Cyclicality of Wages and Union Power

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Abstract

This paper proposes a dynamic model of the labor market which integrates two main features: matching frictions and trade unions. To examine how trade unions shape the volatility of wages over the business cycle, I decompose the volatility of union wages into two components: the volatility of the match surplus and the volatility of the union's effective bargaining power. Formally, I define the effective bargaining power of the union as the share of the total surplus allocated to the workers. Starting from the union's objective function, I prove that its effective bargaining power is endogenous and countercyclical. Intuitively, because the union internalizes the relationship between the wage level and the job creation, it faces a trade-off between the wage rate and the employment rate. Therefore, the union's preferences (wage-oriented or employment-oriented) fluctuate along the cycle and so does its effective bargaining power. As a result, when the economy is hit by a productivity shock, the dynamics of the union's effective bargaining power partially counteract the dynamics of the total surplus and this mechanism delivers wage rigidity. Relatedly, employment reacts stronger when wages are collectively bargained, but its pattern features less persistence.

Keywords: Search and matching; Trade unions; Cycles
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1 Introduction

The role of trade unions is to protect the rights and interests of their members through representation within firms. It includes negotiations with employers on behalf of the workers for better wages and working conditions. Therefore, through their direct participation in the wage determination process, trade unions impact the wage rate level and shape its volatility. This paper integrates search and matching and trade unions to propose a dynamic framework that accommodates two important sources of wage volatility: the volatility of the match surplus and the volatility of the union's effective bargaining power, which is formally defined as the share of the total surplus obtained by the workers. I then study how these two sources interact over the business cycle to shed new light on the properties of the union wage volatility and thus on the properties of the union wage premium volatility.

Specifically, the paper develops a tractable dynamic model that distinguishes and compares two wage bargaining processes. The first one is the individual Nash bargaining traditionally used in the search and matching literature. The second is characterized by a collective Nash bargaining, where a unique trade union negotiates with firms on behalf of its members, who are either employed or unemployed. Those firms react in a second stage by deciding unilaterally how many vacancies to post. I show that, when wages are collectively bargained, the maximization of the Nash product leads to the following equilibrium condition: the share of the total surplus allocated to the workers, I refer to this as the union's effective bargaining power, is not constant but rather fluctuates with the degree of labor market tightness. This new variable enters the wage equation and its volatility gives rise to an additional source of wage volatility. By studying the components of union wages, I make three contributions to our understanding of wage and unemployment fluctuations when wage negotiations take place at a collective level. First, I propose a theoretical framework which allows me to analyze the union's behavior over the cycle. In the present model, the union's preferences (wage-oriented or employment-oriented) are endogenous and react to the tightness of the labor market. Moreover, the fluctuations of the union's preferences are reflected in the fluctuations of the union's effective bargaining power. I demonstrate that this variable is in fact countercyclical, which leads to the second contribution of my work. The union's effective bargaining power enters naturally the wage equation. Therefore, wage fluctuations are not only driven by the dynamics of the total surplus, but also by the dynamics of this additional variable, whose cyclical properties are crucial: the countercyclicality of the union's effective bargaining power partially counteracts the fluctuations of the total surplus which yields rigid wages. Collectively bargained wages are less responsive to the business cycle than individually bargained ones, a result which is consistent with, because directly derived from, the union's utility function. Third, when the economy is hit by a positive productivity shock, the moderate reaction of the union wage translates into a stronger response of employment. Since the union's effective bargaining power increases as the shock propagates, wages go back slower towards their steady state values. In turn, the response of employment in the union sector features less persistence.

This paper builds on Mortensen and Pissarides (1994) search and matching model by introducing trade unions. Search frictions cause match-specific rents, as both the employer and the employee would be worse off if the match ended, due to the delays of filling a vacancy and finding a new job. Such a theoretical framework is promising as it allows to explore different rent sharing rules, i.e. different wage setting processes. Most of the search and matching literature proposes an individual Nash bargaining solution, but alternatives have recently been investigated, often in order to improve the ability of the model to account for the stylized facts of the business cycle .[1] Despite this growing strand of the literature, few papers focus on collective wage bargaining, even though collective bargaining coverage is still high, particularly in Europe,[2] despite the overall decline in union density. In their role as a participant of wage negotiations, their behavior affects necessarily the level and the volatility of wages. Because of this, it is important to take this institutional feature into consideration when modeling wage formation. Moreover, to introduce trade unions into a search and matching framework is necessary in order to compare collective wage bargaining with individual wage bargaining and to isolate its specificity. A first study integrating a trade union, in the form of a monopoly union, in a search and matching framework is the one of Pissarides (1986), extended subsequently by Delacroix (2006) and Garibaldi and Violante (2004). These authors model wage determination in the presence of trade unions and describe the negative impact of unionism on employment due to the union wage premium. However, they propose models in steady state which are incapable of giving any insight on the specific volatility of collectively bargained wages. The model I develop accounts for a dynamic structure of the role of trade union and allows a comparative analysis of the dynamics of both types of wages.

In the present paper, I develop a bisectoral model economy: a non unionized sector where wages are negotiated at an individualized level coexists with a unionized sector where a union interacts with firms in a collective bargaining process over wages. The crucial difference between the two wage setting processes is as follows. Search frictions are turnover costs which give the workers or the union the power to bargain for a wage higher than the reservation wage, higher than the wage for which the outsiders would be willing to work. In an individual wage bargaining, an employed worker, insider, makes full use of his bargaining power to push his wage to the highest possible level, without taking into account the negative impact of this high wage on the firm's hiring decision and therefore on the unemployment rate. When wages are collectively bargained, the presence of unions increases workers' bargaining power as firms

[1] Shimer (2005) points out that, at conventional parameters values, individually Nash bargained wages are excessively volatile, depressing vacancy creation. As a result, employment is far less volatile than in the data. Wage rigidity has been explored as a way to improve the performance of the model.

[2] For a recent study on wage bargaining institutions in most of European countries, United States and Japan, see Caju, Gautier, Momferatou, and Ward-Warmedinger (2008). They provide among other data on collective bargaining coverage and establish that this rate exceeds 80% in most western European countries.

would not be able to produce at all if both parties do not come to an agreement. This lower fall back utility of firms enables the union to capture a larger share of the total rent. The largely documented[3] union wage premium reflects this difference in bargaining power. More interestingly, the union internalizes the impact of wages on the firms' incentive to open vacancies and herewith gives consideration to the outsiders who face more difficulty finding a job when wages are high. Indeed, the existence of unemployment and the threat of more unemployment is the major constraint of union power, and this threat is materialized by the employer's labor demand curve (the job creation curve). The intuition works as follows. The concern of the trade union is the welfare of its members, who can be either employed or unemployed. Therefore the union's utility function increases in both wages (though the insiders' utility) and employment(though the outsiders' utility) and the negative relationship between these two variables represents the trade-off faced by the union. The level of wages the union is demanding reflects its preferences over these two variables. As a result, for a same bargaining power, the collectively bargained wage is lower than an individual one as employment enters the utility function of the union.

The dynamic model I present allows me to compare how the two wage setting processes affect the static characteristics of the labor market as well as its dynamic properties. Therefore, I am able to point out the role of trade unions in shaping the volatility of labor market variables. The argumentation consists of three steps. As a start, I demonstrate that the preferences of the union over wages and employment fluctuate depending on the tightness of the labor market. Indeed, the union's preferences reflect its members' preferences, which are only based on the current status (insider or outsider) of each member. Therefore, the composition of the union's members, i.e. the proportion of (un)employed workers, translates into the orientation of the union. In good times, when the proportion of unemployed workers is low, the unemployment issue is played down and the union pushes for high wages as a large proportion of its members are employed and asking for a high wage rate. In bad times, when the stock of unemployed workers is large, the union moderates the wages in order to boost hirings. In addition, it is worth noticing that the union's preferences translate directly into the union's effective bargaining power, which is defined as the fraction of the match surplus gotten by workers. Therefore, the aforementioned mechanism has an important implication: the union's effective bargaining power is endogenous and decreasing with unemployment. This finding is consistent with the empirical study of Aronsson, Löfgren, and Wikström (1993) who test two models of wage determination, the first characterized by a union's bargaining power which is constant over time, the second where the bargaining power develops with unemployment and labor market characteristics, using time series data for the Swedish construction sector. They find evidence that unemployment tends to decrease the bargaining power of the union. Two other papers (Campbell III (1997) and Fuess (2001)) confirm empirically this result. Using U.S data, Campbell III (1997) finds that union wages are more

[3] See for example Blanchflower and Bryson (2002).

sensitive to the unemployment rate than non union wages. Fuess (2001) obtains from Japanese data that the union power is positively correlated with GDP.

Second, I spell out how the union's effective bargaining power affects wages. In both sectors, the bargained wage is a weighted average of two threat points delimiting the bargaining set, the weights being equal to the share of the match surplus obtained by the workers. This share is endogenous in the collective bargaining setting. As a result, the dynamics of the union wage are not only driven by the fluctuations of the match surplus, but also by the fluctuations of the union's effective bargaining power.

