The effectiveness of financial incentives to postpone retirement with heteregenous agents
- *Preliminary version-*

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Abstract

This article proposes an evaluation of the effectiveness of financial incentives to delay retirement. First we analyse the French 2003 reform which offer a pension bonus to older workers who decide to postpone their retirement after the legal age. Using regression with discoutinuity, our results highlight that higher accruals have no effect on older workers' employment rate but increase wages. To better understand these results, we construct an equilibrium search model with heterogenous agents in labour desutility and endogenous wages. This model show that financial incentives affect workers, but only high-paid workers and also firms. Finally simulations allow to conclude that taking into account the demand side attenuates the impacts of financial incentives that cause a wage increase and only few new jobs.

Key words: incentives to postpone retirement, heterogenous agents, labour disutility, endegenous wages

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1 Introduction

A major stylised fact about labour force in industrialized countries has been the decline of older male's labour participation since the 60's. In the OECD countries, this participation (males aged 55-64) has falled in the 1960-2014 period from 84.7% to 70%, even recording a level of 62.3% in 1995. In a context of population aging, this low participation questioned the financial sustainability of pension systems (Carpetta, 2007 [**?**]). These concerns are even stronger in Europe, where the participation rates of older workers is significantly lower than in other OECD countries (D'Addio *et al*, 2010 [9]. The participation rate of older workers reached 71% in Japan or 64.1% in the United States while it was only 56.1% in Europe (UE21) and 49.1% in France in 2014. This cross-country variability in older workers participation highlight the impact of institutional differences (Nickell, 1997[23] ; Abowd *et al.*, 1999[3] ; Blanchard and Wolfers, 2000[6] ; Saint-Paul, 2009[25]). Life-cycles models (Gordon and Blinder, 1980[11]) clearly show that older workers compare expected utility of remaining employed and this of leaving the labour market. Finally their retirement behaviour strongly responds to the incentives, in particular those embedded in pension systems: the higher the *implicit tax* from remaining in employment, the higher withdrawal rate from labour market (Gruber and Wise, 1999[13]).

To restore incentives to delay retirement, several policies have been recently implemented. One of them consists in financial incentives which offer a pension bonus, when older workers decide to remain in employment after their full pension age, and/or a discount in pensions for early retirement.

The effectiveness of these financial incentives has been investigated in several empirical studies. Gruber and Wise (2004)[12] proposed 12 country estimates and found a strong impact of financial incentives on retirement decisions, except for two countries (Italy and Spain). More recently, Hanel (2004)[**?**] analysed the effect of a pension reduction for early retirees, introduced in Germany during the 1997-2005 period. Given that this reform was a natural experiment, its causal impact on retirement decisions can be robustly identified. Econometric results showed that given the reform, older workers postpone their retirement date by about 14 months. This clearly states that older workers in Germany respond to incentives. The same findings is found in Italy where a "Super-Bonus" pension was given between 2004 and 2007 to private sector workers who had reached seniority pension requirements and who chose to continue working. Using a differences in differences estimation method, Ferrary (2014) [10] concluded that the reform reduced by 12 percentage points the probability to retire. In the same line, Belloni et Alessie (2009)[1] estimated a quasi reduced form model in which the retirement probability depends on financial incentives and individual attributes. They found that higher financial incentives, that is a decrease of 100000 euros in the current social security wealth and of 10000 euros of the expected change, decreases by 30 percentage points the retirement probability. In France, Benallah (2011)[2] found also a clear effect of financial incentives. The introduction of a bonus in pension in 2003 for those who decide to delay their retirement date allowed a two-months postponement of the retirement age and an increase of 16% of the probability of being employed, but only for seniors who have had long careers.

Beyond the global effectiveness of financial incentives to delay retirement, empirical works underlined heterogenous impacts according to individual attributes. Gender seems to influence the impact of incentives, without consensus on the meaning of this influence. Thus, in Australia Warren and Oguzoglu, 2010([**?**]), men seem to respond better to incentives while in Italy, Belloni and Alessie (2009)([1]), women react more strongly. Moreover, sensitivity to financial incentives depends on expected pensions: the higher pension entitlements, the higher the impact of incentives (Albert *et al.*, 2008[4] ; Hanel, 2010[16]). In fact, the effectiveness of financial incentives clearly depends on individual preferences for leisure and productivity (Van Soest and Vonkova, 2014 [27]). Yet these factors are difficult to observe for econometricians, which could weaken the empirical results because of the likely endogeneity and self-selection bias. Empirical studies also suffer from another weakness. Based on reduced-form models (Gruber and Wise, 2004[12]), they expose themselves to the Lucas (1976)[21]' critique who points out that structural models are best suited to judge the impact of economic reforms. If multiple attempts (Belloni and Alessie, 2013[5]) were made in the literature from the option value model (Stock and Wise, 1990[26]), very few studies have considered the role of employers and therefore the importance of frictions on the labor market. But Chetty *et al.* (2011)[8] emphasize that these frictions could largely mitigate observed labor supply responses to financial incentives. While these incentives change the behavior of workers by extending their horizon in the labor market, in fact incentives also alter the horizon for firms, which are likely to adapt by changing wages, training policies, promotion rules, etc. These changes can in turn influence the behavior of workers. Finally, the observed effect of the reform can integrate impacts both on labor supply and demand, without theoretical works, we are not able to identify the contribution of each mechanism.

Our goal in this article is to propose a new analysis of the effect of financial incentives to delay retirement using a two-stage method. First, we will conduct an empirical analysis on French data. As Benallah (2011)[2], we study the impact of the French 2003 reform which introduced a bonus for those who chose to work beyond the legal age of retirement. However, we propose a more comprehensive analysis taking into account all men and not only those who had a long career (with the Enquete Emploi data). Above all, we propose to estimate, using regressions with discontinuity, the effect of the 2003 reform on both employment probabilities and wages. These evaluations show that incentives of the 2003 reform had indeed an impact on firms' behavior through an increase in seniors' wage.

