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Abstract

Intra-firm bargaining between a multiple-worker firm and an individual employee leads to overhiring. Taking advantage of the decreasing returns to scale in employment, 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. Hours are too low at the steady state. This misallocation of labor leads to sizeable welfare losses. Our finding is important for economies in which hours adjustment play an important role as it does in many Euro Area countries.

JEL: Intra-firm bargaining, Distorsions, Optimal Monetary Policy

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1 Introduction

European and US labor markets differ in many respects. Figure 1 shows that in the Euro Area 48% of the variance in total hours is accounted for by variation in hours per employee, whereas this is only 6% for the US.[1] This is true for all large Euro Area countries, except Spain, where most of the adjustment of labor input happens via changes in the number of temporary workers. 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).[2] At the same time, Rogerson (2006) documents that in countries such as France, Germany and Italy, there has been a decline in hours per worker since the 1950s of more than 30%, which has not been the case in the US.[3] These observations point to a gradual shift towards a production structure where individual European workers perform on average fewer, but more volatile, hours.

[insert Figure 1 here]

An intensive use of the hours margin is not the sole peculiar characteristic of European countries. Regarding wage determination, individual wage bargaining between a firm and a worker has become much more prevalent today as the importance of collective bargaining has

[1]The relative high importance of the hours per worker margin in France, Germany and Italy (vs. the US) is also consistent with the findings of Llosa et al. (2012).

[2]As mentioned by ECB (2012), short-time working programs have been use more extensively in European countries than in US during the 2008 crisis which might have limited the deterioration of labor market conditions.

[3]A more recent and up to date dataset from Ohanian and Raffo (2012) confirms the virtual stability of hours worked per worker in the US, whereas in France, Germany and Italy hours worked per worker have continued to decline in the 2000s.

steadily decreased.[4] Moreover, over time 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.[5] Temping agencies allow firms to easily bargain with many individual workers simultaneously.[6] As labor unions lost influence, temping agencies became more important. All together, these facts suggest that intra-firm bargaining and variable hours now belong to the salient features of European labor markets.

In this paper, we are interested in the interaction between hours and employment in an intra-firm bargaining framework. We depart from the typical search-and-matching model à la Mortensen and Pissarides (1994) by assuming that firms can employ multiple workers and they bargain with each of them individually. In this context, without the possibility to commit to long-term wage contracts, the wage rate must be bargained anew each period. In doing so, the firm bargains with each worker as if it were the marginal worker. With a concave production function, hiring a worker lowers the marginal product of labor and reduces also the wage rate for all existing workers. Therefore, firms overhire i.e. they hire too many employees that it is required in the first best allocation (Stole and Zwiebel, 1996; Smith, 1999). Our contribution is to analyze this phenomenon in a setup where, realistically, firms can adjust labor input along two margins, employment and hours per worker. We

[4]OECD measures of trade union density show a steady decline in most European countries.

[5]Forde and Slater (2011) provide evidence for the UK, but this should arguably extend to other European countries. The legal framework is mainly determined by the European Union Temporary Agency Work Directive, which is common to all European countries.

[6]The fact that in European countries on average much more people than in the US report that they are involuntarily working part-time, also suggests that low hours per worker in Europe are an outcome of a deliberate strategy by firms to reduce bargaining power. In the US on average over the business cycle only 3% of all workers report that they are involuntarily working part-time; in the euro area this is about 6%.

show that an intra-firm bargaining model with both labor margins is able to replicate key European labor market stylized facts.

Business cycle models with frictional labor markets have largely neglected the hours margin.[7] This paper extends the literature by highlighting a steady-state misallocation of labor across the two margins, with employment being too high and hours per worker being too low compared with the efficient allocation. Importantly, we show that the overhiring behavior is magnified in the presence of an hours margin. This is because the decision to expand the workforce implies a reduction in the number of hours per employee. This, in turn, reduces the wage that the firm pays. If labor disutility rises steeply in hours worked, the resulting fall in the wage bill is large. Thus, the firm can keep wages down by employing many workers that each provide few hours.

In the presence nominal rigidities, the monetary authority faces a trade-off between eliminating the price dispersion and removing inefficiencies inherent to the steady-state distortions on labor. It is therefore natural to investigate whether the monetary policy is able to address this inefficiencies. We show that a stronger overhiring externality results in a sizeable welfare losses but only a slight amount can be corrected by deviating from price stability.

The intra-firm bargaining feature has been analyzed both from a normative and a positive perspective. Our paper contributes to this literature on both sides. Regarding the former aspect, the seminal paper by Stole and Zwiebel (1996) build the foundations of the intra-firm bargaining model and show the overhiring result in a partial equilibrium. Cahuc and Wasmer (2001) introduce this feature in a typical search-and-matching model and describes the

[7]See, for example, Mortensen and Pissarides (1994), Merz (1995), Shimer (2005), and Hall (2006).

conditions under which overhiring disappears. Bauer and Lingens (2013) determine whether collective bargaining can affect the overhiring result and Hawkins (2015) show that long-term contracts can remove the distortion under certain conditions on firm's productivity.[8] While these papers omit hours per worker as a labor input, we show that this margin makes the overhiring distortion bigger. From a quantitative side, there are several papers which investigate the goodness-of-fit of a model with intra-firm bargaining. Krause and Lubik (2013) show that the transmission channels of technology shocks are slightly affected by this feature. Kim (2015) and Clerc (2015) includes the hours margin this type of model and show that the performance of the model can be improved by modifying the source of fluctuations and the type of bargaining.[9] We show that our model replicates quite well some European labor market moments.

The remainder of the paper is structured as follows. Section 2 presents the model. Section 3 calibrates the model and discusses the implied impulse response functions and second order moments. Section 4 describes the distortions arising in the competitive allocation and highlights how they are affected by the presence of hours as a labor adjustment margin. In Section 5, we analyze optimal monetary policy and compute the welfare losses arising from intra-firm bargaining. Section 6 concludes.

[8] Acemoglu and Hawkins (2014) also look at a model with intra-firm bargaining and heterogeneous firms.

[9] Precisely, Kim (2015) argues that a stochastic bargaining shock increase the volatility of labor market variables. Clerc (2015) emphasize the role of credible bargaining to generate inflation inertia. Thomas (2011) resort also to a multiple-worker-firm with hours but he focuses on real rigidities resulting from Calvo price setting while we abstract from these rigidities by assuming Rotemberg adjustment costs.

2 The Model

Our model features search-and-matching frictions in the labor market and bilateral bargaining à la Mortensen and Pissarides (1994). A firm can employ multiple workers, as in Stole and Zwiebel (1996) or Cahuc and Wasmer (2001) among others. The bargaining process is done at the firm level, i.e. goods producers employ many workers and bargain with each of them as if he was a marginal worker. The production function is non-linear on employment which opens the doors of intra-firm bargaining effect on wages. Labor input can be adjusted along two margins, the extensive margin (employment) and the intensive one (hours per employee). Section 2.1 describes the labor market. We sketch the rest of the model, which is fairly standard, in Section 2.2. The online appendix contains detailed model derivations.

2.1 Labor Market Structure

In this section, we describe the labor decisions made by households and producers.

2.1.1 Search and Matching Frictions

The representative household has $n_t \in (0, 1)$ members that are employed and receive the real wage w_t for providing h_t hours of work. The remaining $1 - n_t$ household members are unemployed and engage in home production. Firms post vacancies and unemployed workers search for jobs. Let $\mathcal{M}_t = \mathcal{M}_0 u_t^{\eta} v_t^{1-\eta}$ denote the number of successful matches, where $u_t = 1 - n_t$ is the unemployment rate, $\eta \in (0, 1)$ is the elasticity of the number of matches to unemployment and $\mathcal{M}_0 > 0$ denotes the matching technology. The probability of a vacancy being filled next period is $q_t = \mathcal{M}_t / v_t$, where the ratio of vacancies to unemployed workers,

$\theta_t = v_t/u_t$, is a measure of labor market tightness. The job finding rate is denoted by $p_t = \mathcal{M}_t/u_t$. A constant fraction $\lambda \in (0,1)$ of matches are destroyed each period, such that $n_{t+1} = (1-\lambda)\, n_t + q_t v_t$ describes the evolution of employment. Newly hired workers become productive only in the next period.

2.1.2 Producers

A continuum of identical firms produce a homogeneous good that is sold to retailers at the perfectly competitive price s_t.[10] The output of an individual firm is produced according to the production function $X_t = f(n_t, h_t)$. Let f_n and f_h denote the marginal product of employment and hours, respectively. The function $f(.)$ satisfies $f(0) = 0$ and is strictly increasing, concave, and thrice differentiable in both arguments, such that $f_i(.) > 0$, $f_{ii}(.) \leq 0$ and $f_{iii}(.) > 0$ for $i = n, h$, where a subscript denotes the derivative with respect to argument i. Also, the cross-derivatives satisfy $f_{ij}(.) \geq 0$ and $f_{ijj}(.) \leq 0$ for $i, j = n, h$ and $i \neq j$. The properties of the production function have key implications for the structure of the firm. When the production function is linear in employment, labor productivity as well as the wage schedule are independent on the number of employees. This coincides to the typical one-worker one-firm model à la Mortensen and Pissarides (1994).[11] On the opposite, a firm employing several workers can take advantage of it when the production function exhibits decreasing returns to scale on employment. Indeed, under a concave production function, marginal product depends on the number of employees within a firm. We show below that

[10] As in many New Keynesian models with labor market search, we separate labor market and price setting frictions in a 'producer-retailer structure'.

