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Endogenous Unemployment Benefits in an Equilibrium Job Search Model over the Life-Cycle

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Abstract

By being indexed backwards on the wage, wage-indexed unemployment benefits have the particularity to grow over the workers' life cycle. In this paper we build an equilibrium job search model with the life cycle of workers to assess the effect of this shape of unemployment benefits taking into account this life cycle dimension. In this model, as workers' productivity tends to rise with age, the monopsony power that firms can exploit extends with age as well. This monopsony power is known to generate inefficient turnover and can be reduced by implementing unemployment benefits. As wage-indexed unemployment benefits (WIUB) grow over the workers' life cycle, despite their negative effect on employment already discussed by Burdett and Mortensen (1998) and Chéron and Langot (2010), WIUB can reduce the inefficient turnover all over the life cycle and be better suited to restore the efficient allocation on the labour market than Beveridgian unemployment benefits. Thanks to the simulation of the model, we find that in that case, the optimal unemployment benefits are wage-indexed at a replacement rate equal to 44%.

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1 Introduction

In the large majority of OECD countries, the unemployment benefits are indexed on past earnings. The purpose of this paper is to assess the relevance of this wage indexation. The literature shows that unemployment benefits can improve social welfare for three reasons. First, unemployment benefits act as an insurance that raise the welfare of risk-averse agents. Second, in a frictional labour market when firms exploit the monopsony power to set wages - which occurs in particular on the low-skilled labour market - the wages are set too low. As a consequence, too many job vacancies are opened and inefficient labour turnover induces extra vacancy and training costs. In this environment, raising the workers' reservation wage by implementing unemployment benefits¹ allows for improvement of social welfare (Stigler (1946), Mortensen (1998), Manning (2003)). Third, Marimon and Zilibotti (1999) and Acemoglu and Shimer (2000) show that a generous UB system can be considered as a subsidy to employment search activity. By raising the reservation wage of workers, they allow workers to select higher productivity jobs and contribute positively to output. For at least the last two reasons, the positive effect of unemployment benefits particularly in the low-skilled labour market depends on their capacity to raise the workers' reservation wage over lower wage offers. The idea we support in this paper is that the capacity of Beveridgian unemployment benefits that offer the same level of unemployment benefits to all unemployed workers to rise the workers' reservation wage varies over the life cycle. As wages tend to rise with age (Becker (1964), Mincer (1974), Bagger et al. (2014) and Menzio et al. (2016)), Beveridgian unemployment benefits become progressively negligible compared to wage opportunities with age. Their effects are therefore often limited to the youth labour market. On the other hand, a Bismarckian system that indexes unemployment benefits on past earnings has the advantage to let unemployment benefits grow together with wage all throughout the life cycle and to remain significant even at older ages. The purpose of this paper is to study the effect of Bismarckian unemployment benefits on the labour market welfare when the life cycle of workers is taken into account.

In literature, the Bismarckian system of unemployment benefits is blamed for creating unemployment (Ljungqvist and Sargent (1998), Ljungqvist and Sargent (2008), Chéron and Langot (2010)). Burdett and Mortensen (1998) show that, when there is pure wage dispersion, the wage-indexed unemployment benefits (WIUB) generate heterogenous unemployment benefits that do not reflect the heterogeneity of workers' abilities. This heterogeneity induces job rejections which create inefficient unemployment. To reach optimality, the distribution of unemployment benefits should therefore collapse to a mass point. Following this result, Chéron and Langot (2010) highlight in

¹or a minimum wage

a job search model with endogenous WIUB, the trade-off between inefficient unemployment on the one hand, and insurance and subsidy motives on the other. In spite of the subsidy motives that favor the Bismarckian system, they show that the Beveridgian system should be preferred.

Yet, this result stands in an economy where workers are homogenous in terms of age. In this economy, all workers have potentially the same working experience and the same wage opportunity. In reality, workers, even if they are homogenous in terms of skills, are heterogenous in terms of past working experience and wage opportunities through their age heterogeneity. Besides, Chéron and Langot (2010) omit to account for the capacity of UB to reduce inefficient turnover (Stigler (1946), Mortensen (1998), Manning (2003)). In this paper, we fill these two gaps and show that the results shown in literature can be questioned.

In this paper, we therefore study the effect of WIUB in an equilibrium job search model, in which workers' turnover is endogenous, and with the life cycle of workers. We consider a life-cycle version of the model studied in Mortensen (1998)². Specifically, we assume three age classes and the finite working horizon of workers. In this model, we assume wages evolve over the life cycle, via the accumulation or loss of human capital, and/or via on the job search which allow workers to climb the wage ladder. We introduce unemployment benefits that are indexed backward on the worker's wage. In this model, the wage posting is endogenous, therefore WIUB become endogenous as well. The heterogeneity of WIUB generate inefficient unemployment and the extent of this inefficient unemployment depends on workers' age class. We consider match specific investment, as suggested by Mortensen (2000) to generate the observed humpshaped wage distributions. Our model therefore allows us to account for the capacity of UB help unemployed workers to select higher productivity jobs (Marimon and Zilibotti (1999), Acemoglu and Shimer (2000)). Contrary to Chéron and Langot (2010), we endogenize job creation of firms, which allows us to capture the effect of UB on inefficient turnover (Stigler (1946), Mortensen (1998), Manning (2003)). Reducing turnover improves welfare in this model since the labour market is frictional, hirings are costly and firms can choose to train workers to increase their productivity. Finally, we assume workers are risk-averse to account for the insurance motives of UB. This model allows to account for the effect of WIUB through the existence of inefficient unemployment and for the three motives of UB, the reduction of inefficient turnover, the increase of job productivity and insurance motive.

We use this model to simulate the French labour market with existing unemploy-

²Besides, Chéron et al. (2008) show that the Mortensen (1998)'s framework allows, with the only restriction of a decreasing return of this match specific human capital, to generate a wage distribution that is not rejected by the data.

ment insurance indexed on past earnings. We then compare labour market outcomes when no unemployment insurance is implemented or when it is flat or more or less strongly indexed on earnings. This exercise shows that WIUB indeed generate the growing unemployment benefits over the life cycle. Agents enter into the labor market unemployed and the youngest employed workers have not yet had time to improve their careers. In contrast, at the end of the life cycle, workers are mostly insiders and their work experience has allowed them to climb the wage ladder and possibly accumulate human capital. In this context, WIUB, contrary to flat unemployment benefits, raise workers' unemployment benefits increasingly with age. As a consequence, WIUB raise wages increasingly with age and appear to be a channel of wage progression over the life-cycle. According to the simulation of the model, they contribute to more than 0.1 percentage points of the French wage progression per year. From a normative perspective, as WIUB are more effective in raising the reservation wage on the market for older workers, they are also more effective in reducing the inefficient turnover and in raising job productivity. Contrary to the existing studies, we show that WIUB can improve welfare by more than when UB only take the form of a lump sum. Yet, optimality is reached when WIUB is combined with a Beveridgian component representing a social minimum, as it is the case in countries where the Bismarckian system is implemented. The optimal wage indexation is 44%. This result has strong implications for policy makers and brings a new interest to the Bismarckian system. Naturally, the induced increase in wages among seniors combined with the short horizon of such seniors yields an increase in the seniors' unemployment rate of almost 1 percentage point compared to the Beveridgian system.

In the second section, we present the model. In the third section, we present the results based on this model's simulations and section four concludes.

2 Equilibrium search model with life-cycle and endogenous UB

We choose to divide the life cycle into three parts to follow the main characteristics of life cycle data: the integration into the labor market (young workers), the intermediate period (adult workers), and the seniority (senior workers). The mass of the entire population is noted m . We assume there is no labor force growth. All variables which are dependant on the workers' age class are indexed by i , which can take the value $i = 1$ for the young, $i = 2$ for adults and $i = 3$ for seniors. The mass of the population of each age class is noted m_i . We assume the economy is in steady state. Following Castaneda et al. (2003), Ljungqvist and Sargent (2008), and Hairault et al. (2012), we assume workers age stochastically. At each period, the probability of aging equals p

and the arrival of new born agents replace an equal number of dead retired workers. Masses m_i are therefore equal and solve:

$$\begin{aligned} pm_1 &= pm_2 = pm_3 \\ m_1 + m_2 + m_3 &= m \end{aligned}$$

We test the sensitivity of our results to this assumption in the section 3.5.

2.1 The workers and the policy

The asset value of being employed at a wage w is noted as $V_i^e(w)$ and solves in each age class:

$$\begin{aligned} rV_i^e(w) &= \frac{(w - \tau)^{1-\sigma}}{1 - \sigma} + \lambda_i \int_w^{\bar{w}_i} (V_i^e(x) - V_i^e(w)) dF_i(x) - s(V_i^e(w) - V_i^u(b(w))) \\ &\quad - p(V_i^e(w) - \text{Max}(V_{i+1}^e(w), V_{i+1}^u(w))) \end{aligned} \quad (1)$$

We denote by r the actualization rate. We use a concave utility function consistent with the risk-averse behavior of agents. The risk aversion coefficient is noted as σ . τ stands for lump-sum taxes that finance the unemployment benefits system. Those taxes are neutral on the agents' behaviors. We choose to exclude the funding of the policy from the analysis. Its effect is not trivial and would require a proper analysis that goes beyond the scope of this paper. Besides, the choice of a progressive fundings is in itself a policy that can be assessed separately from UI. Therefore, we assume as in Chéron and Langot (2010) that taxes are lump-sum taxes. We assume on-the-job search. The arrival frequency of job offers is noted $\lambda_i > 0$. The cumulative distribution function of the wage offered by firms is noted as $F_i(\cdot)$, \bar{w}_i is the highest wage offered on the market i . Each employed worker is displaced into unemployment according to a Poisson process with parameter $s > 0$. Age class changes are stochastic and workers change age class with the same probability p . In that case, the contract is not broken unless the value for the worker of keeping the contract obtained in the previous age period becomes lower than the value of being unemployed in his current age period.³ The asset value of being retired is given by $V_4^e(w) = V_4^u(b) = V_r$ ⁴ When the job of a worker is destroyed, he gets the asset value of being unemployed, $V_i^u(\cdot)$, with a benefit possibly depending on his previous wage $b(w)$.

Unemployment benefits can depend on the workers' previous wage w_{-1} at the rate $\rho < 1$. An unemployed individual with no working experience, for instance a young worker entering the labour market, is not eligible to these WIUB. Yet, these unemployed

³Firms which target youth are therefore exposed to employing senior workers eventually.

⁴Note that we assume here that the probability to retire does not depend on a worker's status nor on the wage earned. In reality unemployed workers retire earlier than employed workers, Hairault et al. (2015) discuss this issue.

workers can receive the social assistance benefit b_0 . For eligible workers, the worker receives the maximum of the two values as shown by the equation 2.⁵

$$b(w_{-1}) = \max\{\rho \times w_{-1}; b_0\} \quad (2)$$

Besides, when ρ is set to zero, the component b_0 also allow unemployment benefits to be flat.

