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# Employment, hours and the welfare effects of intra-firm bargaining <sup>☆</sup>

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## Abstract

Bilateral bargaining between a multiple-worker firm and individual employees leads to overhiring. With a concave production function, the firm can reduce the marginal product by hiring an additional worker, thereby reducing the bargaining wage paid to all existing employees. We show that this externality is amplified when firms can adjust hours per worker as well as employment. Firms keep down workers' wage demands by reducing the number of hours per worker and the resulting labor disutility. Our finding is particularly relevant for European economies where hours adjustment plays an important role.

**Keywords:** Employment, Hours, Intrafirm bargaining, Overhiring

**JEL classification:** D62, E24, E61, E64, H21

## 1. Introduction

In Europe, firms adjust their labor input to a large degree by varying hours per worker rather than the workforce. This motivates our research question: how does allowing for variable hours per worker affect labor market outcomes in the intrafirm bargaining model?

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In an intrafirm bargaining framework, a multiple-worker firm bargains with each of its employees individually over the wage rate. With a concave production function, hiring a worker lowers the marginal product of labor, thereby reducing the bargaining wage. Since all workers are effectively marginal, the wage offered to all (also the infra-marginal) workers, and thus the firm's total wage bill, can be reduced in this way. It is a well-known result that firms exploit this externality and overhire, i.e. they hire too many employees relative to the efficient allocation (Smith, 1999; Stole and Zwiebel, 1996).

Our contribution is to analyze this phenomenon in a setup where, realistically, firms can adjust their labor input along two margins, employment and hours per worker. Business cycle models with frictional labor markets have largely neglected the hours margin.<sup>1</sup> Our model with both labor margins is able to replicate key stylized facts of the Euro Area labor market.

We show that overhiring is magnified in the presence of an hours margin. This is because an expansion of the workforce implies a reduction in the number of hours worked per employee. This, in turn, reduces the marginal disutility of working and thus the wage that the firm pays all its employees. Especially if labor disutility rises steeply in hours worked, the ensuing fall in the wage bill, and therefore the overhiring externality, is large. The resulting misallocation of labor across the two margins, with employment being too high and hours per worker being too low, gives rise to a sizeable welfare loss.

Our paper contributes to the normative and the positive literature on intrafirm bargaining (IFB, henceforth). Regarding the normative literature, the seminal work by Stole and Zwiebel (1996) shows the overhiring result under IFB in partial equilibrium. Smith (1999) and Cahuc and Wasmer (2001) extend this result to a general equilibrium search-and-matching model. Cahuc and Wasmer (2001) show that overhiring disappears if there is another, fully flexible, productive factor (e.g. capital), and the production function exhibits constant returns to scale in all factors. The overhiring distortion can be removed with collective bargaining (Bauer and Lingens, 2013) or long-term wage contracts (Hawkins, 2015). None of the aforementioned papers considers hours per worker as an additional labor margin, as we do in this paper. Kudoh and Sasaki (2011) discuss efficiency in a model with IFB and variable hours. However, in their model variant firms and employees bargain over an earnings schedule; hours are chosen by the firm and do not depend on the firm's workforce. In our paper, the firm uses its hiring decision to strategically affect the number of hours per worker. Reducing hours per worker through overhiring helps the firm to reduce its wage bill even more than in the constant-hours model.

Regarding the positive literature, several papers investigate the goodness-of-fit of the intrafirm bargaining model. Acemoglu and Hawkins (2014) study the cross-sectional implications of a model with IFB and heterogeneous firms. Krause and Lubik (2013) show that the transmission of technology shocks is only marginally affected by IFB. Kim (2015) includes variable hours in a model with IFB and studies the implied volatility of labor market variables. In Kim (2015), the bargaining protocol is different from ours. If wage negotiations break down, the remaining workers bargain with the firm collectively; their bargaining power depends on the business cycle. Here, as in the 'Rolodex game' of (Brügemann et al., 2017), a worker who rejects a wage offer is sent to the back of the 'bargaining queue' and bilateral bargaining resumes with the next worker in line. This allows the firm to treat all workers as marginal. Kudoh et al. (2017) assess the goodness of fit of a search-and-matching model with intrafirm bargaining and hours worked on Japanese data. They show that their model is satisfactory in replicating fluctuations in both margins of labor, especially when hours are chosen by the firm. We show that our model with intrafirm bargaining and bargained variable hours performs rather well in terms of matching key business cycle moments of the Euro Area.

The remainder of the paper is structured as follows. Section 2 provides empirical evidence to motivate our modelling choices. Section 3 presents the model. Section 4 describes the distortion arising in the competitive allocation, how it depends on the properties of the production function and the Frisch elasticity of labor supply, and how an appropriately designed unemployment insurance transfer can remove it. In Section 5, we show how the overhiring distortion is affected by the presence of hours as a labor adjustment margin and we compute the welfare losses arising from intrafirm bargaining. In Section 6, we demonstrate that the proposed model performs well empirically. Section 7 concludes.

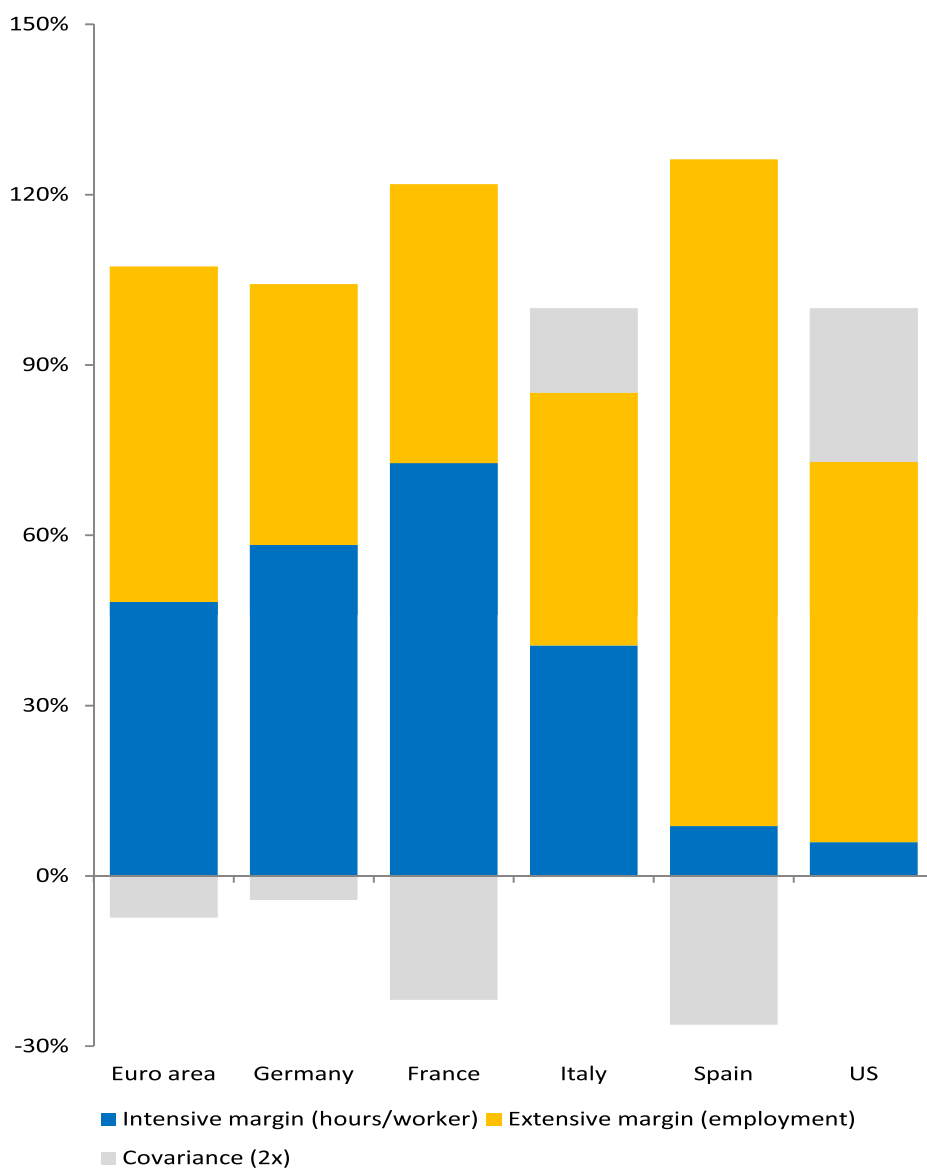
## 2. Empirical evidence

European and US labor markets differ in many respects. Fig. 1 shows that in the Euro Area, 48% of the variance in total hours is accounted for by variations in hours per employee, whereas this is only 6% for the US.<sup>2</sup> The importance of the hours margin in France, Germany and Italy (vs. the US) is consistent with the findings of Llosa et al. (2012). The strict employment protection legislation in Europe, as compared with the US, makes hours per worker relatively more attractive as an adjustment margin (see (OECD, 2013)). Also, as mentioned in ECB (2012), short-time work programs have been used more extensively in European countries than in US during the 2008 crisis, which might have limited the deterioration of labor market conditions.

At the same time, the evidence points to a gradual shift towards a production structure where individual European workers perform fewer hours on average. Rogerson (2006) documents that in France, Germany and Italy, hours per worker declined by more than 30% since the 1950s, a development which was not observed in the US. More recent data from Ohanian and Raffo (2012) confirm the virtual stability of hours worked per worker in the US, whereas in France, Germany and Italy hours per worker have continued to decline in the 2000s. This cannot be ascribed solely to differences in workers'

<sup>1</sup> See, for example, (Merz, 1995; Mortensen and Pissarides, 1994; Shimer, 2005) and (Hall, 2006).

<sup>2</sup> Of the large Euro Area countries, Spain is an outlier; there, most of the adjustment of labor input happens via changes in the number of temporary workers.



