FINANCIAL INCENTIVES TO POSTPONE RETIREMENT
Estimating the impacts of the 2003 French pension reform on the employment and wages of older workers by using a lifetime job search model

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This article analyses whether financial incentives to delay retirement affect the employment and wages of older workers, not just their retirement behavior. We focus on the outcomes of France's 2003 reform that offered pension bonus to older workers who postponed their retirement until the legal age. An equilibrium search model is built in which both employment and wage are endogenous, allowing us to analyze the role of both labor supply and demand in the retirement decision. Simulations of the model show that some firms choose to post higher wages to induce their workers to work longer. Thanks to a higher retention, firms save recruitment and training costs. Finally, demand-side considerations can attenuate the impacts of financial incentives that cause wage increases and too few new jobs.

Keywords: financial retirement incentives, employment, endogenous wages, equilibrium search model.

In France, the recent pension reform project establishing a universal system in 2025 has put the issue of financial incentives to work beyond the legal retirement age back at the center of the debate. This debate is not new and echoes that of 2003 when Fillon's government had already introduced a bonus/malus system.[1] In this article, we return to this landmark episode of French pension reform to try to

1. This bonus consisted in a 0.75% pension increase per additional worked quarter. Between 2004 and 2006, more than 83,000 retirees (equal to approximately 5% of the retiree population) benefited from this pension bonus. The average bonus pension was about 20 euros per month. In 2008, the pension bonus was increased to 1.25% per additional quarter worked. In 2016, 14.1% of the retirees perceived a bonus when postponing their retirement.

understand how the functioning of the labor market may have been modified by the increase in the labor supply of older workers wishing to delay their retirement.

This is all the more important since the literature has focused mainly on the effect of financial incentives on individual retirement decisions and thus on the supply side of the labour market, but has been almost silent about the potential effects of its demand side. Indeed, several empirical studies, spanning various nations, suggest that these incentives increase employment rates among people older than the legal retirement age (Gruber and Wise, 2004; Hanel, 2010; Ferrari, 2019; Belloni et Alessie, 2013; Benallah, 2011; Engels *et al.*, 2017). In frictional labour markets, the return on jobs is determined by their expected duration (Seater, 1977; Bettendorf and Broer, 2003; Hairault *et al.*, 2010). By extending the time horizon during which workers remain in the labor market, these incentives also might alter the preferences that firms exhibit prior to the legal retirement age (Ilmakunnas and Ilmakunnas, 2015), namely, by changing their job creation efforts, wages, training policies and promotion rules. Firms might react by adjusting either the number of jobs available (job creation) or wage they offer (prices). The former adjustment benefits outsiders, whereas the latter benefits insiders.

To better understand the effects of financial incentives to delay retirement on both the supply and demand for labour, we develop a job-search model with age groups able to account for the effect of the policy on both employment and wages. This model must also make the wage distribution explicit to show the possible heterogenous effect according to wage. The equilibrium search model (Mortensen, 1998) is particularly suitable for this purpose. We extend it by making retirement endogenous and therefore potentially affected by financial incentives. We contribute to the literature on lifetime job search model applied to retirement behavior by making the contact rate and the productivity endogenous and thus by analysing both labor demand and supply. Doing so, we include the firm behavior in the complex process of retirement. So far, only the labor supply was taken into account (Hairault *et al.*, 2010). In our model, we go further: firms can react to the change in workers' retirement decisions (due to incentives) by adjusting their job openings and wage offers. Cross-country variability in older workers' labor market participation highlights the impact of institutional differences (Nickell, 1997; Abowd *et al.*, 1999;

Blanchard and Wolfers, 2000; Saint-Paul, 2009). Prior empirical studies also note the heterogenous impacts of financial incentives across countries (Albert *et al.*, 2008; Hanel, 2010) and in relation to individual preferences and productivity (Van Soest and Vonkova, 2014; Reichlin, 2018). Therefore, to model workers' behavior, we augment Mortensen's (1998) model with unemployment benefits indexed on past earnings. We capture heterogeneity in leisure preferences and health conditions (Gielen, 2009; Currie and Madrian, 1999; Cai et Kalb, 2006; Garcia-Gomez, 2011) by assuming a disutility at work that is heterogenous among workers. With this theoretical approach, we identify the transmission channel of the policy on the 50 to 59 years old labour market and simulate the effect of the policy without being exposed to the Lucas' critique (1976). Implementing this type of model makes it indeed possible to highlight the mechanisms underlying the implementation of financial incentives.

We conclude that postponing workers' retirement horizon with an incentive policy affects wages in the previous age class and particularly for earners at the top of the wage distribution, but it does not influence employment. Financial incentives also do not affect workers homogeneously; disutility at work and unemployment insurance cause only highly paid workers to lengthen their career. That is, the main effect of incentive policies is a distortion of the offered wage distribution, such that the policy only benefits insiders already employed with a high wage.

We study the anticipation effects of both senior workers and the firms that employ them. Furthermore, we model firms' anticipatory behaviours in terms of both job creation and wage posting strategy. Simulations based on this structural model provide clear guidance with regards to using financial incentives to delay workers' retirement.

Financial incentives to postpone retirement create a high inertia of income and status inequalities. Since high-paid workers will have greater interest in benefiting from financial incentives, inherited inequalities will therefore continue through these increased pensions. These inequalities existed just before retirement, this period being characterized by more accidents at work, health issues and a high risk of long-term unemployment.