Central to my analysis is thus the additional source of wage volatility in the union sector arising from the volatility of the effective bargaining power. In a third step, I focus on the cyclical properties of this new variable, with the level of productivity as the business cycle indicator, and prove its countercyclicality. To get the intuition behind this result, consider a positive productivity shock. Both the union wage rate and the employment level shift upwards, but employment reacts relatively smoothly.[4] In turn, the marginal rate of substitution of wage for employment increases, and it becomes more valuable for the union to foster employment as each worker benefits from a higher surplus. On impact, the union converts the higher surplus into both higher wages and higher employment, but the shift in its preferences creates a bias towards employment. Subsequently, as the shock propagates in the economy and raises the employment level, the union gives gradually more importance to the wage level. The opposite mechanism works in case of an adverse productivity shock. Given the higher reactivity of wages compared to employment, the union's first concern is to avoid a large decrease in the wage rate and therefore prioritizes wages over employment. In the following periods, as unemployment increases following the adverse shock, the union tends to be more employment-oriented. The behavior of the union is therefore totally explained by the changes in valuation of wages and employment over the cycle and hence in changes in the marginal rate of substitution between these two elements. A similar behavior, unions being more aggressive in bad time, is described by Freeman and Medoff (1984) in their book *What do unions do?*, even though the underlying argumentation differs. Indeed, they explain that one of the main factors behind the countercyclicality of the union wage premium is "the greater capacity of unionized workers to fight employers' effort to reduce wages" when market conditions are unfavorable. This has been proposed by the authors as the reason of the widening of the union wage premium during the Depression of the decades 1920s, 1930's. Blanchflower and Bryson (2004) confirm this theory, based on an empirical study of the union wage premium in the US over the period 1973-2002.

The countercyclical properties of the union's effective bargaining power is at the core of the mechanism of wage rigidity. On impact, the dynamics of this variable partially counteract the dynamics of the total surplus and make the union wage less responsive to the business cycle. In the following periods, the

[4]Note that firms take their hiring decision based on the difference between productivity and wage rate. Employment fluctuates therefore less that wages. This is exactly the starting point of Shimer's critique.

response of the union wage rate to the shock is more persistent in the presence of a union. Symmetrically, employment reacts stronger on impact and features less persistence.

This model provides a convenient framework to analyze the role of unions in shaping the volatility of wage and employment. In this sense, my paper is closely related to three papers: Mattesini and Rossi (2007), Zanetti (2007b) and Faia and Rossi (2009). These papers analyze how the response to productivity shocks of employment and wage is affected by the presence of the union and find that the union dampens wage dynamics and amplifies employment dynamics. However, none of these studies integrates trade unions into a search and matching framework, which is yet crucial in order to understand the specific power of unions and its volatility, as well as the union wage volatility. Moreover, a search and matching framework provides a natural way of modeling the union's objective function, from where the endogenous union's effective bargaining power is derived, and allows a clear comparison between individual and collective wage bargaining. Finally, the second source of wage volatility, which is at the core of the origin of wage rigidity when wages are collectively bargained, is absent of their analysis.

The paper proceeds as follows. The next section lays out the dynamic equations of the model. I introduce within a search and matching framework a sectoral trade union negotiating wages with firms on behalf of its members and I compare the wage formation process with a standard individual Nash bargaining setting. Section 3 focuses on how the unions' effective bargaining power evolves along the cycle and on how this volatility impacts the volatility of union wages. Section 4 analyses quantitatively the dynamic behavior of the model in case of disturbances (productivity shocks). Section 5 concludes.

2 The model

2.1 The environment

2.1.1 A dual labor market

Labor markets are generally characterized by both individual and collective wage formation. The present model reproduces this feature. Indeed, in the bisectoral model economy, two producing sectors coexist: the non unionized sector denoted by the superscript N and the unionized sector denoted by the superscript U. The unique difference between these two sectors stands in the wage bargaining process. In the non unionized sector, wages are negotiated at an individualized level, i.e. employers and employees agree on wages through a bilateral bargaining process. In the opposite, in the unionized sector, they are collectively bargained at the sectoral level, meaning that a unique union negotiates wages with firms on behalf of its members. More precisely, I make two assumptions regarding the unionized sector. First, based on the observation that the bargaining process over wages takes mainly place at the sectoral level

(OECD (1994), Caju, Gautier, Momferatou, and Ward-Warmedinger (2008)), I assume that all the firms belonging to the unionized sector are engaged in collective bargaining over wages. Second, the membership rule is such that each worker in the sector is unionized, regardless of his employment status.[5]

The workers are unable to switch between sectors because each occupation requires specific skills and an extensive investment in training and qualifications.[6] This segmentation can be brought together with the dual labor market described by Doeringer and Piore (1971) where a primary market with relatively high wages, high degree of concentration, and powerful unions, coexists with a secondary market with opposite characteristics.[7] As presented in MacDonald and Solow (1985), the existence of some sort of barriers prevents free movement across sectors.

Some empirical studies (Nickell (1997), Nickell and Layard (1999)) show that a better measure of the unions' size is provided by the collective bargaining coverage rate, given the presence of excess coverage in several countries. This rate is sluggish (Cahuc and Zylberberg (2004)) which justifies the assumption that the share of workers belonging to each sector is fixed in the short run.

2.1.2 Timing

At the beginning of the period, an exogenous shock occurs. Existing matches have a probability λ^i (where $i = N, U$ denotes respectively the non unionized and unionized sector) to end. Subsequently, firms post vacancies and searching firms and unemployed workers meet. This matching process is time-consuming meaning that only a certain percentage of unemployed workers and firms actually form a match each period. The number of new matches in sector i at time t, m_t^i, is determined through a matching function increasing in both the size of the pool of unemployed workers searching for a job u_t^i and the size of the pool of vacancies v_t^i. At the end of the period, production takes place with a level of employment n_t^i and salaries are paid. Notice that in this framework, newly employed workers start to produce within the same period. This allows firms to react immediately when facing a shock, in posting more or less vacancies.

Concerning the point in time when wages are negotiated, the two sectors differ. In the non unionized sector, by the very nature of individual wage bargaining, wages are negotiated once each firm-worker pair has been formed. Firms rationally anticipate the outcome of the wage negotiations when deciding the number of vacancies to post. In the unionized sector, I assume a right-to-manage timing, based on a sequence à la Stackelberg where the union first bargains with firms over wages and then firms respond by unilaterally determining employment. This timing contrasts with the one adopted in the search and matching

[5] In the more generalized case where workers who have been laid off for more than a certain number of periods loose membership, the qualitative results would remain valid.

[6] The utilities sector makes a good example of the unionized sector, whereas the financial sector can represent the non unionized one.

[7] See also Silvestre (1971) who uses such a labor market segmentation to describe the French industry since 1945.

literature but is common practice both in the trade unions literature and in papers integrating trade unions into search and matching frameworks (see Pissarides (1986), Mortensen and Pissarides (1999) and Delacroix (2006)).

2.1.3 Stocks and flows

The labor force is homogeneous and normalized to one, out of which $\alpha^N \in (0,1)$ belong to the non unionized sector and $\alpha^U = 1 - \alpha^N$ belong to the unionized sector. Employment in sector $i = (N, U)$ at the end of period t, n_t^i, evolves according to the following dynamics:

$$n_t^i = \alpha^i - u_t^i + m_t^i \tag{1}$$

whereas the number of unemployed workers at the beginning of period t evolves as:

$$u_t^i = \alpha^i - (1 - \lambda^i) n_{t-1}^i \tag{2}$$

Plugging (2) into (1), I get:

$$n_t^i = (1 - \lambda^i) n_{t-1}^i + m_t^i \tag{3}$$

Notice that the law of motion of end-of-period unemployment, $\bar{u}_t^i$, is:

$$\bar{u}_t^i = \alpha^i - (1 - \lambda^i) n_{t-1}^i - m_t^i$$

and that, by the normalization of the labor force:

$$\bar{u}_t^N + \bar{u}_t^U + n_t^N + n_t^U = 1$$

The matching process in sector i is summarized by the following function:

$$m_t^i = \sigma_m {u_t^i}^{\sigma_u} {v_t^i}^{1-\sigma_u} \tag{4}$$

where σ_m is the matching process efficiency.

The vacancy filling rate is $q_t^i(\theta_t^i) = \frac{m_t^i}{v_t^i}$, where $\theta_t^i = \frac{v_t^i}{u_t^i}$ represents the market tightness, and the job finding rate is $p_t^i(\theta_t^i) = \frac{m_t^i}{u_t^i}$. The matching process presents a congestion externality in the sense that the slacker the labor market, the higher the probability for a vacancy to be filled and the lower the probability for an unemployed worker to find a job.

2.2 Solving the model

Two optimal decisions have to be derived: the optimal hiring decision of firms, in terms of number of vacancies to post for any anticipated (in the non unionized sector) or observed (in the unionized sector) wage rate, and the optimal wage.

2.2.1 Vacancy posting decision

Firms are assumed to be large enough so that by the law of large number the fraction of vacancies filled in each firm is equal to the vacancy filling rate of the sector.

Firms are similar which allows me to focus on a representative firm in each sector. The output in sector i is given by: $y_t^i = z_t n_t^i$ where z_t is the productivity level common to both sectors. The production costs consist of the wage cost and the cost of posting vacancies (c per vacancy). In the non unionized sector, the employment level is determined before wages are negotiated. Therefore, in case wages would depend on the scale of the firms, employers would have the possibility to manipulate the wage through their employment policy. When choosing the number of vacancies to post, wages would be taken into account as a function of the employment level. For simplicity reason, I avoid this issue by assuming constant returns to scale in the production function. As shown by Cahuc and Wasmer (2001), the intra-firm bargaining element vanishes in this case. In the unionized sector, given that firms take their hiring decision in a second stage, once the wage rate has been negotiated, the wage schedule is observed and such an intra-firm bargaining issue is therefore irrelevant.