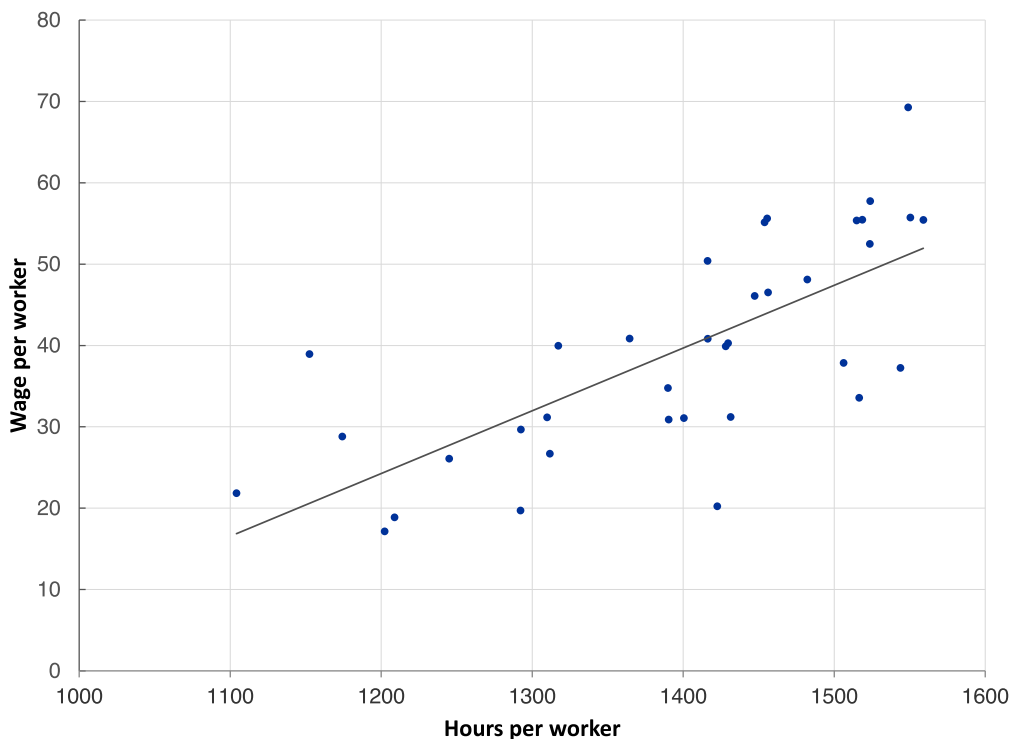
**Fig. 1.** Total hours decomposition. *Note:* The contributions of hours/worker (logged) and employment (logged) to the variance of total hours worked (logged) have been computed as the variance (X)/(variance (X) + variance (Y) + 2covariance (X,Y)). All variables are hp-filtered with smoothing parameter 1600. The decomposition for the euro area has been computed as an average of the contributions for Germany, France, Italy and Spain, weighted by their share in total Euro Area hours worked. The sample is 1999Q1-2015Q4. Data are from [Ohanian and Raffo \(2012\)](#), updated to 2015Q4 with Eurostat and BLS data.

preferences on the two sides of the Atlantic. More Europeans than US citizens report that they work part-time involuntarily, which suggests that low hours per worker in Europe may – at least partially – be the outcome of a deliberate strategy by firms to reduce worker bargaining power. In the US on average over the business cycle, only 3% of all workers report that they work part-time involuntarily; in the Euro Area this figure is about 6%.<sup>3</sup>

Regarding wage determination, bilateral bargaining between a firm and an individual worker has become much more prevalent today as the importance of collective bargaining has steadily decreased.<sup>4</sup> Moreover, institutions such as temping agencies have increasingly become part of the worker-firm relationship. [Forde and Slater \(2011\)](#) provide survey evidence confirming that temping agencies facilitate bilateral wage bargaining between a worker and a firm. While their evidence applies to the UK, the finding should arguably extend to other European countries. The legal framework is mainly determined

<sup>3</sup> Data from the BLS and Eurostat, respectively.

<sup>4</sup> OECD measures of trade union density show a steady decline in most European countries.



**Fig. 2.** Wages and Hours per Worker across German Industries. *Note:* The data cover all available NACE sectors (excluding activities of households as employers), or 36 observations. Hours per worker is the average of annual hours worked per employee over the period 1995–2015. Wage per worker is the average of annual compensation per employee (in thousands of EUR) over the period 1995–2015. Data source: Eurostat.

by the European Union Temporary Agency Work Directive, which is common to all European countries. Temping agencies allow firms to easily bargain with many individual workers simultaneously.

Taken together, these facts suggest that intrafirm bargaining and variable hours now belong to the salient features of European labor markets.

A final piece of evidence that we want to highlight is shown in Fig. 2, which plots sectoral data for Germany. We see that sectors with lower hours per employee also have lower wages. While the figure shows per-person wages, the positive correlation holds also for hourly wages. Our model with IFB and hours will be able to capture this correlation.

### 3. Model

Our model features search-and-matching frictions in the labor market à la (Mortensen and Pissarides, 1994). A firm can employ multiple workers and wages are set through bilateral bargaining, as in Stole and Zwiebel (1996) or Cahuc and Wasmer (2001), among others. The firm can adjust its workforce as well as hours per employee. Hours, like wages, are set through bargaining between the firm and each individual worker.<sup>5</sup>

The timing of events is the following. The period is split into two subperiods: the bargaining stage early in the period and the hiring stage at the end of the period. At the hiring stage, current employment at the firm is given, production and wage payments have already taken place. Let  $x$  be the set of exogenous variables that define the aggregate state, in particular, technology  $A$  and government spending  $G$ . To lighten the notation, we do not use time subscripts. Let a symbol without a prime denote a variable in the current period and let a symbol with a prime denote a variable in the next period. We therefore write the current value of any variable  $y$  as  $y$  and next period's value as  $y'$ . The steady-state value of variable  $y$  is written  $\bar{y}$ .<sup>6</sup>

#### 3.1. Unemployment and matching

Firms post vacancies and unemployed workers search for jobs. Let  $M = M_0 u^\eta v^{1-\eta}$  denote the number of successful matches, where  $u$  is the unemployment rate,  $v$  is the aggregate number of vacancies,  $\eta \in (0, 1)$  is the elasticity of the number of matches to unemployment and  $M_0 > 0$  denotes the matching technology. The probability of a vacancy being filled is

<sup>5</sup> In Germany, it is common that wages and working time, i.e. hours, are set as part of the same bargaining process, see (Bispinck et al., 2010).

<sup>6</sup> The online appendix contains detailed model derivations.

$q \equiv M/v$ , where the ratio of vacancies to unemployed workers,  $\theta \equiv v/u$ , is a measure of labor market tightness. The job finding rate is denoted  $p \equiv M/u$ . Firms and workers take the probability of filling a vacancy  $q$  and the job finding rate  $p$  as given. The employment rate is  $n = 1 - u$ . A constant fraction  $\lambda \in (0, 1)$  of employment relationships are exogenously terminated each period. Newly hired workers join the workforce only in the next period, such that

$$n' = (1 - \lambda)n + qv \quad (1)$$

describes the evolution of the firm's workforce. Given a unit measure of identical firms,  $n$  and  $v$  denote aggregate as well as firm-level employment and vacancies, respectively.

### 3.2. Hiring

Let  $V^v(n, x)$  and  $S^f(n, x)$  denote, respectively, the value to the firm of posting a vacancy and the value to the firm of successfully forming a match in the labor market. In the next period, a vacancy is filled with probability  $q$ , yielding the value  $S^f(n', x')$ , and remains open otherwise, in which case the value of the vacancy is  $V^v(n', x')$ . The value of posting a vacancy is minus the per-period cost of posting a vacancy,  $c$ , plus the expected continuation value,

$$V^v(n, x) = -c + \beta E\{\Lambda(x, x')[qS^f(n', x') + (1 - q)V^v(n', x')]\}, \quad (2)$$

where  $E(\cdot)$  is the expectations operator. The variable  $\Lambda(x, x')$  captures the household's stochastic discount factor and is defined below. Firms are owned by the households and therefore use  $\Lambda(x, x')$  for discounting. The firm posts vacancies as long as the value of a vacancy is greater than zero. In equilibrium,  $V^v(n, x) = 0$  and so the vacancy posting condition is

$$\frac{c}{q} = \beta E\{\Lambda(x, x')S^f(n', x')\}. \quad (3)$$

At the optimal hiring rate, the cost of hiring a worker, given by the vacancy posting cost,  $c$ , multiplied by the average duration of a vacancy,  $1/q$ , equals the present discounted value of the firm's match surplus in the next period.

### 3.3. Firm's match surplus

Each firm on the unit interval employs  $n$  workers. Worker  $j \in [0, n]$  earns a wage  $w(n, x; j)$  for working  $h(n, x; j)$  hours at the firm. The variables  $w$  and  $h$  are indexed by  $j$  to indicate that the wage rate and hours per worker are set for each worker individually through bilateral bargaining. Their dependence on  $n$  reflects the strategic effect the firm's hiring decision has on wages and hours through intrafirm bargaining.

Suppose the firm has formed a match with a worker, with match value denoted  $V^f(n, x)$ . In the next period, the worker remains employed by the firm with probability  $1 - \lambda$ , in which case the match value is  $V^f(n', x')$ , or the employment relation is dissolved with probability  $\lambda$ , then the value of the match to the firm in the next period is zero. The firm's current match value is given by its revenue, minus the wage bill, minus the cost of posting vacancies, plus the expected continuation value,

$$V^f(n, x) = A \left( \int_0^n h(n, x; j) dj \right)^\alpha - \int_0^n w(n, x; j) dj - cv + (1 - \lambda)\beta E\{\Lambda(x, x')V^f(n', x')\}, \quad (4)$$

where  $A$  is an economy-wide technology index and  $\alpha \in [0, 1)$  captures the degree of concavity of the production function in total hours.