To understand this wage increase and its consequences, we then develop an equilibrium search model *la* Mortensen (2008)[?] in which retirement is endogenous and thus can be affected by financial incentives. In this model, firms can react to the change in workers' retirement decision (caused by the incentives) by adjsuting job openings and wage offer strategy. Besides, to correctly model the workers' behavior, we augment the Mortensen (2008)[?]'s model with a wage-indexed unemployment benefit and a disutility of work. Given that leisure preference is heterogenous among workers (Van Soest and Vonkova, 2014 [27]), we assume this desutility to be heterogenous as well and to interact with labor market forces. As desutility impacts workers' retirement decisions and their reaction to financial attributes, this desutility also affects firms' wage game. To better understand the effect of financial incentives to offset the retirements, we offer simulations based on our model.

The contribution of this paper is two fold. First, we can assess the effect of financial incentives on retirement decisions by taking into account both heterogeous preferences and firms' behavior. Second, simulations based on our structural model provide clear guidance on economic policy of financial incentives to delay retirements. According to our results, financial incentives are efficient but have heterogenous effects according to the labor desutility. Consequently, a politic based on a unique incentive cannot be efficient for every workers unless this incentive is very high. With a reasonable incentive (close to actuarially fair), workers with high desutility do not delay their retirement despite the policy unless they are employed at a very high wage. For this reason, the raise of horizon in the labor market is observed mostly for the high-paid workers. Finally to take advantage of the extended horizon thanks to financial incentives to delay retirement, firms are incited to offer sufficiently high wages. This could thus explain why the 2003 reform in France contributes to raise wages. Of course, it benefits clearly to insiders and the impact on the global employment is more ambiguous. Only very few new jobs are created as they have to be high-paid jobs. Besides, the wage increase causes a raise in reservation wage of the unemployed, who experience longer unemployment duration.

This paper proceeds as follows. Section 2 gives an owerview of the 2003 reform in France and presents an empirical evaluation of the impact of financial incentives on older workers' employment and wages. Section 3 presents the equilibrium model and its properties. Section 4 discusses the results from simulations. Section 5 concludes.

2 Empirical Evidence

2.1 Methodology and data

The retirement decision of elder workers depends on multiple factors, among them the financial constraint is especially crucial. The main objective of recent reforms in Europe is to make individuals postpone their retirement date in order to increase the employment rate among seniors. Implementing economic incentives is a widespread measure to encourage individuals delaying their retirement.

We estimate the causal effect of the economic incentives on employment rates among senior workers in France. Until the 2003 reform, the pension system did not include any economic incentive. From this date, workers with a complete career who decided to postpone their retirement received a pension increased by 0.75% per additionnal quarter worked. Other major measures were taken simultaneously to improve the sustainability of the Pay-As-You-Go pension system. The number of contribution years to obtain a full pension was increased. Individuals with a long career were also authorized to retire sooner, to avoid them being penalized by the increased contributory period.

The implementation of economic incentives implied a sharp discontinuity in the pensions calculation rules for a part of the population. This situation is consequently an application of the regression discontinuity (RD) design (Hahn et al., 2001[14]; Imbens and Lemieux, 2008[17]; Lee and Lemieux, 2010[20]). The RD method exploits a discontinuity in a treatment assignment to identify a treatment effect (See appendix A). Economic incentives implemented in 2004 constitute the treatment. The known discontinuity is due to changes in the pension calculation rules for individuals with a complete career. Individuals observed after 2004 were exposed to the new economic incentives. Those observed up to 2003 were not. We compare observations just below the threshold year of 2004 with observations just above that threshold in order to determine if economic incentives had an impact on employment rates and wages after 2004. Having a large sample requires, as a first step, including observations for the years 2001 to 2006. We propose then to select smaller samples in order to assess the robustness of our regression. For that reason, discontinuity samples (DS) including years 2001-2005, and 2002-2006 are also tested.

The employment rate being the main objective of French, and european policy makers, we first estimate the impact on the economic incentives on the employment. However, on labor market, not only workers behavior is impacted by the potentially lengthening career horizon: firms probably endogenize the instituionnal framework change and adapt their wage offering strategies. We also estimate the impact of this reform on wages for full time equivalent male workers.

We use the French survey "Enquête Emploi" which is annually conducted in France since 1950. This survey allows providing the official unemployment rate in France. It reports also employment as well as socio-demographic characteristics. We gather data from years 2001-2006, keeping only men to exclude discontinuous careers of women. We select men aged from 50 to 60, and define different age subsamples in order to highlight an impact as precise as possible on senior workers. With a large sample, there is no reason for individuals to be different on both sides of the treshold. However, to avoid a possible bias due to the level of human capital, we introduce the diploma and the seniority in our estimation.

Finally, given our results, we propose quantile regressions (Koenker and Bassett, 1978[18]) to check if economic incentives can impact differently individuals, according to their wage level.