[11] 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.

the bargained wage is decreasing with the number of employees through hours.[12]

The representative producer posts v_t vacancies at the cost c per vacancy. It maximizes the present discounted stream of future profits,

$$\pi_t = E_0 \sum_{t=0}^{\infty} \beta_{0,t} \left\{ s_t X_t - w_t n_t - c v_t \right\}, \tag{1}$$

subject to the law of motion for employment and the production function. Importantly, as we show below, wages per worker, w_t, depend on labor inputs through intra-firm bargaining, such that $w_t = \mathbf{w}\left(h_t\left(n_t\right)\right)$. The resulting job creation condition (JCC, henceforth) is

$$\frac{c}{q_t} = E_t \left\{ \beta_{t,t+1} \left[\chi_{t+1} + (1-\lambda) \frac{c}{q_{t+1}} \right] \right\}, \tag{2}$$

where $\beta_{t,t+1}$ is the recursive discount factor defined below and χ_t is the shadow value of a marginal worker. A firm posts vacancies until the cost of hiring a worker equals the expected discounted future benefits from employing this extra worker. The costs of hiring a worker are given by the vacancy posting costs, c, multiplied by the average duration of a vacancy, $1/q_t$. The benefits of hiring a worker are his shadow value, plus the vacancy posting costs saved in case the employment relationship continues.

The shadow value χ_t measuring the net benefit extracted by the firm to hire a marginal

[12] As Krause and Lubik (2014) stressed, the intra-firm bargaining effect on wages can be incorporated in a New Keynesian model by adopting a producer-retailer structure and assuming a concave the production function in employment. Alternatively, we could assume that firms take both the price setting and the hiring decision within the same sector and they are demand-constrained. With a linear production and Rotemberg adjustment cost, it yields an identical model equilibrium. We prefer the 'producer-retailer structure' because the intra-firm bargaining effect can be easily removed by assuming a linear production function.

worker, can be expressed in general terms as

$$\chi_t = s_t f_{nt} - w_t - \underbrace{\Upsilon\left(h_t\right)}_{\text{IFB effect}} h_t. \tag{3}$$

In the one-worker-firm framework, the wage is independent of labor inputs such that the last term disappears and the shadow value of an extra worker corresponds to his marginal revenue product, $s_t f_{nt}$, net of his wage, w_t. In contrast, the shadow value (3) contains an extra term $\Upsilon\left(h_t\right)$, that we call the intra-firm bargaining (IFB) effect. It is defined as $\Upsilon\left(h_t\right) \equiv \frac{\partial w_t}{\partial h_t}\varepsilon_{hn}$ where $\varepsilon_{hn} \equiv \frac{\partial h_t}{\partial n_t}\frac{n_t}{h_t}$ measures the elasticity of employment to hours. Employment and hours are substitutes when this elasticity is negative. Factor $\Upsilon\left(h_t\right)$ captures the reduction in the wage bill induced by an additional hire. In a multiple-worker firms model where the extensive margin is the only production input, $\Upsilon\left(h_t\right)$ is simply $\frac{\partial w_t}{\partial n_t}n_t$. Under decreasing returns to employment, 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 ($\frac{\partial w_t}{\partial n_t} < 0$). This leads firms to hire a suboptimally high amount of workers. This known as the "over-hiring result" in the literature (see Stole and Zwiebel 1996, Cahuc and Wasmer, 2001 and Acemoglu, 2014). 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 $\varepsilon_{hn} < 0$. This substitution effect is absent in the intra-firm bargaining model that abstracts from hours. As we show below, the bargaining wage is increasing in the number of hours per worker, $\frac{\partial w_t}{\partial h_t} > 0$, and so the reduction in hours reduces the wage paid to all the firm's employees.

2.1.3 Households

The representative household chooses consumption and saving to maximize lifetime utility,

$$\mathcal{U}_t = E_0 \sum_{t=0}^{\infty} \beta^t \left[u(C_t) - n_t g(h_t) \right], \tag{4}$$

where $\beta \in (0,1)$ is the subjective discount factor and C_t denotes consumption. Labor disutility $g(h_t)$ is twice differentiable, strictly increasing and strictly convex in hours worked: $g_h(.) > 0$, $g_{hh}(.) > 0$, with $g(0) = 0$. As in Andolfatto (1996) and Merz (1995), there exists an insurance technology guaranteeing complete consumption risk sharing between household members, such that C_t denotes consumption by a member as well as overall household consumption. Given that all households are identical in equilibrium, C_t also represents economy-wide consumption. Following Ravenna and Walsh (2012), consumption consists of market goods, C_t^m, and home-produced goods, b, i.e. $C_t = C_t^m + (1 - n_t)\, b$. The household maximizes lifetime utility (4), subject to the budget constraint,

$$C_t^m + \frac{B_t}{R_t P_t} = w_t n_t + \frac{B_{t-1}}{P_t} + D_t + T_t, \tag{5}$$

where B_t are one-period nominal bonds that cost R_t units of currency in t and pay a safe return of one currency unit in period $t+1$, D_t are real profits , and lump sum transfers are T_t. The first order conditions for consumption and bonds imply $R_t E_t\{\beta_{t,t+1}/\Pi_{t+1}\} = 1$, where $\beta_{t-1,t} = \beta \Lambda_{t-1}/\Lambda_t$ is the stochastic discount factor, $\Lambda_t = u_{C,t}$ is the Lagrange multiplier on (5), $u_{C,t}$ is the marginal utility of consumption and $\Pi_t = P_t/P_{t-1}$ is the gross inflation rate.

2.1.4 Intra-Firm Bargaining

The bargaining setup is as follows. Each period, the firm bargains with an individual worker first over hours and then over the real wage. In the absence of a commitment technology for labor contracts, bargaining starts anew each period. Since the firm bargains with all workers individually, each worker is effectively marginal. Through bilateral Nash bargaining, the worker and a firm split the match surplus according to their respective bargaining weights given by γ and $1-\gamma$.

Hours The equilibrium number of hours satisfies

$$\frac{g_{ht}}{\Lambda_t} = s_t f_{nht}. \tag{6}$$

Hours are set such that the marginal rate of substitution between hours and consumption, $\frac{g_{ht}}{\Lambda_t}$, equals the contribution of an extra hour to the marginal product of employment, f_{nht}. Equation (8) describes the relation between employment and hours per employee. It can be shown that the elasticity of hours to employment, ε_{hn}, is given by[13]

$$\varepsilon_{hn} = \frac{\varepsilon_{fnn}}{\varepsilon_{gh} - \varepsilon_{fh}} \leq 0, \tag{7}$$

where $\varepsilon_{gh} = g_{h,t}\frac{h_t}{g(\cdot)} \geq 1$ and $\varepsilon_{fh} = f_{h,t}\frac{h_t}{f(\cdot)} \geq 0$ capture, respectively, the elasticity of labor disutility to hours and the elasticity of output to hours, and the term $\varepsilon_{fnn} = f_{nn,t}\frac{n_t}{f_{n,t}} \leq 0$ denotes the curvature of the production function. The greater the concavity in the production

[13]See Proposition 1 in the online appendix.

function (the lower is ε_{fnn}), the more substitutable are the two labor inputs.

Consider a production function that is linear in employment, such that $\varepsilon_{fnn} = 0$. In that case, hours are invariant to employment, $\varepsilon_{hn} = 0$. A firm's intensive and extensive margins of labor are instead linked if the production function is concave in employment, i.e. if $\varepsilon_{fnn} < 0$. Indeed, the term (7) is negative, conditional on labor disutility rising faster with hours than output, $\varepsilon_{gh} > \varepsilon_{fh}$, an assumption we maintain throughout the analysis. Accordingly, the factors employment and hours per worker are substitutes in production. By hiring an additional worker, the firm reduces the marginal product of that worker. This reduces also the value of an additional hour worked, such that the number of hours per worker set through the hours bargaining process is reduced.

Using the equality of cross-partial derivatives $f_{nht} = f_{hnt}$ (Schwarz' Theorem), defining the elasticity of the marginal product of hours to employment as $\varepsilon_{fhn} = f_{hnt} \frac{n_t}{f_{ht}}$, and using the relation $\varepsilon_{fhn} = 1 + \varepsilon_{fnn}$, we can write the optimality condition for hours (6) as

$$\frac{g_{ht}}{\Lambda_t} = s_t \left(1 + \varepsilon_{fnn}\right) \frac{f_{ht}}{n_t}. \tag{8}$$

As we shall see, (8) is easier to compare with the hours condition of the efficient allocation.