For the firm, the surplus from employing a marginal worker, defined as  $S^f(n, x) \equiv \frac{\partial V^f(n, x)}{\partial n}$ , is given by:

$$S^f(n, x) = \chi(n, x) + (1 - \lambda)\beta E\{\Lambda(x, x')S^f(n', x')\}, \quad (5)$$

where  $\chi(n, x)$  captures the shadow value of a marginal worker,

$$\chi(n, x) \equiv \alpha A \left( \int_0^n h(n, x; j) dj \right)^{\alpha-1} \left[ h(n, x; n) + \int_0^n h_n(n, x; j) dj \right] - \left[ w(n, x; n) + \int_0^n w_n(n, x; j) dj \right]. \quad (6)$$

The marginal worker is identified by setting the index  $j$  to its upper bound,  $j = n$ , such that hours and the wage rate of the marginal employee are  $h(n, x; n)$  and  $w(n, x; n)$ , respectively. The first term on the right hand side of the shadow value (6) is the output produced when hiring an additional worker working  $h(n, x; n)$  hours, where  $h_n(n, x; j) \equiv \frac{\partial}{\partial n} h(n, x; j)$  is the effect of a marginal worker on the number of hours worked by employee  $j$ . The second term on the right hand side of (6) captures the reduction in the wage bill due to an additional employee, where  $w_n(n, x; j) \equiv \frac{\partial}{\partial n} w(n, x; j)$  is the effect of the marginal worker on the equilibrium wage of employee  $j$ . The hiring decision gives rise to an externality in that it affects

both hours and wages of all existing workers. Rewriting the shadow value as follows,

$$\begin{aligned} \chi(n, x) = & \alpha A \left( \int_0^n h(n, x; j) dj \right)^{\alpha-1} h(n, x; n) - w(n, x; n) \\ & + \underbrace{\alpha A \left( \int_0^n h(n, x; j) dj \right)^{\alpha-1} \int_0^n h_n(n, x; j) dj - \int_0^n w_n(n, x; j) dj}_{\text{IFB effect}} \end{aligned} \quad (7)$$

we can identify the intrafirm bargaining effect as the second line in (7). In a model without IFB, the shadow value of an extra worker corresponds to his marginal revenue product, net of his wage. The two terms  $h_n(n, x; j)$  and  $w_n(n, x; j)$  arise through intrafirm bargaining. In the multiple-worker firm model without hours, the IFB-effect is given by  $w_n(n, x; j)$ . See, for instance, (Krause and Lubik, 2013). Here, due to the presence of variable hours per worker, intrafirm bargaining introduces an additional channel captured by the term  $h_n(n, x; j)$ . The dependence of the number of hours worked on employment comes from the substitutability between employment and hours per employee; it is only present when the firm has *both* labor margins at its disposal. It appears neither in the one-worker firm setup with hours of Trigari (2006), nor in the large firm model without hours, see e.g. (Krause and Lubik, 2013). We demonstrate in Section 5 how the introduction of variable hours affects the equilibrium outcome.

Combining the firm's surplus (5) in the next period with the vacancy posting condition (3), we obtain the job creation condition,

$$\frac{c}{q} = \beta E \left\{ \Lambda(x, x') \left[ \chi(n', x') + (1 - \lambda) \frac{c}{q'} \right] \right\}. \quad (8)$$

A firm posts vacancies until the cost of hiring a worker equals the expected discounted future benefits from employing this extra worker. The benefits of hiring a worker are his shadow value, plus the vacancy posting costs saved in case the employment relationship continues.

### 3.4. Worker's match surplus

Let  $W(n, x)$  and  $U(x)$  denote, respectively, the value to the household of the marginal household member being employed vs. unemployed.

A household member that is *employed* receives the wage  $w(n, x; n)$  for working  $h(n, x; n)$  hours. Since the firm bargains with all workers individually, each worker is effectively marginal, such that we set  $j = n$  in the bargaining problem below. In the next period, the worker is either still employed with probability  $1 - \lambda$ , in which case his value to the household is  $W(n', x')$ , or the employment relation is dissolved with probability  $\lambda$ , then the corresponding value in the next period is  $U(x')$ . The current value of being employed is the real wage, minus the disutility of employment (divided by the household's shadow value of consumption,  $\Lambda$ , to convert utils into consumption goods), plus next period's expected value,

$$W(n, x) = w(n, x; n) - \frac{\zeta h(n, x; n)^{1+\sigma}}{1 + \sigma} \frac{1}{\Lambda} + \beta E \left\{ \Lambda(x, x') \left[ (1 - \lambda) W(n', x') + \lambda U(x') \right] \right\}. \quad (9)$$

In (9),  $\zeta > 0$  is the weight on labor in household utility and  $\sigma > 0$  is the inverse Frisch elasticity of labor supply.

An *unemployed* household member produces  $b$  units of market output and receives lump-sum transfers  $T^b$  from the government. In the next period, he either finds a job with probability  $p$ , in which case his value to the household is  $W(n', x')$ , or he remains unemployed with probability  $1 - p$ , then the corresponding value is  $U(x')$ . The current value of being unemployed is thus

$$U(x) = (b + T^b) + \beta E \left\{ \Lambda(x, x') \left[ p W(n', x') + (1 - p) U(x') \right] \right\}. \quad (10)$$

Defining the surplus from employment for a worker as the difference between the employment and unemployment values,  $S^w(n, x) \equiv W(n, x) - U(x)$ , we can subtract (10) from (9) to write

$$S^w(n, x) = w(n, x; n) - \frac{\zeta h(n, x; n)^{1+\sigma}}{1 + \sigma} \frac{1}{\Lambda} - (b + T^b) + (1 - \lambda - p) \beta E \left\{ \Lambda(x, x') S^w(n', x') \right\}. \quad (11)$$

### 3.5. Hours and wages

A worker and the firm Nash-bargain over the individual worker's wage  $w(n, x; n)$  and hours  $h(n, x; n)$ , given the firm's employment level  $n$  and the macroeconomic state  $x$ .<sup>7</sup> In the absence of a commitment technology for labor contracts, bargaining starts anew each period. The parties divide the match surplus according to their respective bargaining weights given

<sup>7</sup> (Brügemann et al., 2017) show that the Stole-Zwiebel bargaining protocol needs to be amended to ensure that the wage is symmetric and equal to the marginal worker's wage: a worker who rejects a wage offer is sent to the end of the queue of workers waiting to bargain with the firm. That threat weakens his bargaining position and makes him accept the wage offer corresponding to the marginal worker's bargaining wage.

by  $\gamma$  and  $1 - \gamma$ ,

$$\max_{w,h} S^w(n, x)^\gamma S^f(n, x)^{1-\gamma}. \quad (12)$$

The first order conditions for wages and hours are, respectively,  $(1 - \gamma)S^w(n, x) = \gamma S^f(n, x)$ , and  $\zeta h(n, x; n)^\sigma / \Lambda = \alpha A (\int_0^n h(n, x; j) dj)^{\alpha-1}$ . Next, imposing symmetry on wages and hours by setting  $h(n, x; j) = h(n, x; n) = h(n, x)$  and  $w(n, x; j) = w(n, x; n) = w(n, x)$  for any  $j \in [0, n]$ , the optimality condition for hours becomes:

$$\frac{\zeta h(n, x)^\sigma}{\Lambda} = \alpha A (nh(n, x))^{\alpha-1}. \quad (13)$$

The left hand side of (13) is the marginal disutility of hours worked, divided by the shadow value of consumption, representing the marginal rate of substitution of work into consumption for an individual worker. The right hand side of (13) is the additional output produced, per worker, by an additional hour worked.

Equation (13) determines hours per employee as a function of employment; its derivative,  $h_n(n, x) = -\Phi \frac{h(n, x)}{n}$ , implies an elasticity of hours to employment given by  $-\Phi$ , where:

$$\Phi \equiv \frac{1 - \alpha}{\sigma + 1 - \alpha} \in (0, 1). \quad (14)$$

Two properties of the elasticity defined in (14) are worth noting,

$$\frac{\partial \Phi}{\partial \alpha} = -\frac{\sigma}{(\sigma + 1 - \alpha)^2} < 0, \quad \frac{\partial \Phi}{\partial \sigma} = -\frac{1 - \alpha}{(\sigma + 1 - \alpha)^2} < 0. \quad (15)$$

First, the greater the concavity in the production function with respect to total hours (the lower is  $\alpha$ ), all else equal, the more substitutable are the two labor inputs (the greater is  $\Phi$ ). Second, the higher is the Frisch elasticity of labor supply (the lower is  $\sigma$ ), the more substitutable are the two labor inputs (the greater is  $\Phi$ ). Consider a production function that is linear in total hours, such that  $\alpha = 1$ , or a disutility function with a zero Frisch elasticity, such that  $\sigma \rightarrow \infty$ . In either case, hours are invariant to employment,  $\Phi = 0$ . A firm's intensive and extensive labor margins are instead substitutes if the production function is concave in total hours, i.e.  $\alpha < 1$ , and the labor disutility function is convex in hours worked, i.e.  $\sigma$  is finite.

Using the elasticity of hours to employment (14), the worker's shadow value (6) becomes:

$$\chi(n, x) = (1 - \Phi)\alpha A (nh(n, x))^{\alpha-1} h(n, x) - [w(n, x) + w_n(n, x)n]. \quad (16)$$

The first term in (16) shows that the shadow value is *reduced* when an additional worker lowers average hours per employee,  $\Phi > 0$ . However, we show below that hiring also reduces the wage bill, such that the overall external effect on the shadow value is positive. The equilibrium wage can be shown to satisfy

$$w(n, x) = (1 - \gamma) \left[ \frac{\zeta h(n, x)^{1+\sigma}}{1 + \sigma} \frac{1}{\Lambda} + (b + T^b) \right] + \gamma \left[ \kappa \cdot \alpha A (nh(n, x))^{\alpha-1} h(n, x) + c\theta \right], \quad (17)$$

where  $\kappa \equiv \frac{1 - \gamma \Phi}{1 - \gamma \Phi (1 + \sigma)} \geq 1$ . Eq. (17) has a similar structure as the bargaining wage in the one-worker-firm model. The wage per worker is a convex combination of two components, where the weights are given by the bargaining shares. One component is the household's marginal rate of substitution between an additional worker and consumption, plus the worker's outside option. The second component is the marginal product of an additional worker, plus the cost of posting a vacancy. Eq. (17) only differs from the equilibrium wage in the one-worker-firm model of e.g. (Trigari, 2006) through the coefficient  $\kappa \geq 1$ , which in turn depends on the degree of substitutability between the extensive and the intensive margins of labor,  $\Phi$ .

Differentiating the wage (17) with respect to employment  $n$ , we see that hiring an additional worker reduces the total wage bill,

$$w_n(n, x)n = -[(1 - \gamma) + \gamma \kappa (1 + \sigma)] \Phi \cdot \alpha A (nh(n, x))^{\alpha-1} h(n, x). \quad (18)$$

Then, combining Eqs. (16), (17) and (18), and after some algebra, the shadow value can be written as

$$\chi(n, x) = (1 - \gamma) \left[ \kappa \cdot \alpha A (nh(n, x))^{\alpha-1} h(n, x) - \frac{\zeta h(n, x)^{1+\sigma}}{1 + \sigma} \frac{1}{\Lambda} - (b + T^b) \right] - \gamma c\theta. \quad (19)$$

We will compare (19) with its counterpart in the efficient allocation.

