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# Why are the older workers discriminated in hirings?\*

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## Abstract

The theoretical part of this paper provides the foundations of three statistical discriminations that are specific to the older workers: employers can think that a senior is characterized by *(i)* a shorter distance to the retirement age, *(ii)* a larger distance to the technological frontier, and/or *(iii)* a smaller ability to move from old toward new occupations than a younger worker. In the empirical part of the paper, a controlled experiments is designed in order to test each of these statistical discriminations. We also present a "pure" discrimination equilibrium and a controlled experiments specific to this assumption. Our empirical results, based on data collected in France, support the view that the older worker are discriminated in the hiring process via these 4 channels. This suggests that the French gap in the employment rate of the older workers is partially explained by significant discriminations.

JEL Classification : E32, J11, J23

Keywords: search, matching, life-cycle, discrimination, correspondence test

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# 1 Introduction

In all European countries, the 90s have been the times of the reforms insuring the sustainability of their pension system: the retirement age has been postponed or the number of contributive periods has been extended (see Gruber and Wise (1999), (2007) and (2010)). These reforms will succeed if workers will work longer, i.e. if the employment rates of the older workers. But, there always exist controversies when these reforms are been implemented<sup>1</sup>: can we ask older people to work longer, while they are less likely than other groups of workers to have a job? If the labor demand addressed to older workers is low, incentives to work longer by postponing the retirement age could not be enough (policy targeting labor supply). Indeed, one can think that we must first put the seniors on the technological frontier to make them employable, or/and allow them to perform more easily job transitions (policy targeting labor demand). This diagnosis is important for economic policy because if the labor demand is sensitive to age, as the labor supply, then pension reforms must be accompanied so that they lead to a significant increase in the employment of seniors.

This paper analyzes the hiring process in order to identify the factors that can explain discrimination against seniors on the labor market. Firstly, we provide theoretical foundations of the statistical discrimination specific to older workers, distinguishing 3 channels: *(i)* the distance to the retirement age, *(ii)* the distance to the technological frontier, and *(iii)* the ability to move from old toward new occupations. To identify each of these channels, we design a specific controlled experiments in order to test if each of these sources of statistical discrimination against older workers exists. Secondly, we present a "pure" discrimination equilibrium for the labor market and propose a controlled experiments specific to this assumption.

All our theoretical analysis is based on extended versions of the search and matching model à la Diamond-Mortensen-Pissarides (DMP) where life-cycle features are introduced as it is done in Hairault, Langot and Sopraseuth (2010), Chéron, Hairault and Langot (2011) and (2013), Menzio et al (2015) or Kitao, Ljungqvist and Sargent (2016).

All our empirical investigations are based on controlled experiments that consist to send fictitious applications and CV at employers. This paper innovates on two points. On the one hand, it overcomes difficulty inherent in the age discrimination measure and on the other hand, it can identify the causality of this discrimination beyond the initial measure. Our evaluation of the discrimination in recruitment consists of constructing a controlled experiment in the labor market (Riach and Rich, (2002) and Petit (2003)). The "correspondence test" method consists of creating two fictitious application (CVs and cover letters), perfectly similar in terms of career and qualifications. The only significant distinction between the two candidates will be the attribute whose effect on access to employment is to be evaluated. These two CVs will then be sent simultaneously in response to the same job vacancies. Since the two candidates are perfectly similar

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<sup>1</sup>See Hairault and Langot (2016) for a survey on this literature or [Financial Times \(2022\)](#).

with the exception of one attribute, any significant disparity in attaining job interviews will only be imputable to the effect of this attribute on the access to employment. The experimental data collected during testing are, as a result, free of selection bias and unobserved heterogeneity.<sup>2</sup> These are the primary contributions of this experimental method.<sup>3</sup> As it is underlined by Neumark, Burn and Button (2015), the main difficulty with the age discrimination comes from the correlation between age and experience: by comparing two workers that only differ with respect to the age, the senior with the same experience than the younger can be perceived as an atypical worker, not really attached to the labor market. This method thus can lead to over-estimates the discrimination against the older workers. Hence, following Riach and Rich (2010), Neumark, Burn and Button (2015) propose to correct this bias by giving an experience "commensurate with age". We follow this idea for the construction of our fictitious CVs. Moreover, our theoretical investigations underline the multidimensional aspect of age. Its "backward" dimension is highly correlated with the experience, the education, and thus to the gap between the technological frontier and the human capital of workers. The "forward" dimension of the worker age provides an indication on the expected joint-profits of the matches and can be directly linked to the "normal" retirement age in a society. Hence, more than the age, what matter is a distance, at the time of the hiring, between the first flow-profit and the last one, given that the horizon of the match is bounded. This bound can come from the Social Security rules, the obsolescence of the worker knowledge or from the high learning costs for displaced workers. From the viewpoint of the statistical discrimination, these channels are different, but can act negatively on the employment rate of the older workers. We then develop a statistical model allowing us to identify each channels of the age discrimination, using Asymptotic Least Squares method, first presented in Chamberlain (1982) and Gouriéroux, Monfort, Trognon (1985).

