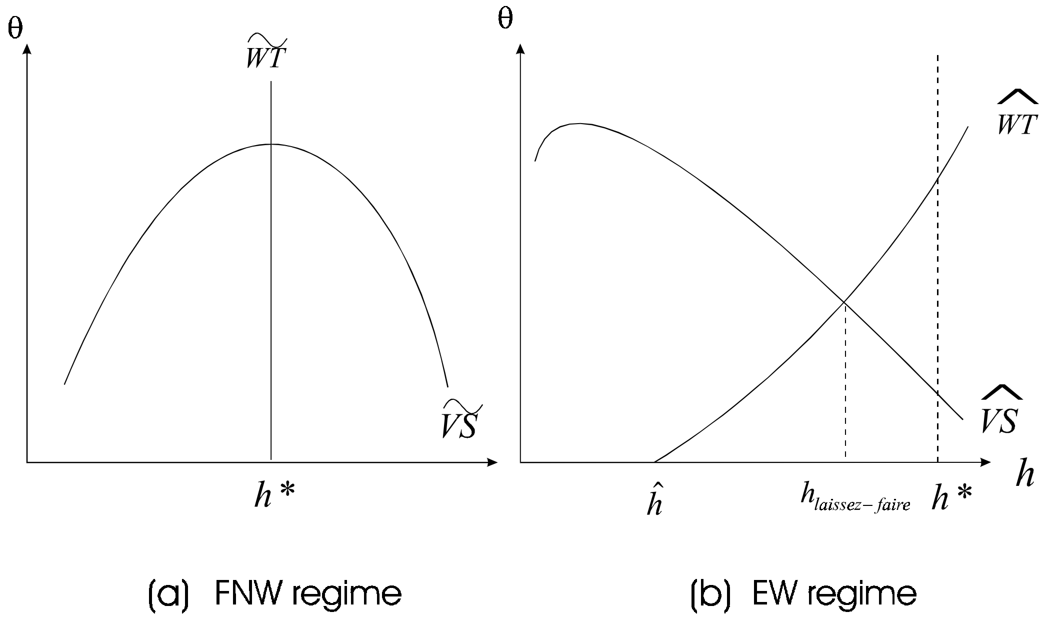

Fig. 2. The two types of equilibrium

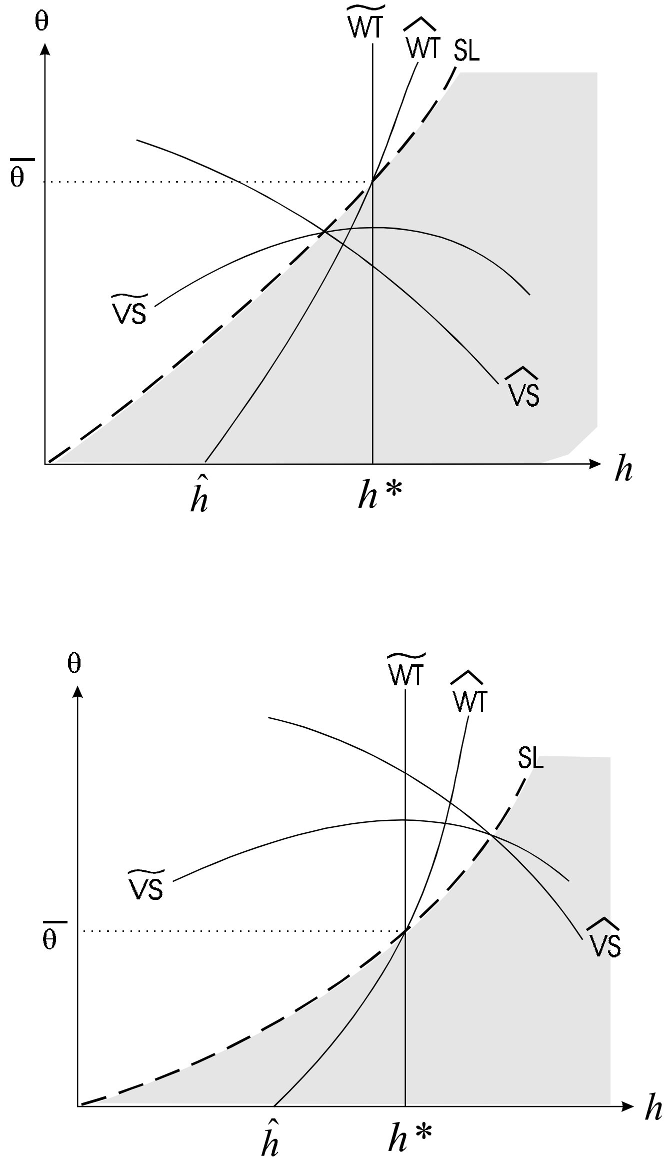

Fig. 3. The separation locus