Section 1 presents the equilibrium model and its properties. Section 2 discusses the results from the simulations. Section 3 concludes.

1. A lifetime job search model

To understand how financial incentives affect wages and employment of seniors, we use the framework developed in Mortensen (1998). This framework has the advantage to model a frictional labour market in which the hiring process is costly in terms of time for firms. In this context, the working horizon of workers affect firms' behavior (Seater, 1977), Bettendorf and Broer, 2003, Hairault *et al.*, 2010). Besides, this approach models this behavior in terms of both job creation, by making the contact rate endogenous and wage strategy, by making job productivity endogenous. In this model, time is continuous and the model is in steady state.[2]

1.1. Model Assumptions

1.1.1. Population dynamics

To study the effect of financial incentives on wages and employment of seniors, we augment Mortensen's (1998) model with life cycle and endogenous retirement variables. We divide the life cycle into four parts. All variables that depend on workers' age class are indexed by i, which can take values of $i = 0$ for young workers, $i = 1$ for young seniors who cannot retire (they have not reached the legal retirement age), $i = 2$ for older seniors who can retire (they have reached the legal retirement age), and $i = 3$ for retired workers. The mass of the population in each age class is denoted m_i. We assume the economy is in a steady state. At each period, the probability of ageing equals δ_i, and the arrival of new agents replaces an equal number of retired workers, so there is no labor force growth. The probability δ_3 is the probability of dying. Masses m_i therefore solve:

$$\delta_0 m_0 = \delta_1 m_1 = \delta_2 m_2 = \delta_3 m_3$$

Depending on their age, workers can achieve three different status levels: employed, unemployed or retired. We denote, by u_i and e_i respectively, the mass of unemployed and employed workers of age class i, and r_{ji} indicates the mass of retired workers of age class i who retire in age class j. We differentiate retired workers according to their retirement age, because the bonus only applies to those who retire

2. Note that a model close to the one presented here (with life cycle yet without endogenous retirement) is applied to unemployment insurance issues in Le Duigou (2020).

later. We then can summarize the composition of workers in each age class as follows:

$$\begin{aligned} m_0 &= e_0 + u_0 \\ m_1 &= e_1 + u_1 \\ m_2 &= e_2 + u_2 + r_{22} \\ m_3 &= e_3 + u_{32} + r_{33} \end{aligned}$$

1.1.2. Employment opportunity

Workers search for a job when they are unemployed or employed, there is on the job search. Firms and workers meet according to the following matching process:

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

where η is the matching function elasticity, v_i indicates the number of job vacancies, and ϕ^0 and ϕ refer to the search effectiveness of unemployed and employed workers, respectively.

We set $\theta_i = v_i / (\phi^0 u_i + \phi e_i)$ to reflect 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 employed and unemployed workers, respectively;

and

$q_i = \phi \theta_i^{-\eta}$ and $q_i^0 = \phi^0 \theta_i^{-\eta}$ for firms to contact an employed or an unemployed worker, respectively.

The cumulative distribution of wages offered by firms on each market, regardless of the worker's status, is endogenous and denoted by $F_i(.)$, as detailed in subsection 1.3.2.

1.2. Workers' Behavior

1.2.1. Bellman Equations

To capture the effect of the reforms on the labour market, we also account for the health conditions of these older workers. Employment decisions by workers at the end of their careers are often meaningfully informed by their health conditions (Currie and Madrian, 1999; Cai and Kalb, 2006; Garcia-Gomez, 2011). Therefore we introduce workers' disutility at work, according to their age class (Gielen, 2009). This disutility is attached to each worker and is heterogeneous across workers. Let d denote it. According to data from the SHARE database, 60-64 year-old seniors have 40% more chronic deceases on average than those between the ages of 50 and 59 years. Health tends to deteriorate between these two age classes. To represent this deterioration, we introduce a parameter α (with $\alpha > 1$) that increases workers' disutility.

Let $V_i^e(.)$ denote the value in each age class of the optimization problem of an employed worker according to the wage, and the disutility at work if his age class is 1 or 2:

$$\begin{aligned} rV_0^e(w) &= w - \tau + \lambda_0 \int_w^{\overline{w}} \left(V_0^e(x) - V_0^e(w)\right) dF_0(x) \\ &-s\left(V_0^e(w) - V_0^u\left(b(w)\right)\right) - \delta_0(V_0^e(w) - Max(V_1^e(w), V_1^u)) \end{aligned} \tag{1}$$

$$\begin{aligned} rV_1^e(w,d) &= w - \tau - d + \lambda_1 \int_w^{\overline{w}} \left(V_1^e(x,d)\right. \\ &\left.-V_1^e(w,d)\right) dF_1(x) - s(V_1^e(w,d) - V_1^u(b(w),d)) \\ &- \delta_1(V_1^e(w,d) - Max(V_2^e(w, d), V_2^u(b(w),d), V_{22}^r)) \end{aligned} \tag{2}$$

$$\begin{aligned} rV_2^e(w,d) &= w - \tau - \alpha d + \lambda_2 \int_w^{\overline{w}} \left(V_2^e(x,d) - V_2^e(w,d)\right) dF_2(x) \\ &- s(V_2^e(w,d) - Max(V_2^u(b(w),d), V_{22}^r)) - \delta_2(V_2^e(w,d) - V_{33}^r) \end{aligned} \tag{3}$$

The value of being unemployed, according to unemployment benefits and the worker's disutility, is denoted by $V_i^u(.,.)$. The value of retiring while in age class i is denoted by V_{ii}^r. In each age class, an employed worker can receive a better job proposal at the arrival rate $\lambda_i(1 - F_i(w))$, and his job is destroyed at a rate s. Retirement is endogenous, because workers can choose to retire once they move from age class 1 to 2, or once they lose their jobs while in age class 2. Workers are forced to retire at the end of age class 2. Unemployed workers receive unemployment benefits denoted by b that depend on their previous wage with a replacement rate of ρ, as follows:

$$b(w) = \rho w$$

The pensions are founded by a lump tax τ that is equal whatever the status of the worker and therefore does not affect any workers' trade-off in the economy.