The number of posted vacancies results from the following profit's maximization process:[8]

$$\max_{v_t^i} F_t^i(n_t^i) = z_t n_t^i - w_t^i n_t^i - c v_t^i + E_t \beta F_{t+1}^i(n_{t+1}^i)$$

$$\text{s.t. } n_t^i = (1-\lambda^i) n_{t-1}^i + q_t^i v_t^i$$

The first order condition is given by:

$$\frac{\partial F_t^i}{\partial v_t^i} = z_t q_t^i - w_t^i q_t^i - c + E_t \beta \frac{\partial F_{t+1}^i}{\partial n_t^i} q_t^i = 0 \tag{5}$$

Using the envelope condition and equation (5), I obtain the expression of $\frac{\partial F_t^i}{\partial n_{t-1}^i}$:

$$\frac{\partial F_t^i}{\partial n_{t-1}^i} = (1-\lambda) \frac{c}{q_t^i} \tag{6}$$

Plugging equation (6) into equation (5), I obtain the job creation equation (JC):

$$\frac{c}{q_t^i} = z_t - w_t^i + E_t \beta (1-\lambda^i) \frac{c}{q_{t+1}^i} \tag{7}$$

This result establishes that firms post vacancies up to the point where the cost of posting a vacancy c times the expected duration of the vacancy $\frac{1}{q_t^i}$ equals the contribution of the worker to the flow of profit plus the vacancy posting cost saved by the firm in $t+1$ in case the match does not end.

[8] Because the intra-firm bargaining element, which could arise in the non unionized sector, vanishes due to the assumption of a constant returns to scale production function, I do not write down the constraint represented by the wage equation $w_t^N = w_t^N(n_t^N)$.

2.2.2 Wage negotiation

Wage negotiation in the non unionized sector In this sector an individual bargaining process takes place over the wage between employers and employees once the matching process has taken place.

The Nash-bargained wage maximizes the product of the net gains of agreement for both parties. At the conclusion of the bargaining, the marginal match provides a welfare W_t^N to the worker, with W_t^N being defined as:

$$W_t^N = w_t^N + E_t\beta\big[(1-\lambda^N+\lambda^N p_{t+1}^N)W_{t+1}^N + \lambda^N(1-p_{t+1}^N)U_{t+1}^N\big] \tag{8}$$

whereas the worker obtains a welfare of U_t^N, with U_t^N being defined as:

$$U_t^N = b + E_t\beta\big[p_{t+1}^N W_{t+1}^N + (1-p_{t+1}^N)U_{t+1}^N\big] \tag{9}$$

if the bargaining fails. Notice that, due to the homogeneity of the labor force and to the similarity of the firms, the value of employment for the marginal worker is the same for all the employees, regardless of the firm they are working in. As for the firms, the marginal match contributes to the flow of profit up to the marginal value of employment $\frac{\partial F_t^N}{\partial n_t^N}$, without regards to the vacancy posting costs which are sunk at the time of the wage negotiation. Therefore, the expression for the value of the marginal job is:

$$\frac{\partial F_t^N}{\partial n_t^N}\bigg|_{v_t^N=\bar{v}_t^N} := J_t^N = z_t - w_t^N + E_t\beta(1-\lambda^N)J_{t+1}^N \tag{10}$$

Hence, the Nash bargained wage results from the following maximization program:

$$\max_{w_t^N}\,[W_t^N - U_t^N]^{\eta^N}[J_t^N]^{1-\eta^N}$$

where $\eta^N \in [0,1]$ is the workers' bargaining power.

The first order condition states that the share of the total surplus allocated to the workers is equal to their bargaining power:

$$\frac{W_t^N - U_t^N}{W_t^N - U_t^N + J_t^N} = \eta^N \tag{11}$$

Rearranging this first order condition and using the expression of the values J_t^N, W_t^N and U_t^N, I obtain the equilibrium wage rate in sector N:

$$w_t^N = \eta^N[z_t + E_t\beta(1-\lambda^N)c\theta_{t+1}^N] + (1-\eta^N)b \tag{12}$$

The bargaining set is delimited by two threat points and contains an infinity of equilibrium wage rates. The sharing rule allocates a constant share of the bargaining set to the worker and the firm. Unlike in the walrasian model, the wage does not equate the worker's productivity. Indeed, the wage rate is a function of two labor market parameters: the cost of posting vacancies and the level of unemployment benefits. Moreover, and more importantly, the wage varies with the degree of the labor market tightness in the following period. To see this, consider an increase in the number of posted vacancies in $t+1$. The duration of a vacancy increases, along with the real cost of posting a vacancy $\frac{c}{q_t+1}$. This translates in period t into a bigger saving of hiring cost in case of match and therefore into a higher value of employment for the firm and a higher total surplus. The workers surplus being a fixed part of the total surplus, the wage increases. The same reasoning can be followed with an increase of unemployment which leads to a decrease of the worker's surplus and finally of the wage rate.

The efficiency condition, established by Hosios (1990), entails that the bargaining power of the workers η^N should equal the elasticity of the vacancy filling rate to the degree of labor market tightness σ_u. Indeed, if this condition is respected, the number of posted vacancies is equal to the one which would prevail in an economy where firms take into account that the vacancy filling rate decreases with the number of posted vacancies.

Wage negotiation in the unionized sector Unlike several recent papers studying trade unions and business cycles (Zanetti (2007a), Mattesini and Rossi (2007), Faia and Rossi (2009)) who adopt a monopoly union model, I assume that, at the beginning of each period, the union bargains with the firms over the wages. Subsequently, firms decide unilaterally the number of vacancies to post, based on the wage rate previously negotiated. This right-to-manage model, in line with Nickell (1982) and Nickell and Andrews (1983), allows me to keep the analysis as general as possible.[9]

Net gain of agreement for the union. I assume that the unique concern of the union is the welfare of its members, who are either employed or unemployed. At the time the wage rate is bargained over, $\alpha^U - u_t^U$ members are employed and will attain with certainty the level of utility W_t^U at the end of the period, while u_t^U members are unemployed, out of which $p_t^U u_t^U$ will form a match and attain the level of utility W_t^U at the end of the period, the remaining $(1-p_t^U)u_t^U$ attaining the level of utility U_t^U. The utility of the union is assumed to be the sum of the end-of-period utility levels of its members and takes consequently the following form:

$$\Omega_t = (\alpha^U - u_t^U)W_t^U + u_t^U[p_t^U W_t^U + (1-p_t^U)U_t^U]$$

$$\Omega_t = n_t^U(W_t^U - U_t^U) + \alpha^U U_t^U \tag{13}$$

[9]Right-to-manage bargained wages are not Pareto-efficient. Efficient contracts can be obtained if firms and unions would bargained simultaneously over wages and employment, as shown by Leontief (1946). However, as argued by Calmfors and Horn (1986) and Oswald (1993), negotiations do generally not include employment explicitly.

Because all the workers of the sector would be unemployed in case of failure of the wage negotiation, the fall back welfare of the workers is $\alpha^U U_t^U$. Therefore, the union's net value of agreement is $n_t^U(W_t^U - U_t^U)$. As mentioned earlier, due to the assumptions of homogeneity of the labor force and the similarity of the firms, the value of employment for the marginal worker is the same for all the employees. Moreover, due to the constant returns to scale production function, the wage rate is independent from the level of employment and the welfare values W_t^U and U_t^U represent respectively the employment and unemployment values of both the marginal and the average worker. Because of this, $W_t^U - U_t^U$ can be interpreted as the average worker's surplus and $n_t^U(W_t^U - U_t^U)$ as the total surplus of the workers.

This utilitarian specification presents several advantages. First, this specification, in keeping with MacDonald and Solow (1981) and Oswald (1982), is a common approach in the trade union literature (see Calmfors (1982), Sampson (1983), Kidd and Oswald (1987), Pissarides (1986) among others). Second, it allows a immediate comparison of the workers' objectives across sectors. Indeed, while each worker in sector N seeks to maximize his own surplus $W_t^N - U_t^N$, the union aims at maximizing the sum of the workers' surpluses $n_t^U(W_t^U - U_t^U)$. Both the workers and the union foresee that their demands will affect the hiring decision of the firms. However, the specificity of the unionized sector is that the union internalizes the negative impact of wages on employment when negotiating wages, because it seeks to maximize not only the individual surplus but also the proportion of workers receiving this surplus. Third, the search and matching framework provides a natural way of modeling the workers' fall back utility U_t^U, which is not fixed but fluctuates with the expected evolution of the degree of market tightness. Fourthly, the unions' objective is directly derived from the members' preferences, which is not the case with Stone-Geary utility forms. Moreover, the unions' specification, as described by equation (13), allows for political considerations. Indeed, even if employment and wages have equal weight in the unions' utility function, I will show later in this section that the relative importance of these issues is endogenous and varies along the cycle.