2.2 Results

We test many specifications to check if the implementation of economic incentives effectively encouraged individuals to stay longer in employment. We find no effect (See Table 6). We selected three different age subsamples: 50-60 years old, 50-55 and 56-60 years old. We tried also years subsamples mentionned above. One could expect also from individuals to stay in activity but unemployed. Such a choice leaves the possibility for individuals to find a job and to obtain the increment for deferring their pension. For this reason, we substitute as dependant variable the activity instead of the employment. But once again, there is no effect of the economic incentives. Some reasons could explain the failure of the measure. The main one is the setting up of the specific device for long careers in the 2003 reform. Individuals completing some conditions[1] were authorized to retire early. It seems that those eligible to early retirement choose this option, especially in case of strong risk aversion. Because of institutionnal uncertainty, individuals usually express a strong preference for the retirement instead of a continued activity.
First analysis of the economic incentives conducted in 2008 (Albert et al., 2008[**?**]) reported that 7,6% of the Insured postponed their retirement and benefited from an increased pension. However, in 2003, just before the implementation of this new device, 7% of the Insured completed already all conditions to benefit from it. The authors suspect a windfall for the beneficiaries. Finally the incentives appear quite low to be really incentive: in average 32 euros per month for a retirement at the age of 63 (Albert et al., 2008[**?**]).

[1] Depending on their birthyear, the number of quarters worked before the age of 16 or 20, individuals could be authorized to leave at the ages 56, 57, 58, 59 or 60.

Until now, the literature on retirement and seniors' employment focused mainly on workers' decisions, and firms behaviors were excluded from studies frameworks. However, changes of PAYG pension system parameters, such as economic incentives to postpone retirement, modify the employment horizon of elder workers. This has to be taken into account by employers also. We found that increment for delayed retirement impacts significantly wages for workers aged 50 to 55 (See Table 7). In 2008, Albert et al. reported that mainly high income earners postponed their retirement to benefit from economic incentives. When combining quantile regressions (Koenker and Bassett, 1978[18]) with the RD design, we precise indeed that the significant impact on wages concerns more precisely those with high wages. Depending on the specification used for the function $h(.)$, we estimate that the implementation of economic incentives increased by about 5 to 6% the wages for the 75th percentile[2](See Table 8).

Many different measures were taken simultaneously after the 2003 reform. Consequently, identifying empirically a clear picture of the seniors employment after the implementation of economic incentives seems very difficult. However, the wages increase for part of the elder workers let us guess that the firms behavior confronted with a potentially longer employment relationship should also be taken into account.

3 The Model

3.1 Model Assumptions

3.1.1 Population dynamics

In order to study the effect of the retirement policy on wage and employment of seniors, we augment the [22] model with life cycle and endogenous retirement. We choose to divide the life cycle into four parts. All variables which are dependant on the workers' age class are indexed by i, which can take the value $i = 0$ for the young, $i = 1$ for young seniors who cannot retire, $i = 2$ for older seniors who can retire, and $i = 3$ for retired workers. Workers can have three different status: employed, unemployed, retired. By denoting by u_i and e_i, the mass of unemployed and employed workers of age class i, and r_{ji} the mass of retired workers of age class i who get retired in age class j, we can sum up the composition of workers in each age class by the following:

[2]Our results appear robust to different assumptions about the functionnal form of $h(.)$. We tested also quadratic and cubic forms.

$$m_0 = e_0 + u_0$$

$$m_1 = e_1 + u_1$$

$$m_2 = e_2 + u_2 + r_{22}$$

$$m_3 = r_{32} + r_{33}$$

The mass of the population of each age class is noted m_i. We assume the economy is in steady state. At each period, the probability of aging equals δ_i and the arrival of new born agents replace an equal number of dead retired workers, there is no labor force growth. Masses m_i therefore solve:

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

3.1.2 Employment opportunity

Workers search for a job when unemployed and employed. Firms and workers meet according to the following matching process:

$$M_i = v_i \left(\phi^0 u_i + \phi e_i\right)^1$$

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

We set $\theta_i = \frac{v_i}{{}^0 u_i + \ e_i}$, the labor market tightness on each market. The meeting frequencies between workers and firms are given by:

$\lambda_i = \phi\theta_i^1$ and $\lambda_i^0 = \phi^0\theta_i^1$, for employed and unemployed workers

$q_i = \phi\theta_i$ and $q_i^0 = \phi^0\theta_i$, for firms to contact an employed or an unemployed worker

The cumulative distribution of wage offered by firms on each market whatever the worker's status is denoted by $F_i(.)$.

3.2 Workers' Behavior

3.2.1 Bellman Equations

From age class 1, we assume workers can undergo a desutility at work denoted by d. We assume this desutility is attached to the worker and is heterogenous among workers. Let $V_i^e(.)$ denote the value in each age class of the optimization problem of an employed worker according to his wage, and his desutility at work if he has some:

$$rV_0^e(w) = w + \lambda_0 \int_{w}^{\overline{w}} (V_0^e(x) - V_0^e(w))dF_0(x) - s(V_0^e(w) - V_0^u(b(w))) - \delta_0(V_0^e(w) - Max(V_1^e(w), V_1^u))$$

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

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

where $V_i^u(.)$ is the value of being unemployed according to unemployment benefits and the worker's desutility and V_{ii}^r the value of retiring in age class i. 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 the rate s. Retirement is endogenous as workers can choose to retire when he ages from age class 1 to 2, or if he looses his job during 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 value of being unemployed in each age class $V_i^u(.)$ according to unemployment benefits and desutility at work solves:

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

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

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

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

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

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

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

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

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

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

During age class 3, the early retired keep on receiving the pension p_2 and the other receives the pension p_3.

3.2.2 The incentive policy

The incentive policy suggests that pensions raise when workers work longer, that is $p_3 > p_2$. Both an increase in p_3 or a decrease in p_2 widens 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 being early retired.

3.2.3 Employment and Retirement Decisions

Workers make several decisions on the labor market: they choose when to retire whether they are employed or unemployed, when to resign if employed, and when to accept a job if unemployed. These arbitrages occur therefore between the three status: unemployment and employment, employment and retirement, and unemployment and retirement. We define decision matrix that sum up the 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 $V_0^{e}(w) < V_0^{u}(b)$.
- 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 $V_i^{e}(w,d) < V_i^{u}(b,d)$.
- 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 $V_2^{u}(b,d) < V_{22}^{r}$.
- 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.