The value of being unemployed in each age class $V_i^u(.)$, according to unemployment benefits and disutility at work, thus can be determined as follows:

$$rV_0^u(b) \quad = b - \tau + \lambda_0^0 \int_{\underline{w}}^{\overline{w}} Max(V_0^e(x) \\ -V_0^u(b),0)dF_0(x) - \delta_0(V_0^u(b) - V_1^u(b)) \tag{4}$$

$$rV_1^u(b,d) = b - \tau + \lambda_1^0 \int_{\underline{w}}^{\overline{w}} Max(V_1^e(x,d) - V_1^u(b,d),0)dF_1(x) \\ -\delta_1(V_1^u(b,d) - Max(V_2^u(b,d),V_{22}^r)) \tag{5}$$

$$rV_2^u(b,d) = b - \tau + \lambda_2^0 \int_{\underline{w}}^{\overline{w}} Max(V_2^e(x,d) \\ -V_2^u(b,d),0)dF_2(x) - \delta_2(V_2^u(b,d) - V_{33}^r) \tag{6}$$

The disutility at work also affects V_i^u for $i = 1{,}2$ by decreasing the value of job opportunities $V_i^e(x,d)$. Similar to employed workers, unemployed workers can choose to retire when they move from age class 1 to 2.

The value of being retired is V_{ij}^r, where i is the current age class and j is the age class in which the worker retires. The value of being retired in age class 2 is:

$$rV_{22}^r = p_2 - \tau - \delta_2(V_{22}^r - V_{32}^r) \tag{7}$$

In age class 3, the asset value of these workers is given by:

$$rV_{32}^r = p_2 - \tau - \delta_3 V_{32}^r \tag{8}$$

If workers only retire in age class 3, their asset value is given by:

$$rV_{33}^r = p_3 - \tau - \delta_3 V_{33}^r \tag{9}$$

In age class 3, early retirees keep receiving the pension p_2, and all others receive a pension p_3. As in Hairault *et al.* (2010), we assume the pensions are lump sums and not indexed on the last wage. Indeed, in France the pensions are computed based on the 25 best years and not only on the last wage. The latter can be quite heterogenous among workers, yet, as the agents in the model are ex-ante homogenous (same individual productivity, same layoff and hiring hazard, same wage offers lottery), the mean wages of the best years of these agents are necessarily very close from one another. A pension that takes the form of a lump sum is therefore more accurate to model the workers retirement behavior than a wage indexation.

1.2.2. Pension scheme: The incentive policy and the workers' choices

The incentive policy suggests pensions rise when workers work longer, so $p_3 > p_2$. Both an increase in p_3 and a decrease in p_2 widen the gap between being active or retiring early. An increase in p_3 raises the value of being active in age class 2, V_2^e and V_2^u. A decrease in p_2 reduces the value of retiring early.

Workers make several decisions relative to the labor market: When to retire, whether they are employed or unemployed, when to resign if employed, and when to accept a job if unemployed. These arbitrages therefore involve three states: unemployment and employment, employment and retirement, and unemployment and retirement. Using equations 1, 2, 3, 4, 5, 6, 7, 8, we define a decision matrix that summarize workers' arbitrage as follows:

- I_0^{eu} such that $I_0^{eu}(w,b) = 1$ if $V_0^e(w) > V_0^u(b)$ and $I_0^{eu}(w,b) = 0$ if $V_0^e(w) < V_0^u(b)$. Each point of the matrix $I_0^{eu}(w,b)$ takes the value 1 if and only if the value of being employed at w is higher than the value of being unemployed at b.

- I_i^{eu} for $i = 1,2$, such that $I_i^{eu}(w,b,d) = 1$ if $V_i^e(w,d) > V_i^u(b,d)$ and $I_i^{eu}(w,b,d) = 0$ if $V_i^e(w,d) < V_i^u(b,d)$. Each point of the matrix $I_i^{eu}(w,b,d)$ takes the value 1 if and only if in the age class i, the value of being employed at w with a desutility at work d is higher than the value of being unemployed at b.

- I^{ur} such that $I^{ur}(b,d) = 1$ if $V_2^u(b,d) > V_{22}^r$ and $I^{ur}(b,d) = 0$ if $V_2^u(b,d) < V_{22}^r$. Each point of the matrix I^{ur} takes the value 1 if and only if in the age class 2, the value of being unemployed at w with a desutility at work d is higher than the value of being retired.

- I^{er} such that $I^{er}(w,d) = 1$ if $V_2^e(w,d) > V_{22}^r$ and $I^{er}(w,d) = 0$ if $V_2^e(w,d) < V_{22}^r$ for all w. Each point of the matrix I^{er} takes the value 1 if and only if in the age class 2, the value of being employed at w with a disutility at work d is higher than the value of being retired.