The asset value of unemployed workers receiving a benefit $b(w_{-1})$ is noted as $V_i^u(b(w_{-1}))$ and solves:

$$rV_i^u(b(w_{-1})) = \frac{(b(w_{-1}) - \tau)^{1-\sigma}}{1-\sigma} + \lambda_i^0 \int_{R_i(b(w_{-1}))}^{\bar{w}_i} (V_i^e(x) - V_i^u(b(w_{-1}))) dF_i(x) - p(V_i^u(b(w_{-1})) - V_{i+1}^u(b(w_{-1}))) \quad (3)$$

When workers are unemployed, they receive job offers with the frequency $\lambda_i^0 > 0$. The worker does not accept job offers unless the wage attached to the job is greater than $R_i(b(w_{-1}))$, the reservation wage induced by the benefit $b(w_{-1})$. For the sake of simplicity, we assume displaced workers are always eligible⁶ and cannot lose their eligibility to unemployment benefits.⁷

By setting $V_i^u(b(w_{-1})) = V_i^e(R_i(b(w_{-1})))$ and using equations 1 and 3, we can deduce the workers' reservation wage function $R_i(\cdot)$ according to wage-indexed unemployment benefits as follows:

$$\frac{(R_i(b) - \tau)^{1-\sigma}}{1-\sigma} = \frac{(b - \tau)^{1-\sigma}}{1-\sigma} + (\lambda_i^0 - \lambda_i) \int_{R_i(b)}^{\bar{w}} (V_i^e(x) - V_i^e(R_i(b))) dF_i(x) + s(V_i^u(b) - V_i^u(R_i(b))) + p(V_{i+1}^u(b) - V_{i+1}^u(R_i(b))) \quad (4)$$

When unemployment benefits are wage-indexed, unemployed workers' reservation wages depend on the workers' previous wage. As workers can have different wage trajectories, they evolve over the life cycle and, because of pure wage dispersion existing in job search environment, are heterogenous among workers of the same age.

2.2 The matching technology

Firms and workers meet according to the following matching process:

$$M_i = v_i^\eta (\phi^0 u_i + \phi(m_i - u_i))^{1-\eta}$$

⁵If $b_0 = 0.5$ and $\rho = 0.4$, when a worker with a wage equal to 1 is laid off, he receives $\max(0.5; 0.4) = 0.5$

⁶In France, a displaced worker needs at least a two years in a row experience to be eligible to two years of unemployment benefits.

⁷It would be possible to assume that workers lose their eligibility after a certain time and get the minimum allocation as the young entering the labor market. We found that this would add complexity to the model without changing significantly the mechanisms we want to highlight in the paper.

with η the matching function elasticity, v_i the number of vacancies, u_i the mass of unemployed workers, $m_i - u_i$ the mass of employed workers, and ϕ^0 and ϕ the search effectiveness of respectively unemployed and employed workers.

We set $\theta_i = \frac{v_i}{\phi^0 u_i + \phi(m_i - u_i)}$, the labor market tightness on each market. The meeting frequencies between workers and firms are given by $\lambda_i = \phi \theta_i^{1-\eta}$ and $\lambda_i^0 = \phi^0 \theta_i^{1-\eta}$, for workers, respectively employed and unemployed, and $q_i = \phi \theta_i^{-\eta}$ and $q_i^0 = \phi^0 \theta_i^{-\eta}$, for firms, to meet respectively an employed and an unemployed.

2.3 The firms' behavior over the life cycle

As in Burdett and Mortensen (1998), wages are posted by firms and there is no negotiation over them. We assume firms can direct their search on workers' age classes.⁸

The firms' surplus over the life cycle. As in Mortensen (1998), we assume the productivity of the match depends on a match specific investment operated by the firm. This assumption allows us to account (i) for the positive output effect of the job selection from workers and (ii) for the negative effect of turnover. Besides, Mortensen (1998) shows that the endogenous productivity resulting from this investment allows indeed to generate a realistic wage distribution. The productivity of workers according to the match specific investment k is given by:

$$y_i(k) = y_i + \left(\frac{q}{\alpha}\right) k^\alpha$$

Where $q > 0$ and $0 < \alpha < 1$ are exogenous. The workers' productivity given by y_i that depends on age is exogenous and captures the individual component of a match's productivity (it includes absenteeism, effectiveness at the workplace etc...). The match specific component of the productivity ($\frac{q}{\alpha} k^\alpha$) is an increasing concave function of the match specific investment that the firm can operate after meeting the worker. This investment is costly for firms and we note β_i the age-dependant cost of this investment. β_i can be seen as a proxy for the workers' human capital. A low β means that the match specific investment is cheaper for firms and suggests that workers already have human capital.

When a firm employ a worker, it anticipates the workers' aging. The firms' expected surplus induced by employing a worker of a given age depends on the expected surplus induced by employing the same worker once he gets older. The firms' surplus are given

⁸They can discriminate workers through experience requirements. When a firm enters one of the three markets, the production generated by employing a worker from the two other markets is null. Therefore, workers do not cheat.

by:

$$J_1(w, k) = \frac{y_1(k) - w + pJ_2(w, k)}{r + p + s + \lambda_1(1 - F_1(w))} - \beta_1 k \quad (5)$$

$$J_2(w, k) = \frac{y_2(k) - w + pJ_3(w, k)}{r + p + s + \lambda_2(1 - F_2(w))} - \beta_2 k \quad (6)$$

$$J_3(w, k) = \frac{y_3(k) - w}{r + p + s + \lambda_3(1 - F_3(w))} - \beta_3 k \quad (7)$$

From equations 5, 6 and 7, we can deduce the discounted expected job duration according to the workers' age:

$$D_3(w) = \frac{1}{r + p + s + \lambda_3(1 - F_3(w))} \quad (8)$$

$$D_2(w) = \frac{1}{r + p + s + \lambda_2(1 - F_2(w))} (1 + pD_3(w)) \quad (9)$$

$$D_1(w) = \frac{1}{r + p + s + \lambda_1(1 - F_1(w))} (1 + pD_2(w)) \quad (10)$$

The discounted expected job duration is increasing with wage since firms avoid the poaching of their workers by paying them well. Note in this context that the higher the labour market tightness, the stronger the poaching threat. The shortening of the working horizon reduces the expected job duration and therefore the tenure return of offering high wages. Consequently, the short working horizon of older workers reduces the firms' surplus and acts against the level of their wage offers.

The matches' productivity over the life cycle. Maximizing equations 7, 6, and 5 subject to k and using 10, 9 and 8 gives us the optimal level of this investment according to wage:

$$k_i(w) = \left(\frac{qD_i(w)}{\beta_i} \right)^{\frac{1}{1-\alpha}} \quad (11)$$

The cost β_i decreases the level of this investment. The equation 11 therefore shows that firms are induced to employ workers with much human capital in more productive jobs. The discounted expected job duration D_i reduces the return of this investment. The shorter horizon of older workers therefore also acts against the productivity of their match. The matches' productivity decision has a backward effect on the level of wage offers.

The hiring frequency. The hiring frequency of firms is the frequency at which they meet a worker, employed or unemployed, ready to accept the wage w . As in Burdett and Mortensen (1998) and Mortensen (1998), firms cannot observe the status or the reservation wage of workers: information is imperfect. The hiring frequency therefore

depends on the cumulative distribution of workers according to their unemployment benefits that we note $U_i(\cdot)$ and according to their wage that we note $G_i(\cdot)$ as follows:

$$h_i(w) = q_i^0 u_i U_i(R_i^{-1}(w)) + q_i(m_i - u_i)G_i(w) \quad (12)$$

The hiring frequency is positive as soon as one unemployed worker is ready to accept the offered wage. Consequently, firms can be ready to offer a wage below some unemployed workers' reservation wage. When workers' reservation wages are heterogeneous, this behavior induces job rejections from unemployed workers. Unemployment induced by these rejections is called in this paper, the inefficient unemployment.

The firms' expected profit for each age class associated with the wage offer w and the match specific investment k according to equations 12, 5, 6 and 7:

$$\Pi_i(w, k) = h_i(w)J_i(w, k) \quad (13)$$

2.4 Equilibrium

2.4.1 The wage posting

At equilibrium, firms post wages so that equiprofit is guaranteed. To better understand the intuition behind the wage game of firms described by Burdett and Mortensen (1998), let's assume firms successively enter each market. When there is only one firm on the market, its maximum instantaneous profit is reached at the lowest wage possible. Then, the second firm entering the market would be interested in offering a wage slightly superior to the first firm to be able to poach the employed workers of the first one, and so on for the other firms entering the market. Finally, Burdett and Mortensen (1998) show that at equilibrium, when firms have equiprofit, this wage game generates a wage distribution on a wage interval. Without any minimum wage regulations, the lowest wage offered by firms on each market is the wage which maximizes the profit when $F_i(w) = 0$.⁹ As the shape of the profit is different from one market to another, it is likely that these minimum wages would also be different. Here, consistently with the French institutions, we assume there is an institutional minimum wage noted \underline{w}_I . The actual minimum wages are therefore the maximum between the market and the institutional minimum wage as follows:

$$\underline{w}_i = \max\{\underset{w}{\operatorname{argmax}} \Pi_i(w), \underline{w}_I\} \quad (14)$$

with $\underline{\Pi}_i$ the profit of firms offering the lowest wage on each market (i.e. when $F_i(w) = 0$). On each market, firms spread out their wage offer to insure the equiprofit up to

⁹By definition, w such that $F_i(w) = 0$ is the lowest wage in the economy since no offered wage is below it

the maximum wage \bar{w}_i that can induce this equiprofit. The offered wage distribution F_i therefore solves on $[\underline{w}_i; \bar{w}_i]$:

$$\underline{\Pi}_i(\underline{w}_i) = \Pi_i(w) \tag{15}$$

2.4.2 The free entry condition.

At equilibrium, firms enter each market as long as profit is superior to vacancy cost, noted as c . Labour market tightness on each market therefore solves:

$$\underline{\Pi}_i(\underline{w}_i, \theta_i) = c \tag{16}$$

The labor market tightness on each market, which depends on the firms' profit, drives the meeting frequencies between firms and workers. It therefore partly accounts for the extent of the inefficient turnover.

2.4.3 Equilibrium conditions

Equilibrium distributions $G_i(\cdot)$, $F_i(\cdot)$ and $U_i(\cdot)$, the function $R_i(\cdot)$ and the equilibrium value of θ_i are reached when four conditions are filled together, in each market:

1. Workers' reservation wages are such as the value of being employed is equal to the value of being unemployed (equation 4)
2. Firms post wages so that equiprofit is guaranteed (equation 15)
3. Firms enter labour market until all expected profit is exhausted (equation 16)
4. In and out workers' flows for each status and level of wage are equal (appendix B, and A, page 32).

Given the size of the model, we need to proceed to numerical simulations to compute these equilibrium results.