Net gain of agreement for the firms. For the firms, the fall back position is zero. Indeed, if the bargaining with the union fails and no wage agreement is found, the firms can not find any non unionized workers in the sector to be able to produce. If the bargaining is successful, each firm gets an end-of-period profit $F_t^U + cv_t^U$, because the vacancy filling costs, being paid at the middle of the period before the matching process takes place, are sunk at the end of the period (even though they are not sunk at the time of the bargaining).[10] It is showed in Appendix A that, in both sectors, the profit of the firms can be

[10] This choice of eliminating the vacancy filling costs in the wage bargaining is done in order to ease the comparison with the non unionized sector. Otherwise, the differences in the wage equations across sectors would stem from both the difference in the level at which the wage bargaining takes place and the difference in the timing (ex ante wage bargaining in the unionized sector, and ex post wage bargaining in the non unionized sector).

written as a function of the marginal value of employment:

$$F_t^i = n_t^i J_t^i - cv_t^i$$

This implies that the net gain for the firms is equal to $n_t^U J_t^U$. It also implies that J_t^U represents the firms' ex post (i.e. once the vacancy filling costs have been sunk) employment value of both the marginal and the average match.

Wage equation. From equation (13), one can observe that the utility of the union depends both on the rate rate and on the employment level. A high wage rate increases the individual worker's surplus, but, because the job creation curve is downward sloping, lowers the incentive for the firms to post vacancies, and therefore lowers the employment rate.

$$\Omega_t = \Omega_t(w_t^U, n_t^U(w_t^U)) \text{ with } \Omega'_w > 0,\ \Omega'_n > 0 \text{ and } n'_w < 0$$

The negative correlation between the wage rate and the job finding rate embodies the trade-off faced by the union. This trade-off would disappear in case the vacancy posting decision were taken before the wage bargaining and both wage negotiation processes would lead to the same equilibrium. In this sense, the timing assumption is crucial is this sector.[11]

The union maximizes therefore its objective function containing wage and employment, constrained by the firms' labor demand function[12], the job creation curve, and the maximization program of this right-to-manage model is written as the following:

$$\max_{w_t^U} [n_t^U (W_t^U - U_t^U)]^{\eta^U} [n_t^U J_t^U]^{1-\eta^U}$$

$$\text{s.t JC curve: } \tfrac{c}{q_t^U} = z_t - w_t^U + E_t \beta (1 - \lambda^U) \tfrac{c}{q_{t+1}^U}$$

where η^U is the union's bargaining power.

The FOC leads to the following equilibrium condition which states that the share of the total surplus allocated to the workers is (see Appendix B.1):

$$\frac{W_t^U - U_t^U}{W_t^U - U_t^U + J_t^U} = \tilde{\eta}_t^U \tag{14}$$

where

$$\tilde{\eta}_t^U = \frac{\eta^U \sigma_u n_t^U}{\sigma_u n_t^U + (1 - \sigma_u) m_t^U} \leq \eta^U$$

[11] To see this, consider the alternative timing were vacancies are posted ex ante. With this timing, the hiring decision would be based on the expected, or promised, wage level. But the union can not credibly announce that it will moderate the wage rate in order to promote hirings. Indeed, once the vacancies have been posted, nothing prevent the union to deviate from its announcement and push the wage to the highest possible level. With this timing, the level of employment n_t^U would be taken as given. The maximization program would be reduced to the case of the wage bargaining of the average match, which is equal to the wage bargaining of the marginal match due to the constant returns to scale.

[12] For an empirical test of this maximization program, see Dertouzos and Pencavel (1981).

I define the concept of effective bargaining power of a agent (workers or union) as the share of the total surplus allocated to the workers . In the non unionized sector, bargaining power and effective bargaining power are two similar concepts: the workers' bargaining power equals the share of the surplus allocated to the workers (see equation (11)). In the unionized sector, these two concepts are different: the union's bargaining power η^U does not equal the unions' effective bargaining power $\tilde{\eta}_t^U$.

It follows from equation (14) that the wage curve in the unionized sector is (see Appendix B.2):

$$w_t^U = \tilde{\eta}_t^U \left[z_t + E_t \beta (1 - \lambda^U) c \theta_{t+1}^U \right] + (1 - \tilde{\eta}_t^U) b - \Theta_t \tag{15}$$

where

$$\Theta_t = E_t \beta (1 - \lambda^U) \frac{c}{q_{t+1}^U} (1 - p_{t+1}^U) \frac{\tilde{\eta}_{t+1} - \tilde{\eta}_t}{1 - \tilde{\eta}_{t+1}}$$

Two comments are in order when considering the wage equation (15) and when comparing it with the corresponding equation for the non unionized sector, equation (12). First, the structure of the equation is the same as in the non unionized sector, with the two same extreme wage levels which demarcate the bargaining set, $z_t + E_t \beta (1 - \lambda^U) c \theta_{t+1}^U$ and b. Indeed, the third term in the right hand side of equation (15), Θ_t, which indicates how the expected evolution of the union's effective bargaining power impacts the workers' demand, becomes negligible as the persistence of the model increases. Second, unlike in the non unionized sector, the sharing rule does not allocate a constant share of the bargaining set to the union and to the firm. Indeed, the weights, $\tilde{\eta}_t$ and $(1 - \tilde{\eta}_t)$, are not fixed but endogenous. These remark leads to an important result. The fluctuations of the wage rate in the unionized sector stem from two different sources: the fluctuations of the total surplus and the fluctuations of the union's effective bargaining power.

Union's effective bargaining power. In order to get the intuition behind the properties of the union's effective bargaining power, I write it as an expression of the beginning-of-period stock of unemployed workers u_t^U and the out-of-unemployment probability p_t^U:

$$\tilde{\eta}_t = \eta^U \frac{\sigma_u (\frac{1}{u_t^U} - 1 + p_t^U)}{\sigma_u (\frac{1}{u_t^U} - 1) + p_t^U} \tag{16}$$

for which the following properties hold:

$$\frac{\partial \tilde{\eta}_t}{\partial u_t^U} < 0 \qquad\qquad \frac{\partial \tilde{\eta}_t}{\partial p_t^U} < 0$$

The union's effective bargaining power is equal to its bargaining power η^U multiplied by a second term smaller than one and decreasing in both the beginning-of-period unemployment level and the job finding rate.

To understand the negative correlation between the union's effective bargaining power and the beginning-of-period unemployment level, consider the union's utility function, equation (13). The union's preferences reflect its members' preferences, which are only based on the current status (insider or outsider) of each member. Indeed, the determination of the union's preferences being renewed each period, no commitment forces the workers to take into account their expected status in the following periods. Therefore, the current composition of the union's members, i.e. the proportion of (un)employed workers, translates into the orientation of the union. If the period starts with a large stock of unemployed workers, the union tends to moderate the pressure on the wage rate to give the firms the incentive to post vacancies. The union is naturally more willing to boost employment the more relevant the unemployment issue is, because a relatively large proportion of its members are outsiders who benefit from a moderate wage rate. By the same token, if the employment level is high at the beginning of the period, the union is more wage oriented as the unemployment issue is played down and a relatively large share of its members are employed and claiming for a high wage rate.

Consequently, I find the following salient result. The union's preferences over wages and employment, driven by the proportion of (un)employed workers within the union, are endogenous and fluctuating with the situation on the labor market. Said differently, the degree of market tightness reflects on the composition of the unions and, through this channel, shapes the unions' preferences over wages and employment.

Notice that in the theoretical case where there were no unemployment at the beginning of the period (or more realistically, if unemployed workers were not taken into consideration by the union), the union's effective bargaining power would be equal to its bargaining power η^U. The result would be similar to an individual Nash bargaining. Indeed, in this case, the union's members would all have the same preferences over wages and employment (they would claim for a high wage rate), and the union would make full use of its bargaining power to push the wage to the highest possible level. The collectively bargained wage rate departs from the individually bargained one only because the union is partly composed by unemployed workers who value employment and wages differently compared to employed workers. The heterogeneity of the union's members introduces political considerations and reflects the internal conflict within the union. The higher the proportion of unemployed workers, the stronger the downwards pressure on the wage rate, the lower the union's power to drag a large part of the total surplus. As a result, the composition of the union impacts the outcome of the wage negotiation.

Next, concerning the negative correlation between the union's effective bargaining power and the job finding rate, two observations have to be made. First, notice that this job finding rate reflects the scale of the search frictions characterizing the labor market. The smaller these frictions, the faster the job finding. Second, the match-specific rents are generated by the search frictions. Therefore, the smaller the search frictions are, the closer the labor market is from a competitive market, where the wage rate equals the reservation wage. Combining these two observations, the mechanism behind the negative correlation between the union's effective bargaining power and the job finding rate is the following. When the labor market converges towards a competitive market (when the search frictions becomes negligible), the probability to find a job tends towards infinity and the workers' surplus fades. This induces the vanishing of the union's effective bargaining power. In turns, the wage rate tends towards the competitive outcome, i.e. the reservation wage. And vice versa.

3 Countercyclical union power

In this section, I seek to illustrate the mechanism through which wage rigidity arises when wages are collectively bargained. The degree of wage rigidity is assessed based on how the wage fluctuates when the economy is hit by a productivity shock.

3.1 Linearization

In order to analyze the channels through which the productivity shock affects the labor market, I consider a log-linear approximation of the model.