The incentive policy affects I^{ur} and I^{er} directly by increasing the value of staying active. It also affects I^{eu} indirectly, because employment is more valuable if the horizon is more distant.

Through these decisions, the incentive policy affects the mass of workers, according to their status, wages, unemployment benefits, and disutility. The mass of employed workers according to their wage and disutility $e_i(.,.)$ and the mass of unemployed workers according to their unemployment benefits and disutility $u_i(.,.)$ can be deduced from the decision matrix, as presented in Appendix A.

1.3. Firms' Behaviour

By changing the condition of workers according to their status, wages, and unemployment benefits, the incentive policy also indirectly affects firms' behavior, both in relation to job creation, and in wage decisions. We assume firms can define their searches according to workers' age classes[3] such that there are three labor markets: $i = 0,1,2$. We assume firms cannot observe disutility at work, the status, or the reservation wage of workers, yet they are aware that a distribution of workers exists according to these characteristics.

1.3.1. Job Creation Decision

Firms enter each market as long as this equiprofit is superior to the vacancy cost, denoted as c. We use $\mathrm{S}_i(\theta_i)$ to denote the profit of firms that target age class i, according to the tightness of the labor market. At equilibrium, labor market tightness can solve the following free entry condition:

$$\mathrm{S}_i(\theta_i) = c \qquad (10)$$

Labor market tightness also depends on firms' profit and drives the meeting frequencies between firms and workers. As indicated in subsection 1.1.2, the higher the labor market tightness, the higher the exit rate from unemployment.

1.3.2. Wage Posting Decision

The intuition behind the wage game of firms (Burdett and Mortensen, 1998) relies on the assumption that firms successively enter each market. When only one firm appears in the market, its maximum instantaneous profit occurs at the lowest wage possible (here, the minimum wage). A second firm entering the market might

3. They can discriminate among workers by setting 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.

then offer a wage slightly superior to the first firm, to poach the employed workers of the first firm, and so on for the following firms entering the market. At equilibrium, when firms reach equiprofit, this wage game generates a wage distribution on an interval $[\underline{w};\overline{w}]$.

Therefore, the offered wage distribution F_i solves the following equiprofit condition:

$$\text{S}_i(\underline{w_i}) = \text{S}_i(w) \tag{11}$$

with $\underline{w_i}$ the minimum wage proposed in age class i.[4] The incentive policy raises the expected profit in age classes 1 and 2 by inducing a lower separation probability. In the presence of generous unemployment benefits, and given the disutility of workers, this increase should be particularly notable among firms offering rather high wages. In this case, this policy is likely to affect the offered wage distribution in age classes 1 and 2 by inducing more firms to offer higher wages.

1.3.3. Effects on Firms' Behaviour

By noting $h_i(.)$, the hiring frequency of firms according to the offered wage, and $J_i(.)$, the surplus of the firms according to the wage, we can calculate firms' expected profit according to the wage:

$$\text{S}_i(w) = h_i(w)\,J_i(w)$$

Hiring frequency depends on the mass of workers ready to accept a given wage. Since firms can recruit both unemployed and employed workers, this frequency depends on the distribution of workers according to their current wage, unemployment benefits, and disutility. Firms hire workers at the following frequencies according to the offered wage:

$$h_0(w) = q_0^0 \int_{\underline{b}}^{\overline{b}} u_0(b) I_0^{eu}(w,b)db + q_0 \int_{\underline{w}}^{w} e_0(x)dx$$

$$h_i(w) = q_i^0 \int_{\underline{b}}^{\overline{b}} \int_{\underline{d}}^{\overline{d}} u_i(b,d) I_i^{eu}(w,b,d)dd.db + q_i \int_{\underline{d}}^{\overline{d}} \int_{\underline{w}}^{w} e_i(x,d)dddx$$

4. Without any minimum wage regulations, the lowest wage offered by firms on each market is the one that maximizes the profit when $F_i(w) = 0$, since there is no positive offered wage that could lie below it. The shape of the profit differs from one market to another, so these minimum wages should also be different. If the institutional minimum wage $\underline{w}$ is above these wages, the market minimum wages equal this institutional minimum wage. Actual minimum wages can therefore be computed as follows: $\underline{w_i} = \max\{\text{argmax}_w \underline{\text{S}_i}(w), \underline{w}\}$
where $\underline{\text{S}_y}$, $\underline{\text{S}_a}$, and $\underline{\text{S}_s}$ refer to the profit of firms offering the lowest wage on each market (i.e, when $F_i(w) = 0$)

The policy increases the mass of workers in age class 2 that remain in the labor force ($e_2 + u_2$) and therefore increases hiring frequency on this market.

1.3.4. Firm Surplus

With this frequency, firms generate a surplus. We use k to denote the match-specific investment that firms devote to each match, and β_i is the cost of this investment per worker at the job creation date according to age class. This parameter allows the investment cost to differ over age classes. For instance, it could account for the fact that a worker with a larger work experience has already accumulated some human capital that makes this investment less costly. Mortensen (1998) shows that the endogenous productivity resulting from this investment when it contributes at a deacreasing rate to productivity generates a realistic wage distribution. Production also depends on an individual productivity component that reflects the age class y_i.