The incentive policy affects I^{ur} and I^{er}. This policy induces workers (both employed and unemployed) to delay their retirement. This result is consistent with [15]. The sensibility of the workers' decision to retire early to the policy depends on three other parameters: the desutility of workers, the firms' wage posting behavior, and the generosity of unemployment benefits.

- In age class 1 and 2, workers' desutility decreases directly the value of being employed and indirectly the value of being unemployed through job opportunities. It therefore affect negatively the value of being active on the labor market (I^{er} and I^{ur}) and within the labor market the value of being employed (I_i^{eu}). Workers with high desutility at work are therefore more induced to retire early, to resign or to have long unemployment spells.

- Wages raise directly the value of being employed. The global offered wage distribution raises indirectly the value of being unemployed through job opportunities. The existence of high wages therefore raise the value of being active on the labor market (I^{er} and I^{ur}) and within the labor market the value of being employed (I_i^{eu}). Individually, workers with high wages are less induced to retire early and to resign. Besides, in an economy with high offered wages, workers (both employed and unemployed) are less induced to retire early.

- Unemployment benefits raise directly the value of being unemployed and indirectly the value of being employed. They therefore raise the value of being active on the labor market (I^{ur} and I^{er}) and within the labor market the value of being unemployed (I_i^{eu}). Individually, unemployed workers with high unemployment benefits are less induced to retire early yet have longer unemployment spells. Besides, in an economy with generous unemployment benefits, workers (both employed and unemployed) are less induced to retire early.

Through these decisions, the incentive policy affects the mass of workers according to their status, wages and unemployment benefits.

3.2.4 Workers' Flows of Seniors

We denote by $u_i(.)$ and $e_i(.)$, the mass of unemployed and employed workers according to respectively unemployment benefits and the wage, and according to the desutility for $i = 1, 2$. The workers' decision made during age class 2 affects greatly the workers' flows on the labor market of senior. We present here the workers' flows of seniors (age class 2) and the workers' flows of the other populations are presented in appendix C, page 25. The density function of workers' desutility is denoted by $h(.)$. In steady state, the cumulative distribution attached to the density $e_2(w, d)$ according to the wage $\int_{\underline{w}}^{w} e_2(x, d)dx$ solves the following flow equation:

$$(\delta_2 + s + \lambda_2(1 - F_2(w))) \int_{\underline{w}}^{w} e_2(x, d)dx = \lambda_2^0 \int_{\underline{w}}^{w} \int_{\underline{b}}^{\overline{b}} u_2(b, d) I_2^{eu}(d, b, x) f_2(x) dx db + \delta_1 \int_{\underline{w}}^{w} e_1(x, d) I^{er}(x, d) I^{eu}(x, b(x), d) dx$$

Workers employed at a wage no greater than w leave employment of age class 2 by getting older, being laid off, or finding a better job opportunity. Workers' decision to retire early when employed affects the flow in employment via I^{er}. Employed workers of age class 1 remain employed in age class 2 if both $I^{er} = 1$ and $I_2^{eu} = 1$. In steady state, $u_2(b, d)$ solves the following flows equation:

$$\left(\lambda_2^0 \int_{\underline{w}}^{\overline{w}} I_2^{eu}(x,b,d) f_2(x)\ dx + \delta_2\right) u_2(b,d) =$$

$$I^{ur}(b,d)\left(\delta_1 u_1(b,d) + s e_2(b^{\;1},d)\right) + \delta_1 I^{ur}(b,d)\left(1 - I_2^{eu}\left(\frac{b}{\rho}, b, d\right)\right) e_1(b^{\;1},d)$$

In age class 2, workers exit unemployment of age class 2 either by finding a job or getting older. Workers' decision to retire early when unemployed affects the flow in unemployment via I^{ur}. Unemployed workers of age class 1 and laid off employed workers remain unemployed only if $I^{ur} = 1$. Employed workers of age class 1 becomes unemployed if they'd rather resign $I_2^{eu} = 0$ yet do not retire $I^{ur} = 1$.

Given these workers' choices, the mass of early retirees of age class 2 solves:

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

Early retirees arrive from unemployment when being retired is preferred to being unemployed, $I^{ur} = 0$, and from employment of age class 1 when being retired is preferred to being unemployed and employed, $I^{er} = 0$ and $I_2^{eu} = 0$.

The incentive policy raises the mass of employed workers via I^{er} and the mass of unemployed workers via I^{ur}. After implementing an incentive policy, new workers, with higher desutility at work or lower wage or unemployment benefits than the other active workers are ready to delay their retirement.

3.3 The Firms' Behaviour

The incentive policy can affect the two decisions of firms: the job creation decision, and the wage posting decision. We assume firms can direct their search on workers' age classes. [3] There are therefore three labor markets: $i = 0, 1, 2$. We assume firms cannot observe the desutility at work, the status and the reservation wage of workers yet they are aware of the distribution of workers according to these characteristics.

3.3.1 Hiring Frequency of Firms

The hiring frequency depends on the mass of workers ready to accept a given wage. Firms can recruit both unemployed and employed workers, this frequency depends therefore on the

[3] They 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.

distribution of workers according to their current wage, unemployment benefits and desutility. Firms hire workers at the following frequencies according to the offered wage:

$$
\begin{aligned}
h_0(w) &= q_0^0 \int_{\underline{b}}^{\overline{b}} u_0(b) I_0^{eu}(w,b)db + q_0 \int_{\underline{w}}^{w} e_0(x)dx \\
h_i(w) &= q_i^0 \int_{\underline{b}}^{\overline{b}} \int_{\underline{d}}^{\overline{d}} u_i(b,d) I_i^{eu}(w,b,d)dd.db + q_i \int_{\underline{d}}^{\overline{d}} \int_{\underline{w}}^{w} e_i(x,d)dddx
\end{aligned}
$$

The policy raises the mass of workers of age class 2 in the labor force (e_2+u_2) and therefore raises the hiring frequency on this market. Yet in presence of generous unemployment benefits, when the policy is implemented workers with a high desutility at work can choose to be unemployed with a high reservation wage rather than retiring, when early retirement becomes less profitable. In that case, the hiring frequency mostly raise for firms offering high wages.