3 Model simulation and optimal unemployment benefits

3.1 The calibration

We use the 2012 French Labor Force Survey data to give exogenous parameters, reasonable values for the French economy.¹⁰ We calibrate annually the model and only consider male low skilled workers. The data are presented in appendix C, page 33.

¹⁰The French economy is well-suited to study WIUB because:

- French unemployment benefits are totally indexed on the past wage up to 6 times the minimum wage.

We set the annual interest rate r to 4%. Risk aversion coefficient is set to 2 as in Hairault et al. (2010). As in the theoretical model, we define three age classes of even length: 20 to 32 years old, 33 to 45 years old, and 46 to 58 years old¹¹, and therefore set p to $\frac{1}{13}$. We normalize population, the institutional minimum wage, the cost of vacancy and the young workers' investment cost, β_1 , since only the difference between β_1 and β_2 and β_3 matters here. We set the matching function elasticity to 0.7 as estimated by Borowczyk-Martins et al. (2011). We use the values provided by Postel-Vinay and Robin (2004) for the French economy to set the contact rate of the employed ϕ and the job destruction rate s . We set b_0 to 40% of the minimum wage (this equals French social minima). We calibrate the replacement rate ρ to reproduce the mean unemployment benefit observed in the data of 87% of minimum wage. The calibrated unemployment replacement rate of 0.5 is found to be equal to the value of the replacement rate set in Chéron and Langot (2010). We set ϕ_0 in order to reproduce the unemployment rate of 10.7%. The production function parameters allow to reproduce various moments of the wage distribution: the mean wage, the median wage and the 6th decile of the three wage distributions.¹² The table 1 sums up the values of these parameters.

3.2 Equilibrium distributions

We compute new moments which were not used for calibration to assess the fit of the model to the data. Figure 1 presents the model's ability to reproduce these new moments. The model allows in particular to reproduce quite well the U-shape in unemployment by age. Youth unemployment is high because the young starts in unemployment. For older workers the high unemployment is explained by the increase in reservation wage with age combined with the negative effect of a short working horizon on the labour market tightness. We also simulate the distribution of wages and unemployment benefits presented in figure 2. The shapes of the simulated wage and unemployment benefits distributions are consistent with the actual ones presented in figures 11 and 12 in the appendix C, page 33.¹³ Both the observed and simulated

-
- The eligibility period is long, from 2 to 3 years for workers who have been working for 2 years at least.
 - French unemployment benefits are not digressive over this eligibility period.

¹¹In 2012, the average retirement age of French males was slightly less than 60 years old (59.7, OECD (2013)). In 2010, the average labor market entry age for high school degree holders was 20 years old (Céreq (2010)).

¹²The workers' productivity y_1 , y_2 and y_3 , are set to reproduce the mean of their respective wage distribution. The parameters linked to the match specific investment (q , α and β_i make it possible to capture the global shape of the wage distribution, which is hump-shaped (Mortensen (1998))

¹³The observed steps on seniors' simulated wage and benefits distribution are due to the cessation of reporting the distribution of the previous age classes. This would fade away as the number of age

Parameters based on external information		
Parameter	Value	Moment targeted
r	0.04	Discounted rate
σ	2	Hairault et al. (2010)
p	1/13	Working life duration (39 years)
\underline{w}	1	Normalized
β_1	1	Normalized
m	1	Normalized
c	1	Normalized
η	0.7	Borowczyk-Martins et al. (2011)
b_0	0.4	Minimum social assistance
s	0.1	Postel-Vinay and Robin (2004)
Calibrated parameters		
ϕ^0	3.8	Unemployment rate (10.7%)
ϕ	2.3	Mean contact frequency of the employed ^a (0.7)
q	0.335	$D6_1$ (1.4)
α	0.7	Median Wage (1.54)
y_1	1.06	Mean of young (1.38)
y_2	1.34	Mean of adults (1.63)
y_3	1.59	Mean of seniors (2.02)
β_2	0.97	$D6_2$ (1.71)
β_3	0.64	$D6_3$ (2.12)
ρ	0.5	Mean unemployment benefit (0.87)

Table 1: Calibration Parameters

Note: Mean wages, percentiles and median wages are computed thanks to the $g_i(\cdot)$ density and to the $g(\cdot)$ density ($= (m - u_1)g_1(\cdot) + (m - u_2)g_2(\cdot) + (m - u_3)g_3(\cdot)$). Mean unemployment benefits and unemployment rates are computed thanks to $u_i(\cdot)$ as described in appendix B, page 32.

^aThis value is computed by Postel-Vinay and Robin (2004) and used by Chéron and Langot (2010)

unemployment benefits distributions have the particularity to present a second smaller mode. The existence of this second mode is explained by the fact that when workers are quite homogenous¹⁴ workers with higher unemployment benefits can be more selective than those with lower unemployment benefits.

According to our calibration results, human capital accumulation over the life cycle dominates depreciation.¹⁵ The productivity component β_i is needed to fit the data correctly. In the absence of this parameter, there is a conflict between an accurate wage distribution shape and the increasing path of wages with age. Indeed, the observed shape of wage distribution can only be obtained by assuming firms' endogenous productivity. Yet, in that case, firms are induced to create lower quality jobs for seniors due to their shorter working horizon (see equation 11). To fit the data, training costs β_i should decrease with age. Figure 3 presents the wage distribution when we omit this parameter, i.e. we set $\beta_1 = \beta_2 = \beta_3 = 1$.

3.3 The effect of WIUB on the labour market

We use this calibration on French data as a benchmark. To isolate the effect of WIUB, we compare this benchmark with the same economy without WIUB, i.e. $\rho = 0$, and assess their effect in difference on wages and unemployment. We can also simulate the economy with flat UB equivalent to the mean UB in France (0.87). Table 2 presents these three simulations.

WIUB have the particularity to generate age-increasing unemployment benefits, as we observe in figure 1. They therefore induce an increasing raise in the reservation wage with age, and yield age-dependant effects on unemployment and wages. Burdett and Mortensen (1998) and Chéron and Langot (2010) show that WIUB increase unemployment. Comparing the first column with the third column on table 2 shows that this effect is, in reality, strongly age-dependant. WIUB induce a sharper increase in seniors' unemployment rate: an increase of 2.2 percentage points compared to the flat equivalent UB (third column). Besides, as young unemployed workers are more numerous (as they all start as unemployed) the existence of job rejections induced by WIUB affects strongly their unemployment rate: an increase of 1.6 percentage points compared to the flat equivalent UB (third column). WIUB increase particularly the unemployment of the the young and seniors.

WIUB also raise wages increasingly with age. They therefore contribute to workers' wage growth over the life cycle. Compared to flat equivalent UB, WIUB explain more

classes increase.

¹⁴As it is the case here since we select French male workers with the same education attainment.

¹⁵ β_i decreases and y_i increases with age.

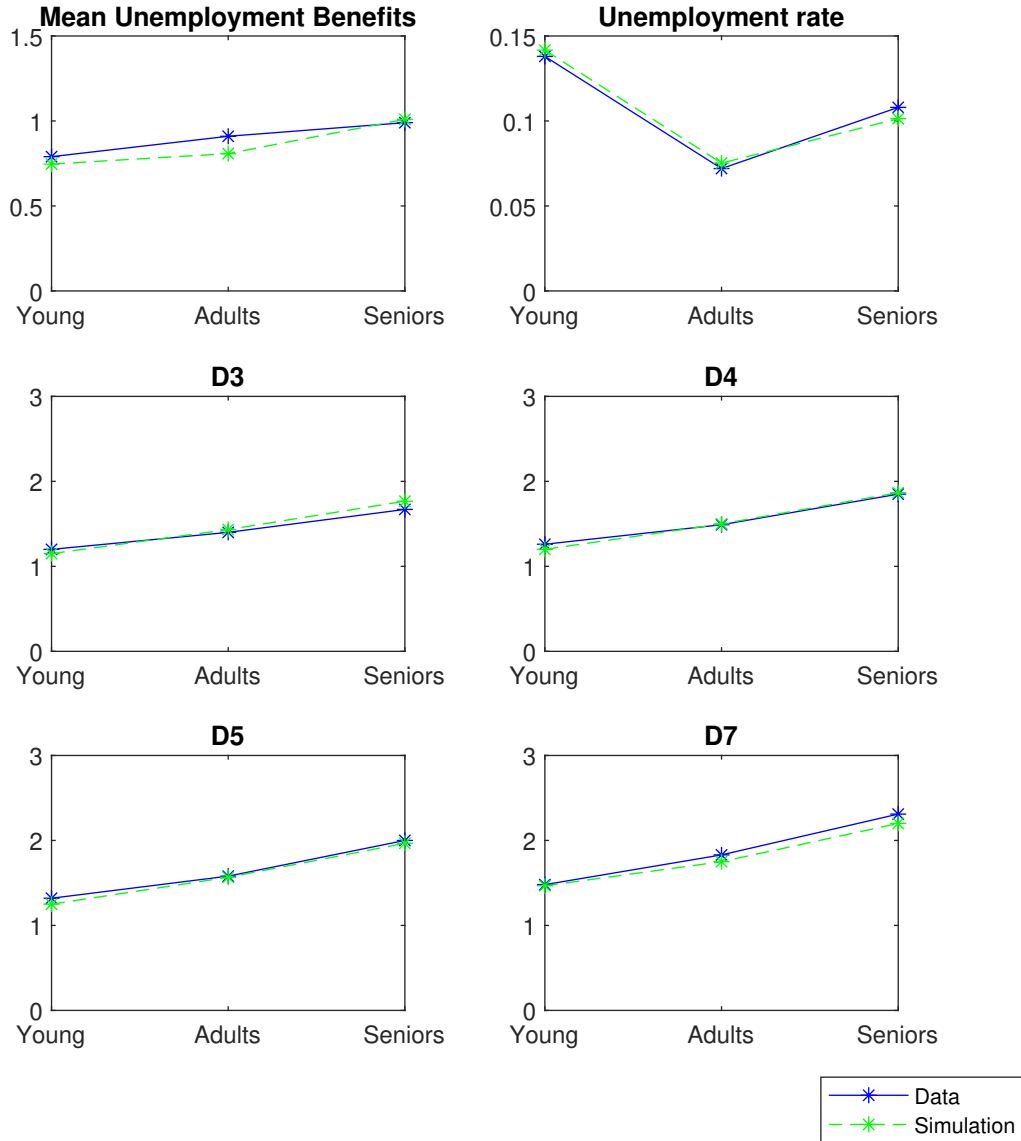


Figure 1: Unemployment benefits, unemployment rate and wage distribution deciles over the life cycle according to the model simulation and in the data

Source: Model simulation and French data. Model simulation: We use $g_i(\cdot)$, the density associated to the cumulative function $G_i(\cdot)$ (see appendix A, page 32) to compute the moments D3, D4, D5, D7. We use $u_i(\cdot)$, the density associated to the cumulative function $U_i(\cdot)$ (see appendix B, 32) to compute mean unemployment benefits and unemployment rates. French Data: appendix C, page 33