The matches' productivity according to the match-specific investment is therefore given by:

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

where the exogenous parameter $q > 0$ is the share of productivity that results from the firms' human capital investment and where the exogenous parameter $0 < \gamma < 1$ accounts for the decreasing return of the production function according to human capital. The value of the firms' expected surplus is given by:

$$J_0(w) = \frac{y(k) - w + \delta_0 \left(\int_{\underline{d}}^{\overline{d}} I_1^{eu}(w,d) h(d) dd \right) Max(J_1(w), 0)}{r + s + \delta_0 + \lambda_0 (1 - F_0(w))} - \beta_0 k \tag{12}$$

$$J_1(w) = \frac{y(k) - w + \delta_1 \left(\int_{\underline{d}}^{\overline{d}} I^{er}(w,d) I_2^{eu}(w,d) \frac{e_1(w,d)}{e_1(w)} dd \right) Max(J_2(w), 0)}{r + s + \delta_1 + \lambda_1 (1 - F_1(w))} - \beta_1 k \tag{13}$$

$$J_2(w) = \frac{y(k) - w}{r + s + \delta_2 + \lambda_2 (1 - F_2(w))} - \beta_2 k \tag{14}$$

Maximizing equations 12, 13, and 14, subject to k provides the optimal level of this investment chosen by firms. It fully depends on wages. The probability that a firm keeps an employee hired in age class 0 during age class 1 depends on the wage and disutility at work that the worker has in this age class. If the wage is enough to compensate for the disutility, the worker remains employed. In age class 2, workers remain employed if they choose not to resign and not to retire early, $I_2^{eu} = I^{er} = 1$. This decision also depends on the wage and disutility at work. The distribution of workers according to their disutility is not homogeneous according to wages though, because workers with high disutility reject more job offers. Intuitively, workers with a high disutility are less often employed. Yet when employed, they enjoy high wages. The probability that a firm employ a worker at wage w when that worker has disutility d is $e_1(w,d)/e_1(w)$ where $e_1(w)$ denotes the density of workers employed at wage w.

Across age classes 0, 1, and 2, the probability that the firm keeps its employee in the next age class increases with wages, because the higher the wage, the lower the poaching risk. Also, in age class 1, the higher the wage, the less likely workers are to resign or retire. The incentive policy reduces the risk of workers retirement from firms offering high wages. The expected surplus mostly increases for firms offering high wages.

1.4. Equilibrium Conditions

The equilibrium distributions $e_i(.,.)$, $u_i(.,.)$, and $F_i(.)$; the decision vectors; and the equilibrium value of θ_i can be achieved when four conditions are fulfilled, in each market:

- Decision vectors are such that conditions of section 1.2.2 are fulfilled.
- Firms post wages so that equiprofit is guaranteed (equation 11).
- Firms choose the optimal level of human capital investment by maximizing equations 12, 13, and 14, subject to k.
- Firms enter the labor market until all expected profit is exhausted (equation 10).
- Workers' flows in and out of the market for each status and wage level are equal (Appendix A).

The incentive policy raises the profit in age classes 1 and 2. Whether any firm's profit increases only if it offers high wages or not is a crucial question. If the policy raises the level of equiprofit in a market, labor market tightness increases and firms create more jobs. If instead the policy only affects the profit of firms offering high wages, equiprofit might not be affected such that only the wage distribution would change.

We proceed to numerical simulations to compute these equilibrium results.

2. Incentive Policy Simulations: An application to the 2003 French pension reform

2.1. Model Calibration

We use parameter values consistent with the French economy before the reform in 2003. We use data from the 2003 French Labor Force Survey, and retain only men in the sample for the three age classes, as defined in the model. That is, workers can retire at the end of the age class 1, and since the legal retirement age in 2003 was 60, we set the end of the age class 1 at 59 the beginning of this class at 50. For the numerical simulation, we hence assume the three age classes to be: Age class 0 from 20 to 49, age class 1 from 50 to 59, and age class 2 from 60 to 64.[5] Workers younger than 50 years can be considered as unaffected by the reform. Workers over 60 are necessarily affected; they are the target of the reform. Workers aged between 50 and 59 can be affected by the reform through an anticipation effect.

To take into account a potential increase of labour disutility with age, we assume disutility to be distributed as older workers' health conditions are. We use the number of chronic diseases as a proxy for health condition and use the SHARE database to compute the number of chronic diseases. Appendix B details the number of chronic diseases among men aged between 50 and 59. The shape of this distribution leads us to anticipate that workers' disutility follows a log-normal distribution, with μ as the mean and σ as the standard deviation. The values of the model parameters are shown in table 1.

We distinguish two subsets of parameters, according to our calibration. We use the same calibration as Le Duigou (2020). The first subset $\{r, \delta_i, s, p_2, p_3\}$ is based on external information. We use values from Postel-Vinay and Robin (2004) to set the job destruction rate. The age class transition rates depend on the length of the age class: length of classes 0, 1 and 2 are 30, 10, 5 respectively, so $\delta_0 = 1/30$, $\delta_1 = 1/10$,

5. Because we assume workers between 20 and 59 cannot retire, we exclude inactivity from the data for these workers. After 50, many unemployed workers are registered as inactive, because in 2003, job search was not compulsory for unemployed senior workers. We assume the inactive are registered as unemployed rather than retired.

$\delta_2 = 1/5$. The value of pensions p_2 and p_3 corresponds to the French policy before 2003. At retirement age, we set the mean retirement ratio at 0.85, similarly to Hairault *et al.* (2012).