3.3.2 Surplus of Firms

With this frequency, firms generate a surplus $J_i(w)$. We denote by k the match specific investment that firms can operate on each match, and β_i, the cost of this investment per worker at creation date. [22] shows that the endogenous productivity resulting from this investment allows to generate a realistic wage distribution. It is therefore necessary to introduce this component here.

This investment yield the following matches' productivity:

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

With q and α strictly positive and exogenous. The value of the firms' expected surplus is given by:

$$
\begin{aligned}
J_0(w) &= \frac{y(k) - w + \delta_0 \left(\int_{\underline{d}}^{\overline{d}} I_1^{eu}(w,d)h(d)dd \right) Max(J_1(w),0)}{r + s + \delta_0 + \lambda_0(1 - F_0(w))} - \beta_0 k && (1) \\
J_1(w) &= \frac{y(k) - w + \delta_1 \left(\int_{\underline{d}}^{\overline{d}} I^{er}(w,d) I_2^{eu}(w,d) \frac{e_1(w;d)}{e_1(w)} dd \right) Max(J_2(w),0)}{r + s + \delta_1 + \lambda_1(1 - F_1(w))} - \beta_1 k && (2) \\
& && (3) \\
J_2(w) &= \frac{y(k) - w}{r + s + \delta_2 + \lambda_2(1 - F_2(w))} - \beta_2 k && (4)
\end{aligned}
$$

Maximizing equation 1, 2, and 4 subject to k leads to the optimal level of this investment chosen by the firms. This level fully depends on wage, see appendix **??**.

The probability for a firm to keep its employee hired in age class 0, during age class 1 depends on the wage and the desutility at work that the worker has in age class 1. Given this desutility, if the wage is enough to compensate it, the worker remains employed, otherwise he resigns. 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 the desutility at work. The repartition of workers according to their desutility is not homogenous according to workers' wage since workers with high desutility reject more job offers. Intuitively, workers with a high desutility are less often employed yet when employed are employed at a good wage. The probability for a firms employing a worker at a wage w that his worker has the desutility d is $\frac{e_1(w;d)}{e_1(w)}$. With $e_1(w)$, the density of workers employed at a wage w.

In both age class 0, 1 and 2, the probability for the firm to keep its employee in the next age class is increasing in wage because the higher the wage, the lower the poaching risk. Besides, in age class 1, the higher the wage, the less likely workers resign or retire. The incentive policy reduces the risk of the worker's retirement for firms. Yet, here again, in presence of generous unemployment benefits, when the policy is implemented, workers with a low wage can choose to resign rather than retiring, when early retirement becomes less profitable. In that case, the expected surplus mostly raises for firms offering high wages.

3.3.3 Wage Posting Decision

The global firms' expected profit according to the wage is given by:

$$\Pi_i(w) \quad = \quad h_i(w)J_i(w)$$

As in [7], wages are posted by firms and there is no negotiation over them. At equilibrium, on each market, firms spread out their wage offer to insure the equiprofit. Low wages yield low hiring frequency and low job tenure yet a high immediate profit. High wages the other way around. This wage posting game generates a wage distribution on an interval $[\underline{w};\overline{w}]$. The offered wage distribution F_i solves the following equiprofit condition:

$$\Pi_i(\underline{w_i}) = \Pi_i(w) \tag{5}$$

The incentive policy raises the expected profit in age class 1 and 2. In presence of generous unemployment benefits and given the desutility at work of workers, this increase occur in particular for firms offering rather high wages. In this case, this policy is likely to affect the offered wage distribution in age class 1 and 2 by inducing more firms to offer higher wages.

3.3.4 Job Creation Decision

At equilibrium, firms enter each market as long as this equiprofit is superior to the vacancy cost, denoted as c. We denote by $\Pi_i(\theta)$ the profit of the firms targeting age class i according to the labor market tightness. The labor market tightness on each market therefore solves the following free entry condition:

$$\Pi_i(\theta_i) = c \tag{6}$$

Appendix D, 26 explains in details how this free entry condition is derived. The labor market tightness on each market, which depends on the firms' profit, drives the meeting frequencies between firms and workers. Given the section 3.1.2, the higher the labor market the higher the exit rate from unemployment.

3.4 Equilibrium Conditions

Equilibrium distributions $e_i(.,.)$, $u_i(.,.)$ and $F_i(.)$, the decision vectors, and the equilibrium value of θ_i are reached when four conditions are filled together, in each market:

- Decision vectors are such that conditions of section 3.2.3 are fulfilled.
- Firms post wages so that equiprofit is guaranteed (equation 5).
- Firms enter labor market until all expected profit is exhausted (equation 6).
- In and out workers' flows for each status and level of wage are equal (appendix C, page 25).

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

4 Results of Policy Simulations

The incentive policy raises profit in age class 1 and 2. Whether the profit of firms is raised only for high wages or for any firm is crucial to study job creation. If the policy raises the level of equiprofit on a market, the labor market tightness raises and firms create more jobs on this market. Yet if this policy only affect the profit of firms offering high wages, it is possible that equiprofit is not impacted and that only wage distribution is changed.