### 3.6. Consumption and saving

There exists a unit mass of identical infinitely-lived households, each with a large number of members. In the representative household, a fraction  $n \in (0, 1)$  of members are employed in the market economy. The household's employment rate  $n$  corresponds to aggregate employment. The household may consume  $C$  or save in terms of riskless bonds  $B$  that cost one unit of the final good and yield a return of  $(1 + r)$  units one period later. Let  $W(x)$  denote the value function of the representative household. The maximization problem is expressed as

$$W(x) = \max_{C, B'} \left\{ \ln C - \int_0^n \frac{\zeta h(n, x; j)^{1+\sigma}}{1 + \sigma} dj + \beta E\{W(x')|x\} \right\}, \quad (20)$$



where  $\beta \in (0, 1)$  is the household's discount rate, consumption is the sum of goods produced in the market,  $C^m$ , and home-produced goods,  $C = C^m + (1 - n)b$ , subject to the budget constraint,

$$C^m + B' + T \leq \int_0^n w(n, x; j) dj + (1 - n)T^b + (1 + r)B + D, \quad (21)$$

where  $T$  are lump-sum taxes and  $D$  are firm profits, both of which are taken as given by the households. The first order condition for the optimal consumption-savings decision yields  $1 = (1 + r)\beta E\{\Lambda(x, x')|x\}$ , where  $\Lambda(x, x') = C/C'$ . As in [Andolfatto \(1996\)](#) and [\(Merz, 1995\)](#), there exists an insurance technology guaranteeing complete consumption risk sharing between household members, such that  $C$  denotes consumption by a member as well as overall household consumption. Given that all households are identical in equilibrium,  $C$  also represents economy-wide consumption.

### 3.7. Market clearing and equilibrium

We aggregate the budget constraint (21) over households and impose zero net supply of bonds,  $B = B' = 0$ . Then, we combine the aggregate household budget constraint with the government budget constraint,  $T = G + (1 - n)T^b$ , and aggregate profits,  $D = A(nh)^\alpha - wn - cv$ , to obtain the aggregate accounting identity,

$$A(nh)^\alpha + (1 - n)b = C + G + cv. \quad (22)$$

Total output, i.e. the sum of market output and home-produced output, must equal private consumption, government consumption and the resources used up for posting vacancies.

**Definition 1.** A *competitive allocation* is a set  $\{h, v, n', C\}$  at which, given an initial employment level  $n$ , employment follows the law of motion (1), households maximize utility, firms maximize profits, goods and bond markets clear.

## 4. Overhiring and optimal unemployment insurance

In the following, we characterize the steady-state distortions arising in our model. We investigate the role of hours for these distortions in the next section. We first derive the efficient allocation, then we calibrate the model and provide a graphical illustration of the overhiring result. We also show how the distortion can be removed with an appropriate unemployment insurance scheme. The starred variables denote the allocations that solve the planner problem.

### 4.1. Labor market distortion

The social planner maximizes household utility subject to the evolution of employment and the resource constraint.

**Definition 2.** An *efficient allocation* is a set  $\{h^*, v^*, n^{*f}, C^*\}$  which, given an initial employment level  $n^*$ , maximizes utility (20), subject to the employment dynamics (1) and the resource constraint (22).

The efficient allocation is characterized by the same first order condition for hours as the competitive allocation (13), and the same job creation condition (8), where the efficient shadow value of an extra worker is

$$\chi^* = (1 - \eta) \left[ \alpha A(n^* h^*)^{\alpha-1} h^* - \frac{\zeta (h^*)^{1+\sigma}}{1+\sigma} C^* - b \right] - \eta c \theta^*. \quad (23)$$

Eq. (23) is the efficient counterpart of (19). It states that a new worker adds an amount  $\alpha A(n^* h^*)^{\alpha-1} h^*$  to goods produced in the market and generates three costs: a utility cost of working,  $\frac{\zeta (h^*)^{1+\sigma}}{1+\sigma} C^*$ , foregone home production,  $b$ , and vacancy posting costs.

**Proposition 1.** Suppose that the worker bargaining power and the matching function elasticity are equal,  $\gamma = \eta$ . Then, in the absence of employment insurance,  $T^b = 0$ , a distortion in employment and hours worked arises if the production function is non-linear in total hours,  $\alpha \neq 1$ . In particular, decreasing returns to total hours in production,  $\alpha < 1$ , imply that employment is too high and hours per worker are too low in the competitive allocation.

**Proof.** To see that the competitive allocation is distorted when  $\gamma = \eta$  and  $T^b = 0$ , compare the shadow value in the decentralized allocation (19) with its counterpart in the efficient allocation (23). Given that  $\kappa > 1$ , we see that, for a given marginal rate of substitution (from the viewpoint of the household) between an additional worker and consumption,  $\frac{\zeta h^{1+\sigma}}{1+\sigma} C$ , the shadow value of a marginal worker is higher in the decentralized allocation than in the efficient allocation, implying that firms have an incentive to overhire. As a consequence, hours per worker are too low in the competitive allocation, see (13).  $\square$

Note that we abstract from another distortion that arises when the elasticity of matches to unemployment  $\eta$  is different from the worker bargaining weight  $\gamma$ . When  $\eta$  is high, a firm that posts a vacancy increases vacancy duration for all other

**Table 1**  
Externally calibrated parameters.

<b>Preferences and production</b>		
$\beta$	0.99	Discount factor; 4% average annualized real interest rate
$\sigma$	3	Inverse Frisch elasticity of labor supply; (Keane and Rogerson, 2012)
$\alpha$	0.60	Production elasticity to labor
$\bar{Y}$	1	Steady state output; normalization
$\bar{h}$	0.30	Steady state hours; One third of total time for working
$\bar{G}/\bar{Y}$	0.21	Steady state share of government consumption in GDP; Euro Area data
<b>Labor market</b>		
$\bar{u}$	0.096	Steady state unemployment rate; Euro Area data
$\eta$	0.60	Elasticity of matches to unemployment; (Petrongolo and Pissarides, 2001)
$\gamma$	0.60	Workers' bargaining power; (Petrongolo and Pissarides, 2001)
$\bar{q}$	0.70	Steady state vacancy filling rate; (Christoffel et al., 2009)
$\lambda$	0.03	Job separation rate; (Christoffel et al., 2009)
$c\bar{v}/\bar{Y}$	0.01	Steady state share of total vacancy posting cost in GDP; (Andolfatto, 1996)

**Table 2**  
Implied parameters.

<b>Preferences and production</b>		
$\bar{A}$	2.18	Steady state technology
$\zeta$	99	Weight on labor disutility
$M_0$	0.41	Scale parameter matching function
$\bar{C}/\bar{Y}$	0.82	Steady state share of consumption in GDP
<b>Labor market</b>		
$\bar{n}$	0.904	Steady state employment
$\bar{p}$	0.28	Steady state job finding rate
$\bar{\theta}$	0.40	Steady state labor market tightness
$c$	0.25	Cost of posting a vacancy
$\bar{v}$	0.04	Steady state number of vacancies
$\bar{w}$	0.84	Steady state wage rate
$b$	0.50	Home production

firms, creating a congestion effect. This effect has to be offset by giving more bargaining power to workers, which discourages firms from posting vacancies. See (Pissarides, 2006). In order to isolate the intrafirm bargaining distortion, we assume that the so-called Hosios condition is satisfied by setting  $\gamma = \eta$ , see (Hosios, 1990).

Under IFB, the returns to total hours in the production function have key implications for the firm's optimal hiring decision. When the production function is linear in total hours ( $\alpha = 1$ ), labor productivity as well as the wage schedule are independent of the number of employees, as in the one-worker-firm model à la (Mortensen and Pissarides, 1994).<sup>8</sup> In contrast, a firm employing several workers can strategically affect the marginal product, and thus the bargaining wage, through its hiring choices when the production function exhibits decreasing returns to total hours. Indeed, under a concave production function, the marginal product depends negatively on the number of employees within the firm. An additional hire reduces the marginal product of a worker. That lowers the bargaining wage paid to all existing workers, such that the wage bill is reduced,  $w_n(n, x; j) < 0$ . This leads firms to hire a suboptimally high number of workers – this is the well-known overhiring result in the intrafirm bargaining literature (see (Acemoglu and Hawkins, 2014; Cahuc and Wasmer, 2001; Stole and Zwiebel, 1996)). Now, when firms are allowed to adjust their labor input through the hours margin, a new worker reduces hours worked of the firm's other employees by shifting production from the intensive to the extensive margin, such that  $h_n(n, x; j) < 0$ . This substitution effect, captured by the term  $h_n(n, x; j)$ , is absent in the intrafirm bargaining model that abstracts from hours.

The elasticity of hours to employment, measured by  $\Phi$ , drives the strength of the overhiring externality. Since  $0 \leq \alpha \leq 1$ ,  $0 \leq \gamma \leq 1$  and  $\sigma \geq 0$ , the wage depends negatively on employment. Notice that the slope of the wage curve (17) with respect to  $n$ , depends on the IFB externality through  $\Phi$ . With a linear production function ( $\alpha = 1$ ) or inelastic labor supply ( $\sigma \rightarrow \infty$ ), there is no substitution between employment and hours ( $\Phi = 0$ ) and the bargained wage is invariant to the number of employees within the firm ( $w_n(n, x) = 0$ ). Instead, the more substitutable are the two labor margins (the higher is  $\Phi$ ), the more an additional worker reduces hours worked and, in turn, the equilibrium real wage.

#### 4.2. Calibration

The model parameters are calibrated at a quarterly frequency for the Euro Area. Table 1 lists the externally calibrated parameters and Table 2 describes the remaining variables implied by the model's steady state, given these parameters.

<sup>8</sup> (Cahuc and Wasmer, 2001) highlight the conditions under which a multiple-worker firm model with constant returns to scale is equivalent to the standard one-worker-firm model.