The second subset, $\{\phi, \phi^0, q, y_i, \beta_i, \rho, \gamma, \sigma, \mu, \alpha\}$, is designed to mimic different moments in the economy. The parameters $\{\phi, \phi^0\}$ respectively mimic the contact rate of employed workers (Postel-Vinay and Robin, 2004) and the unemployment rate of workers aged between 20 and 49. Without disutility, considering the observed levels of wages and unemployment, the employment rate of workers aged between 50 and 64 should be higher. We therefore use μ and α to fit correctly the employment rate of the 50-59 and 60-64 age groups. The value of parameter α indicates that the disutility of the 60-64 age group is 50% higher than the disutility of the younger group, assuming 40% more chronic diseases. The parameter σ reproduces the shape of the distribution of the number of chronic diseases among men aged between 50 and 59, for the 5th to 9th decile ratio of the distribution. Appendix B depicts the theoretical distribution of disutility for the 50-59 age group, with calibrated values of μ and σ.

The parameters $\{y_i, \beta_i, \gamma, q\}$ are set to mimic the level and shape of wage distributions over the age classes. Parameters y_0 is set to mimic the mean wage of 20-49 years old and β_0 is normalized to one. The parameters y_1, y_2 and β_1, β_2 capture the wage growth with age due to human capital accumulation. We assume $y_1 = y_2$ and $\beta_1 = \beta_2$, meaning that we assume that there is no significant human capital accumulation between 50-59 and 60-64. These two parameters are set to mimic the 50-59 and 60-64 mean wage. The two remaining parameters of the production function γ and q allow to create wage dispersion (Mortensen, 1998) in the model. We use these two parameters to mimic the 6th and 7th decile of the 20-49 wage distribution. The parameter ρ is set to mimic the 50-59 mean unemployment benefits.[6] We assume here that unemployment benefits never end in the model. This assumption is consistent with the long elegibility period for senior workers in France (3 years followed by some special programs for seniors). Note that we do not address the unemployment rate for the 60 to 64 age group, yet the model, given wages, the unemployment benefits, and the disutility distribution, can reproduce its value of 0%.

6. Calibration is precise at 2% on wage levels and half a percentage point for employment rate.

Table 1. **Model parameter values**

Parameter	Value	Targeted moment
Parameters based on external information		
$\underline{w}$	1	Normalised
β_y	1	Normalised
r	0.04	Discount rate
δ_i	1/n	Age class
s	0.1	Postel-Vinay and Robin (2004)
p_2	0.85*50-59 mean wage	Hairault *et al.* (2012)
p_3	p_2	**No incentive policy**
Parameters based on internal information		
ϕ	3.2	Contact rate of the employed (0.7)
ϕ^0	4.8	20-49 Unemployment rate (9%)
q	0.29	20-49 7th decile (1.92)
y_0	1.6	20-49 Mean Wage (1.79)
$y_1 = y_2$	2.1	50-59 Mean Wage (2.17)
$\beta_1 = \beta_2$	0.85	60-64 Mean Wage (2.27)
γ	0.78	20-49 6th decile (1.73)
ρ	0.5	50-59 Mean unemployment benefits (1)
μ	0.9	50-59 Employment rate (75%)
σ	0.95	Median to the 9th decile of disutility distribution (0.33)
α	1.45	60-64 Employment rate (11%)

2.2. Results

Table 2 lists statistics pertaining to employment, unemployment, retirement rate, mean wage, offered wages and unemployment benefits according to age classes in the benchmark economy.

Table 2. **Benchmark economy before the reform ($p_3 = p_2$)**

Age	Employment	Unemployment	Inactivity	Mean Wage	Mean offered wage	Mean unemployment benefits
20-49	90.9%	9.1%	—	1.779	1.554	0.791
50-69	74.5%	25.5%	—	2.176	2.084	1.012
60-64	11.6%	0%	88.4%	2.303	1.990	—

Source: authors' computations.

Table 3. **Simulation of the economy after the reform ($p_3 = p_2 * 1.15$)**

Age	Employment	Unemployment	Inactivity	Mean Wage	Mean offered wage	Mean unemployment benefits
20-49	90.7%	9.3%	—	1.786	1.564	0.794
50-69	74.5%	25.5%	—	2.222	2.106	1.034
60-64	35.9%	11.7%	52.4%	2.224	1.791	1.265

Source: authors' computations.

The incentive policy of 0.75% per quarter is equivalent to, over five years, a bonus of 15%. Consequently, before the policy $p_3 = p_2$, and after $p_3 = p_2 * 1.15$. Table 3 presents the results of a simulation taking the bonus into account. By comparing the benchmark in table 2 with the economy after the reform in table 3, we observe that the policy increased the employment rate among workers aged 60-64. Some workers responded to the reform by delaying their retirement. Thus, active workers in this age group become more numerous in our theoretical model: from 11.5% to 48%. This result is consistent with research that shows that an incentive policy can raise the employment rate of workers who are over the legal retirement age (Gruber and Wise, 2004; Hanel, 2010; Ferrari, 2019; Belloni and Alessie, 2009; Benallah, 2011). We also assess the theoretical effects on received and offered wages. Before the reform, only very well paid workers were active between 60 and 64, as reflected in the wage increase in table 2 between the 50-59 and 60-64 age classes. This increase results from a mere composition effect; the offered wages decrease between the two age classes. In table 3, after the reform, the selection effect diminishes, because active workers between 60 and 64 of age grow more numerous. The mean wage and offered wage for these workers decrease compared with what prevailed before the reform.

The spillover effect on the 50-59 years old wages.