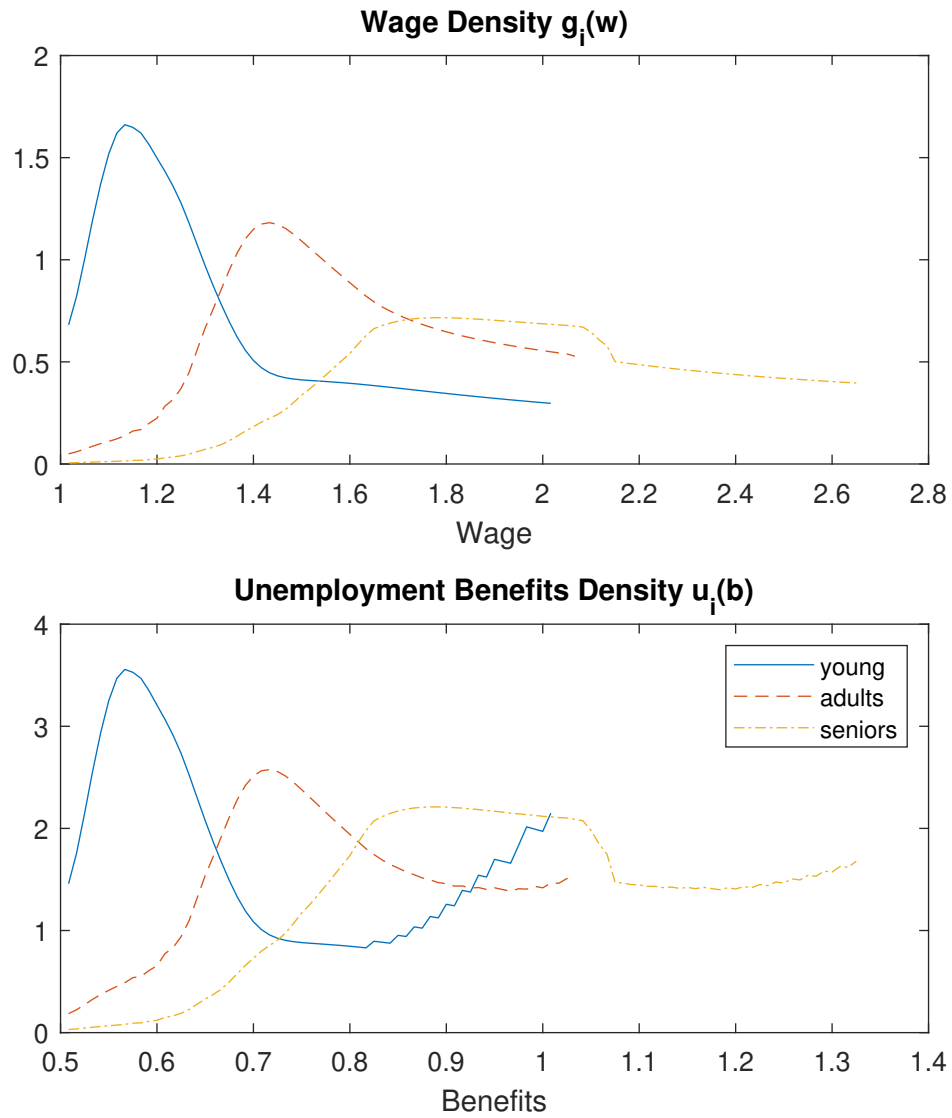


Figure 2: Simulated wage and unemployment benefits distribution over the life cycle

Source: Model simulation: We use $g_i(\cdot)$, the density associated to the cumulative function $G_i(\cdot)$, and $u_i(\cdot)$, the density associated to the cumulative function $U_i(\cdot)$ (see appendix B, 32 and A, page 32) to plot these distributions.

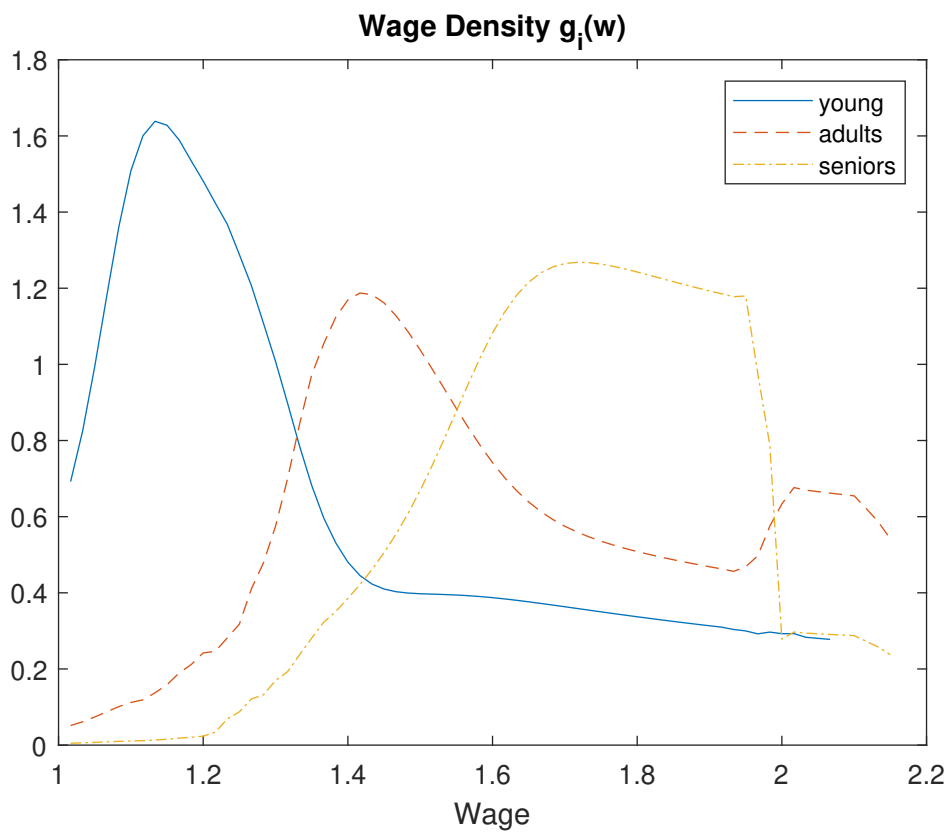


Figure 3: Simulated wage distribution over the life cycle without human capital accumulation

We use $g_i(\cdot)$, the density associated to the cumulative function $G_i(\cdot)$ (see appendix A, page 32) to plot these distributions.

than 0.1 percentage point of the annual workers' wage growth over the life cycle¹⁶.

	Benchmark	Without WIUB	With flat UB
ρ	0.5	0	0
b_0	0.4	0.4	0.87
u	10.61%	8.96%	9.03%
u_1	14.17%	12.55%	12.53%
u_2	7.52%	6.57%	6.68%
u_3	10.13%	7.74%	7.89%
w	1.6675	1.6428	1.6451
w_1	1.3764	1.3709	1.3699
w_2	1.6139	1.6038	1.6056
w_3	2.0123	1.9537	1.9598
$\frac{w_3}{w_1} - 1$	0.462%	0.425%	0.431%

Table 2: The effect of WIUB on wages and unemployment

Source: Model simulations for different values of ρ and b_0 . The first scenario corresponds to the French calibration, the second, to the French economy with only the Beveridgian component and the third to the flat UB that lead to the same mean UB.

3.4 Optimal unemployment benefits

We can compute the global production and the welfare in this economy. The global production Y is the sum of all wages distributed in the economy. In this model, we assume the free entry of firms. There is therefore no firms' surplus: profits are spent on vacancy costs, investment costs and wages. This is different from Chéron and Langot (2010) since they do not assume the free entry of firms. We consider only workers' surplus to compute welfare in this economy. All workers finance unemployment benefits and the budget is balanced, i.e. the sum of taxes equal the sum of distributed unemployment benefits.

$$Y = (m_1 - u_1) \int w g_1(w) dw + (m_2 - u_2) \int w g_2(w) dw + (m_3 - u_3) \int w g_3(w) dw \quad (17)$$

As the UB system aims at smoothing consumption, we also choose to take into account the redistributive motive of unemployment benefits. Hence, the welfare Ω depends on the risk aversion coefficient σ and is given by:

¹⁶The wage growth $\frac{w_3}{w_1} - 1$ corresponds to the wage growth over 26 years, therefore the annual wage growth gap between the two scenarios corresponds to $\frac{0.462\%}{26} - \frac{0.431\%}{26} = 0.12\%$

$$\begin{aligned}
\Omega = & (m_1 - u_1) \int \frac{(w - \tau)^{1-\sigma}}{1 - \sigma} g_1(w) dw + (m_2 - u_2) \int \frac{(w - \tau)^{1-\sigma}}{1 - \sigma} g_a(w) dw \\
& + (m_3 - u_3) \int \frac{(w - \tau)^{1-\sigma}}{1 - \sigma} g_3(w) dw + \int \frac{(b - \tau)^{1-\sigma}}{1 - \sigma} u_1(b) db \\
& + \int \frac{(b - \tau)^{1-\sigma}}{1 - \sigma} u_2(b) db + \int \frac{(b - \tau)^{1-\sigma}}{1 - \sigma} u_3(b) db
\end{aligned} \tag{18}$$

By simulating the model with various levels of b_0 and ρ , we can assess the effect of different shapes and levels of unemployment benefits on the production and welfare. To understand how unemployment benefits affect production and welfare, we assess their effect on:

1. inefficient turnover, via the mean frequency of job to job transition (labour turnover) and the cost of vacancies
2. job selection, via the mean quality of jobs
3. unemployment rate

First, we assess the effect of unemployment benefits when they take the form of a lump sum (The Beveridgian system), then when they are wage-indexed (The Bismarckian system).

3.4.1 The Beveridgian system

We assume that all workers receive the same level of UB, we therefore set $\rho = 0$. In table 3, we let the Beveridgian component b_0 vary ¹⁷. Up to $b_0 = 0.82$, the UB do not change economic behaviors. The reservation wages induced by UB up to this level are lower than the minimum wage. Yet, they affect the welfare via the redistributive effect from employed to unemployed workers. This level is close to the one found in Chéron and Langot (2010) ($b_0 = 0.85$). Yet contrary to Chéron and Langot (2010), in our case, this level does not correspond to optimality: from $b_0 = 0.82$, the presence of UB starts raising slightly the production compared to the laissez-faire situation. In our framework, because we account for life-cycle, when firms have the monopsony power to set wages, wages are set too low on the adults' and seniors' labour market where productivity is higher than on the labour market for the young, which generates an inefficient labour turnover. As predicted by the theory, raising the workers' reservation wage in this context allows to raise production and welfare. Yet the extent of this raise remains very small. With a precision of 0.01, the production is maximized for $b_0 = 0.88$ and reaches 1.5008, vs 1.499 for $b_0 = 0.8$ (the laissez-faire situation). The social welfare

¹⁷Yet, this component cannot be equal to zero due to risk aversion.

is reached for the same level of b_0 and reaches -0.7306. For this level of UB, there is no job rejection from the young, their reservation wage remains below the minimum wage, yet there are few from adults and seniors, their reservation wages are respectively equal to 1.05 and 1.067 times the minimum wage. Note that the same level of b_0 induces slightly higher reservation wage as workers age since workers face higher offered wage distribution and therefore waiting before accepting an offer can pay more. The figure 4 that presents the trend of production according to b_0 shows that the extent of this effect is very low because if b_0 raises above 0.88, the production falls sharply. For $b_0 \geq 0.88$, the Beveridgian UB start increasing reservation wage and reducing employment on the labour market for the young.