- (End of period) employment dynamics:

$$\hat{n}_t^N = -\frac{\lambda^N}{p^N}\hat{u}_t^N + \lambda^N \hat{m}_t^N \qquad \hat{n}_t^U = -\frac{\lambda^U}{p^U}\hat{u}_t^U + \lambda^U \hat{m}_t^U$$

- (Beginning of period) unemployment dynamics:

$$\hat{u}_t^N = -\frac{p^N}{\lambda^N}(1-\lambda^N)\hat{n}_{t-1}^N \qquad \hat{u}_t^U = -\frac{p^U}{\lambda^U}(1-\lambda^U)\hat{n}_{t-1}^U$$

Using these two equations and the Beveridge curve, I can write:

$$\hat{n}_t^N = (1-\lambda)\hat{n}_{t-1}^N + \lambda^N \hat{m}_t^N \qquad \hat{n}_t^U = (1-\lambda)\hat{n}_{t-1}^U + \lambda^U \hat{m}_t^U$$

- Matching process:

$$\hat{m}_t^N = \sigma_u \hat{u}_t^N + (1-\sigma_u)\hat{v}_t^N \qquad \hat{m}_t^U = \sigma_u \hat{u}_t^U + (1-\sigma_u)\hat{v}_t^U$$

- Vacancy filling rate:

$$\hat{q}_t^N = \hat{m}_t^N - \hat{v}_t^N \qquad \hat{q}_t^U = \hat{m}_t^U - \hat{v}_t^U$$

- Job finding rate:

$$\hat{p}_t^N = \hat{m}_t^N - \hat{u}_t^N \qquad \hat{p}_t^U = \hat{m}_t^U - \hat{u}_t^U$$

- Labor market tightness:

$$\hat{\theta}_t^N = \hat{v}_t^N - \hat{u}_t^N \qquad \hat{\theta}_t^U = \hat{v}_t^U - \hat{u}_t^U$$

- JC curve:

$$\hat{\theta}_t^N = \phi^N \hat{z}_t - \phi^N \bar{w}^N \hat{w}_t^N + \beta(1-\lambda^N)\hat{\theta}_{t+1}^N$$
$$\hat{\theta}_t^U = \phi^U \hat{z}_t - \phi^U \bar{w}^U \hat{w}_t^U + \beta(1-\lambda^U)\hat{\theta}_{t+1}^U$$

where $\bar{w}^i = \frac{w^i}{z}$, $\phi^i = \frac{1}{\sigma_u C^i}$ and $C^i = \frac{c}{zq^i}$, $i = N, U$.

- Wage rate:

$$\hat{w}_t^N = \frac{\eta^N}{\bar{w}^N}\hat{z}_t + \frac{\eta^N}{\bar{w}^N}\left[\beta(1-\lambda^N)\bar{c}\theta^N\right]\hat{\theta}_{t+1}^N \tag{17}$$

$$\hat{w}_t^U = \frac{\tilde{\eta}}{\bar{w}^U}\hat{z}_t + \frac{\tilde{\eta}}{\bar{w}^U}\left[\beta(1-\lambda^U)\bar{c}\theta^U\right]\hat{\theta}_{t+1}^U + \frac{\tilde{\eta}}{\bar{w}^U}\left[(1-\bar{b}) + \beta(1-\lambda^U)\bar{c}\theta^U\right]\hat{\tilde{\eta}}_t + \hat{\tilde{O}}_t \tag{18}$$

where $\hat{\tilde{O}}_t = \frac{1}{\bar{w}^U}\left[\beta(1-\lambda^U)C^U(1-p^U)\frac{\tilde{\eta}}{1-\tilde{\eta}}\right](\hat{\tilde{\eta}}_t - \hat{\tilde{\eta}}_{t+1})$
and $\bar{b} = \frac{b}{z}$, $\bar{c} = \frac{c}{z}$ and $C^U = \frac{c}{zq^U}$.

- Union's effective bargaining power:

$$\hat{\tilde{\eta}}_t = -\Big(\gamma^U(1-\lambda^U + \frac{\lambda^U}{p^U})\Big)\hat{u}_t^U - \Big(\gamma^U(1-\sigma_u)(1-\lambda^U)\Big)\hat{\theta}_t^U \tag{19}$$

where $\gamma^U = \frac{(1-\sigma_u)\lambda^U}{(1-\sigma_u)\lambda^U + \sigma_u}$.

3.2 Countercyclical effective bargaining power and wage rigidity

Equation (19) reveals that the union's effective bargaining power is countercyclical. Indeed, u_t^U being the beginning-of-period unemployment, it does not shift on impact and the labor market tightness is obviously procyclical.

The intuition behind this property works as follows. Consider the utility function of the union, equation (13), which is increasing in both the wage rate and the level of employment. A productivity shock impacts both variables, but the wage rate reacts relatively more than the employment level. Indeed, the vacancy posting decision being motivated by the difference between the level of productivity and the wage rate, the reaction of the employment level is smoother than the one of the wage rate. This leads to the following observation: a productivity shock modifies the marginal utility of both the employment level and the wage rate and hence modifies the marginal rate of substitution between these two elements. Said differently, a productivity shock alters the relative value that the union attaches to the employment level and the wage rate. To see this, consider a positive productivity shock. The wage rate increases relatively more than the employment level. After the shock, an additional increase in the employment level therefore provides a higher level of utility than previously, relative to an additional increase in the wage rate. The marginal rate of substitution of wage for employment increases. This leads to a shift in the union's preferences towards employment. Intuitively, because the wage rate and therefore the worker's surplus are relatively reactive, it becomes more valuable for the union to foster employment when a positive shock occurs as each worker benefits now from a greater surplus.

As a result, the orientation, or preferences, of the union fluctuates along the cycle in the following way. By the aforementioned mechanism, when a positive productivity shock occurs, the union becomes, on impact, more employment-oriented. In the following periods, as employment goes up and the wage rate goes back to its steady state value, the marginal utility of employment decreases while the marginal utility of the wage rate increases. This leads to a decrease of the marginal rate of substitution of wage for employment. The union gives therefore more and more importance to wages relative to employment. The opposite occurs when the economy is hit by an adverse productivity shock. The union becomes more aggressive on impact, and more populist as the shock propagates in the economy.

Consequently, the wage rate is driven by two variables: the procyclical surplus from the match and the countercyclical unions' effective bargaining power. The fluctuations of the second variable, which is fixed in the non unionized sector, is at the core of the wage rigidity mechanism. Indeed, the dynamics of the union's effective bargaining power partially counteracts the dynamics of the total surplus and, as a result, dampens the wage rate fluctuations.

My comments are twofold. First, the current model provides a micro foundation for the wage rigidity. Collectively bargained wages are less responsive to the business cycle not because of any ad hoc mechanism but because of the countercyclical properties of a union-specific variable which arises directly from the union's maximization program and enters the wage equation. Second, it is worth noting that the nature of the wage rigidity arising here contrasts with a part of the literature that models either constant wages either wages with a backward-looking component, often with the view to amplify the volatility of unemployment and vacancies and thus to respond to the Shimer critique. For instance, Hall (2005) followed by Shimer (2004) assume that wages do not fluctuate with the cycle and are set at a constant socially acceptable level. In Krause and Lubik (2007), the wage is a weighted average of the Nash bargained wage and a wage norm. Gertler and Trigari (2009) introduce a staggered wage setting, where only a certain proportion of the contracts are renegotiated each period. In Blanchard and Gali (2007), Christoffel and Linzert (2006) and Shimer (2010), the wage is a weighted average of the past wage level and a current equilibrium wage level[13]. In the present model, the union wage rate fluctuates with the current productivity level and is not an explicit function of its past value, i.e. it is not a state variable. Notwithstanding, the union wage rate is function of the characteristics of the labor market at the beginning of the period, specifically of the level of employment which determines the composition of the union. Therefore, past labor market conditions impact the wage rate indirectly through the beginning-of-period employment level. This opens a second channel though which shocks propagate. It is in sharp contrast with the non unionized sector, where such a propagation mechanism does not exist. Indeed, when wages are individually bargained, they are independent of the beginning-of-period employment level and hence of previous levels of productivity.

4 Quantitative assessment of the model

In this section the quantitative properties of the model are investigated by studying the impulse response of the labor market to a positive productivity shock in both sectors.

4.1 Calibration

The calibration of the model is described in table 1. These values are chosen to match the empirical regularities of U.S.

I interpret a period as a month. The discount factor is set to $0.99^{1/3}$ which corresponds to a yearly interest rate of 4% commonly used in the macro-RBC literature.

The log productivity level z_t is assumed to follow an AR(1) process: $\log(z_t) = \rho \log(z_{t-1}) + \epsilon_t$ where $\epsilon \sim N(0, \sigma^2)$. The persistence of the technology shock is set to $\rho = 0.98$ and the standard deviation to $\sigma = 0,008$. This standard calibration is used by Rogerson and Shimer (2010) and is based on the estimations of Cooley and Prescott (1995). The mean of z is normalized to one.

I target the probability p^N that an unemployed worker forms a match within the period to 45%, implying unemployment spells of around two months. This choice is consistent with Hall (2005) who estimates an monthly job finding rate of 0.48% and in line with the measure of this rate presented by Rogerson and Shimer (2010) for the US for the period 1948-2009. Each match has a probability to end λ^N set to $0, 1/3$. This value is comprised within the broadly accepted range of $8\% - 10\%$ proposed by Hall (2005) and is similar to Shimer (2005) who measures this exit probability at $0, 1/3$ in average in the US. I target the degree of labor market tightness θ^N to 0.5, which is consistent with the estimate of 0.539 obtained by Hall (2005).

Considering the matching process, two parameters have to be discussed. First, the weight on unemployment σ_u, which represents the elasticity of the

[13] This current equilibrium wage level is the Nash bargained wage level in Christoffel and Linzert (2006) and Shimer (2010) and the marginal rate of substitution between consumption and leisure in Blanchard and Gali (2007).