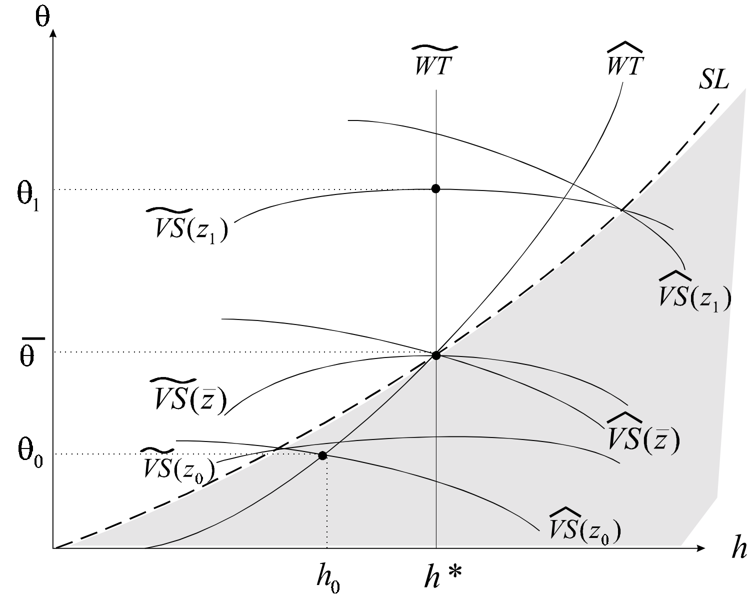

Fig. 4. The complete solution

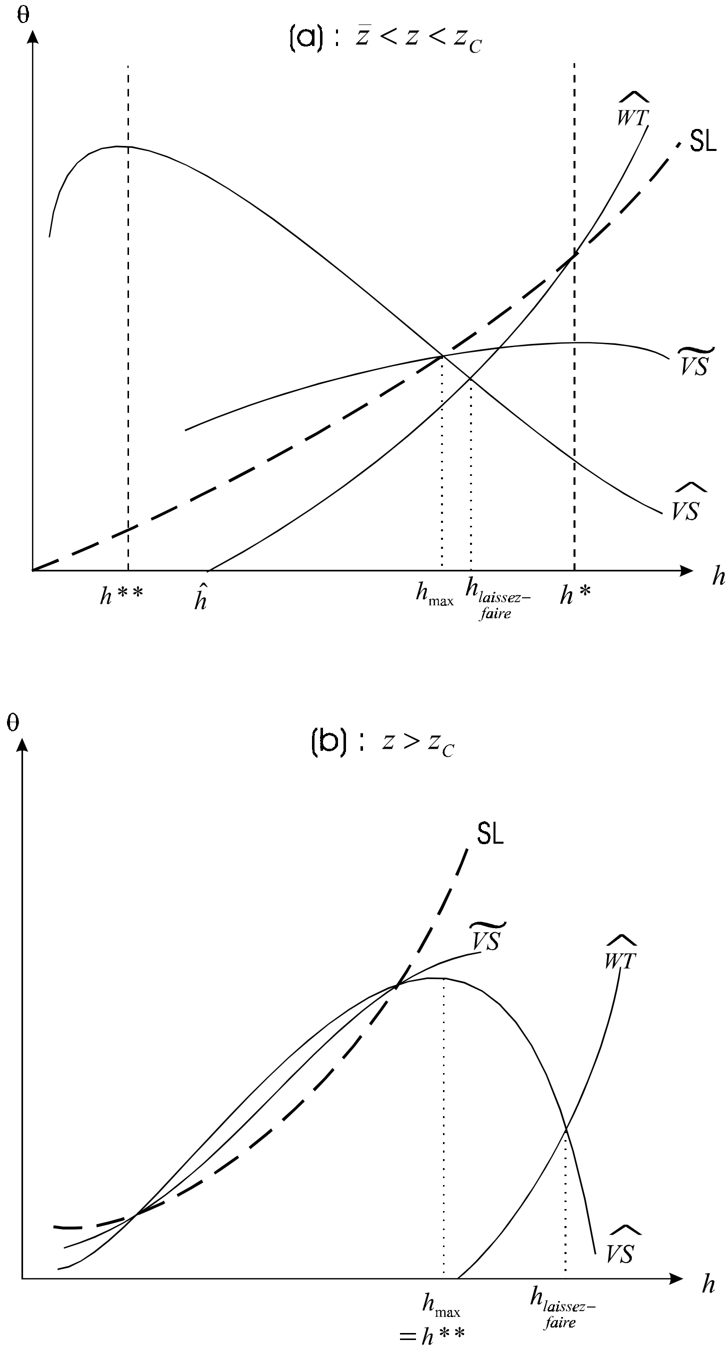

Fig. 5. Optimal regulation of the working time