All externally calibrated parameters in Table 1 are either set to values commonly accepted in the literature or to target empirical evidence from the Euro Area. The discount factor in household preferences is set to  $\beta = 0.99$ , implying a steady state annualized real interest rate of 4%. We set the inverse Frisch elasticity of labor supply to  $\sigma = 3$ , which corresponds to the intermediate values suggested by Keane and Rogerson (2012). Since the wage is not equal to the marginal product of labor in a search-and-matching model, the value of the production elasticity of labor  $\alpha$  is not exactly equal to the labor share. We set  $\alpha = 0.6$ , which is close to the conventional value in the frictionless model. This value implies a steady state labor share of 75% in our baseline calibration. It is larger than the average labor share (55%) in the Euro Area.<sup>9</sup> Steady state TFP,  $\bar{A}$ , is deduced from the production function with market output normalized to unity ( $\bar{Y} = 1$ ). The scale parameter in labor disutility,  $\zeta$ , is calibrated to meet the target  $\bar{h} = 0.3$ . This target means that roughly one third of the time endowment (normalized to one) is spent working. The share of government spending in GDP,  $\bar{G}/\bar{Y}$ , is set to 21%, which corresponds to the average share of public spending in the Euro Area.

The rest of the externally calibrated parameters in Table 1 are specific to the search-and-matching literature. The steady state unemployment rate is set to 9.6%, which corresponds to the average unemployment rate in the Euro area between 1999 and 2015. The elasticity of the number of matches to unemployment is set to  $\eta = 0.6$ , which is the mid-point of the range 0.5–0.7 proposed by Petrongolo and Pissarides (2001). The worker's bargaining weight,  $\gamma$ , is also set to 0.6, which is close to the value suggested by Christoffel et al. (2009).<sup>10</sup> Following (Christoffel et al., 2009), we set the vacancy filling rate,  $\bar{q}$ , to 0.7 and the job separation rate,  $\lambda$ , to 0.03, in line with Euro area data on job flows. Total vacancy costs amount to 1% of GDP ( $c\bar{v}/\bar{Y} = 0.01$ ); this is larger than the value in Christoffel et al. (2009) but it is in line with Andolfatto (1996); Gertler and Trigari (2009) and (Sunakawa, 2015).

Given these calibrated values, we can deduce the remaining parameters implied by the model's steady state (see Table 2). Home production accounts for a small proportion of market output,  $b\bar{u}/\bar{Y} = 0.05$  (for  $b = 0.5$ ) as suggested by Gertler and Trigari (2009). Interpreting the home production parameter  $b$  as an unemployment benefit, we have a replacement rate,  $\frac{b}{\bar{w}}$ , of 0.60, which is close to Christoffel et al. (2009) value of  $\frac{b}{\bar{w}h} = 0.65$ , where their  $\bar{w}$ , however, denotes the hourly wage rate. Our implied steady state job finding rate is  $\bar{p} = 0.28$  and the labor market tightness,  $\bar{\theta}$ , is 0.4, both values being very close to Christoffel et al. (2009), who also calibrate their model to the Euro Area.

The values we obtain for technology  $\bar{A}$ , government spending  $\bar{G}$ , the weight on labor in utility  $\zeta$ , the matching technology  $M_0$ , home production  $b$  and vacancy posting cost  $c$  are then kept fixed across allocations.

### 4.3. Illustration

Fig. 3 displays the competitive and efficient allocations in the labor market. In the upper panel, we study the employment margin by plotting, in  $(u, v)$ -space, the downward-sloping Beveridge Curve together with the upward-sloping competitive and efficient job creation conditions (JCC). The Beveridge Curve is the law of motion for employment (1) rewritten as:

$$v = \left( \frac{(1-u)\lambda}{M_0 u^\eta} \right)^{\frac{1}{1-\eta}}. \quad (24)$$

The competitive and efficient JCC curves, i.e. Eq. (25) and (26) respectively, are obtained by using the optimality condition for hours (13) in the respective expressions for the shadow value, (19) and (23), such that:

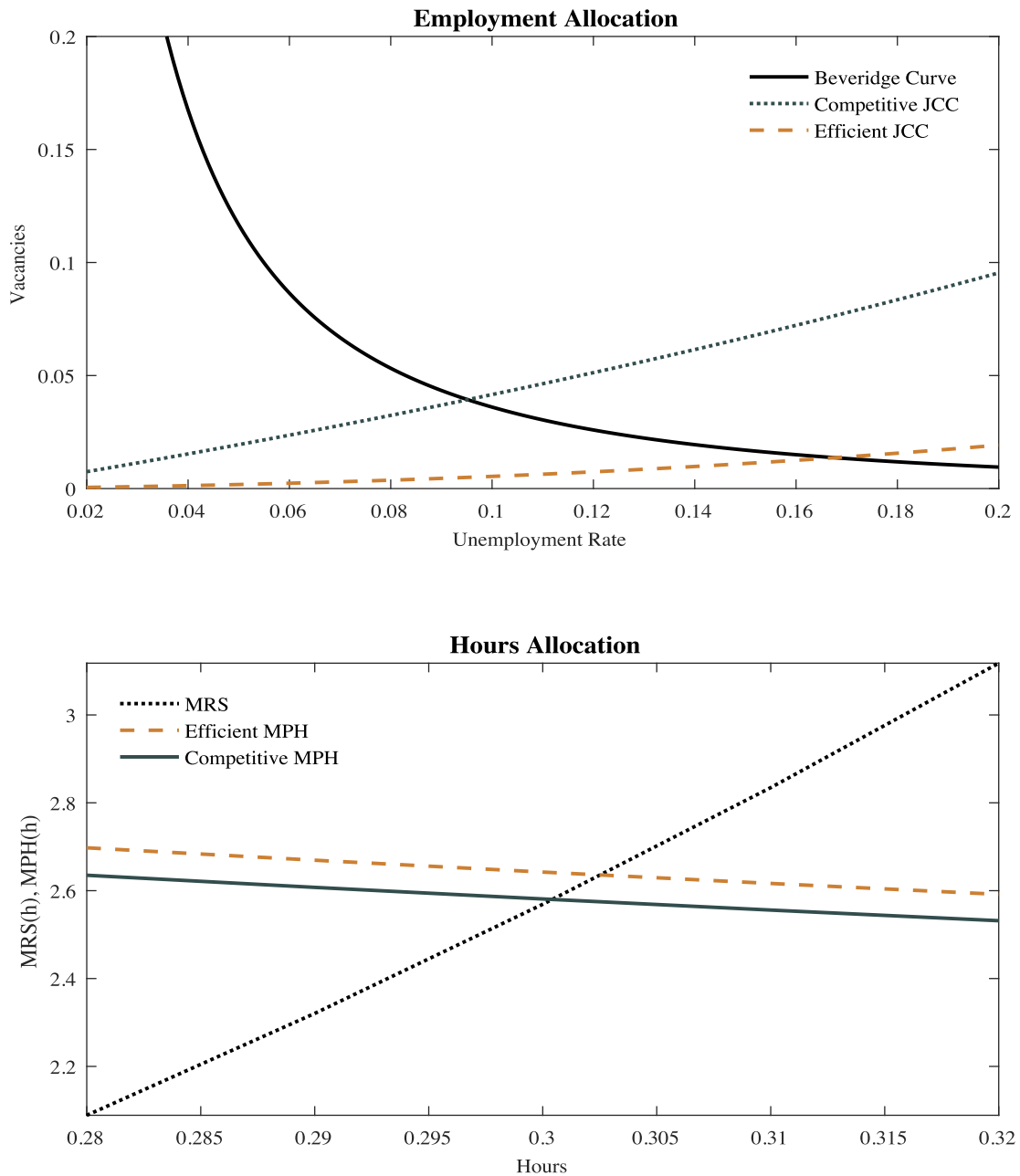
$$\frac{1 - \beta(1 - \lambda)}{\beta} \frac{c}{M_0} \left( \frac{v}{u} \right)^\eta = (1 - \gamma) \left[ \frac{1}{1 - \gamma \Phi(1 + \sigma)} \cdot \frac{\sigma}{1 + \sigma} \alpha A ((1 - u)h)^{\alpha-1} h - b \right] - \gamma c \frac{v}{u}, \quad (25)$$

$$\frac{1 - \beta(1 - \lambda)}{\beta} \frac{c}{M_0} \left( \frac{v^*}{u^*} \right)^\eta = (1 - \eta) \left[ \frac{\sigma}{1 + \sigma} \alpha A ((1 - u^*)h^*)^{\alpha-1} h^* - b \right] - \eta c \frac{v^*}{u^*}. \quad (26)$$

Comparing (25) and (26), where  $[1 - \gamma \Phi(1 + \sigma)]^{-1} > 1$ , we see that in the competitive allocation, vacancies respond more to unemployment than in the efficient allocation. The competitive JCC curve is steeper than the efficient JCC curve. This illustrates the overhiring distortion; the equilibrium unemployment rate – at the intersection between the Beveridge Curve and the competitive JCC – is lower than the efficient unemployment rate. The lower panel in Fig. 3 shows that hours per employee are too low in the competitive allocation. Looking at the hours decision (13), inefficiency in the intensive margin in labor only comes from the misallocation in employment. Put differently, since hours and employment are substitutes, overhiring goes hand in hand with suboptimally low hours. With substitutability between hours and employment, hiring a worker allows the firm to reduce hours per worker. In Trigari (2006)'s one-worker-firm setup where both wages and hours

<sup>9</sup> We use data from Eurostat, over the sample 1995q1-2015q4, the labor share is measured as the ratio between total compensation and gross value added. We provide robustness exercises for the normative analysis in Section 5 and in the online appendix for the positive analysis.

<sup>10</sup> Christoffel et al. (2009) suggest  $\gamma = 0.5$  for the Euro Area. We prefer the value  $\gamma = \eta$  in the spirit of the so-called (Hosios, 1990) condition. As shown by Cahuc et al. (2008) and in Proposition 1, this condition is not sufficient to ensure an efficient level of employment in our model. However,  $\gamma = \eta$  ensures that the inefficiency in the extensive margin comes from the concavity in the production function only, and thus we are able to study the IFB distortion in isolation.