Even if the extent of the effect described here is very low, this result gives the intuition that an UI system that generates higher reservation wages for older workers, like the Bismarckian UI system, can raise production and social welfare in a framework that accounts for life cycle. This system is the subject of the next section.

ρ	0	0	0	0	0
b_0	0.6	0.7	0.8	0.88	1
Y	1.4999	1.4999	1.4999	1.5008	1.4800
Ω	-0.7722	-0.7526	-0.7390	-0.7307	-0.7318
Labour turnover	0.1821	0.1821	0.1821	0.1817	0.1696
Vacancies cost	0.0712	0.0712	0.0712	0.0682	0.0469
Mean quality of jobs	1.1902	1.1902	1.1902	1.19	1.1855
u	8.96%	8.96%	8.96%	9.07%	11.12%

Table 3: The effect of flat unemployment benefits on production (Y), welfare (Ω), labour turnover, job quality and unemployment rate

Source: Model simulations when $\rho = 0$ and for different values of b_0 . Labour turnover corresponds to the job to job transition rate that is given by $\frac{1}{m-u_1-u_2-u_3} \sum_1^3 (m_i - u_i) \lambda_i \int_{\underline{w}}^{\overline{w}} g_i(x) (1 - F_i(x)) dx$. The cost of vacancies is given by $c * (v_1 + v_2 + v_3)$. The mean job quality is given by $\frac{1}{m-u_1-u_2-u_3} \sum_1^3 \int_{\underline{w}}^{\overline{w}} g_i(x) \frac{q}{\alpha} k_i(x)^\alpha dx$.

3.4.2 The Bismarckian system combined with a Beveridgian component (social minimum)

We now let the Bismarckian component ρ vary. The Beveridgian component b_0 cannot be equal to zero, it must be superior to a certain level because everyone pays the taxes that fund the UB and $b_0 - \tau$ needs to be positive as we take into account the risk aversion behavior of agents. We therefore assess in this section the effect of the Bismarckian system combined with a Beveridgian component (social minimum). This combination is consistent with what we observe in countries in which the Bismarckian system is implemented. The figure 5 shows the trend of production according to both b_0 and

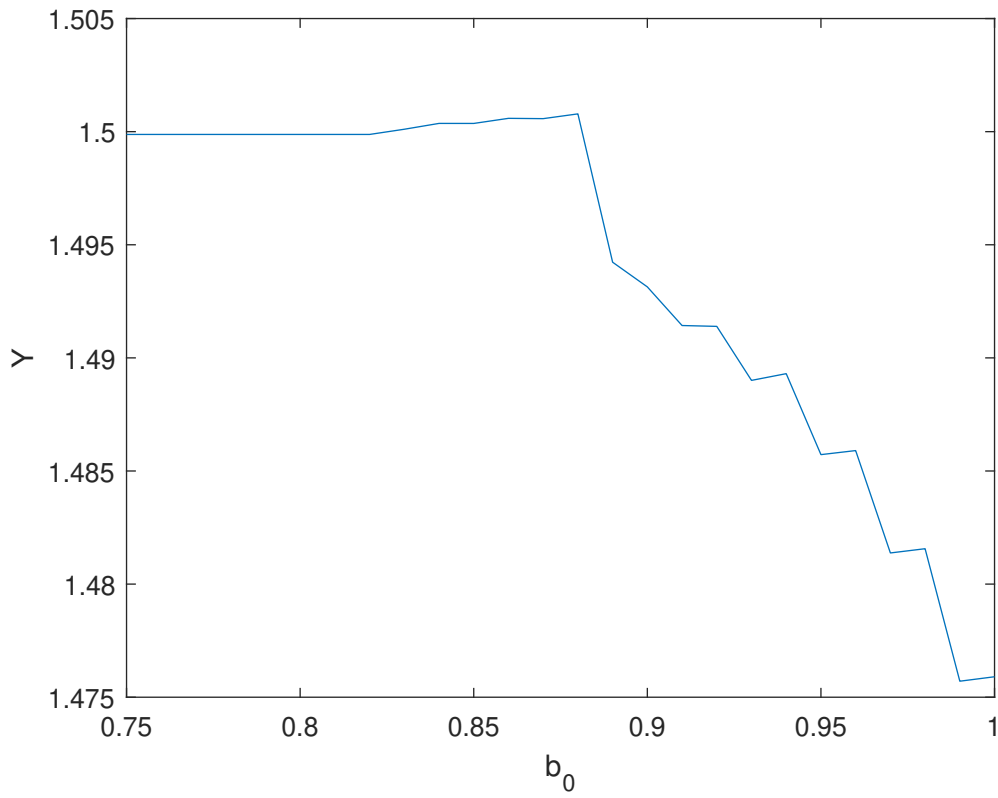


Figure 4: The effect of flat unemployment benefits on production (Y).

Source: Model simulations when $\rho = 0$ and for different values of b_0 .

ρ . With a precision of 0.01, this figure shows that the production is maximized for $\rho = 0.43$ and $b_0 = 0.86$ and reaches 1.5027. The figure 6 shows the trend of production according to ρ when b_0 is set to 0.86. This trend draws a hump-curve which reaches its maximum in $\rho = 0.43$. Raising the Bismarckian component first improves production by reducing the inefficient turnover, then reduces it because of the adverse effect of UB on employment.

The figure 7 shows the trend of social welfare according to both b_0 and ρ . With a precision of 0.01, this figure shows that the social welfare is maximized for $\rho = 0.44$ and $b_0 = 0.88$ and reaches -0.7294. The figure 8 shows the trend of the social welfare according to ρ when b_0 is set to 0.88. This trend also draws a hump-curve which reaches its maximum in $\rho = 0.44$. When the redistributive motive of UB is taken into account, the optimal level of b_0 and ρ rise.

3.4.3 Discussion

According to our results and contrary to Chéron and Langot (2010), the Bismarckian system when combined with a Beveridgian component (social minimum) generates a production and a welfare at the least equivalent to the Beveridgian system (for production, 1.5027 in the Bismarckian system versus 1.5008 in the Beveridgian and for welfare -0.7294 in the Bismarckian system versus -0.7307 in the Beveridgian).

Without the life cycle, Chéron and Langot (2010) show that the production is maximized when unemployment benefits take the form of a lump-sum. Indeed, when they are wage-indexed - beside their welfare-improving effect on the firms' monopsony power - they also induce job rejections from unemployed workers due to the heterogeneity of reservation wages.

The table 4 and 5 draw a comparison between these two optima. WIUB reduce more efficiently the vacancies costs and further increase the job quality for older workers than flat UB alone. This effect slightly dominates the adverse effect of WIUB on employment through job rejections from unemployed workers.

WIUB present an advantage when the life cycle is taken into account. As productivity tends to increase over the life cycle (see the increasing trend of y_i on table 1), so does the firms' monopsony power: as productivity is higher, more firms are induced to enter the labour market. A homogenous unemployment benefit all over the life cycle cannot reduce efficiently the firms' monopsony power on the labour market for older workers. A labour market with a higher workers' productivity requires a higher unemployment benefit. WIUB have the particularity to generate age-increasing unemployment benefits (see figure 1) that induce an increase in reservation wage with age. They can therefore reduce the firms' monopsony power that generates inefficient

turnover and lower job quality on the market for older workers without having too much effect on the labour market for the young. The stronger effect of WIUB on the labour market for older workers is made possible because the youth are subjected to smaller unemployment benefits when they are wage-indexed.

In spite of their negative effect on employment, the age-dependant dimension of WIUB is well suited to improve production and welfare. Besides, the simulations presented in this paper show that the policy existing in France is not optimal. Wage-indexation should be smaller and the social minimum larger.

System	Bismarckian	Beveridgian
ρ	0.43	0
b_0	0.86	0.88
Production	1.5027	1.5008
Total vacancies cost	0.0635	0.0682
Labour market: young (1)	0.0202	0.0196
Labour market: adults (2)	0.0327	0.0334
Labour market: seniors (3)	0.0106	0.0152
Mean quality of jobs	1.1911	1.19
Labour market: young (1)	0.9393	0.9403
Labour market: adults (2)	0.9986	1.0065
Labour market: seniors (3)	1.6296	1.6133
Unemployment Rate	9.3	9.07
Labour market: young (1)	12.43	12.52
Labour market: adults (2)	6.72	6.73
Labour market: seniors (3)	8.76	7.94

Table 4: The comparison of the two systems of unemployment benefits that maximize production: effect on vacancies cost, mean job production, and unemployment over the life cycle

Source: Model simulations.

3.5 Robustness

The calibration we choose may influence the results presented in this paper. Most parameters are set so that to reproduce moments of the French economy. Yet three parameters, r , η and σ , are set to usual values found in the literature, in that sense, even if these values are reasonable values, they still are the result of assumptions. In this section, we choose to show the sensitivity of our results to the value assumed for these parameters. We therefore make these parameters vary and calibrate the other parameters to fit the targeted moments presented in table 1.