Wages It can be shown that the bargaining wage satisfies

$$w_t = \gamma \left[s_t f_{nt} - \Upsilon\left(h_t\right) h_t + c\theta_t\right] + (1-\gamma)\left[\frac{g(h_t)}{\Lambda_t} + b\right], \tag{9}$$

An employed worker suffers the disutility $g(h_t)$ from working, which we divide by Λ_t to convert utils into consumption goods. His outside option is represented by home production b. The firm's surplus from employing a marginal worker equals the latter's contribution to profits. First, there is the traditional direct effect of an additional employee on output, captured by the term $s_t f_{nt}$. It is clear from (9) that the wage is invariant to the number of employees under constant returns to employment, since f_{nt} is invariant to n_t and $\varepsilon_{hn} = 0$. Under decreasing returns to employment, the marginal product of employment f_{nt} varies with n_t, such that firms internalize that labor inputs affect wages through the IFB effect $\Upsilon(h_t)$. More precisely, hiring a worker reduces the number of hours per worker through (6), which in turn lowers the wages paid to all workers.

Intra-firm Bargaining Effect The feedback effect of IFB can be explicitly expressed by plugging the hours equation (8) into the wage curve (9)

$$w_t = \varkappa \frac{g(h_t)}{\Lambda_t} - \gamma \Upsilon(h_t) h_t + \gamma c \theta_t + (1-\gamma) b, \tag{10}$$

with $\varkappa = \gamma \varepsilon_{gh} / \varepsilon_{fh} + (1-\gamma) \geq 0$. Using the method of undetermined coefficient, we get

$$\Upsilon(h_t) \equiv \frac{\partial w_t}{\partial h_t} \varepsilon_{hn} = \left(\frac{\varepsilon_{gh} \varepsilon_{hn}}{1 + \gamma \varepsilon_{gh} \varepsilon_{hn}} \right) \varkappa \frac{g(h_t)/h_t}{\Lambda_t} < 0. \tag{11}$$

Since $0 \leq \varepsilon_{gh} \varepsilon_{hn} < 1$ wage depends negatively on employment. Notice that the slope of the wage curve (10) is positive in hours and it depends on the IFB externality through ε_{hn}. If the production function is linear in employment ($\varepsilon_{fnn} = 0$), there is no substitution between employment and hours in that case ($\varepsilon_{hn} = 0$). Then the wage curve has slope $\varkappa$ and is equivalent to the one obtained in the one-worker-firm setup including hours.[14] For a given bargaining power γ, the parameter $\varkappa$ is increasing in the ratio of the curvature of the disutility of hours worked ε_{gh} to the elasticity of output to hours, ε_{fh}. Thus, the wage curve is steeper in hours, the higher is the utility cost of hours compared to the returns to hours in production. Instead, if the production function displays decreasing returns to employment, the wage curve becomes even steeper in hours. The more substitutable are the two labor margins (the lower is ε_{hn}), the more an additional worker reduces hours worked and, in turn, the equilibrium real wage. Accordingly, the IBF externality implies that wages are more sensitive to hours because firms can adjust both labor margins.

Using the wage curve (10), we express the shadow value (3) equivalently as

$$\chi_t = (1-\gamma)\left[s_t f_{nt} - \frac{g(h_t)}{\Lambda_t} - \Upsilon\left(h_t\right) h_t - b\right] - \gamma c \theta_t. \tag{12}$$

With decreasing returns to employment in production ($\varepsilon_{fnn} < 0$), the IFB effect measured by $\Upsilon\left(h_t\right)$ is negative: when the firm hires a new worker, the marginal product of employment falls and with it the value to the firm of an extra hour ($\varepsilon_{hn} < 0$). This reduces the number of hours set through bargaining, see (6). As a result, the bargained wage falls since $\partial w_t / \partial h_t > 0$ and, as all employees are paid less, this lowers the firm's production costs. Due to this feedback effect, firms have an incentive to hire many employees in order to reduce workers' bargaining position within the firm.

[14] For a formal proof, see the online appendix.

2.2 Additional Model's Features

The model is closed with a description of the retail sector, a resource constraint, and a monetary policy rule.

Each one of the monopolistically competitive retailers – indexed by $i \in [0,1]$ – buys homogeneous goods X_t at price s_t, transforms them into differentiated goods Y_{it} with a linear technology and sells the output to households. Retailers face quadratic price adjustment costs measured in terms of final goods à la Rotemberg (1982).[15] Optimal price setting by profit-maximizing retailers yields the New Keynesian Phillips Curve,

$$\kappa\Pi_t\left(\Pi_t - 1\right) = \varepsilon s_t - \left(1-\tau^f\right)\left(\varepsilon - 1\right) + \kappa E_t\{\beta_{t,t+1}\Pi_{t+1}\left(\Pi_{t+1}-1\right)\frac{Y_{t+1}}{Y_t}\}, \tag{13}$$

where κ captures the size of price adjustment costs, ε is the elasticity of substitution between the individual varieties and τ^f is a tax on firm revenues.

The aggregate accounting identity equates the sum of market and home production to the sum of consumption, government spending G_t, vacancy posting costs, and price adjustment costs,

$$Y_t + \left(1-n_t\right)b = C_t + G_t + cv_t + \frac{\kappa}{2}\left(\Pi_t - 1\right)^2 Y_t. \tag{14}$$

Monetary policy sets a path for the inflation rate and is described below.

[15]The Rotemberg price setting scheme allows us to write the model in non-linear form, which we use to derive the Ramsey first-order conditions in Section 5

3 Quantitative Analysis

Before turning to a normative analysis, we investigate the performance of the intra-firm bargaining model to replicate key stylized facts in the Euro Area and we analyze the transmission channels of supply and demand shocks. To do so, we adopt standard functional forms for technology and preferences and the model is calibrated for the Euro Zone.

3.1 Functional Forms and Calibration

We assume that the production function and the utility functions for consumption and labor are governed by

$$X_t = A_t n_t^{\alpha} h_t^{\alpha\varphi}, \qquad u(C_t) = \ln C_t \qquad \text{and} \qquad g\left(h_t\right) = \frac{\zeta h_t^{1+\sigma}}{1+\sigma}, \tag{15}$$

where $\alpha \in [0,1]$ denotes the returns to employment in production, $\varphi \in [0,1]$ drives the returns to hours in production, ζ determines the weight on labor disutility and $\sigma \geq 0$ determines the curvature of labor disutility. Let A_t denote an aggregate TFP shock. Notice that $\varepsilon_{fnn} = \alpha - 1$, $\varepsilon_{fn} = \varphi\alpha$ and $\varepsilon_{gh} = 1 + \sigma$, which implies $\varepsilon_{hn} = \frac{\alpha-1}{1+\sigma-\varphi\alpha}$. If the production function is linear in employment (i.e. $\alpha = 1$), hours and employment are independent, $\varepsilon_{hn} = 0$. Monetary policy is characterized by an interest rate rule of the form

$$\frac{R_t}{R} = \left(\frac{\Pi_t}{\Pi}\right)^{\tau} \varsigma_t, \tag{16}$$

where ς_t is a monetary policy shock. Search-and-matching models are known to fail at replicating the volatility of employment, as highlighted by Shimer (2005, 2010). The real wage rigidities have been widely used to get round this issue. For instance, a wage norm à la Hall (2005) amplifies the volatility of employment through a reduction in the wage volatility.[16] To give better chance to our model to fit the data, we adopt this specification by assuming that the wage received by households, $\tilde{w}_t$, is such that $\tilde{w}_t = \varrho w + (1 - \varrho) w_t$, where ϱ is the degree of real wage rigidity. The model is log-linearized around the zero-inflation steady state.

Table 1 summarizes the model's parametrization

[insert Table 1 here]

The discount factor in household preferences is set to $\beta = 0.99$, implying a steady-state annualized real interest rate of 4%. The share of government spending to GDP G/Y is set to 21%, which corresponds to the average share of public spending in Euro Area GDP. We assume decreasing returns to scale with $\alpha = 0.7$, which is roughly consistent with a labor share of 66%. We set $\varphi = 1$ such that employment and hours have the same returns. 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 $\tau^f = 1/(1 - \varepsilon)$.

[16] Wage norm has been used by several authors like for instance Krause and Lubik (2007) who show that a standard search-and-matching model does a better job at replicating labor market stylized facts in the US. However, Sveen and Weinke (2008) reveals 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. Clerc (2015) shows that replacing the wage norm by an alternative real wage rigidity, namely a credible wage bargaining à la Rubinstein (1982) provides identical results. Unlike these authors, we assume that hours are efficiently bargained instead of being chosen only by the firm.

The price adjustment cost, κ, is set to 44 which broadly ensures that the slope of the NKPC is the one we would get under Calvo price staggering and one year contract length. This value is close to Krause and Lubik (2007). The Taylor rule parameter, τ, is set to 1.5 in line with Smets and Wouters' (2007) estimation.