**Fig. 3.** Employment and hours distortion. *Note:* In the upper panel, the solid line displays the Beveridge curve, the dotted line displays the competitive JCC and the dashed line displays its efficient counterpart. In the lower panel, the dotted line 'MRS' is the marginal rate of substitution,  $\frac{c(h(n,x))}{\lambda}$ ; the solid line displays the competitive marginal product of hours  $\alpha A(nh(n,x))^{\alpha-1}$  and the dashed line is its efficient counterpart.

are determined through Nash bargaining, hours are set efficiently. This is what (Trigari, 2006) calls 'efficient bargaining'. Here, due to the IFB externality, hours per worker are not efficient despite being determined by Nash bargaining. The inefficiency in the extensive margin carries over to the intensive margin. In Section 5, we investigate how the inclusion of the intensive margin affects this overhiring behavior.

#### 4.4. Optimal unemployment insurance

We have shown that in our model, firms tend to hire too many workers and each one of them works too few hours. How can policy address this distortion? Given that the distortion works only through the shadow value of a marginal worker, any instrument that lowers this shadow value can be used to restore efficiency. An additional worker should be made

less attractive to firms, which should discourage hiring. Essentially, our aim is to flatten the JCC curve in Fig. 3. Several instruments are possible: a hiring tax, an unemployment transfer or an increase in the workers' bargaining power, insofar as the latter can be influenced by the policy maker. We have opted for unemployment insurance as the most plausible and empirically relevant policy tool. Given that the hours margin is undistorted for an efficient allocation of employment, a policy that removes the overhiring incentive automatically leads to an efficient level of hours per worker.

**Proposition 2.** *The optimal transfer scheme to the unemployed, defined as the value of  $T^b$  that equalizes the shadow value in the competitive and the efficient allocation, is given by*

$$T^b = \frac{\gamma \Phi(1 + \sigma)}{1 - \gamma \Phi(1 + \sigma)} \sigma \cdot \zeta h^\sigma C. \quad (27)$$

**Proof.** Substitute the optimal unemployment transfer from (27) in the competitive shadow value (19) to verify that the resulting equation is identical to the efficient shadow value (23).  $\square$

The optimal unemployment transfer is proportional to the marginal rate of substitution between hours and consumption,  $\zeta h^\sigma C$ . Its dynamics closely track those of private consumption, rising after a favorable technology shock and falling in response to a wasteful government spending expansion that leads to a crowding-out effect.<sup>11</sup>

## 5. Effect of hours margin on IFB externality

To understand how the hours margin affects the overhiring result, we derive the model with IFB and constant hours. Then, for a range of parameter values, we compute employment and hours in the competitive allocation relative to the efficient allocation, as well as the associated welfare loss.

### 5.1. Model with constant hours

In the following, we outline an alternative model where hours per worker are held constant, discussing only those model features that are different from the benchmark model. The representative firm produces output by employing  $n$  workers, each working a constant number of  $\bar{h}$  hours. The firm's match surplus and the job creation condition are as in the benchmark model, with the shadow value given by

$$\chi(n, x) = \alpha A(n\bar{h})^{\alpha-1} \bar{h} - \left[ w(n, x; n) + \int_0^n w_n(n, x; j) dj \right]. \quad (28)$$

Compare the above expression for the shadow value with Eq. (6) in the benchmark model. In the constant-hours model, the effect of hiring on the marginal product through hours per employee, given by the term  $h_n(\cdot)$ , is absent. Once we have solved the Nash bargaining problem to obtain the equilibrium wage, we can rewrite the shadow value as follows:

$$\chi(n, x) = (1 - \gamma) \left[ \tilde{\chi} \cdot \alpha A(n\bar{h})^{\alpha-1} \bar{h} - \frac{\zeta \bar{h}^{1+\sigma}}{1 + \sigma} C - (b + T^b) \right] - \gamma c\theta, \quad (29)$$

where  $\tilde{\chi} \equiv 1/[1 - \gamma(1 - \alpha)]$ . The competitive shadow value (29) with  $T^b = 0$  is larger than its efficient counterpart, i.e. (23) with hours set constant, since  $\tilde{\chi} > 1$ . Thus, there is overhiring. The wedge between  $\tilde{\chi}$  and 1 stems from intrafirm bargaining in the model with constant hours.

Now, comparing the shadow value in the benchmark model (19) with the one in the constant-hours model (29), the hours margin works through two channels. On the one hand, a given marginal product raises the shadow value more in the constant-hours model than in the benchmark model, as  $\tilde{\chi} > \chi$ . On the other hand, the household's marginal rate of substitution differs across the two models due to the underuse of hours in the benchmark model. Inefficiently low hours reduce  $\frac{\zeta \bar{h}^{1+\sigma}}{1 + \sigma} C$  relative to the constant-hours case, which has a positive effect on the shadow value. Which of these two effects dominates depends on parameter values.<sup>12</sup>

### 5.2. Overhiring and welfare: Numerical analysis

Does an hours margin lead to more or less overhiring in the intrafirm bargaining model? To answer this question, we compute: (a) employment in the competitive allocation relative to efficient employment, (b) hours in the competitive allocation relative to efficient hours, and (c) the welfare loss from intrafirm bargaining. We compute these three objects in the benchmark model and in the constant-hours model, for the parameter ranges  $\alpha \in (0.2, 1)$  and  $\sigma \in (1, 3)$ . The remaining parameters are calibrated as described in Section 4.2.

<sup>11</sup> See online appendix for details.

<sup>12</sup> In addition, the marginal product depends negatively on hours per worker, which adds another layer of complexity.

The welfare loss is expressed in terms of consumption equivalent units. Welfare in the *competitive* allocation,  $W(x)$ , is defined in expression (20). The *efficient* welfare level in any given period, conditional on the realization of the aggregate state  $x$ , is defined as follows:

$$W^*(x) = \ln C^* - n^* \frac{\zeta h^{*(1+\sigma)}}{1+\sigma} + \beta E\{W^*(x')|x\}, \quad (30)$$

where the starred variables consumption, employment and hours denote the allocations that solve the planner problem set out in Section 4. Let's consider period-0 conditional lifetime utility in the efficient and competitive allocations, where the aggregate state is  $x_0$ , denoted  $W_0^*$  and  $W_0$ . Following (Lucas, 1987), we can determine the fraction  $\Delta$  by which efficient consumption must be reduced in each period so as to obtain the same welfare level as in the competitive allocation. More technically, there exists a  $\Delta \in (0, 1)$  such that

$$W(x) = \ln[(1 - \Delta)C^*] - n^* \frac{\zeta h^{*(1+\sigma)}}{1+\sigma} + \beta E\{W(x')|x\}. \quad (31)$$

We can rewrite the above expression, at period 0, in terms of the efficient welfare level,  $W_0 = \frac{\ln(1-\Delta)}{1-\beta} + W_0^*$ , and then solve for  $\Delta$  to obtain the % welfare loss in the competitive allocation:

$$\Delta = 1 - \exp[(1 - \beta)(W_0 - W_0^*)]. \quad (32)$$

Note that, in order to quantify the inefficiency from intrafirm bargaining, we are computing the welfare loss at the steady state. As shown by Ravenna and Walsh (2012) the dynamic inefficiencies arising from imperfectly competitive labor markets under search frictions are rather small. Krause and Lubik (2013) show that the dynamic effects of IFB in a business cycle model are negligible. Therefore, the welfare loss computed as above, comparing period-0 lifetime utility levels conditional on certain exogenous shock processes, does not differ much from the one that compares steady state welfare levels.<sup>13</sup>

We now assess how the hours margin affects the overhiring behavior and the welfare implications. To do so, we make a robustness analysis by focusing on two parameters that are the main drivers of the degree of substitutability between hours and employment, namely  $\sigma$  and  $\alpha$ .

### 5.2.1. Overhiring as a function of $\sigma$

Fig. 4 shows that, over the whole range of parameters considered for the *inverse Frisch elasticity of labor supply*  $\sigma$ , overhiring is greater in the benchmark model than in the constant-hours model. In the benchmark model, hours are 1–2 percentage points lower than in the efficient allocation. Despite greater overhiring, the welfare loss in the benchmark model is always smaller than in the constant-hours model, due to the fact that each worker's hours are reduced, leading to lower disutility from working. We find a welfare loss of between 0.35% and 0.45%. These values are in the same ballpark as Ravenna and Walsh (2012), who investigate the welfare cost of violating the Hosios condition.

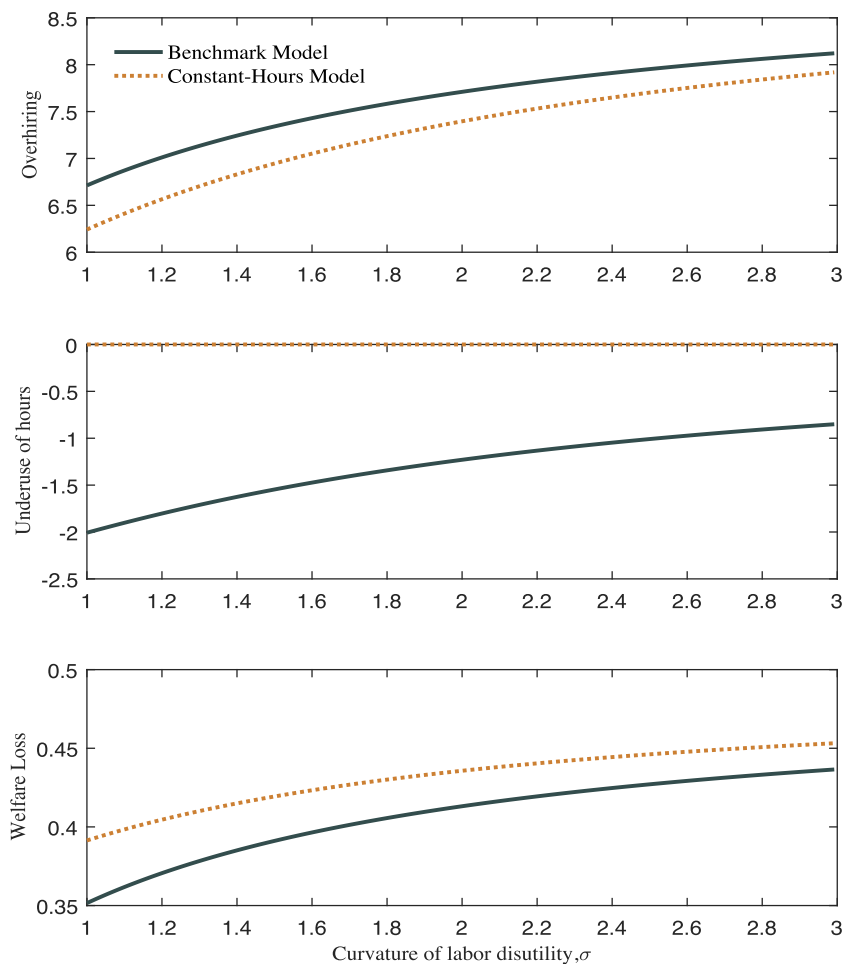
As we reduce the labor supply elasticity (i.e. increase  $\sigma$ ), the underuse of hours is reduced, whereas overhiring and the associated welfare loss rise. To understand this result, consider the shadow value in the constant-hours model (29). Higher values of  $\sigma$  reduce the household's marginal rate of substitution,  $\frac{\zeta \bar{h}^{1+\sigma}}{1+\sigma} C$ , and, in turn, the workers' wage demands in the bargaining problem. The shadow value increases, and so does overhiring. In the benchmark model with endogenous hours, overhiring leads to an underuse of hours. This additional channel reduces even more the marginal rate of substitution in (19), exacerbating the overhiring externality. For ever larger values of  $\sigma$ , overhiring in the benchmark model and in the constant-hours model converge, see the discussion in Section 4. This is intuitive: as  $\sigma \rightarrow \infty$ , hours matter less and less for utility and the substitutability between the two labor margins disappears ( $\Phi \rightarrow 0$ ). The additional incentive to overhire disappears, and the underuse of hours goes to zero.