We give parameters values consistent with French economy before the reform. In 2003, French government implemented the incentive policy that corresponds, on a five years period, to a bonus of 15%. Consequently, before the policy $p_3 = p_2$ and after $p_3 = p_2 * 1.15$. Data of employment status and wages are given in table 4.

Table 1: Data

	Employment	Unemployment	Inactivity	Mean Wage	Mean UB
20-50	88%	8%	4%	2.1	0.9
50-60	73%	5.3%	21%	2.5	1.05
60-65	7.7%	0.3%	92%	2.7	-

Because we assume in the model that workers between 20 and 60 cannot retire since the legal retirement age is 60 years old in 2003, we need to exclude inactivity from the data of workers between 20 and 50 years old. Among the age class, employment rate becomes $\frac{88\%}{0:96} = 92\%$ and unemployment rate $\frac{8\%}{0:96} \simeq 8\%$. From the age of 50, a large part of unemployed are registered as inactive because in 2003, job search was not compulsary for unemployed senior workers. We assume $21\% - 4\% = 17\%$ of the inactive can be registered as unemployed. All figures are rounded up to unity. We therefore calibrate the model on the data given by the table 4.

Table 2: Data used for calibration

	Employment	Unemployment	Inactivity	Mean Wage	Mean UB
20-50	92%	8%	-	2.1	0.9
50-60	78%	22%	-	2.5	1.05
60-65	8%	0%	92%	2.7	-

Given the observed levels of wages and unemployment, employment rate of workers between 50 and 65 ought to be higher. To fit correctly the data we choose to introduce the desutility of work that is indeed increasing with age (Gielen, 2009) and can interact with employment decision of workers at the end of their career (Currie et Madrian, 1999, Cai et Kalb, 2006, Garcia-Gomez, 2011). We assume for now that desutility is homogenously distributed.

Parameters based on external information		
Parameter	Value	Moment targeted
r	0.04	Discount rate
δ_i	1/n	Age class
$\underline{w}$	1	Normalised
β_y	1	Normalised
p_3	p_2; $p_2 * 1.15$; $p_2 * 1.25$	Policy
Calibrated parameters		
s	0.07	Unemployment rate(20-50) (8%)
ϕ^0	8	Unemployment duration (20-50) (1.21 an)
ϕ	2	Job to Job transition (20-50) (7%)
q	0.255	C75 (20-50) (2.3)
γ	0.8	Median Wage (1.57)
y_0	1.8	Mean Wage (20-50) (2.13)
$y_1 = y_2$	2.16	Mean Wage (50-60) (2.52)
$\beta_1 = \beta_2$	0.7	$C75_1/C75_2$ (1.17)
ρ	0.45	Mean Unemployment Benefits (0.95)
p_2	2.3	Retirement Replacement rate (0.9)
$\overline{d}$	1.5	Retirement rate (0.92)
α	1.2	Employment rate (50-60) (0.78)

The simulation of the model gives the table 4. This table includes the wages offered by the firms. According to the model, the higher wage observed among the 60-65 are the result of the report of the highest wages from the previous age class (a selection effect), and not the result of the creation of new well-paid jobs since firms offer in reality very few jobs and jobs with a

Table 3: Simulation of the economy before the reform ($p_3 = p_2$)

	Employment	Unemployment	Inactivity	Mean Wage	Mean Offered Wage	Mean UB
20-50	92%	8%	-	2.13	1.85	0.9
50-60	77%	23%	-	2.52	2.34	1.04
60-65	8%	0%	92%	2.77	1.37	-

low wage to these workers due to the horizon effect.

By comparing the benchmark economy of the table 4 with the economy after the 2004 reform of the table 4, we observe that the incentive policy has indeed rosen the employment rate of 60 to 65 workers. Part of them decide thanks to the reform to delay their retirement. This result is already well established in the literature. Yet, how does this increase in horizon affect the labor market of younger workers. In the direct previous age class, firms decide to raise their wage offer since they know that the increase of horizon occurs only at this price. As in the empirical analysis, wage increase occurs in particular among high paid jobs since the median wage is raised by 12% when the third quartile (p75) by 17%. Lower paid jobs experience no lengthened horizon. Consequently the equiprofit of firms actually does not raise. On the contrary the expected return of job search increases for workers, consequently their reservation wage raises. This induces a pervert effect on employment of 50-60 years-old workers. The report of the higher wages of the 50-60 induces a wage raise among the 60-65. This raise is not yielded by a change in firms' behavior on this market since the offered wages do not change.

In table 4, we present the economy if an incentive twice as large as what has been implemented in 2003 were implemented. This policy has been implemented in January 2009. The employment and activity rate keeps raising among the 60-65. As a larger part of workers are employed at these ages, firms' profit targeting the previous age class increases slightly compared to the economy with the smaller incentive and this has a positive consequence on employment of workers of 50 to 60 years old. Firms keep on offering higher wages to 50-60 workers due to this raise in the activity rate. Because active workers are now more numerous, firms start targeting 60-65 workers more massively and offer them higher wage.

Table 4: Simulation of the economy after the reform ($p_3 = p_2 * 1.15$)

	Employment	Unemployment	Inactivity	Mean Wage	Mean Offered Wage	Mean UB
20-50	92%	8%	-	2.08	1.88	0.8
50-60	68%	32%	-	2.9	2.69	1.1
60-65	35%	0%	65%	3	1.37	-

Postponing the workers' horizon thanks to an incentive policy is not neutral and has different effects on the labor market than postponing legal retirement age for instance. Indeed, this incentive induces a selection effect: only the best paid workers are induced to remain active.