Table 1: Calibration

Description	Parameter	Value
Stochastic process for labor productivity		
Autocorrelation	ρ	0.98
Standard deviation	σ	0.008
Common parameters		
Discount rate	β	$0.99^{1/3}$
Elasticity of m with respect to u	σ_u	0.5
Unemployment income	$\bar{b}$	0.8
Efficiency of the matching process	σ_m	0.6364 set to target $\theta^N = 0.5$
Vacancy posting cost	c	0.3553 set to target $p^N = 0.45$
Non unionized sector		
Separation rate	λ^N	0.1/3
Workers' bargaining power	η^N	0.5
Unionized sector		
Separation rate	λ^U	0.1/3
Unions' bargaining power	η^U	0.9

matches with respect to unemployment but also the elasticity of the vacancy filling rate with respect to the labor market tightness, is set equal to 0.5. This value is consistent with the range $[0.5 - 0.7]$ proposed by Burda and Wyplosz (1994) based on estimations of the matching function for some western European countries.[14] Second, σ_m is obtained from steady state calculations.

Following the literature, I set the value of η^N to 0.5 to satisfy the Hosios condition[15] and therefore to obtain an efficient decentralized equilibrium. This value is suggested by Mortensen (1994) and Mortensen and Pissarides (1994) for reasons of symmetry.

In contrast with the other parameters and targets, there exists a debate about the value of non work activity $\bar{b} = b/z$, revived by the recent paper by Hagedorn and Manovskii (2008) which proposes a new estimate of this value at 0.95. Indeed, unlike Shimer (2005) who restricts the value of non work activity to the unemployment benefits and sets $\bar{b}$ equal to 0.4, Hagedorn and Manovskii (2008) additionally integrate the home production and the value of leisure. Delacroix (2006) also distinguishes within the unemployment income set at 0.6 a home production of 0.3 and unemployment benefits of 0.3, the value

[14]See Petrongolo and Pissarides (2001) for a literature review on the estimation of the matching function's parameters.

[15]See Hosios (1990).

of b is set at 0.6. In order to keep my results as plausible as possible, I choose an average value of 0.8.

If the same effective bargaining power were applying for the workers in the non unionized sector and for the unions in the unionized sector, the steady state values would be equal in both sectors. This condition can be written as the following: $\eta^U = \bar{\eta}^U$ s.t. $\tilde{\eta}(\bar{\eta}^U) = \eta^N$.

That the presence of unions increases workers' bargaining power is beyond dispute. Indeed, the fall back level of utility is lower in case of collective wage bargaining as the firms are not producing at all in case of disagreement. This observation requires to fix the unions' effective bargaining power $\tilde{\eta}$ greater than the workers' bargaining power η^N, or equivalently to set $\eta^U > \bar{\eta}^U$. In the search and matching literature, the value of the workers bargaining power is generally set at 0.5 for symmetry reason because of a lack of evidence. There is not more evidence for the value of the unions' bargaining power η^U beside the observation that it lies in the interval $[\bar{\eta}^U,\ 1]$. I set $\eta^U = 0.9$ in the baseline calibration and propose in the last section to check the implications of alternative values ($\eta^U = \bar{\eta}^U$, $\eta^U = 0.7$ and $\eta^U = 1$) for the model's dynamics.

In order to ease the comparison between the two sectors and to identify the specificity of the collective wage bargaining, the separation rate in the unionized sector is set equal to the one prevailing in the non unionized sector. A robustness check with an alternative calibration for λ^U is provided in the last section.

The steady state of the model is shown in table 2. In the non unionized sector, the steady state beginning-of-period unemployment rate u is at 7.1%. The same rate in 10 percentage points higher in the unionized sector. This result is quantitatively in line with the one proposed by Delacroix (2006). The high level of the wage rate in the unionized sector decreases the firms' value of employment and restrains the vacancy postings. As a result, the unemployment rate is higher and the unemployment duration is larger.

Table 2: Steady State

	Sector N	Sector U
Wage	0.985	0.995
Vacancies	0.036	0.012
Unemployment rate	7.1%	17.1%
Unemployment duration	2.2m.	6m.

4.2 Dynamics

In this section, I first study the business cycle properties of the model with the baseline calibration. In a next step, I check the robustness of the results for alternative values of η^U and λ^U.

4.2.1 Impulse responses to productivity

Figure 1 shows the response of the labor market to a positive productivity shock of one standard deviation. In order to disentangle the effect on the labor market dynamics of, in one hand, the difference in steady state (called steady state effect) and, in the other hand, of the volatility of the effective bargaining power (called bargaining power effect), I show with the dotted line the dynamics of a non unionized sector artificially pushed at the steady state level of the unionized sector. This artificial case is referred to as the intermediate sector. The difference between the dashed line (unionized sector) and the dotted line only stems from the volatility of the effective bargaining power. The difference between the plain line (non unionized sector) and the dotted line arises from the difference in steady state between the two sectors.

Let us first compare the unionized sector with the intermediate one. The key of the mechanism lies the countercyclical unions' effective bargaining power, which contrasts with the fixed workers' bargaining power in the non unionized sector. On impact, its decrease slightly dampens the volatility of the wage (the dashed line lies below the dotted line), enough to create a extra surplus for the firms which react in posting more vacancies. Relatedly, employment reacts more strongly. As employment goes up, more employees call for a high level of wage, which results in unions being more "‘wage-oriented"’. The unions' effective bargaining power increases, slowing down the returning of the wage towards its steady state. The firms' surplus, as well as the vacancies and the employment rate, decreases relatively sharply.

Second, I compare the non unionized sector with the intermediate one. It is interesting to notice that even though the wage responds more in the intermediate sector, employment reacts also more. The following reasoning explains this result. As argued by Hagedorn and Manovskii (2008), what gives the incentive to firms to post vacancies is the size of the percentage changes of the firms' surplus in response to a shock. These percentage changes are bigger the smaller the firms' surplus. In the intermediate sector, the workers' bargaining power and therefore the wage are higher. The firms' surplus is smaller. Moreover, the vacancy duration is lower the higher the unemployment rate, which leads to a lower saving of hiring cost in case of match in the intermediate sector. This decreases the total surplus and, the firms' surplus being a fixed part of the total surplus, the firms' surplus. As a result, the percentage changes of the firms' surplus are bigger in the intermediate case, and so is the firms' incentive to post vacancies.

4.2.2 Robustness

Analyzing the dynamic properties of the model using different values for η^U and λ^U can be seen as a robustness check.

The value of η^U Given the lack of evidence to pin down the value of η^U, I propose to analyze the response of the labor market for 4 values of η^U: $\eta^U = \bar{\eta}^U$ (value for which the steady states of both sectors are equalized), $\eta^U = 0.7$, $\eta^U = 0.9$ (baseline calibration) and $\eta^U = 1$ (monopoly union). Figure 2 shows how the (workers and unions') effective bargaining power, the wage and the employment rate respond to the positive productivity shock. An interesting aspect of the model is that the quantitative effect of the volatility of the effective bargaining power becomes larger the higher the unions' bargaining power. Indeed, if this effect is negligible for low values of η^U, it is striking in the monopoly union case. The reason for that can be seen in equation (17). The change in the effective bargaining power $\hat{\tilde{\eta}}_t$ has a higher impact on the wage the higher the steady state value $\tilde{\eta}$ and therefore the higher η^U. Moreover, the greater the change in the wage, the greater the impact on the labor market tightness θ^U, the bigger the change in the unions' effective bargaining power. Intuitively, as η^U goes up, the workers' surplus raises and unions moderate the wage increase in order to boost employment so that a higher proportion of workers can benefit from this surplus.

The value of λ^U One could argue that the separation rate is lower in the unionized sector. The empirical literature proposes some evidence for this phenomenon. For example, Freeman (1980) shows that, in the US, tenure is greater for workers covered by union contracts and that the probability for their match to end is lower. Knight and Latreille (2000) and Antcliff and Saundry (2009) find similar results in the UK. To be in line with this strand of research, I consider the case where $\lambda^U = 0.08/3 < \lambda^N = 0.1/3$ and compare the results with the ones obtained in the previous section.

As shown in figure 3, the bargaining power effect is not substantially modified by the alternative calibration. The decrease of λ^U dampens the volatility of the effective bargaining power but the overall effect on the wage and employment dynamics is small. However, the alternative calibration modifies the steady state effect. Hirings increase less than with the baseline calibration, because the firms benefit from a bigger surplus when the exit rate is low and this leads to smaller percentage changes of the firms' surplus. By the aforementioned mechanism, firm's incentive to post vacancies is lower, with explains the moderate increase in employment.

5 Concluding remarks

By modeling labor union in a search and matching framework, I develop a tractable model of the labor market in which the bargaining power of the union is analyzed. I show that the unions' effective bargaining power fluctuates countercyclically, creating a second source of union wage volatility and dampening the union wage fluctuations. When hit by a positive productivity shock, the union reacts in moderating the wage increase. I am therefore able to explain and micro-found the origin of the wage rigidity, which generates in turn an amplification of the employment response.

This paper chooses a simplistic framework in order to give a good intuition on how labor unions affect the labor market. This explains my choice of focusing only on the labor market. The possible extension of the model, which can be addressed in future research, is therefore to introduce the pricing policy of firms when allowing for interaction between the two sectors, which would lead to a study of the role of labor union in shaping the volatility of inflation.

To conclude, the model presented in the present paper represents an improvement over the current literature by bringing together two strands of research. It develops our theoretical understanding of the source of wage and employment volatility as well as the role of labor unions in shaping these volatilities.