### 5.2.2. Overhiring as a function of $\alpha$

In Fig. 5, we plot employment, hours and welfare relative to the efficient allocation, for different values of the *returns to total hours in production*,  $\alpha$ . With a linear production function ( $\alpha = 1$ ), the intrafirm bargaining externality vanishes. As we increase the concavity of the production function by reducing  $\alpha$  below 1, the overhiring externality increases and so does the welfare loss. In the benchmark model, the underuse of hours per employee initially rises as  $\alpha$  is reduced. Overhiring is greater in the benchmark model than in the constant-hours model; however, the reduction in hours per worker - and the associated reduction in labor disutility - dampens the loss in welfare, such that the welfare loss is always greater in the constant-hours model.

For very small values of  $\alpha$ , overhiring tends to decrease with  $\alpha$  in both models. This result can be understood by looking at the shadow value in the constant-hours model (29). Suppose that we start from a linear production function, then make it more and more concave. The coefficient  $\tilde{\alpha}$  rises above 1 as  $\alpha$  is reduced below 1. This increases the shadow value. However, two forces decrease the shadow value by lowering the marginal product per worker,  $\alpha A(n\bar{h})^{\alpha-1}\bar{h}$ ; one is direct, the other is indirect. First, for a given workforce, the marginal product falls as we reduce  $\alpha$ . Second, the marginal product falls as the firm expands its workforce  $n$ . Fig. 5 shows that the positive effect working through the coefficient  $\tilde{\alpha}$  dominates for high

<sup>13</sup> Additional results on the alternative computation of the welfare loss are available from the authors upon request.



**Fig. 4.** Overhiring and the curvature of the labor disutility function ( $\sigma$ ). *Note:* The upper panel plots overhiring at the steady state,  $(\bar{n} - \bar{n}^*)/\bar{n}^*$ , in percentage terms, for different values of  $\sigma$ . The middle panel plots the underuse of hours at the steady state,  $(\bar{h} - \bar{h}^*)/\bar{h}^*$ , in percentage terms, for different values of  $\sigma$ . The lower panel plots the value of  $\Delta$ , in percentage terms, from Eq. (32), i.e. the welfare loss is expressed in terms of consumption equivalent units for different values of  $\sigma$ . The solid lines correspond to the benchmark model and the dashed correspond to the constant-hours model.

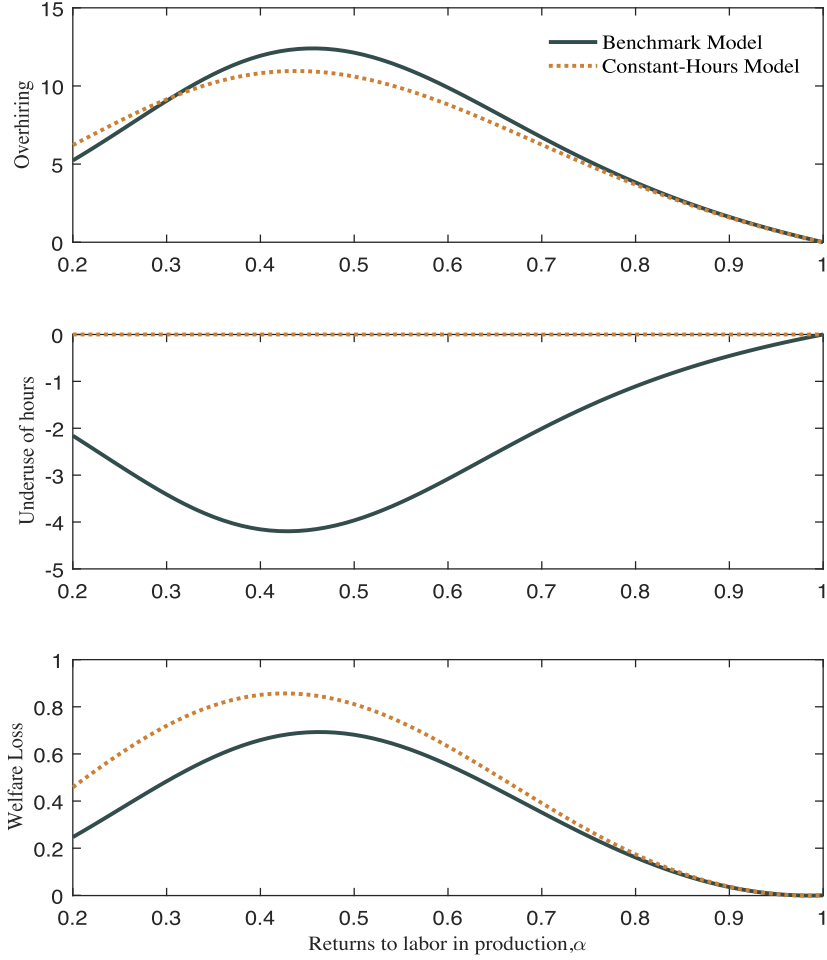
values of  $\alpha$ ; however, for low values of  $\alpha$ , the negative effect through the marginal product dominates, such that overhiring starts to fall. As overhiring falls, the underuse of hours falls, too.

In the benchmark model with variable hours per worker, the two effects on the shadow value described above are dampened. First, the coefficient on the marginal product in the shadow value,  $\kappa$ , is smaller than the corresponding coefficient in the constant-hours model,  $\tilde{\kappa}$ . This dampens the first effect. Second, the fall in hours per worker has a positive impact on the marginal product, which dampens the second effect. We see in Fig. 5 that overhiring is larger in the benchmark model for values of  $\alpha$  above 0.3.<sup>14</sup> These findings illustrate our main result: the overhiring externality is magnified when hours per worker are variable. With substitutability between hours and employment, hiring a worker allows the firm to reduce hours per employee. If labor supply is highly elastic, i.e.  $\sigma$  is low, or if the production function is highly concave in total hours worked, i.e.  $\alpha$  is low, employment and hours become more substitutable. Reducing hours per worker allows the firm to reduce the marginal rate of substitution and thus the wage demands of a worker. Through intrafirm bargaining, this lowers the wages of infra-marginal workers.

## 6. Empirical performance

In this section, we assess the goodness-of-fit of the baseline model by comparing model-based and data-based second-order moments for the Euro Area.

<sup>14</sup> How large is  $\alpha$  empirically? Estimates of  $\alpha$ , based on the labor share of output, are typically around 2/3, which allows us to ignore very small values of  $\alpha$ . In a model with search-and-matching,  $\alpha$  does not fully correspond to the labor share. Nevertheless, its value usually lies in the range [0.6; 0.7]. As mentioned in Section 4.2, we set  $\alpha = 0.6$ , implying a labor share of 0.75 in our benchmark model.



**Fig. 5.** Overhiring and the concavity of the production function ( $\alpha$ ). *Note:* The upper panel plots overhiring at the steady state,  $(\bar{n} - \bar{n}^*)/\bar{n}^*$ , in percentage terms, for different values of  $\alpha$ . The middle panel plots the underuse of hours at the steady state,  $(\bar{h} - \bar{h}^*)/\bar{h}^*$ , in percentage terms, for different values of  $\alpha$ . The lower panel plots the value of  $\Delta$ , in percentage terms, from Eq. (32), i.e. the welfare loss is expressed in terms of consumption equivalent units for different values of  $\alpha$ . The solid lines correspond to the benchmark model and the dashed correspond to the constant-hours model.

## 6.1. Strategy

We use real GDP, employment, hours per employee, vacancies, wages and the inflation rate in European data. The sample covers 1999Q1-2015Q4. Since neither the number of vacancies nor the vacancy rate are available over a long sample for the Euro Area, we use the German series as a proxy. Data are taken from the Area Wide Model (AWM), which aggregates quarterly national data for the whole Euro Area, except for hours worked, which are available from Eurostat, and German vacancies, which are from the OECD database.<sup>15</sup> Table 3 displays the empirical second-order moments and their theoretical counterparts for different variants of the model.

The calibration strategy is the same as in Section 4.2. Additionally, fluctuations are driven by a TFP shock ( $A$ ) and a government spending shock ( $G$ ), which both follow an AR(1) process (in logs). The shock parameters are calibrated as follows. The standard deviation and the autoregressive parameter of the technology shock ( $\sigma_A$  and  $\rho_A$ , respectively) are estimated using the model-based measure of TFP,  $A = \log(y) - \alpha \log(nh)$ . By regressing real GDP on total hours (both in logs and HP-filtered), we find  $\sigma_A = 0.006$  and  $\rho_A = 0.74$ . The parameters associated with government spending shocks ( $\sigma_G$  and  $\rho_G$ ) are obtained by estimating an AR(1) process on the HP-filtered log of general government final consumption expenditure, which yields  $\sigma_G = 0.003$  and  $\rho_G = 0.85$ .