Fluctuations are driven by one supply shock (A_t) and two demand shocks (G_t and ς_t) which all follow an AR(1) process (in logs). The persistence of these shocks is set to 0.8 and their size are calibrated to replicate the volatility of real GDP observed in Euro Area data.[17]

We set the inverse Frisch elasticity of labor supply to $\sigma = 3$ which corresponds to the intermediate values suggested by Keane and Rogerson (2012). 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 to 0.7 proposed by Petrolongo and Pissarides (2001). The worker's bargaining weight is set to satisfy the Hosios (1990) condition such that $\gamma = \eta$. The steady-state unemployment rate is set to 9.6%, which corresponds to the average unemployment rate in the Euro Area between 1999 and 2013. Hours worked in steady state are normalized to $h = 0.3$. Following Christoffel et al. (2009), we set the vacancy filling rate, q, to 0.7, the job separation rate, λ, to 0.03, in line with Euro area data on job flows. Total vacancy costs amount to 1% of the GDP as ($cv/Y = 0.01$). This value is larger than Christoffel et al. (2009) but it is in line with a strengh of the literature including Andolfatto (1996), Gertler and Trigari (2009) or Sunakawa (2015). In this section, the degree of real wage rigidity is set to 0.8 which corresponds to the value suggested by Christoffel and Linzert (2010). The steady-state output level Y is

[17] In pratice, we use a simple grid method to determine the size of the shocks that make the theoretical output volatility as close as possible to its empirical counterpart. We find that supply shocks are one third less volatile than demand shocks. This relative size of shocks is somewhat smaller than the findings of Smets and Wouters (2007) but larger than Villa (2014) who estimates the same model over a recent sample.

normalized to unity. Given these calibrated values, we can deduce the remaining variables implied by the model's steady state, see Table 2.

[insert Table 2 here]

The share of home production in GDP is deduced from the model's steady state and it reaches $bu/Y = 0.05$. This means that home production counts for a small proportion of total output, as suggesting by Trigari and Gertler (2009). Interpreting the home production parameter b as unemployment benefit instead means that the replacement rate is 0.71 which is in the same range than Christoffel et al. (2009). The steady-state job finding rate $p = 0.34$ is in line with Christoffel et al.'s (2009) calibration as for the number of vacancies ($v = 0.04$).

3.2 Labor Market Volatility

We assess the ability of the baseline model to reproduce keys labor market stylized facts in the Euro Area. To do so, we compare in Table 3 second order moments in the data and in the model. We use real GDP, employment, hours per employee, vacancies, wage and the inflation rate. The sample covers 1999Q1-2015Q4. Since neither the number of vacancies or 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) model which aggregates quarterly national data for the whole Euro Area, except for hours worked which is available from Eurostat and German vacancies which are from the OECD database.[18] In Table 3, we

[18]The AWM mnemonic are 'YER' for real GDP, 'LNN' for employment, 'YED' for GDP deflator and 'WIN' for total wages. Hours worked are from Eurostat. Inflation is computed as the annualized growth rate of GDP deflator. Real Wages per workers are computed as (WIN/LEN)/YED. Vacancies are the 'Total

compare the data with our baseline model and two variants, namely an intra-firm bargaining model abstracting from hours (no-hours IBF, with $\sigma \to \infty$, $h_t = h$) and a model without intra-firm bargaining (one worker-firm model, with $\alpha = 1$).[19]

[insert Table 3 here] (17)

The baseline model does a good job at replicating the relative volatility of both the intensive and the extensive labor margins. In particular, the model is able to replicate the relative volatility of hours worked (0.3). The volatility of employment is slightly lower in the model (0.46) than in the data (0.53) and it generates a large volatility in vacancies (14.4). Overall, this baseline model seems not being exposed to the "Shimer (2005) puzzle" that suggests that search-and-matching model cannot generate the high volatility for unemployment and vacancies in response to technology shocks. Besides that we combine supply and demand shocks, this can be explained by the inclusion of a wage norm that is nevertheless not sufficient to replicate the low volatility in real wages (0.51 instead of 0.23).[20] Notice that the 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

Unfilled vacancies (stock)' from the OECD.stat database. All series are seasonally adjusted, expressed in log and HP-filtered (except for inflation). The AWM dataset provides data up to 2014Q4 and we update to 2015Q4 using Eurostat data.

[19] The online appendix shows the performance of the simple search-and-matching model without intra-firm bargaining neither hours.

[20] The online appendix shows the results in a model without a wage norm. The standard deviation of wage relative to output is too high (1.76) while the relative volatility of employment is too low (0.14). An alternative way to magnify unemployment volatility is to modify the calibration of the opportunity cost of employment as suggested by Hagedorn and Manovski (2008). The online appendix also shows robustness analysis under different calibrations.

frictions and show that they generate an excess of inflation volatility.[21] Overall, our model fits quite well empirical data. The results are hardly changed when hours are omitted from the IFB model. Inflation is even more volatile (1.59) and becomes counter-cyclical. The one worker-firm model replicates well employment volatility but it generates too much volatility in hours (0.43 instead of 0.30 in the data) and vacancies (17 instead of 9). Using a formal measure of fit based on the root mean squared error, we find that our baseline model performs better than the one worker-firm model.[22]

3.3 Impulse Response Functions

We now graphically illustrate the behavior of our baseline model in the aftermath of the three underlying model's shocks. Figure 2 displays the impulse response functions of output, employment, hours and wages to expansionary TFP ($\hat{A}_t$), government spending ($\hat{G}_t$) and monetary policy shocks ($\hat{\varsigma}_t$). We compare our baseline model with the two variants described above.

$$\text{[insert Figure 2 here]} \tag{19}$$

[21] 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. Notice that our model fails to replicate inflation inertia (not shown) but Clerc (2015) in a model similar to ours argues that it can be corrected through credible wage bargaining.

[22] In practice, the root mean squared error is defined as

$$\text{RMSE} = \sqrt{\frac{1}{m}\sum\left(\Theta_T - \Theta_{sim}\right)^2}, \tag{18}$$

where m is the number of matched moments, Θ_T and Θ_{sim} are empirical and theoretical moments reported in Table 3. We do not compare our baseline model with the no-hours IFB model since the latter is confronted to a smaller number of moments. Our baseline model provides a smaller RMSE (1.70) than the one worker-firm model (2.86).

All shocks generate a surge in output combined with a boost in the extensive margin of labor. The demand shocks stimulate consumption. On one side, firms meet this rise in aggregate demand by increasing hours per worker since employment cannot be adjusted instantaneously.[23] On the other side, firms post more vacancies since the marginal worker becomes more valuable. This boosts labor demand as well as labor market tightness. Employment increases eventually so as for wages. A technology shock has similar effect except that hours per employee decrease since the firm needs less inputs to meet the demand. Therefore, total hours worked decrease after a technology shock in our model while there is no consensus regarding the empirical behavior of hours in response to TFP shock.[24] The boost in production raises future expected profits which give incentive to firms to post vacancies. Therefore, real wages and employment increase.

Let compare the baseline model's predictions with its two variants. Interestingly, the response of output and employment to a TFP shock are unaffected. This is in line with Krause and Lubik (2013) and Kim's (2015) findings who argue that adding intra-firm bargaining to a typical search-and-matching model slightly change the transmission mechanisms of TFP shocks.[25] The baseline model provides similar responses though. The differences are slightly more notable in the case of demand shocks. Precisely, employment is less responsive in models with intra-firm bargaining. The reason resides in the general equilibrium effect mentioned by Krause and Lubick (2015): on one side real wages increase by less because of the IFB

[23]In the online appendix, we show that employment is more reactive to a shock when the employee is immediately productive.

[24]See among others Galí (1999) and Christiano et al. (2004) for US data. Peersman and Straub (2009) estimate a SVAR on the Euro Area and show that the response of total hours depends on the identification strategy of the shock.

[25]Kim (2015) argues that the IFB effect modifies more substantially the model's dynamic when a bargaining shock is considered.

effect but in the other side firms post more vacancies which increase labor market tightness and makes new workers harder to find.

Overall, the three models are relatively similar and the introduction of intra-firm bargaining slightly affects the transmission channel of the shocks. Our paper points out instead that intra-firm bargaining might have implications in terms of welfare, in particular when the firm can resort to the two labor margins.

4 Efficient Allocation and Distortions

In the following, we first derive the efficient allocation. Second, we characterize the steady-state distortions to employment and hours that arise in the competitive equilibrium. Finally, we show how the presence of the hours margin amplifies the employment distortion.