Besides, in this paper, we choose to divide the life cycle into three parts of even length. This assumption allows to minimize the heterogeneity in productivity and wage within age classes. Indeed, according to our findings, because workers of each age class

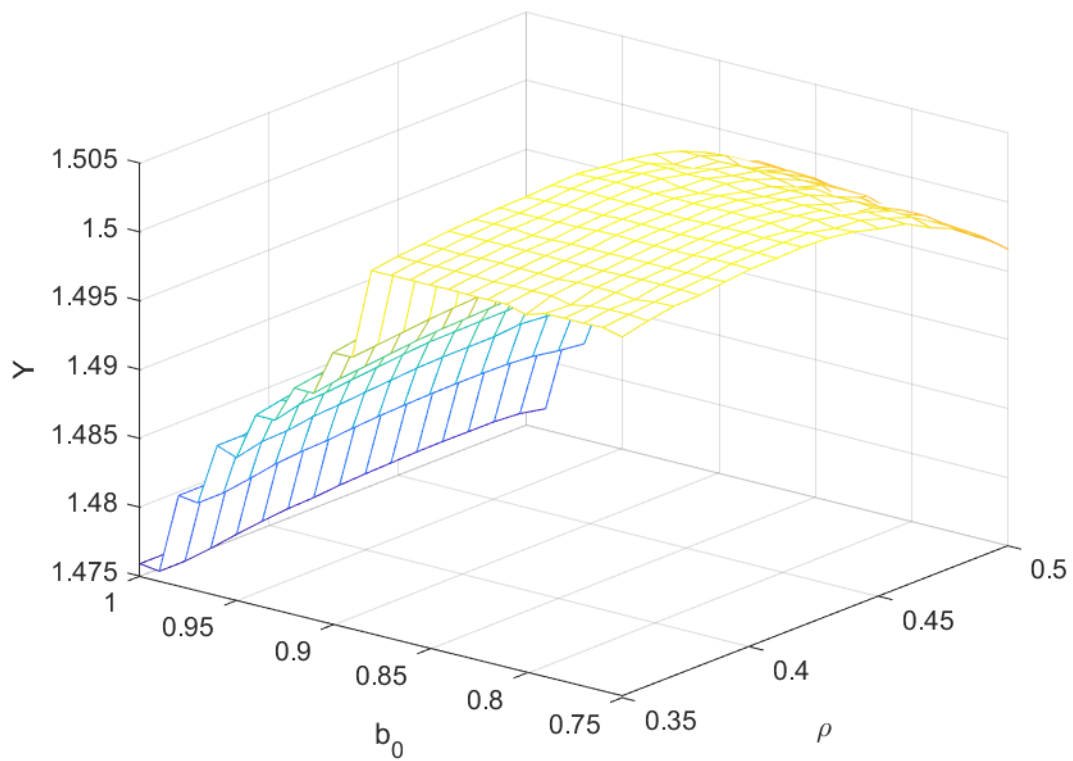


Figure 5: Level of the production according to the unemployment replacement rate and the social minimum.

Source: Model simulations for different values of ρ and b_0 .

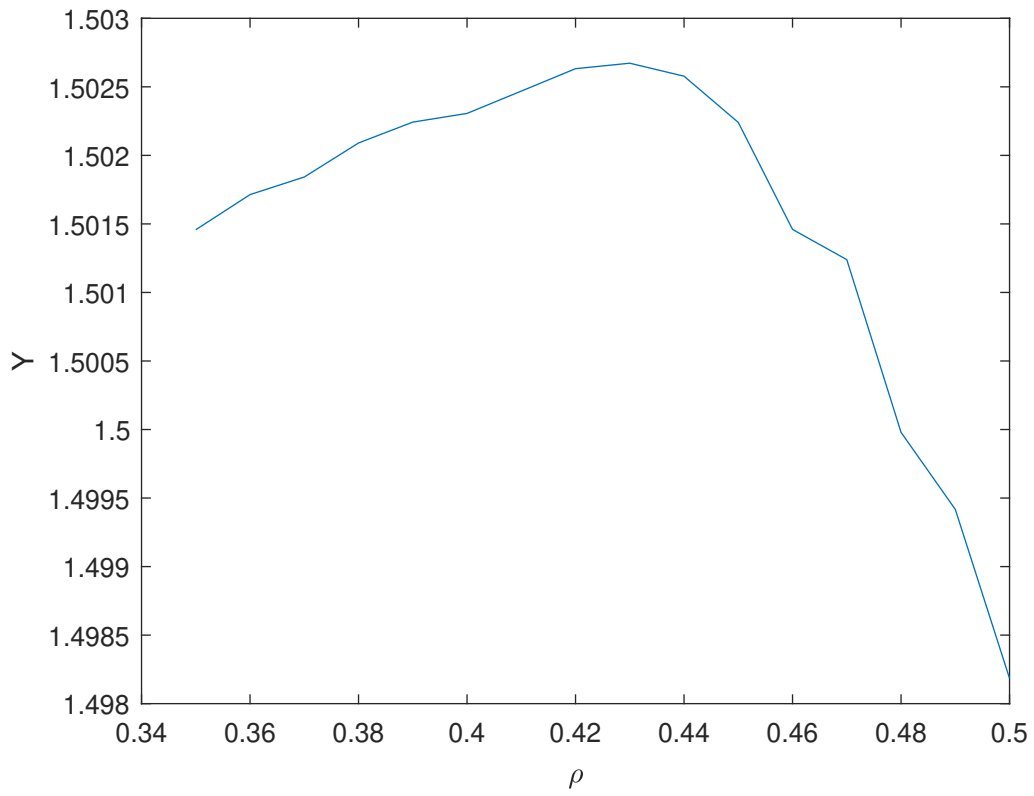


Figure 6: Level of the welfare according to the unemployment replacement rate when the social minimum is set to 0.86.

Source: Model simulations for different values of ρ when $b_0 = 0.86$.

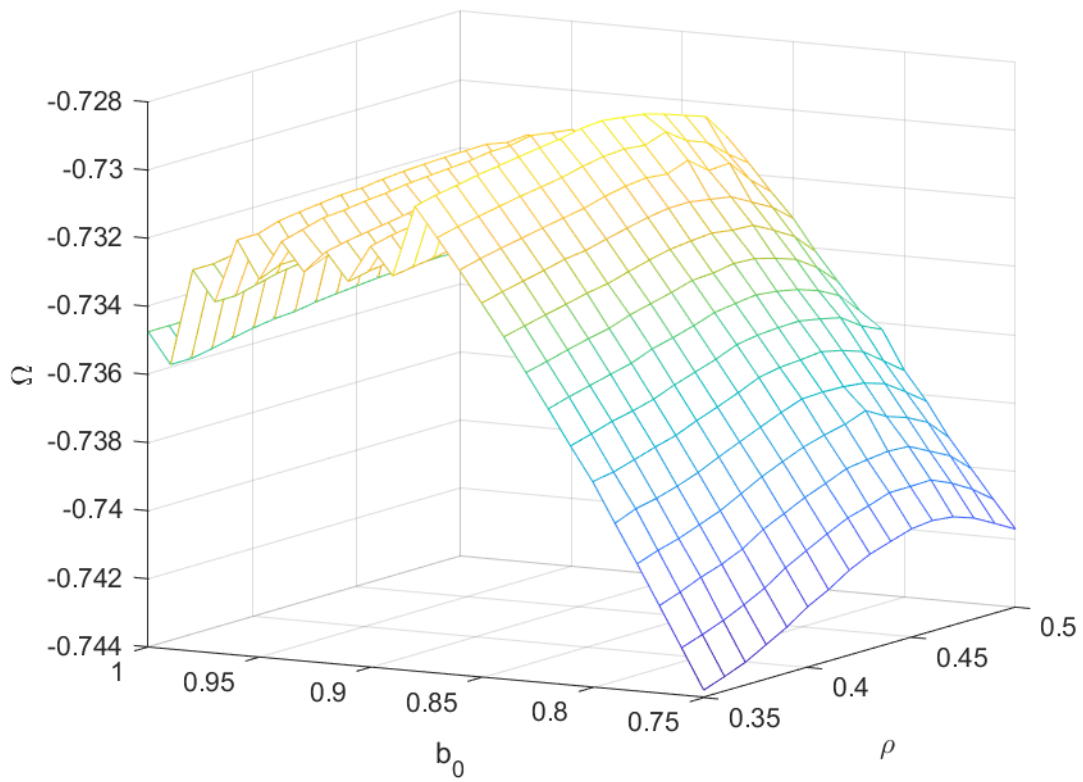


Figure 7: Level of the welfare according to the unemployment replacement rate and the social minimum.

Source: Model simulations for different values of ρ and b_0 .

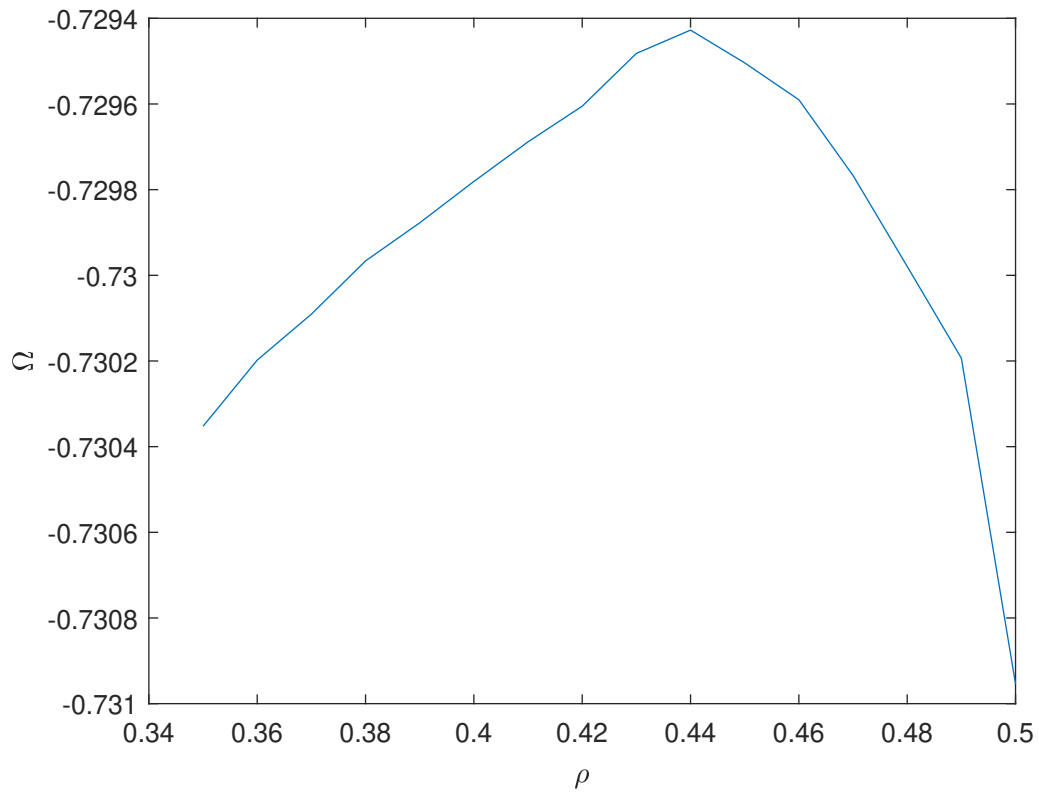


Figure 8: Level of the welfare according to the unemployment replacement rate when the social minimum is set to 0.88.

Source: Model simulations for different values of ρ when $b_0 = 0.88$.

System	Bismarckian	Beveridgian
ρ	0.44	0
b_0	0.88	0.88
Ω	-0.7294	-0.7307
Total vacancies cost	0.0622	0.0682
Labour market: young (1)	0.0201	0.0196
Labour market: adults (2)	0.0317	0.0334
Labour market: seniors (3)	0.0103	0.0152
Mean quality of jobs	1.1917	1.19
Labour market: young (1)	0.9388	0.9403
Labour market: adults (2)	0.9989	1.0065
Labour market: seniors (3)	1.6317	1.6133
Unemployment Rate	9.37	9.07
Labour market: young (1)	12.47	12.52
Labour market: adults (2)	6.79	6.73
Labour market: seniors (3)	8.85	7.94

Table 5: The comparison of the two systems of unemployment benefits that maximizes social welfare: effect on vacancies cost, mean job production and unemployment over the life cycle.