Table 5: Simulation of the economy after the reform ($p_3 = p_2 * 1.25$)

	Employment	Unemployment	Inactivity	Mean Wage	Mean Offered Wage	Mean UB
20-50	92%	8%	-	2.04	1.85	0.8
50-60	69%	31%	-	3.1	2.88	1.11
60-65	55%	10.1%	34%	3	2.03	-

Taking into account both employment and wages is important when it comes to assess such policies. Indeed, without taking into account the effect of such policy on the wage distribution, the effects on employment are significant (Hairault et al. (2010)). Yet we observe in this model that this positive effect sticks to the highest paid workers. Only profits of high paid jobs raise and the main effect of the policy is the translation of the wage distribution rightwards. This result is rather consistent with the empirical part.

5 Conclusion

In this paper, we choose to study the effect of incentive policy to delay retirement on the labor market of active seniors. According to our empirical and theoretical results, the increase in horizon induced by this policy has mostly for consequence an increase in wage. This increase in wage is according to our theoretical analysis due to a change in the firms' wage posting behavior. This adjustment by the wage offered by firms occurs at the expense of an adjustment by the quantity and therefore at the expense of employment.

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A RD Design: the model

In the sharp RD design, the treatment assignment depends in a deterministic way on a variable Z with a known discontinuity at point Z_0. The assignment of the treatment is totally time dependent: all people retiring from 2004 are treated, while those retired before are not.
Let denote p_i the indicator for assignment to the incentive, the rule is then:

$$p_i = \begin{cases} 1 & \text{if } Z_i \geq Z_0 = 2004 \\ 0 & \text{otherwise} \end{cases}$$

With Z_i the year for observation i and Z_0 the threshold, fixed at 2004. The empirical approach exploits the discontinuity in pension calculation from 2004. We are interesting in observing if the incentive policy impacts significantly the outcome variable denoted Y. We study both the employment and the wage (in log).
Let Y_1 represent the potential outcome if the individual receives the treatment, i.e. is exposed to economic incentives to postpone his retirement date, and Y_0 the potential outcome in case of no exposition. The objective is to estimate the average treatment effect at the threshold Z_0. This average treatment effect (ATE) can be expressed as $ATE = E[Y_1 - Y_0|Z = Z_0]$.

When the support of Z is continuous, non-parametric and semi-parametric procedures for estimation are appropriate (Hahn et al., 2001[14]; Porter, 2003[24]). However, when the support of Z is discrete, taking J different values, Lee and Card (2008) show that parametric methods should be preferred. Identification of the ATE can be achieved by estimating the following regression function:

$$E[Y|Z = z_j] = \beta_0 p_j + h(z_j) \tag{7}$$

Where $h(.)$ is a continuous function capturing the time trend effect on the outcome variable, and $p_j = 1[z_j \geq 0]$. The assignment variable Z, here the observation year, is normalized so that the discontinuity point is represented by $z_j = 0$. As consequence, $z_j =$ year of observation $-$ 2004. The key identification assumption is the continuity of $h(.)$. Introducing covariates(X) in our model, equation [7] can be also express as :

$$Y_{ij} = \beta_0 p_j + h(z_j) + \delta X_i + \epsilon_{ij} \tag{8}$$

With the specification [8], and under this assumption, the treatment effect β_0 is obtained by estimating the discontinuity in the empirical regression at the point where treatment switches from 0 to 1, in our case at year 2004.

In [8], Y_{ij} is the outcome variable for the i^{th} individual, in year j, i.e. the j^{th} value of the assignment variable Z. The hypothesis that $h(.)$ is smooth implies that, controlling other characteristics, the economic incentive (i.e. the treatment) is the only source of discontinuity in the outcome variable in year 2004. It is common practice to regress Y_{ij} on $h(.)$ assuming it is a low order polynomial function. If the polynomial function assumed is correct, conventional least squares inference is appropriate (Lee and Card, 2008[19]). Two different forms are assumed for $h(.)$: a linear form, and a spline linear function.

B Estimates tables results

Table 6: Estimate of the employment rate among elder workers

	50-60 years old	50-54 years old	55-60 years old
CAP-BEP (Youth Training, BTEC First Diploma)	0.207***	0.069***	0.079***
	(90.022)	(16.769)	(16.514)
A-levels	0.163***	0.081***	0.120***
	(50.689)	(14.726)	(17.926)
Diploma of higher education	0.337***	0.109***	0.178***
	(67.063)	(18.183)	(20.954)
Master's diploma	0.299***	0.138***	0.317***
	(89.058)	(30.105)	(57.765)
Treatment 0/1	-0.005	0.001	-0.011
	(-1.269)	(0.195)	(-1.357)
Normalized assignment variable (Z)	0.004**	-0.004	0.003
	(2.449)	(-1.277)	(0.756)
$Z * I(Year > 2004)$	-0.010***	0.005	-0.014***
	(-4.434)	(1.324)	(-2.899)
Constant	0.216***	0.789***	0.518***
	(66.064)	(122.716)	(66.927)
R^2	0.067	0.018	0.041
N	2.66e+05	46940.000	62122.000

$*p < 0.10, **p < 0.05, ***p < 0.01$

Models are estimated with a sample including years 2001-2006.

Table 7: Wages estimates among elder workers

	50-60 years old	50-54 years old	55-60 years old
CAP-BEP (Youth Training, BTEC First Diploma)	0.116***	0.096***	0.147***
	(16.741)	(11.161)	(12.707)
A-levels	0.400***	0.370***	0.443***
	(37.074)	(26.867)	(25.624)
Diploma of higher education	0.571***	0.545***	0.612***
	(38.387)	(33.754)	(20.789)
Master's diploma	0.892***	0.859***	0.936***
	(61.758)	(47.146)	(40.579)
Seniority under 1 year	-0.260***	-0.210***	-0.364***
	(-11.934)	(-7.900)	(-9.653)
Seniority between 1 and 5 years	-0.188***	-0.163***	-0.235***
	(-18.038)	(-13.832)	(-11.573)
Temporary contract	-0.280***	-0.319***	-0.212***
	(-10.166)	(-8.771)	(-5.074)
Treatment 0/1	0.016	0.038**	-0.019
	(1.180)	(2.278)	(-0.850)
Normalized assignment variable (Z)	-0.007	-0.012*	0.001
	(-1.432)	(-1.867)	(0.089)
$Z \times I(Year \geq 2004)$	-0.007	-0.012	-0.003
	(-0.950)	(-1.301)	(-0.223)
Constant	7.330***	7.327***	7.335***
	(602.759)	(478.185)	(368.652)
R^2	0.279	0.270	0.294
N	21982.000	13455.000	8527.000

$*p < 0.10, **p < 0.05, ***p < 0.01$

Models are estimated with a sample including years 2001-2006.