4.1 Efficient Allocation

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

Definition 1 *An efficient allocation is a set of paths* $\left\{h_t^*, v_t^*, n_{t+1}^*, C_t^*\right\}_{t=0}^{\infty}$ *which maximizes utility (4), subject to the employment dynamics constraint and the resource constraint,*

$$n_{t+1}^* = (1-\lambda)\, n_t^* + \mathcal{M}_0 \left(1-n_t^*\right)^{\eta} \left(v_t^*\right)^{1-\eta}, \tag{20}$$

$$f\left(n_t^*, h_t^*\right) + \left(1-n_t^*\right) b = C_t^* + G_t + c v_t^*. \tag{21}$$

The efficient allocation is characterized by two conditions determining hours and employment. First, the efficient hours choice satisfies

$$\frac{g_{ht}^*}{\Lambda_t^*} = \frac{f_{ht}^*}{n_t^*}. \tag{22}$$

Equation (22) states that the utility cost of providing an additional hour of work (the marginal rate of substitution) must equal the marginal product of hours per employee (the marginal rate of transformation).

Second, the efficient choice of employment satisfies the job creation condition (2), where the efficient shadow value of an extra worker is

$$\chi_t^* = (1-\eta)\left[f_{nt}^* - \frac{g(h_t^*)}{\Lambda_t^*} - b\right] - \eta c \theta_t^*. \tag{23}$$

The shadow value has several components, appropriately weighted by the bargaining shares. A new worker adds an amount f_{nt}^* to goods produced in the market but it also generates three costs which has to be compensated: the utility cost of working, $\frac{g(h_t^*)}{\Lambda_t^*}$, the home goods no longer produced by this person, b^*, as well as the cost of posting a new vacancy.

4.2 Distortions

We show that the competitive steady state is distorted by comparing the decentralized allocations of hours and employment (8) and (12) with the respective efficiency conditions, (22) and (23). There are three potential sources of distortion in our model, which are due to (*i*) the labor market rigidities, (*ii*) the presence of monopolistic competition and (*iii*) the

IFB effect. These distortions make the two labor margins inefficient.

The first distortion arises when the elasticity of matches to unemployment η is different from the worker bargaining weight γ. We eliminate this distortion by satisfying the so-called Hosios (1990) efficiency condition, i.e. $\gamma = \eta$.[26] The second distortion is related to monopolistic competition in goods markets. As is well known, it generates a goods price markup, which reduces the steady-state real marginal costs below unity ($s < 1$). Consequently, employment and hours per worker are too low, all things equal. Subsidizing profits via τ^f to ensure that $s = 1$ removes this distortion.

The third distortion, described in Result 1, is inherent to intra-firm bargaining externality.

Result 1 *With an appropriate profit subsidy to ensure* $s = 1$*, and under the Hosios condition* $\gamma = \eta$*, a distortion in employment and hours worked arises if the production function is non-linear in employment, i.e. if*

$$\varepsilon_{fnn} \neq 0. \tag{24}$$

Decreasing returns to employment in production, $\varepsilon_{fnn} < 0$*, imply that employment is higher and hours per worker are lower in the competitive allocation compared with the efficient steady state.*

Smith (1999) already showed that the Hosios condition is not sufficient in a model with intra-firm bargaining to restore efficiency. All things equal, a firm facing diminishing marginal product on labor internalizes that an additional worker reduces wages which

[26]When η is high, a firm that posts a vacancy greatly increases vacancy duration for all other firms, creating a congestion effect. This effect has to be offset by the central planner by giving a lot of bargaining power to workers, which discourages firms from posting vacancies. See Pissarides (2006).

leads it to hire too many workers compared to efficiency. We enrich this result by showing that overhiring is magnified in a multiple-worker firm model with hours because hours per worker are too low. Consequently, both labor margins are inefficient.

4.3 Effect of Hours Margin on the IFB Externality

To understand how the hours margin affects the overhiring result, we adopt the standard functional forms for technology and preferences described in (15) and we derive the labor market equilibrium in models with and without hours. In both models we obtain an overhiring inefficiency gap which we show to be greater in the model with hours. We also provide a graphical illustration of this result.

4.3.1 Labor Market Equilibrium

The labor market equilibrium is summed up with the wage curve (10), the shadow value of a extra worker (12) and the hours equation (6). Using functional forms (15), these equations are respectively

$$w_t = \gamma \Phi_{wc} s_t f_{nt} + \gamma c \theta_t + (1-\gamma)\, b, \tag{25}$$

$$\chi_t = \Phi_{jcc} s_t f_{nt} - \gamma c \theta_t - (1-\gamma)\, b, \tag{26}$$

$$\lambda_h h_t^{1+\sigma} C_t = s_t \varphi \alpha f_{nt}, \tag{27}$$

with the marginal product of labor $f_{nt} = X_t / n_t$ and $\Phi_{wc} \equiv \left(1 + \frac{(1-\gamma)\varphi\alpha}{\gamma(1+\sigma)}\right)\left(1 - \frac{\gamma(1-\alpha)(1+\sigma)}{(1+\sigma)-\varphi\alpha}\right)^{-1}$ measuring the sensitivity of the wage to the marginal labor productivity. Additionally, $\Phi_{jcc} \equiv 1 - \gamma\alpha\left(\frac{1+\sigma-\varphi}{1+\sigma-\alpha\varphi}\right)\Phi_{wc}$ reflects the firm's internalization of employment decisions on wages. Notice that under the efficient allocation, we get $\Phi^*_{jcc} = (1-\gamma)\left(1 - \frac{\varphi}{(1+\sigma)}\right)$.

The gap between Φ_{jcc} and Φ^*_{jcc} measures the inefficiency gap resulting from the IFB effect. How does the intensive margin of labor affect this inefficiency gap? Let first consider an intra-firm bargaining model abstracting from hours. By setting inelastic labor supply ($\sigma \to \infty$), the feedback effect is $\Phi_{jcc} = \frac{(1-\gamma)}{1-\gamma(1-\alpha)}$ which is larger than what it should be at the efficiency, i.e. $(1-\gamma)$. The inefficiency gap is therefore positive: firms employ too many workers because the shadow value of an extra worker is too high. All things given, having intra-firm bargaining affects the slope of the job creating condition: it rotates anticlock from efficiency, generating too many vacancies and suboptimal unemployment.[27] Now, it is shown in the online appendix that including hours in the intra-bargaining firm model necessarily leads to a larger inefficiency gap ($\Phi_{jcc} - \Phi^*_{jcc}$). This confirms that the overhiring behavior is magnified when a firm can adjust both labor margin. We illustrate this result in a graphical illustration.

4.3.2 Graphical Illustration

Figure 3 displays steady-state competitive and efficient allocations on the labor market using the functional forms and the calibration described in Section 3.1.

[insert Figure 3 here]

[27]As explained by Krause and Lubick (2014) and Kim (2014), this effect can be diminished in general equilibrium due to the rise in labor market tightness which pushes wages up.

The left panels of Figure 3 depicts the competitive and efficient employment allocations in an intra-firm bargaining model with hours (top panel) and without (bottom panel). The employment allocation is determined through two steady-state equations: the Beveridge curve and the job creation condition.[28] Figure 3 shows that the unemployment rate is suboptimally low; firms overhire because of the IFB externality. The right panel shows that the overhiring effect is magnified; the presence of a second margin of labor makes the wage more sensitive to employment. With substitutability between hours and employment, hiring a worker allows the firm to reduce hours worked. If labor disutility rises strongly in hours, the bargaining wage becomes more sensitive to a fall in hours, making an additional worker more valuable.

The lower panel in Figure 3 confirms that hours are too low compared to efficiency. Since hours and employment are substitutes, overhiring goes hand in hand with hours being too low. To see this, consider the ratio between the competitive hours equation (8) and the efficient one (22) at the steady state, using the functional forms in (15),

$$\frac{h}{h^*} = \left(s\alpha \frac{n^*}{n} \right)^{\frac{1}{1+\sigma}} . \tag{28}$$

To derive (28), notice that the scale parameter ζ, technology A and the ratio of consumption to market output C/Y at the steady state are identical in the competitive and efficient allocation. As argued above, decreasing returns to employment ($\alpha < 1$) lead to overhiring,

[28]The online appendix describes in details how the Beveridge curve and the JCC are calibrated both at the competitive and the efficient allocation. In short, we rewrite the law of motion for employment and the JCC over the plan(u, v). Vacancy posting costs, c and home production b are set to the same value in the competitive and efficient allocation. The Hosios condition is satisfied and the steady-state real marginal cost, s, is set to unity.

such that $n > n^*$. This implies from (28) that competitive hours are too low, $h < h^*$. In Trigari's (2006) one-worker-firm setup where both wages and hours are determined through Nash bargaining, hours are set efficiently. This is what Trigari (2006) calls 'efficient bargaining'. Here, due to the intra-firm bargaining externality, hours per worker are not efficient despite being determined by bargaining. Firms tend to hire too many workers and, as a consequences, each one of them works too few hours. In the next section, we compute the welfare costs due to these steady-state distortions and we investigate whether the monetary authority can remove it.

5 Optimal Monetary Policy

In the following, we characterize optimal monetary policy when prices are sticky. To this end, we compute the paths that the Ramsey policy maker chooses for the model variables in order to maximize household utility, subject to the decision rules of households and firms. A formal definition of the Ramsey policy is given next.