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A Profit of the firms and marginal value of employment

In this appendix, I drop the superscript i to simplify the notation.

The profit of the firms satisfies the following Bellman equation:

$$\pi_t = z_t n_t - w_t n_t - cv_t + E_t \beta \pi_{t+1}$$

Equation 10 states that the Bellman equation of the marginal value of employment J_t is:

$$J_t = z_t - w_t + E_t \beta (1-\lambda) J_{t+1}$$

Therefore:

$$\begin{aligned}\pi_t = n_t J_t - n_t E_t \beta (1-\lambda) J_{t+1} - cv_t \\ + E_t \beta [n_{t+1} J_{t+1} - n_{t+1} E_t \beta (1-\lambda) J_{t+2} - cv_{t+1}] \\ + E_t \beta^2 [n_{t+2} J_{t+2} - n_{t+2} E_t \beta (1-\lambda) J_{t+3} - cv_{t+2}] + E_t \beta^3 ...\end{aligned}$$

Using the law of motion of employment $n_{t+1} = (1-\lambda) n_t + q_{t+1} v_{t+1}$, I obtain:

$$\begin{aligned}\pi_t = n_t J_t - cv_t - E_t \beta (n_{t+1} - q_{t+1} v_{t+1}) J_{t+1} \\ + E_t \beta [n_{t+1} J_{t+1} - cv_{t+1} - \beta (n_{t+2} - q_{t+2} v_{t+2}) J_{t+2}] \\ + E_t \beta^2 [n_{t+2} J_{t+2} - cv_{t+2} - \beta (n_{t+3} - q_{t+3} v_{t+3}) J_{t+3}] + E_t \beta^3 ...\end{aligned}$$

$$\begin{aligned}\pi_t = n_t J_t - cv_t \\ + E_t \beta [n_{t+1} J_{t+1} - n_{t+1} J_{t+1} - cv_{t+1} + q_{t+1} v_{t+1} J_{t+1}] \\ + E_t \beta^2 [n_{t+2} J_{t+2} - n_{t+2} J_{t+2} - cv_{t+2} + q_{t+2} v_{t+2} J_{t+2}] + E_t \beta^3 ...\end{aligned}$$

Using the equation of J_t: $J_t = \frac{c}{q_t}$, I get:

$$\pi_t = n_t J_t - cv_t + E_t \beta [-cv_{t+1} + cv_{t+1}] + E_t \beta^2 [-cv_{t+2} + cv_{t+2}] + E_t \beta^3 ...$$

$$\pi_t = n_t J_t - cv_t$$

B Equilibrium wage in the unionized sector

B.1 Link between the worker and the firm's surplus in the unionized sector

The maximization program of the union is the following (here again, I drop the superscript $i = U$ to simplify the notation but keep in mind that we are in the unionized sector):

$$\max_{w_t} [n_t (W_t - U_t)]^{\eta} [n_t J_t]^{1-\eta}$$

$$\text{s.t JC equation: } \frac{c}{q_t} = z_t - w_t + E_t\beta(1-\lambda)\frac{c}{q_{t+1}}$$

FOC:

$$n_t' J_t^{1-\eta}(W_t - U_t)^\eta + n_t(1-\eta)J_t^{-\eta}(W_t - U_t)^\eta \frac{\partial J_t}{\partial w_t} + n_t \eta J_t^{1-\eta}(W_t - U_t)^{\eta-1}\frac{\partial W_t}{\partial w_t} = 0$$

$$-n_t' = -n_t(1-\eta)J_t^{-1} + n_t\eta(W_t - U_t)^{-1}$$

It comes from the definition of $n_t = 1 - u_t + m_t$ that:

$$n_{t_w}' = \sigma_m(1-\sigma_u)u_t\theta_t^{-\sigma_u}\theta_{t_w}'$$

Moreover, from the JC and the definition of q_t I get:

$$\theta_t = \left[\frac{\sigma_m}{c}\left(z_t - w_t + E_t\beta(1-\lambda)\frac{c}{q_{t+1}}\right)\right]^{\frac{1}{\sigma_u}}$$

Therefore:

$$\theta_{t_w}' = -\frac{\sigma_m}{\sigma_u c}\theta_t^{1-\sigma_u}$$

Plugging the expression of θ_{t_w}' in the expression of n_{t_w}', I obtain:

$$n_{t_w}' = -\frac{(1-\sigma_u)m_t}{\sigma_u J_t}$$

Using this expression, the FOC can be rewritten:

$$(W_t - U_t)\left(\frac{1-\eta}{\eta} + \frac{1-\sigma_u}{\sigma_u}\frac{m_t}{n_t}\frac{1}{\eta}\right) = J_t$$

$$W_t - U_t = \frac{\eta\sigma_u n_t}{(1-\sigma_u)m_t + (1-\eta)\sigma_u n_t}J_t$$

which is equivalent to (14).

B.2 Wage curve in the unionized sector

For convenience I omit again the superscript $i = U$.
From (8) and (9), we have:

$$W_t - U_t = w_t - b + E_t(1-\lambda)\beta(1-p_{t+1})(W_{t+1} - U_{t+1})$$

Using the condition (14) we can rewrite this equation as:

$$\frac{\eta\sigma_u n_t}{(1-\sigma_u)m_t + (1-\eta)\sigma_u n_t}J_t = w_t - b + E_t(1-\lambda)\beta(1-p_{t+1})\frac{\eta\sigma_u n_{t+1}}{(1-\sigma_u)m_{t+1} + (1-\eta)\sigma_u n_{t+1}}J_{t+1}$$

Plugging the value of $J_t = \frac{c}{q_t} = z_t - w_t + E_t\beta(1-\lambda)\frac{c}{q_{t+1}}$ into this equation:

$$\frac{\eta\sigma_u n_t}{(1-\sigma_u)m_t + (1-\eta)\sigma_u n_t}(z_t - w_t + E_t\beta(1-\lambda)\frac{c}{q_{t+1}})$$
$$= w_t - b + E_t(1-\lambda)\beta(1-p_{t+1})\frac{\eta\sigma_u n_{t+1}}{(1-\sigma_u)m_{t+1} + (1-\eta)\sigma_u n_{t+1}}\frac{c}{q_{t+1}}$$

Rearranging leads to:

$$w_t = \frac{\eta\sigma_u n_t}{(1-\sigma_u)m_t + \sigma_u n_t}\Big[z_t + E_t\beta(1-\lambda)\frac{c}{q_{t+1}}\Big]$$
$$+\frac{(1-\sigma_u)m_t + (1-\eta)\sigma_u n_t}{(1-\sigma_u)m_t + \sigma_u n_t}\Big[b - E_t\beta(1-\lambda)\frac{c}{q_{t+1}}(1-p_{t+1})\frac{\eta\sigma_u n_{t+1}}{(1-\sigma_u)m_{t+1} + (1-\eta)\sigma_u n_{t+1}}\Big]$$

$$w_t = \tilde{\eta}_t\Big[z_t + E_t\beta(1-\lambda)\frac{c}{q_{t+1}}\Big] + (1-\tilde{\eta}_t)\Big[b - E_t\beta(1-\lambda)\frac{c}{q_{t+1}}(1-p_{t+1})\frac{\tilde{\eta}_{t+1}}{1-\tilde{\eta}_{t+1}}\Big]$$

with $\tilde{\eta}_t = \frac{\eta\sigma_u n_t}{(1-\sigma_u)m_t + \sigma_u n_t}$.

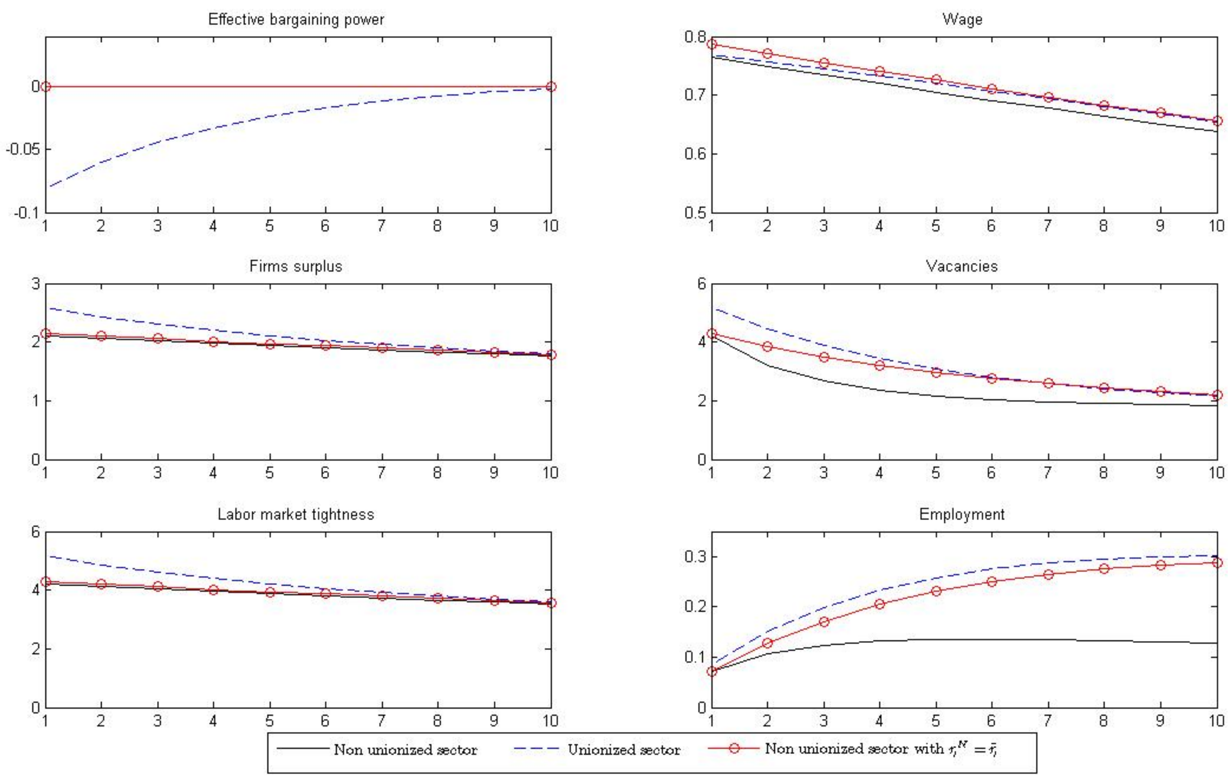
$$w_t = \tilde{\eta}_t\Big[z_t + E_t\beta(1-\lambda)\frac{c}{q_{t+1}}p_{t+1} + E_t\beta(1-\lambda)\frac{c}{q_{t+1}}(1-p_{t+1})\Big]$$
$$+ (1-\tilde{\eta}_t)b - (1-\tilde{\eta}_t)\Big[E_t\beta(1-\lambda)\frac{c}{q_{t+1}}(1-p_{t+1})\frac{\tilde{\eta}_{t+1}}{1-\tilde{\eta}_{t+1}}\Big]$$