<sup>15</sup> The AWM mnemonic are 'YER' for real GDP, 'LNN' for employment, 'YED' for the GDP deflator and 'WIN' for total wages. Hours worked are from Eurostat. Inflation is computed as the annualized growth rate of the GDP deflator. Real wages per worker are computed as  $(\text{WIN}/\text{LEN})/\text{YED}$ . Vacancies are the 'Total unfilled vacancies (stock)' from the OECD.stat database. All series are seasonally adjusted, expressed in logs and HP-filtered (except for inflation).



**Table 3**  
Second-order moments.

	Data	Model (I) Benchmark	Model (II) Real wage rigidity	Model (III) Full model
$\sigma_y$ (%)	1.32	0.98	0.98	1.19
$\sigma_n/\sigma_y$	0.54	0.08	0.10	0.38
$\sigma_h/\sigma_y$	0.30	0.05	0.05	1.31
$\sigma_v/\sigma_y$	9.04	2.25	3.00	13.28
$\sigma_w/\sigma_y$	0.28	0.85	0.28	0.28
$\sigma_{4\pi}$ (%)	0.80	–	–	2.37
$\rho(\hat{h}_t, \hat{y}_t)$	0.82	0.86	0.87	0.68
$\rho(\hat{h}_t, \hat{y}_t)$	0.70	-0.81	-0.81	0.65
$\rho(\hat{h}_t, \hat{h}_t)$	0.53	-0.76	-0.78	0.79
$\rho(\hat{v}_t, \hat{y}_t)$	0.82	0.95	0.95	0.73
$\rho(\hat{w}_t, \hat{y}_t)$	0.17	0.99	0.99	0.17
$\rho(4\hat{\pi}_t, \hat{y}_t)$	0.37	–	–	0.61

The benchmark model presented in Section 3 is entitled Model (I). We consider two extensions that are known to better capture key business stylized facts. First, it is widely accepted that typical search-and-matching models fail at replicating the volatility of employment, as highlighted by Shimer (2005, 2010). Real wage rigidities have been widely used to get round this issue. In Model (II), we assume pro-cyclicality of firms' bargaining power – i.e. firms can bargain a wage closer to the worker's reservation wage in boom periods. This allows us to reduce wage volatility (see Jung and Kuester, 2015). Hall and Schulhofer-Wohl (2017) point out the importance of labor market tightness in unemployment cyclicality. In this spirit, we follow (Yedid-Levi, 2016) by assuming that firms' bargaining power is an increasing function of labor market tightness. Specifically, we adopt a firm's bargaining power of the form:

$$1 - \tilde{\gamma} = \frac{(1 - \gamma)}{(1 - \gamma) + \gamma(\bar{\theta}/\theta)^\nu}, \quad (33)$$

where  $\gamma$  and  $\bar{\theta}$  are calibrated in Table 1,  $\theta$  is the contemporaneous value of labor market tightness and  $\nu \geq 0$  drives the degree of wage variability.<sup>16</sup> We set  $\nu = 1.04$  in order to match wage volatility.<sup>17</sup>

In Model (III), the benchmark model is enriched with both real wage rigidities and nominal frictions through sticky prices, since it is well accepted that monetary models are good candidates to replicate key business cycle stylized facts. Two equations are added to the system, namely the New Keynesian Phillips Curve (NKPC) and the Taylor Rule, i.e. respectively:

$$\kappa \Pi(\Pi - 1) = \varepsilon s - (1 - \tau^f)(\varepsilon - 1) + \kappa E \left\{ \beta \Pi'(\Pi' - 1) \frac{Y'}{Y} \right\}, \quad (34)$$

$$\frac{R}{\bar{R}} = \left( \frac{\Pi}{\bar{\Pi}} \right)^\tau \zeta, \quad (35)$$

where  $\Pi$  is the gross inflation rate,  $s$  is the real marginal cost,  $R$  is the nominal interest rate. Parameter  $\kappa$  is the slope of the NKPC,  $\varepsilon$  is the elasticity of substitution between intermediate goods,  $\tau^f$  is a profit subsidy, and  $\zeta$  is an AR(1) monetary policy shock. Regarding the calibration, four additional parameters have to be set. The substitution elasticity between intermediate goods is set to  $\varepsilon = 6$ , yielding a net price markup of 20% and we set the steady state real marginal cost  $s$  to one with  $\tau^f = 1/(1 - \varepsilon)$ . The price adjustment cost,  $\kappa$ , is set to 44, which implies that the slope of the NKPC is the one we would get under Calvo price staggering and a one-year contract length. This value is close to Krause and Lubik (2007). The Taylor rule parameter,  $\tau$ , is set to 1.5 in line with Smets and Wouters (2005)'s estimate is worth noticing that we set  $\nu = 2.05$  in order to ensure that the full model matches wage volatility.<sup>18</sup> Incorporating a nominal side in the model also allows us to enlarge the set of shocks. The standard deviation and the persistence parameter of the monetary policy shock ( $\sigma_\zeta$  and  $\rho_\zeta$ , respectively) are estimated by regressing the nominal interest rate on the annualized HIPC inflation rate and the HP-filtered log of real GDP.<sup>19</sup> We obtain  $\sigma_\zeta = 0.016$  and  $\rho_\zeta = 0.65$ .

<sup>16</sup> There are other assumptions that dampen wage volatility in search-and-matching models. For instance, a wage norm a la (Hall, 2005) amplifies the volatility of employment through a reduction in wage volatility. It has been used by several authors e.g. (Krause and Lubik, 2007). However, (Sveen and Weinke, 2008) reveal that the amplification mechanism resulting from the wage norm is diminished when firms can choose the number of hours worked, since they resort to the intensive margin of labor instead of the extensive one. Alternatively, (Hagedorn and Manovskii, 2008) suggest calibrating the model's parameters in order to replicate the average market tightness and the elasticity of wages with respect to productivity. We show in the on-line appendix that this re-parametrization is not sufficient to generate an empirically plausible degree of wage smoothness. This result is in line with Atolia et al. (2018) who argue that departing from the household's risk neutrality and an infinite Frisch elasticity (as usually assumed in search-and-matching models) alter (Hagedorn and Manovskii, 2008) conclusions.

<sup>17</sup> (Yedid-Levi, 2016) uses the same calibration strategy for  $\nu$  and obtains  $\nu = 0.91$  for US data.

<sup>18</sup> Unsurprisingly, nominal rigidities dampen model-based wage volatility, implying that the value of  $\nu$  is lower in Model (II) than in Model (III).

<sup>19</sup> The AWM mnemonic are 'HIPC' for the HIPC, Overall Index, Index, Working day and seasonally adjusted data, Index base year 1996; 'STN' for the nominal interest rate, short term interest rate, Nominal Short-Term Interest Rate, Euribor 3-month, Percent per annum, Last trade price.

## 6.2. Results

Table 3 shows the second-order moments in the data and in Models (I), (II), (III). The shocks we use are sufficient to generate a value for output volatility that is close to the data, especially when we include the monetary policy shock in Model (III), since the empirical GDP variance is 0.013 while its theoretical counterpart is 0.011. As is standard in search-and-matching models (see (Shimer, 2005)), the benchmark model generates a too strong volatility in wages (0.85 in the model and 0.28 in the data). Introducing procyclical firms' bargaining power fixes this issue (0.28 in Models (II) and (III)). The introduction of real wage rigidity helps amplifying the volatility of the labor margin even though its intensive margin is too volatile in the full model ( $\sigma_h/\sigma_y = 1.31$  with an empirical value of 0.31). Apart from that, the full model (III) does a better job in replicating most of the moments. In particular, the relative volatility of employment is well replicated (0.38 in the model and 0.54 in the data) as well as the relative volatility of vacancies (13.28 in the model and 9.04 in the data). Thomas (2011) shows that employment volatility can be magnified in presence of real wage rigidities. The introduction of the typical ingredients, real wage and nominal rigidities, along with the inclusion of the monetary policy shock, also helps in replicating the procyclicality of the hours margin. Finally, notice that the full model generates too high volatility in inflation. This result is in line with Christoffel et al. (2009), who compare a set of New Keynesian models featuring search-and-matching frictions and show that they generate excess inflation volatility.<sup>20</sup> In conclusion, our stylized model is able to replicate key stylized facts of the labor market, and the inclusion of additional frictions further improves its goodness-of-fit.

## 7. Conclusion

Two features of the labor market are of increasing importance for economies today. First, empirical evidence suggests that variations in hours per worker are an important margin along which firms adjust their labor input, especially in European countries. Second, wage bargaining between a firm and individual workers is becoming more prevalent as trade unions lose influence. This paper investigates the labor market effects of allowing for variable hours per worker in a general equilibrium model with intrafirm bargaining.

By bargaining with each worker individually, a multiple-worker firm is able to treat each worker as marginal and, in doing so, to weaken the worker's bargaining position. This is because, under decreasing returns in production, an additional hire reduces the marginal product of labor. And that lowers the equilibrium wage paid to infra-marginal workers, such that the firm's overall wage bill is reduced. Firms exploit this externality and overhire; this is a well-known result in the literature (see (Cahuc and Wasmer, 2001; Smith, 1999; Stole and Zwiebel, 1996)).

We argue that overhiring is larger when firms are allowed to adjust their labor input through the hours margin. The firm uses its hiring decision to strategically affect the number of hours per worker. Hiring a new worker reduces the number of hours of the firm's existing employees, which lowers the disutility of working and hence workers' wage demands. Therefore, the incentive to overhire is greater than in the constant-hours model. The resulting labor market outcome is distorted; employment is too high and hours per worker are too low. This misallocation has important welfare implications.

Our model can explain the joint occurrence of labor hoarding and low hours per worker, a feature that characterizes many European labor markets. It also provides a justification for transfers to the unemployed, which help to reduce overhiring by improving a worker's outside option.

## Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.jmoneco.2018.09.002](https://doi.org/10.1016/j.jmoneco.2018.09.002).

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<sup>20</sup> This result is not only the pattern of search-and-matching models, as documented by Krause et al. (2008). Beaudry and Portier (2013) also document the excess of inflation volatility generated by New Keynesian models in the absence of labor market frictions.

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