Definition 2 *The Ramsey optimal policy is a set of plans for the control variables* $\{h_t, v_t, n_{t+1}, C_t, s_t, \Pi_t\}_{t=0}^{\infty}$ *that, for a given initial employment level* n_0*, maximizes household utility (4) subject to the implementability conditions (2), (6), (13), (14) and the law of motion of employment.*

We derive the first order-conditions of the Ramsey problem using the Lagrangian problem and linearize them around the deterministic steady state. In the absence of labor externalities and wage markup fluctuations, e.g. in the form of nominal or real wage rigidities, strict inflation targeting is optimal since hours are set through Nash bargaining (Faia, 2009; Thomas, 2008).[29] Indeed, under sticky prices, real marginal costs are the only time-varying wedges around an efficient steady state. Therefore, the optimal monetary policy can replicate flexible-price fluctuations by stabilizing prices. However, our model features three types of frictions along with prices stickiness: monopolistic competition, search frictions and intra-firm bargaining which all make the steady state inefficient. Abstracting from the two first sources of distortions, we investigate whether the IFB externality generates a trade-off between inflation and unemployment. Is price stability optimal in a intra-firm bargaining environment with two margins of labor. Unemployment rate is below the efficient one in that context, at least at the steady-state. Then, the monetary authority should discourage firms to hire in response to shocks by increasing inflation. Intuitively, it boosts the real marginal cost and reduces firms' profits. A deterioration in the expected flow of revenue restrains firms to hire and therefore suppress inefficient fluctuations.[30] As we have shown above, the presence of the intensive margin of labor in our model magnifies the overhiring behavior of firms. Therefore, we might suspect high complementarity between employment and hours generates larger deviation from price stability. Figure 4 confirms this intuition. It displays the optimal inflation volatility in a model with and without hours, as a function of α.[31]

[insert Figure 4 here] (29)

[29]Sunakawa (2013) shows that the optimal policy slightly deviates from price stability when hours are set through a right-to-manage process even under an efficient steady-state. However, this deviation is modest.

[30]Faia (2009) provides a similar intuition for inefficiencies resulting from search externalities.

[31]The volatility is given by the standard deviation of annualized inflation under the Ramsey policy. In this exercise, we abstract from real wage rigidities in order to assess the "pure" distortive effect of intra-firm bargaining. The figure under a wage norm is provided in the online appendix. As expected, the optimal inflation volatility is larger.

As expected, price stability is optimal in two distinct cases, namely in a New-Keynesian-alike model ($\alpha = 0$) and in a search-and-matching model without IBF externality, i.e. $\alpha = 1$, since nominal rigidities are the only source of inefficiency.[32] Within this interval, optimal monetary policy deviates from price stability. The central banker faces a trade-off between stabilizing inflation and unemployment because of the combination of nominal rigidities and IFB externalities generating inefficient fluctuations on unemployment. As expected, optimal inflation volatility is larger when the firm can resort to the two margins of labor since it encourages the overhiring behavior by even more. To gauge the magnitude of this deviation, we follow Ravenna and Walsh (2012) by decomposing the welfare gap between the first best and the second best allocation. Precisely, we compute

$$\mathcal{W}_t^* - \mathcal{W}_t^{ram} = (\mathcal{W}_t^* - \mathcal{W}_t^{fp}) + (\mathcal{W}_t^{fp} - \mathcal{W}_t^{ram}), \tag{30}$$

where $\mathcal{W}_t^*$ denotes the efficient welfare level (first-best allocation) and $\mathcal{W}_t^{ram}$ denotes its counterpart under a constrained Ramsey policy (second-best allocation). Let $\mathcal{W}_t^{fp}$ denote the households' welfare level obtained in the flexible price allocation. The first term into brackets in (30) corresponds to the 'search gap', as designated by Ravennna and Walsh (2012); It should be zero if the steady-state distortions are removed. The second term into brackets measures the deviation from price stability and it equals zero when price rigidities are the only distortion and the search gap is zero. The difference in welfares is expressed in terms of consumption equivalent units: it is defined as the fraction $\mathcal{C}$ of consumption that

[32]Remember that the Hosios condition is satisfied and distortions due to monopolistic competition are removed through a subsidy on firm's profit through τ^f.

households would be willing to give away in each period to reach the welfare of the reference economy ($\mathcal{W}_t^*$ in the search gap and $\mathcal{W}_t^{fp}$ in the price stability gap).[33] Table 4 summarizes our results.

$$\text{[insert Table 4 here]} \tag{31}$$

Under our benchmark calibration with $\alpha = 0.7$, the search gap goes from 0.32% to 1.51% of the expected consumption stream by including hours into the intra-firm bargaining model.[34] However, the monetary policy can increase welfare by only 0.08% relative to price stability. These findings illustrate our main result: the overhiring externality is magnified by combining the two labor margins which results in a large gap between the competitive (flexible price) and efficient allocation but the optimal policy can compensate by only a slight amount the welfare cost due to IFB externalities.

6 Conclusion

This study introduces variable hours into a model with intra-firm bargaining. The model can explain the joint occurrence of too high employment and low hours per worker, which is a feature especially of European labor markets. This misallocation of labor across the two margins is a result of overhiring behavior by firms who keep down workers' bargaining position by bargaining with each employee individually.

Our model features search-and-matching frictions in the labor market and bilateral bar-

[33]The welfare levels are computed from the solution of the second-order approximation to the model equilibrium around the deterministic steady state. The online appendix describes the computation of $\mathcal{C}$ from these welfares.

[34]These values are in the same range than Ravenna and Walsh (2012) who investigate the welfare cost of a violated Hosios condition.

gaining à la Mortensen and Pissarides (1994). We adopt the large-firm version of the model where a firm can employ multiple workers. Intra-firm bargaining between the firm and an individual worker potentially affects the wages of all other employees at the firm, as in Stole and Zwiebel (1996) or Cahuc and Wasmer (2001) among others. Together with a production function that is concave in employment, this opens the door to an externality. Firms have an incentive to overhire so as to reduce the bargaining wage, resulting in labor hoarding. We depart from the literature by allowing for variable hours per worker. Much empirical evidence exists that is in line with our key model assumptions, intra-firm bargaining combined with an hours margin along which firms can adjust their labor input.

As this paper shows, the combination of these two model features gives rise to a distortion in that employment is too high and hours per worker are too low in steady state. This misallocation magnifies the overhiring behavior of firms and has important welfare consequences.

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Table 1: **Calibration**

Preferences and Production		
β	0.99	Discount factor; 4% average annualized real interest rate
σ	3	Inverse Frisch elasticity of labor supply; Keane and Rogerson (2012)
ε	6	Elasticity between goods varieties; stst markup of 20%
α	0.70	Returns to labor in production; average labor share
φ	1	Returns to hours in production; benchmark value
Y	1	Stst output; normalization
h	0.30	Stst hours; normalization
G/Y	0.21	Stst share of government consumption in GDP; Euro Area data
Labor Market		
u	0.096	Stst unemployment rate; Euro Area data
q	0.70	Stst vacancy filling rate; Christoffel et al. (2009)
λ	0.03	Job separation rate; Christoffel et al. (2009)
η	0.60	Elasticity of matches to unempl; Petrolongo and Pissarides (2001)
γ	0.60	Workers' bargaining power; Petrolongo and Pissarides (2001)
ub/Y	0.60	Share of home production
cv/Y	0.01	Stst share of total vacancy posting cost in GDP; Andolfatto (1996)
Rigidities and Shocks		
κ	44	Rotemberg price adjustment cost; Krause and Lubik (2007)
a_p	1.50	Interest rate rule coefficient on inflation; Smets and Wouters (2007)
ρ_A, ρ_G, ρ_ς	0.8	Persistence of shocks
σ_A	0.0072	Std of TFP shock
σ_G	0.009	Std of government spending shock
σ_ς	0.006	Std of monetary policy shock

Table 2: **Calibration: Implied Parameters**

Preferences and Production		
A	2.46	Stst technology
ζ	79	Weight on labor disutility
C/Y	0.83	Stst share of consumption in GDP
Labor Market		
n	0.904	Stst employment
p	0.34	Stst job finding rate
θ	0.49	Stst labor-market tightness
c	0.25	Cost of posting a vacancy
v	0.04	Stst number of vacancies
w	0.98	Stst wage rate
b	0.64	Productivity in home production