Source: Model simulations.

have different productivity and wage, they also need different levels of UB so that to limit the firms' monopsony power. The monopsony power of firms depends positively on the gap between the workers' productivity and reservation wage. The levels of productivity and wage are therefore crucial in our results and to be as accurate as possible, we choose to minimize their heterogeneity within each age class by separating the life cycle in age class of even length. Yet, one can still wonder if the results we obtain depends on this choice of age class size. In this robustness exercise, we propose to reduce the size of the first and the third age classes, and to extend the second. Even if these alternative sizes raise consequently the wage and productivity heterogeneity in the second age class in which both grow quickly, they are rather consistent with employment stylized facts.

The calibrations used to run these new simulations are presented in appendix D, page 26.

Sensitivity to r : The optimal value of unemployment benefits is very weakly sensible to the value of r . Starting from $r = 0.2$ to $r = 0.6$ leads to an optimal value of ρ going from 0.43 to 0.44 and a stable value of b_0 to 0.88. Besides, as in the benchmark, WIUB are preferred to flat unemployment benefits whatever the value of r , in terms of both production and social welfare.

Sensitivity to η : Starting from $\eta = 0.5$ to $\eta = 0.9$ leads to a value of ρ that maximizes production going from 0.37 to 0.47 and value of ρ that maximizes welfare going from 0.39 to 0.46. Yet, we observe no clear trend of b_0 according to η . The table 6 shows the raise of the optimal values of ρ according to η . The elasticity of the job finding frequency to the labour market tightness is given by $1 - \eta$. As η raises, the negative externality of unemployment on the job finding decreases. The effect of a raise in unemployment on production and social welfare is therefore lower and the optimal level of ρ that has the perverse effect of generating inefficient unemployment raises. Besides, as in the benchmark, WIUB are preferred to flat unemployment benefits whatever the value of η , in terms of both production and social welfare.

	Y	Ω
η	ρ	ρ
0.5	0.39	0.37
0.6	0.4	0.43
0.7	0.43	0.44
0.8	0.44	0.45
0.9	0.46	0.47

Table 6: The effect of η on the optimal value of ρ

Source: Model simulations of the optimal value of ρ for different values of η according to the two criteria Y and Ω

Sensitivity to σ : Starting from $\sigma = 0$ to $\sigma = 2.5$ leads to a value of ρ that maximizes production going from 0.37 to 0.43 and a value of b_0 going from 0.8 to 0.89 and a value of ρ that maximizes welfare going from 0.44 to 0.48 and a value of b_0 going from 0.87 to 0.96. The table 7 shows the raise of these optimal values of ρ and b_0 given σ . The value of b_0 in the case of the only Beveridgian system follows the same trend. This raise is rather intuitive since σ captures the redistributive motive of the unemployment benefits. Note that for $\sigma = 0$, flat unemployment benefits are very slightly preferred to WIUB (1.5038 vs 1.5030), yet for $\sigma = 1.5$ to 2.5, WIUB are preferred to flat UB.

Sensitivity to the size of age classes: In this robustness exercise, we propose to set the first and the third age classes to 10 years, and the second to 19. The results of this new simulation are presented in table 8.

Our main result stands with these alternative age class sizes since, as in the benchmark, WIUB remain preferred to flat unemployment benefits in terms of both production and social welfare. The values of ρ and b_0 that maximize production in both the Bismarckian and Beveridgian system are very close or equal to the benchmark. Yet those that maximize welfare are higher, in particular for b_0 . As explained in section

σ	Bismarckian UI				Beveridgian UI	
	Y		Ω		Y	Ω
	ρ	b_0	ρ	b_0	b_0	b_0
0	0.37	0.74	-	-	0.8	-
1.5	0.42	0.83	0.44	0.87	0.86	0.86
2	0.43	0.86	0.44	0.88	0.88	0.86
2.5	0.44	0.89	0.45	0.89	0.89	0.89

Table 7: The effect of σ on the optimal value of ρ and b_0

Source: Model simulations of the optimal value of ρ and b_0 for different values of σ according to the two criteria Y and Ω

Bismarckian UI				Beveridgian UI	
Y		Ω		Y	Ω
ρ	b_0	ρ	b_0	b_0	b_0
0.42	0.85	0.47	0.97	0.87 or 0.88 ^a	0.97

Table 8: The effect of the size of the age class on the optimal value of ρ and b_0

Source: Model simulations of the optimal value of ρ and b_0 when the age classes last 10 years (young), 19 years (adults) and 10 years (seniors), according to the two criteria Y and Ω

^aThese two values of b_0 induce the same production

3.4.1, there is a threshold value of b_0 from which the Beveridgian UB start increasing the reservation wage of the young and reducing their employment. From this threshold value, the production of the young and as a consequence, the overall production falls. In the benchmark, this fall in production comes together with a decrease in welfare so that the optimal level of b_0 in the Beveridgian system is the same whether it maximises production or welfare. When we reduce the size of the first age class, the share of production of the young in the overall production is lower and the fall in the overall production is less sharp when b_0 raises over its threshold value. A worker aged 30 is now assumed to share the same productivity and offered wages as the 30 to 50 age class, whereas during this age class, both productivity and wage grow quickly. The negative effect of high reservation wage on employment of this worker is therefore lower than in the benchmark and than in reality. In this context, the redistributive motive of UB captured by the welfare criterion compensates more than in the benchmark the fall in production, and the welfare is maximized for higher values of ρ and b_0 . This effect is observed when comparing the figure 5 and 7 with the figure 9 and 10.

4 Conclusion

The aim of this paper is to build a framework in which WIUB can interact with the firms' wage and job creation strategy over the life cycle. This model allows to assess the

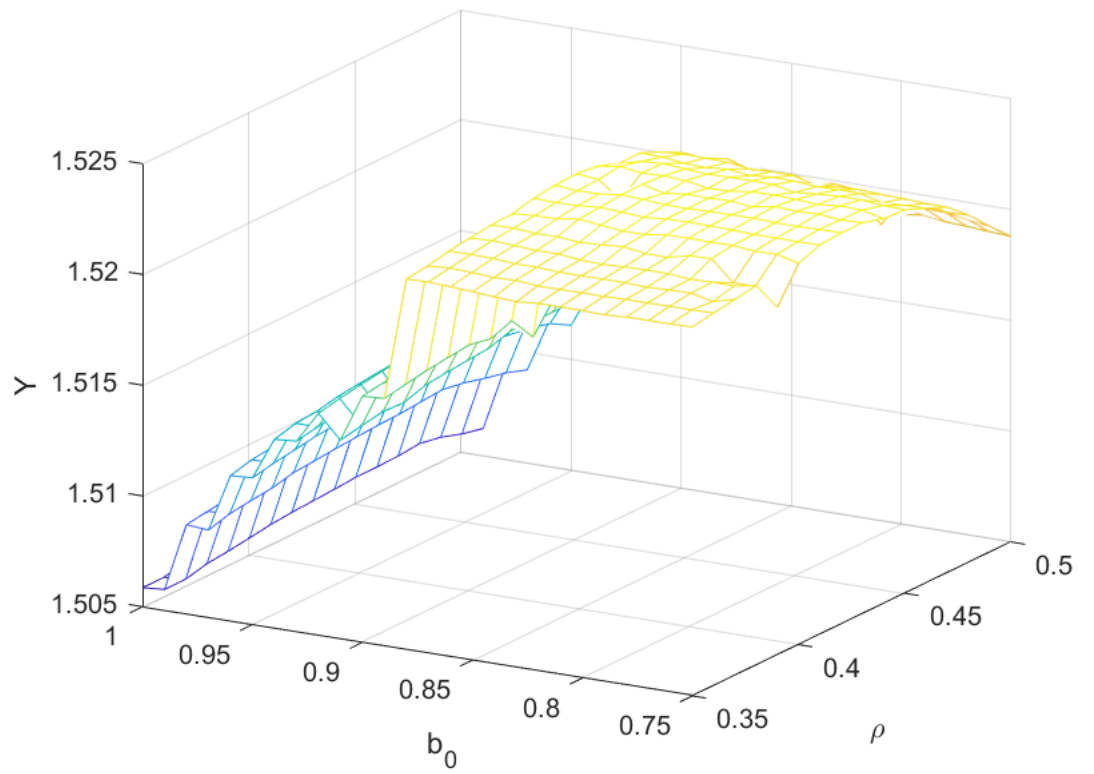


Figure 9: Level of the production according to the unemployment replacement rate and the social minimum.

Source: Model simulations for different values of ρ and b_0 , when the age classes last 10 years (young), 19 years (adults) and 10 years (seniors)

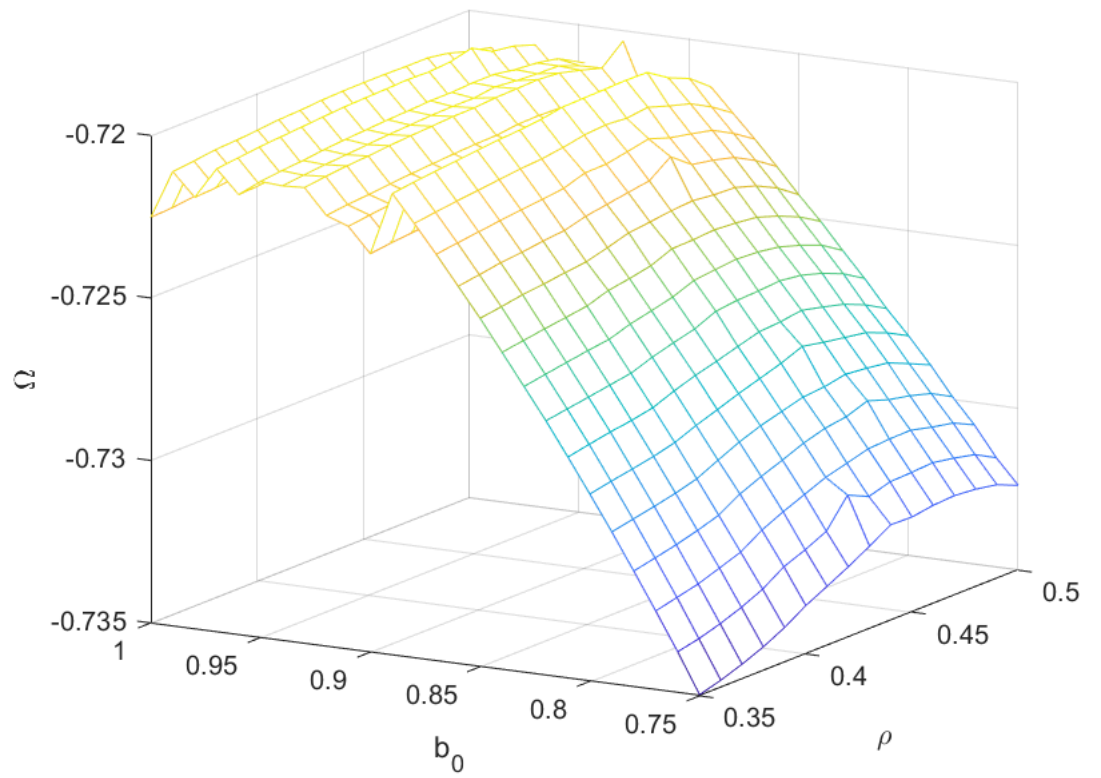


Figure 10: Level of the welfare according to the unemployment replacement rate and the social minimum.