Table 8: Wages estimates among 50-54 years old workers

	25th percentile	50th percentile	75th percentile
CAP-BEP (Youth Training, BTEC First Diploma)	0.090***	0.107***	0.090***
	(10.999)	(11.914)	(8.240)
A-levels	0.313***	0.407***	0.448***
	(25.281)	(29.961)	(27.152)
Diploma of higher education	0.472***	0.574***	0.622***
	(32.046)	(35.491)	(31.720)
Master's diploma	0.780***	0.895***	1.005***
	(56.453)	(58.940)	(54.548)
Seniority under 1 year	-0.207***	-0.189***	-0.182***
	(-11.874)	(-9.843)	(-7.832)
Seniority between 1 and 5 years	-0.182***	-0.166***	-0.157***
	(-17.347)	(-14.435)	(-11.223)
Temporary contract	-0.339***	-0.232***	-0.239***
	(-14.314)	(-8.900)	(-7.578)
Treatment 0/1	0.025	0.016	0.052**
	(1.611)	(0.913)	(2.488)
Normalized assignment variable (Z)	-0.007	-0.005	-0.018**
	(-1.199)	(-0.835)	(-2.367)
$Z * I(Year > 2004)$	-0.004	-0.008	-0.006
	(-0.463)	(-0.831)	(-0.503)
Constant	7.121***	7.303***	7.508***
	(508.063)	(474.312)	(401.960)
N	13455	13455	13455

$*p < 0.10, **p < 0.05, ***p < 0.01$

Models are estimated with a sample including years 2001-2006.

C Workers' flows

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

We assume that workers' desutility at work is heterogenous. The cumulative distribution of d in the population is denoted by $H(.)$, its associated density function by $h(.)$. 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:

$$\begin{aligned}
&\left(\lambda \int_{\underline{w}}^{\overline{w}} I_1^{eu}(x,b,d) f_1(x)\ dx + \delta_1\right) u_1(b,d) = \\
&\qquad \delta_0 u_0(b) h(d) + s e_1(b^{\ 1}, d) + \delta_0 (1 - I_1^{eu}(b^{\ 1}, b, d)) e_0(b^{\ 1}) h(d) \\
&\left(\lambda \int_{\underline{w}}^{\overline{w}} I_2^{eu}(x,b,d) f_2(x)\ dx + \delta_2\right) u_2(b,d) = \\
&\qquad \delta_1 I^{ur}(b,d) u_1(b,d) + s I^{ur}(b,d) e_2(b^{\ 1}, d) + \delta_1 I^{ur}(b,d)(1 - I_{eu}^2(b^{\ 1}, b, d)) e_1(b^{\ 1}, d)
\end{aligned}$$

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

$$\begin{aligned}
(\delta_0 + s + \lambda(1 - F_0(w))) \int_{\underline{w}}^{w} e_0(x) dx &= \lambda \int_{\underline{w}}^{w} \int_{\underline{b}}^{\bar{b}} u_0(b) I_1^{eu}(b,x) f_0(x) dx db \\
(\delta_1 + s + \lambda(1 - F_1(w))) \int_{\underline{w}}^{w} e_1(x,d) dx &= \lambda \int_{\underline{w}}^{w} \int_{\underline{b}}^{\bar{b}} u_1(b,d) I_1^{eu}(d,b,x) f_1(x) dx db \\
&+ \delta_0 \int_{\underline{w}}^{w} e_0(x) h(d) I_1^{eu}(x, b(x), d) dx \\
(\delta_2 + s + \lambda(1 - F_2(w))) \int_{\underline{w}}^{w} e_2(x,d) dx &= \lambda \int_{\underline{w}}^{w} \int_{\underline{b}}^{\bar{b}} u_2(b,d) I_2^{eu}(d,b,x) f_2(x) dx db \\
&+ \delta_1 \int_{\underline{w}}^{w} e_1(x,d) I^{er}(x,d) I^{eu}(x, b(x), d) dx
\end{aligned}$$

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

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

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

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

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

D Free Entry Condition

To better understand the intuition behind the wage game of firms described by [**?**], 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 (here, the minimum wage). 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, [**?**] show that at equilibrium, when firms have equiprofit, this wage game generates a wage distribution on an interval $[\underline{w};\overline{w}]$. Without any minimum wage regulations, the lowest wage offered by firms on each market is the wage which maximizes the profit when $F_i(w) = 0$. [4] As the shape of the profit is different from one market to another, it is likely that these minimum wages would also be different. If the institutional minimum wage $\underline{w}$ is above these wages, then the market minimum wages will equal this institutional minimum wage. Actual minimum wages can therefore be computed as follows:

$$\underline{w_i} = \max\{\operatorname*{argmax}_w \underline{\Pi_i}(w), \underline{w}\} \tag{9}$$

with $\underline{\Pi_y}$, $\underline{\Pi_a}$ and $\underline{\Pi_s}$ the profit of firms offering the lowest wage on each market (i.e. when $F_i(w) = 0$).

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