Table 3: **Second Order Moments**

	Data	Baseline IFB, h_t	Small-scale IFB IFB, $h_t = h$	One worker-firm no-IFB, h_t
σ_y (%)	1.32	1.31	1.33	1.32
σ_n/σ_y	0.53	0.46	0.41	0.53
σ_h/σ_y	0.30	0.29	–	0.43
σ_v/σ_y	9.04	14.43	12.79	16.95
σ_w/σ_y	0.23	0.51	0.47	0.58
$\sigma_{4\Pi}$ (%)	0.82	1.44	1.59	1.34
$\rho(\hat{n}_t, \hat{y}_t)$	0.82	0.63	0.42	0.83
$\rho(\hat{h}_t, \hat{y}_t)$	0.70	0.13	–	0.49
$\rho(\hat{h}_t, \hat{n}_t)$	0.53	0.72	–	0.69
$\rho(\hat{v}_t, \hat{y}_t)$	0.82	0.58	0.36	0.71
$\rho(\hat{w}_t, \hat{y}_t)$	0.14	0.51	0.38	0.79
$\rho(4\hat{\Pi}_t, \hat{y}_t)$	0.37	0.18	-0.15	0.55

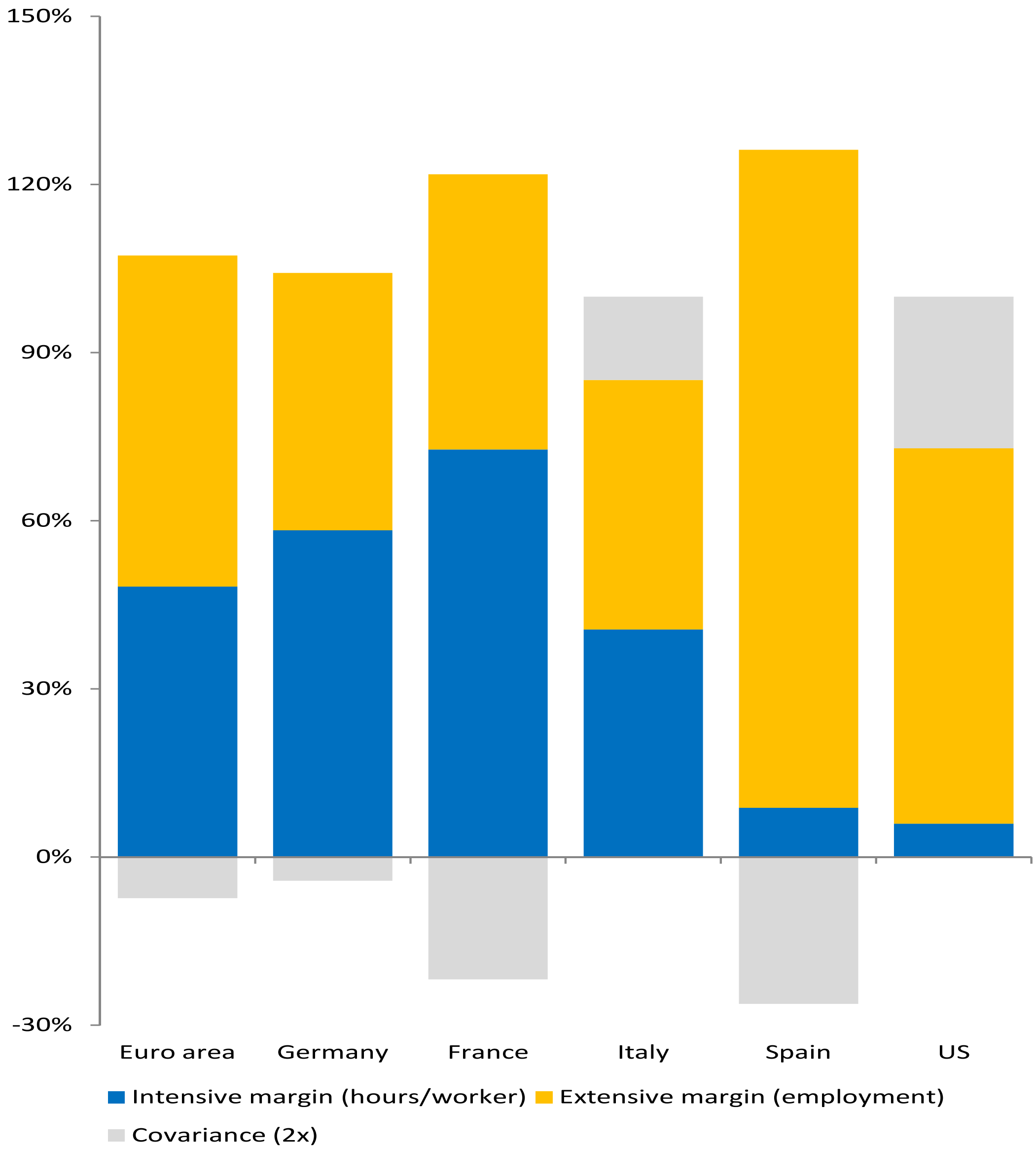
Note: All empirical series are for the Euro Area except the vacancies stock which is proxied by vacancy German data. Sample: 1999Q1-2015Q4. All data are in log and HP-filtered except for inflation. σ_x means standard deviation of variable $\hat{x}_t$ and $\rho\left(\hat{x}_t, \hat{y}_t\right)$ means correlation between variables $\hat{x}_t$ and $\hat{y}_t$.

Table 4: **Welfare Cost of Intra-Firm Bargaining**

		Search gap $\mathcal{W}_t^* - \mathcal{W}_t^{fp}$	Loss relative to price stability $\mathcal{W}_t^{fp} - \mathcal{W}_t^{ram}$
No-Hours IFB	with IFB, $h_t = h$	0.32%	-0.0825
Baseline	with IFB, h_t	1.50%	-0.0826

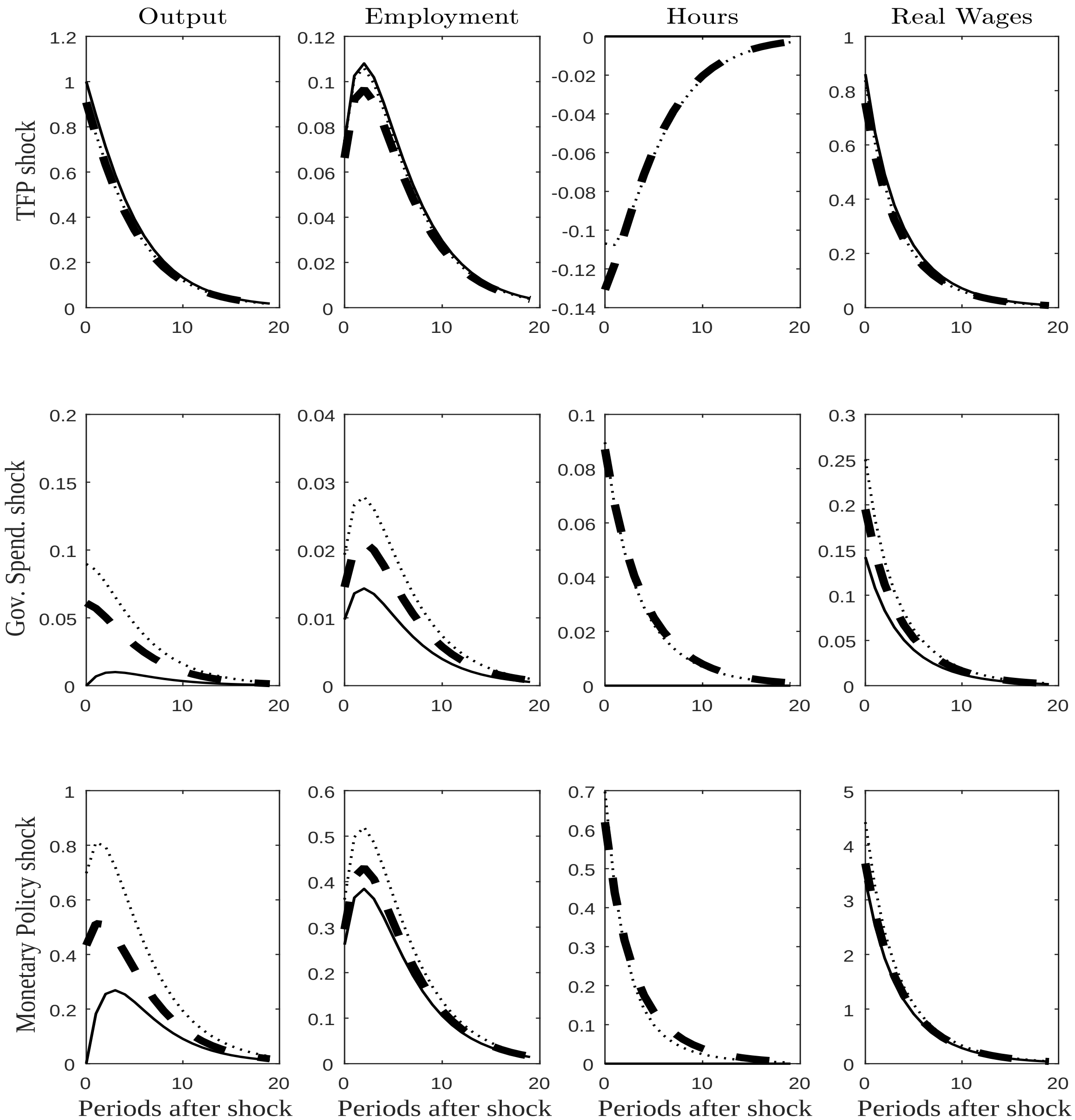
Note: Each welfare cost is expressed in terms of consumption equivalent units: it is defined as the fraction $\mathcal{C}$ of consumption that households would be willing to give away in each period to reach the welfare of the reference economy ($\mathcal{W}_t^*$ in the search gap and $\mathcal{W}_t^{fp}$ in the price stability gap).