Beyond this effect on workers over 60 we note the effect of the reform on employment and wage of younger workers too. To understand what happens in this age class, we need to go back to the wage game: Firms have at first interest to pay the lowest wage possible, yet as increasing the wage offer implies raising the probability to hire a worker (speed up the hiring process) and to raise the job horizon, firms can raise their wage as long as their profit does not go below the profit of paying the minimum wage (the equiprofit). Before the incentive policy, very few workers were working after 60. Firms anticipated that they would very likely loose their employee as soon as he or she reached 60. After the policy is implemented, more than a third still work after 60. Firms can anticipate an extended horizon. Yet because of disutility at work, those who remain employed after 60 necessarily have a rather high wage, the other retire early or resign themselves to remain unemployed. Given this possible extended horizon, new wages, at the top of the wage distribution become profitable, some firms therefore decide to raise again their wage offer. Yet, this spreading of wage does not affect the equiprofit of opening a vacancy on the 50-59 years-old market: it is not more profitable to employ someone aged 50-59. It is only more profitable to offer high wages to these workers, firms start offering high wages that used to induce too low a profit before the implementation of the policy. The job creation equation (10) remains unchanged. However, even if we observe no change in employment among workers aged between 50 and 59 the employment rate for those aged between 50 and 64 increases overall from 54% to 61% due to the reform. Beyond this effect on workers aged 60 or older, we note the effect of the reform on younger workers too. In the immediately younger age class, contrary to Hairault *et al.* (2012), we find no effect on unemployment.

Firms do not create more jobs, yet they choose to raise the wage of existing jobs. We obtain this new result as the model accounts for endogenous job creation and wage distribution. According to the simulation, wages increase by 2% (from 2.176 to 2.222). Besides, the model shows that this raise does not occur homogeneously over the wage distribution. It is driven mostly by high paying jobs (see table 4) such that a median wage increases by 1% (from 2.200 to 2.222), but the highest quartile increases by 3.7% (from 2.329 to 2.415). This increase in wages results from an increase in the wage offer (from 2.084 to 2.106) and therefore reflects a change in firms' wage policy. As workers undergo a growing disutility at work with age, those who earn low wages retire early or resign themselves to remain unemployed. Firms acknowledge that the extended horizon comes only at the cost of a rather high wage. The lower paying jobs do not exhibit a lengthened time horizon. Nor does the equiprofit of firms (equation 11); only the wage distribution changes. However, even if we observe no change in employment among workers aged between 50 and 59, the employment rate for those aged between 50 and 64 increases overall from 54% to 61% due to the reform.

Table 4. **Wage increases after the reform ($p_3 = p_2 * 1.15$), 50-59 age class**

	$p_3 = p_2 * 1.15$
Mean	2 %
5th decile	1 %
6th decile	1.9 %
7th decile	2.8 %
75th centile	3.7 %

Source: authors' computations.

Postponing workers' horizon through an incentive policy thus induces a selection effect: Only the best paid workers remain active. Taking into account the firms' behaviors allows us to show that such policies affect wages among the immediately younger age class but not on their employment. With this model, we demonstrate that the positive effect of the reform is limited to the highest paid workers. Theoretically, the main effect of the policy is thus the deformation of the wage distribution, rightwards.

3. Conclusion

We provide some initial evidence that incentive policies designed to delay retirement affects the wage policies adopted by firms. Using a theoretical approach, we show that financial incentives might imply a wage increase for older workers, especially highly paid ones.

We focus on the 2003 French pension reform (implemented in 2004) that gave older workers who decided to postpone their retirement a 0.75% pension bonus per additional quarter worked. The theoretical analysis details the various mechanisms that can explain these results and identify how policy exerts an impact on older workers. The equilibrium search model *à la* Mortensen (Mortensen, 2008), with endogenous retirement and heterogenous work disutility among workers shows that after the reform, the median wage for workers between 50 and 59 years of age increased by 1%, and they rose even more among the highest paid workers. The wage increase therefore appears due to a change in the firms' wage posting behavior. As the horizon grows longer, firms anticipate an extended employment duration for their employees, and offering higher wages becomes more interesting as a means to retain workers. This adjustment occurs at the expense of an adjustment to the quantity of jobs, and therefore at the expense of increased employment. Insiders benefit more from these incentive policies than outsiders. Therefore postponing workers' retirement horizon implies a selection effect: only the best paid are encouraged to remain active.

To improve the effect of financial incentives on the employment of older workers in general and not only at retirement, it would therefore be necessary to accompany them with policies aimed at reducing the inequalities between older workers even before retirement, for example through specific job-search aids for this category of workers and trainings aimed at increasing the employability of older workers in skilled jobs.

Following this research, several extensions could be proposed. The optimal incentive policy could be analysed, taking into account the welfare costs for workers who suffer from high disutility at work at the end of their career but continue to work anyway.

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APPENDIX A. WORKERS' FLOWS

We denote by $u_0(b)$ and $e_0(w)$, the mass of young unemployed and employed workers drawing respectively unemployment benefit b and wage w and by $u_i(b,d)$ and $e_i(w,d)$, the mass of unemployed and employed workers with a disutility d and drawing respectively the unemployment benefit b and the wage w.