Source: Model simulations for different values of ρ and b_0 , when the age classes last 10 years (young), 19 years (adults) and 10 years (seniors).

effect of WIUB on the labour market over the life cycle and to find the optimal design of unemployment benefits. WIUB have the particularity to have age-dependant effects on the labour market: they raise the workers' reservation wage and wage increasingly with age. They therefore contribute to workers' wage progression over the life cycle: WIUB raise wage progression by more than 0.1% per year. This age-dependant effect of WIUB also allows to reduce more effectively the firms' monopsony power at older ages. WIUB combined with a Beveridgian component (social minimum) are found in a life cycle framework to further improve welfare compared to pure Beveridgian unemployment benefits. The optimal replacement rate is found to be 44% of the previous wage.

An interesting extension of this model could be to reconsider this result when retirement is endogenous. Indeed, in that case, high unemployment benefits received by senior workers could also act as a subsidy for labour activity and have an ambiguous effect on employment.

A Employed Workers' Flows

In steady state, the flows into and out of firms offering a wage no greater than w for each age class are equal. The mass of workers receiving a wage no greater than w is represented for each age class by $(m_i - u_i)G_i(w)$ and solves:

$$\begin{aligned} (p + s + \lambda_y(1 - F_1(w)))(m - u_y)G_1(w) &= \lambda_1^0 \int_{\underline{w}}^w U_1(R_1^{-1}(x))dF_1(x) \\ (p + s + \lambda_a(1 - F_2(w)))(m - u_a)G_2(w) &= \lambda_2^0 \int_{\underline{w}}^w U_2(R_2^{-1}(x))dF_2(x) + p(m - u_1)G_1(w) \\ (p + s + \lambda_s(1 - F_3(w)))(m - u_s)G_3(w) &= \lambda_3^0 \int_{\underline{w}}^w U_3(R_3^{-1}(x))dF_3(x) + p(m - u_2)G_2(w) \end{aligned}$$

On the left side of these equations, there is the flow of workers out of firms offering a wage no greater than w . These workers either experience an exogenous shock, change age class or resign to be employed in a higher paying job. On the right side there is the flow of workers into firms offering a wage no greater than w . The second term of the left side for adults and seniors refers to the part of the workers already employed when they change age class (young workers all start as unemployed). The wage distribution of adult workers partly depends on that of the young workers, and the wage distribution of seniors on that of adult workers. Note that wage distribution depends on unemployment benefits distribution.

B Unemployed Workers' Flows

The mass of unemployed workers according to the benefits b is noted as $u_i(\cdot)$. $g_i(\cdot)$ is the density function associated to the cumulative distribution $G_i(\cdot)$. Agents enter into the labour market unemployed. Workers with no job experience get the social assistance benefit b_0 . The mass of young unemployed workers according to their benefit b solves therefore in steady state the following flows equations:

For $b = b_0$,

$$[\lambda_1^0(1 - F_1(R_1(b))) + p]u_1(b_0) = s(m - u_1)G_1\left(\frac{b_0 - all}{\rho}\right) + p \cdot m \quad (19)$$

Otherwise,

$$[\lambda_1^0(1 - F_1(R_1(b))) + p]u_1(b) = s(m - u_1)g_1\left(\frac{b - all}{\rho}\right) \quad (20)$$

All young workers entering the labour market ($p \cdot m$) receive the social assistance benefit.

For the other age classes, $u_i(\cdot)$ solves for all b :

$$\begin{aligned}
[\lambda_1^0(1 - F_1(R_1(b))) + p]u_1(b) &= s(m - u_1)g_1 \left(\frac{b - all}{\rho} \right) \\
[\lambda_2^0(1 - F_2(R_2(b))) + p]u_2(b) &= s(m - u_2)g_2 \left(\frac{b - all}{\rho} \right) + pu_1(b) \\
[\lambda_3^0(1 - F_3(R_3(b))) + p]u_3(b) &= s(m - u_3)g_3 \left(\frac{b - all}{\rho} \right) + pu_2(b)
\end{aligned} \tag{21}$$

Unemployed workers who receive a benefit b do not accept a job unless the wage proposal associated with this job is above $R_i(b)$. The exit rate from unemployment therefore differs according to unemployment benefits. The number of unemployed on each market u_i can be deduced by summing the mass of unemployed workers for each level of unemployment benefits.

C The data presentation

We use the 2012 French Labour Force Survey (Enquête Emploi) data to calibrate the model. A yearly exercise conducted by INSEE¹⁸ on 150 000 people, the French Labour Force Survey provides data regarding professions, earnings, working hours and individual characteristics. We restrict our study on a rather homogenous group of workers in terms of educational attainment since workers are homogenous when they start their working life in our theoretical framework.¹⁹ We choose as educational attainment, the high school degree or equivalent. That corresponds to the larger sub-sample of low-skilled workers. We choose to use wages of male wage-earners. We use figures for the three age classes defined in the model.

We study wages in cross section. As the real economy is not in a steady state like the theoretical economy described in the model, this cross section approach can show some limits. By studying the wages of different age classes at a time t , we mix the notion of age and cohort. According to Baizen and Charni (2017), this could lead us to underestimate the extent of the wage progression over the life cycle. Yet, by restricting our study to workers with similar educational attainments, we are partly protected from the bias generated by the cross section approach. We therefore choose this approach aware of its limits and knowing that a stronger wage progression would in fact lead to a reinforcement of the effect of the wage-indexed unemployment benefits.

We deduce hourly wages from the variable "monthly earnings"²⁰ and "hours worked"

¹⁸Institut National de la Statistique et des Etudes Economiques

¹⁹The dispersion generated by the ex ante workers' heterogeneity cannot therefore be captured by the model. This limit could be overcome by assuming an exogenous distribution of the ex-ante productivity of young workers: y_y .

²⁰From the French Labour Force Survey database.

by workers and express wage in function of the institutional minimum wage (7.06 euros net). As workers are assumed ex ante homogenous in the model, the model cannot pretend to reproduce the extreme wages existing in the actual wage distribution. We therefore calibrate this model on the first 95 percentiles of the wage distribution of each age. The distribution of unemployment benefits is given by the variable "last unemployment benefits received" ²¹.

D Alternative calibrations for robustness tests

To test the robustness of our results, we need to calibrate the model depending on alternative values of r , η , σ and the size of the age classes. The value parameters that change in comparison to the benchmark in these calibrations are presented in tables 9, 10, 11 and 12.

r	q
0.02	0.306
0.03	0.32
0.05	0.35
0.06	0.365

Table 9: Calibration parameters for different values of r

η	ϕ^0	y_1	ϕ
0.5	6.8	1.04	4.1
0.6	5.2	1.05	3.2
0.8	2.7	1.075	1.7
0.9	1.8	1.075	1.13

Table 10: Calibration parameters for different values of η

	ϕ^0	ϕ
0	3.9	2.4
1.5	-	-
2.5	-	-

Table 11: Calibration parameters for different values of η

²¹Associated with the ARE (Aide au Retour à l'Emploi) system, the standard unemployment insurance system in France.

ϕ^0	y_3	β_2	β_3
3.7	1.65	0.98	0.54

Table 12: Calibration parameters when the age classes last 10 years (young), 19 years (adults) and 10 years (seniors)

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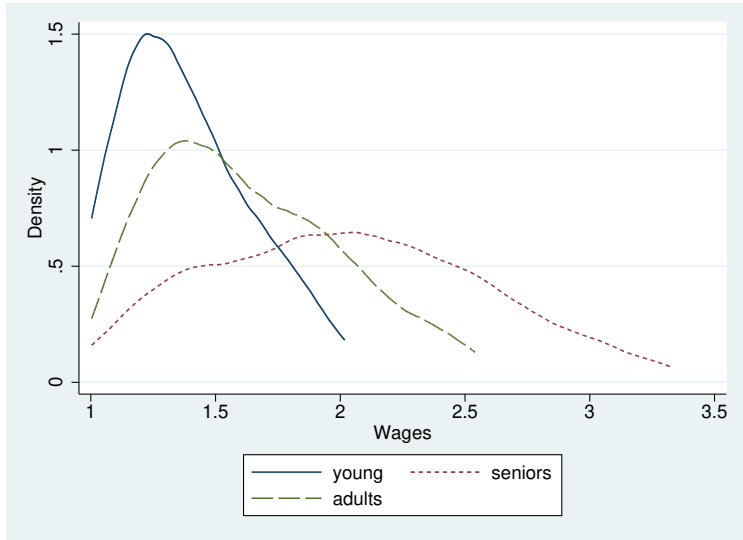


Figure 11: French wage distributions

Source: French Data, appendix C, page 33

Note: Young are workers between 20 and 32 years old, adults between 33 and 45, and seniors between 46 and 58. Expressed in the French minimum wage. 95 first percentiles.

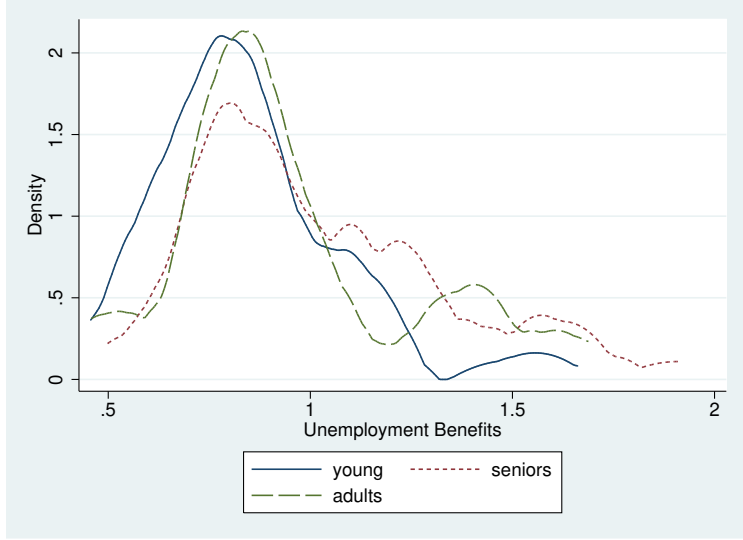


Figure 12: French unemployment benefits distributions

Source: French Data, appendix C, page 33

Note: Young are workers between 20 and 32 years old, adults between 33 and 45, and seniors between 46 and 58. Expressed in the French minimum wage. 95 first percentiles.