$$w_t = \tilde{\eta}_t\Big[z_t + E_t\beta(1-\lambda)c\theta_{t+1}\Big] + (1-\tilde{\eta}_t)b - \Big[E_t\beta(1-\lambda)\frac{c}{q_{t+1}}(1-p_{t+1})\Big]\Big[-\tilde{\eta}_t + \frac{\tilde{\eta}_{t+1}(1-\tilde{\eta}_t)}{1-\tilde{\eta}_{t+1}}\Big]$$

$$w_t = \tilde{\eta}_t\Big[z_t + E_t\beta(1-\lambda)c\theta_{t+1}\Big] + (1-\tilde{\eta}_t)b - \Big[E_t\beta(1-\lambda)\frac{c}{q_{t+1}}(1-p_{t+1})\Big]\Big[\frac{\tilde{\eta}_{t+1} - \tilde{\eta}_t}{1-\tilde{\eta}_{t+1}}\Big]$$

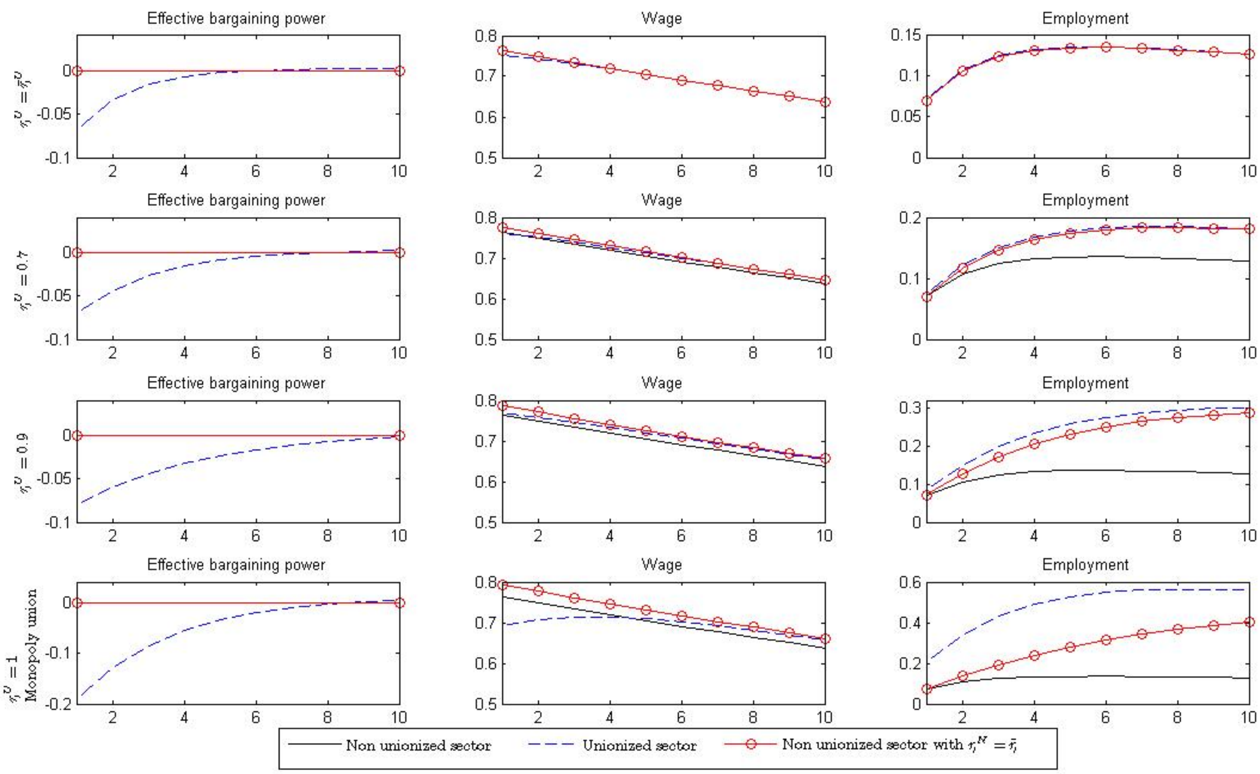
This is equivalent to (15).

Figure 1: Impulse responses to a positive productivity shock



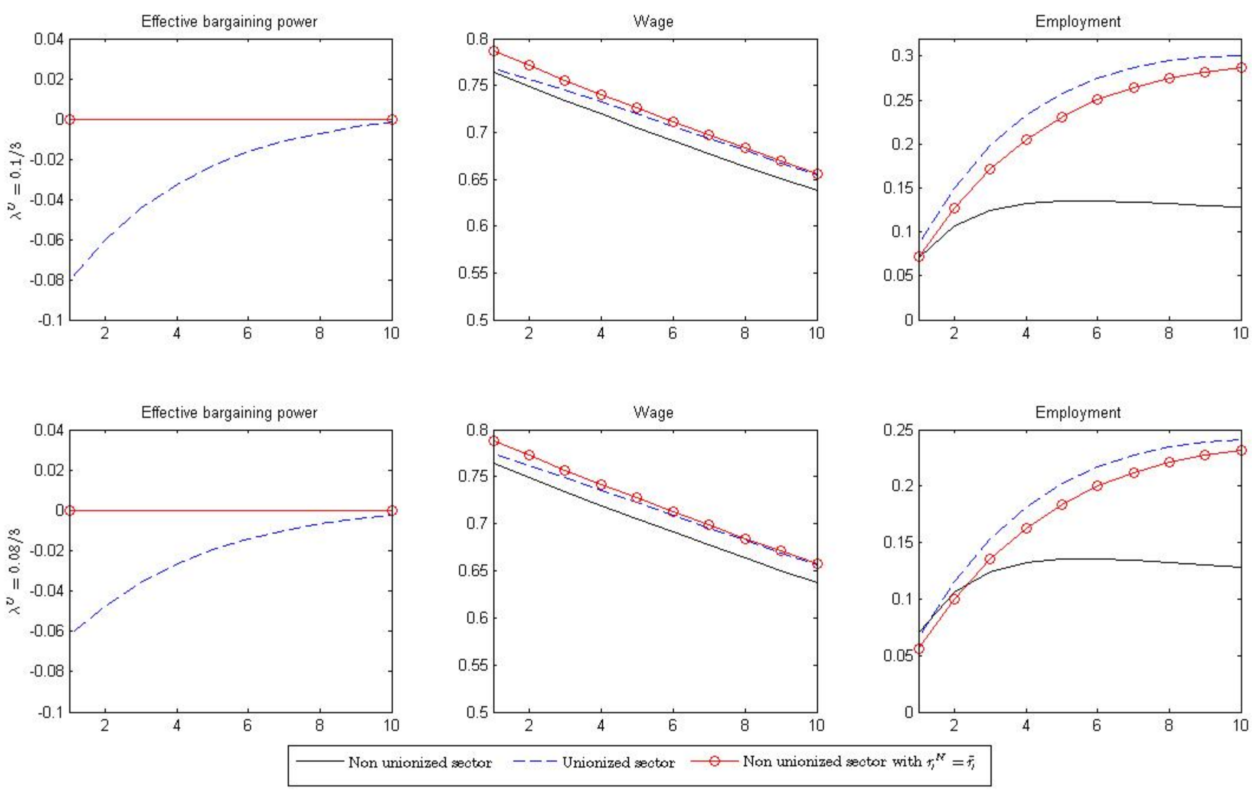
Note: Percentage deviation from the steady state following a positive productivity shock of one standard deviation.

Figure 2: Impulse responses to a positive productivity shock



Note: Percentage deviation from the steady state following a positive productivity shock of one standard deviation.

Figure 3: Impulse responses to a positive productivity shock



Note: Percentage deviation from the steady state following a positive productivity shock of one standard deviation.