Figure 1: **Total Hours Decomposition**



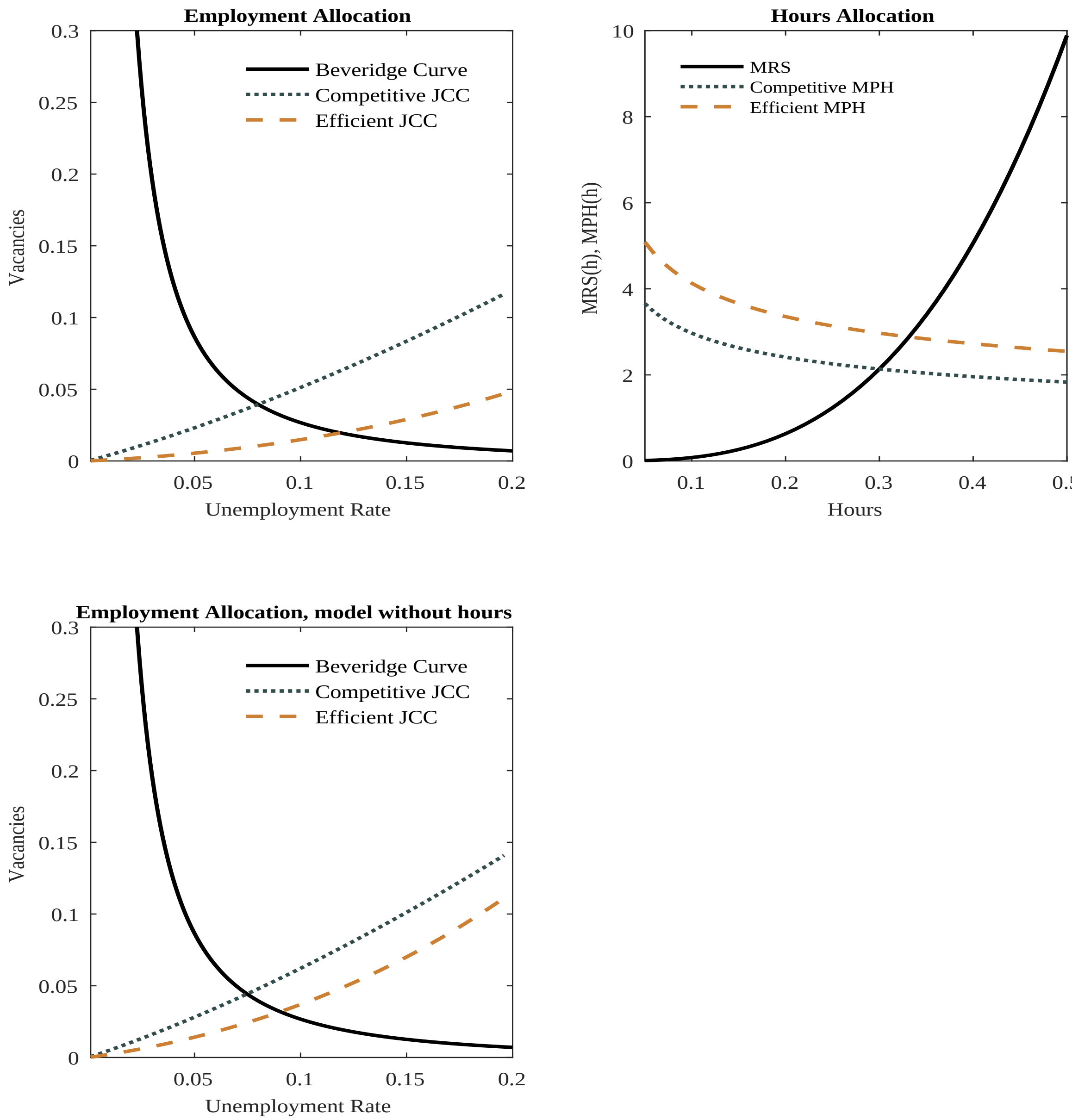
Note: The contributions of hours/worker (logged) and employment (logged) to the variance of total hours worked (logged) have been computed as the variance (X)/(variance (X) + variance (Y) + 2covariance (X,Y)). All variables are hp-filtered with smoothing paramter 1600. The decomposition for the euro 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.

Figure 2: **Impulse Response Functions**



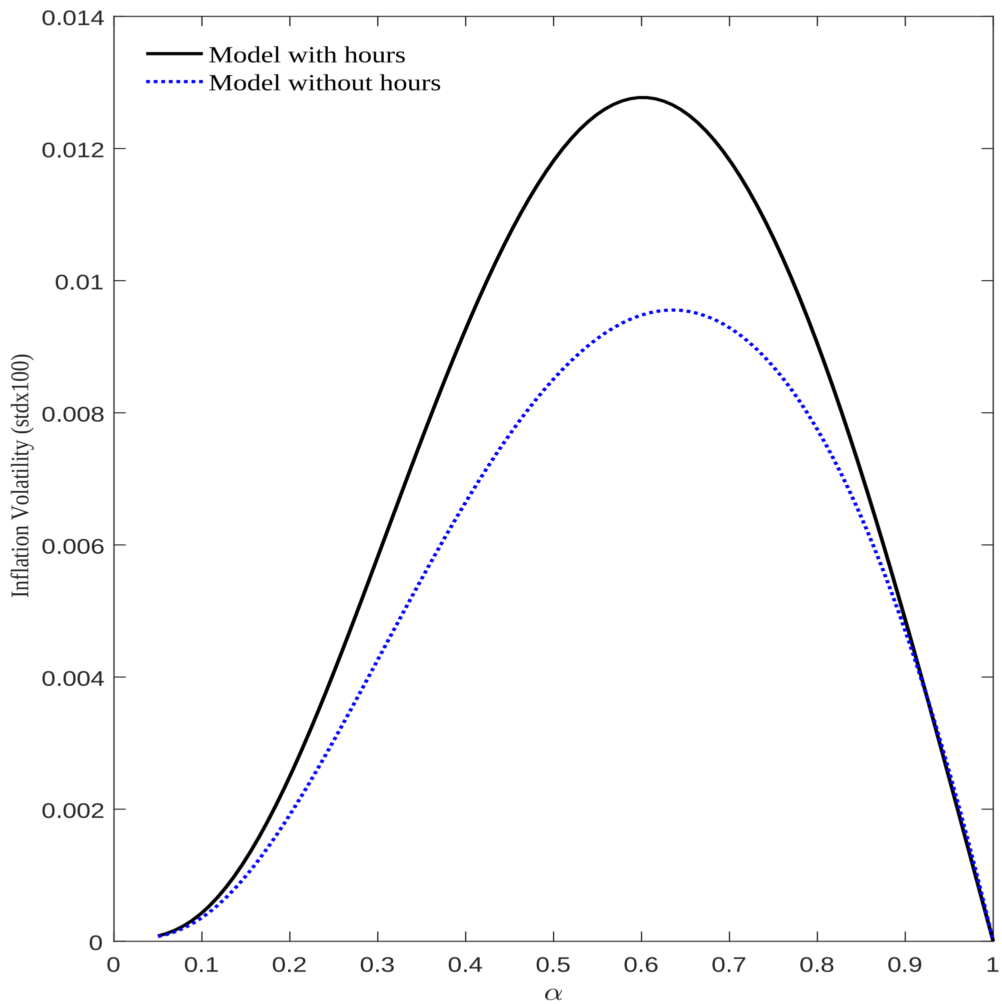
Note: The dash lines correspond to the IRFs in the baseline model with intra-firm bargaining and hours. The solid lines are for an intra-firm bargaining model in the absence of hours. The dotted lines correspond to a typical one worker-firm model with hours. All shocks are normalized to 1 percent and the IRFs are expressed in percentage deviation from the steady state.

Figure 3: **Employment and Hours Allocation**



Note: On the left panels, the solid line displays the Beveridge curve, the dotted line displays the competitive JCC and the dashed line displays its efficient counterpart. On the right panels, the MRS displays the marginal rate of substitution g_{ht}/Λ_t, the dotted line display the competitive marginal product of hours $s_t\,(1+\varepsilon_{fnn})\,f_{ht}/n_t$ and the dashed line displays its efficient counterpart.

Figure 4: **Optimal Inflation Volatility**



Note: The optimal inflation volatility is computed as the standard deviation of annualized inflation (in percent). The solid (dashed, resp.) line displays the optimal inflation volatility in an intra-firm bargaining model with (without, resp.) hours.