We assume that workers' disutility at work is heterogeneous. Let $H(.)$ and $h(.)$ denote respectively the cumulative distribution of d in the population and its associated density function. In steady state, $u_0(\underline{b})$ solves the following flows equation:

$$\left(\lambda \int_{\underline{w}}^{\overline{w}} I_0^{eu}(x,\underline{b}) f_0(x)\ dx + \delta_0\right) u_0(\underline{b}) = \delta_3 m_3 + s e_0(\underline{b}^{-1})$$

For unemployment benefits larger than $\underline{b}$, $u_0(b)$ solves:

$$\left(\lambda \int_{\underline{w}}^{\overline{w}} I_0^{eu}(x,b) f_0(x)\ dx + \delta_0\right) u_0(b) = s e_0(b^{-1})$$

For $i = 1,2$, $u_i(b,d)$ solves:

$$\left(\lambda \int_{\underline{w}}^{\overline{w}} I_1^{eu}(x,b,d) f_1(x) dx + \delta_1\right) u_1(b,d) \\ = \delta_0 u_0(b) h(d) + s e_1(b^{-1},d) \\ + \delta_0\left(1 - I_1^{eu}(b^{-1},b,d)\right) e_0(b^{-1}) h(d)$$

$$\left(\lambda \int_{\underline{w}}^{\overline{w}} I_2^{eu}(x,b,d) f_2(x) dx + \delta_2\right) u_2(b,d) \\ = \delta_1 I^{ur}(b,d) u_1(b,d) + s I^{ur}(b,d) e_2(b^{-1},d) \\ + \delta_1 I^{ur}(b,d)(1 - I_{eu}^2(b^{-1},b,d)) e_1(b^{-1},d)$$

The cumulative distribution functions of wage earned by employed workers of age class 2 with disutility d is noted $G_2(w,d)$ and solve in steady state:

$$\left(\delta_0 + s + \lambda\left(1 - F_0(w)\right)\right) \int_{\underline{w}}^{w} e_0(x) dx = \lambda \int_{\underline{w}}^{w} \int_{\underline{b}}^{\overline{b}} u_0(b) I_1^{eu}(b,x) f_0(x) dx db$$

$$\left(\delta_1 + s + \lambda\left(1 - F_1(w)\right)\right) \int_{\underline{w}}^{w} e_1(x,d)dx$$
$$= \lambda \int_{\underline{w}}^{w} \int_{\underline{b}}^{\overline{b}} u_1(b,d) I_1^{eu}(d,b,x) f_1(x) dx db$$
$$+ \delta_0 \int_{\underline{w}}^{w} e_0(x) h(d) I_1^{eu}(x, b(x), d) dx$$

$$\left(\delta_2 + s + \lambda\left(1 - F_2(w)\right)\right) \int_{\underline{w}}^{w} e_2(x,d)dx$$
$$= \lambda \int_{\underline{w}}^{w} \int_{\underline{b}}^{\overline{b}} u_2(b,d) I_2^{eu}(d,b,x) f_2(x) dx db$$
$$+ \delta_1 \int_{\underline{w}}^{w} e_1(x,d) I^{er}(x,d) I^{eu}(x, b(x), d) dx$$

The mass of early retirees of age class 2 and 3 according to disutility solves as:

$$\delta_2 r_{22}(d) = \delta_1 \int_{\underline{b}}^{\overline{b}} \left(1 - I^{ur}(b,d)\right) u_1(b,d) db$$
$$+ \delta_1 \int_{\underline{w}}^{\overline{w}} e_1(x,d)\left(1 - I^{ur}(b(x),d)\right) (1 - I^{er}(x, b(x), d)))dx$$
$$+ s \int_{\underline{b}}^{\overline{b}} e_2(x,d)\left(1 - I^{ur}(b(x),d)\right) db$$
$$\delta_3 r_{23}(d) = \delta_2 r_{22}(d)$$

The mass of late retirees of age class 3 according to disutility solves as:

$$\delta_3 r_{33}(d) = \delta_2 (h(d) m_2 - r_{22}(d))$$

Given these flow equations, the distribution of disutility among the unemployed, the employed, and the retired is different in steady state. Workers with high disutility are more likely to retire earlier, yet some workers with high disutility can also remain employed if they are employed at a high wage. Both wage and disutility distribution are endogenous.

APPENDIX B. CHRONIC DISEASE AND DISUTILITY

Figure 1. **Distribution of the number of chronic disease among men between 50 and 59**

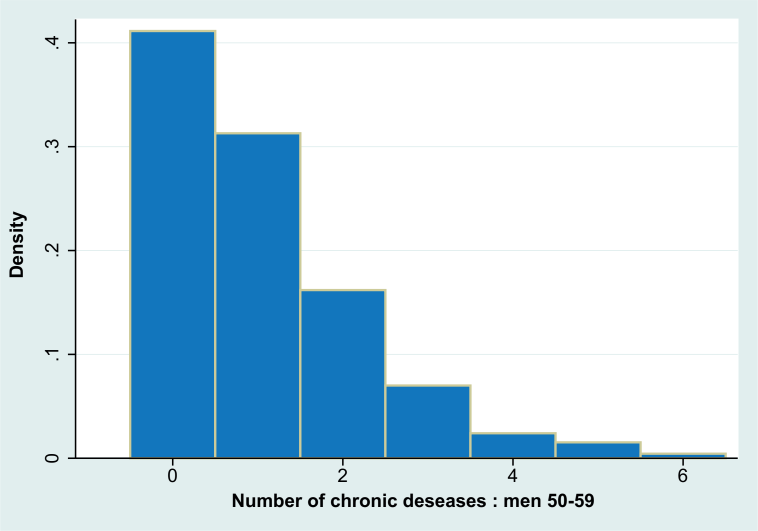

Figure 2. **Theoretical distribution of disutility among people aged between 50 and 59**