Our results, based on data collected between mid-January and mid-August 2015 in the French area which is the most dense in employment (Paris-Ile de France),<sup>4</sup> support the view that the older worker are discriminated in the hiring process: the three channels of statistical discriminations à la Arrow (1972) and Phelps (1972) as well as the a "pur" discrimination process à la Becker (1957) are significant. Therefore, this discrimination against older workers may explain why the French employment rate of senior is so low (see [OECD data](#)).

The paper is organised as follows. A survey of literature is presented in section 2. The section 3 describes (i) the theoretical foundations of 3 potential sources of statistical discriminations, (ii) a labor market equilibrium where a pure age discrimination base on subjective taste can occur, and (iii) our original econometric approach to test these theoretical propositions. Section 4 presents our empirical results. Finally, section 5 provides concluding remarks.

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<sup>2</sup>We test only, the access to the job interview and not the result of this interview itself. This second phase is subject to biases influenced by the personality and the appearance of candidates.

<sup>3</sup>The main limitation of the controlled experiment method is that it does not provide a measure of hiring discrimination in all the labor market (Heckman (1998)). Indeed, the results are partial (some occupations tested), occasional (some months of experimentation) and localized (some employment areas examined). Precautions need to be taken in regard to the generalization of the results.

<sup>4</sup>6361 applications have been sent, allocated on seven occupations and twenty-eight profiles.

## 2 Related Literature

Over the last thirty years, in most OECD countries, a lot of research measured discrimination in access to employment, by using controlled experiments as correspondence tests, without being always able to identify the causes, taste or statistical discrimination (Riach and Rich (2002)). But, there have been very few applied studies on labor market discrimination that considered age as a criterion. To our knowledge, only four correspondence tests of access to the recruitment interview, measure the age discrimination. The main reason lies in the difficulty to measure the age discrimination. It comes to comparing access to employment of individuals with different ages, but with the same productive attributes. Nevertheless, the age and some productive attributes, such as experience are necessarily correlated.

In the United States, Bendick et al. (1997) compare the chances of candidates of the same sex, one 32 years of age and another 57, in two occupations (computing for men and administration for women). They bring to light a strong age discrimination against older workers. Riach and Rich (2010) consider, in the English labor market the chances of two candidates, one 27 years of age and another 47 in three occupations (administration and sales for women, food service for men). Strong age discrimination was highlighted against older workers on administration jobs, one more moderate on food service jobs and age discrimination in favor of women on sales jobs.<sup>5</sup>

Neumark, Burn and Button (2015) explore the age discrimination in twelve US towns allocated in eleven States, which differ by the rate of seniors in the population and a law against discrimination more or less severe. Almost 40 000 fictitious applications of men and women have been sending in response to the low-skilled job offers: sales and cashier (men or women), caretakers and cleaning persons (men), safety officers (men), secretary and administrative assistant (women). The fictitious candidates are differentiated by their age (30, 50, 65 years old), and for candidates aged of 50 and 65 years old, by their professional experience: low (as the candidate aged 30), or then higher. In the second case, Neumark, Burn and Button (2015) make to vary the professional career of fictitious candidates. At the moment where they apply, two candidates of 50 and 65 years old are in the continuity of their career: they are skilled on the kind of jobs. Two other candidates of 50 and 65 years old, by contrast, were previously occupied on a higher skilled jobs in the same sector of activity. For them, it is a downgrading in their professional position, a transitional job. Finally, for another candidate who is aged of 65 years, this downgrading did act 10 years earlier. Their main results are following: firstly, the age discrimination concerns more the candidates which are close to retirement (65 versus 50 years old). This discrimination against them appears, also, in the strategy of downgrading. Secondly, if the age discrimination appears systematically in their results for the women, it is more ambiguous for men. If in all

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<sup>5</sup>To permit comparison with the young candidate and the senior, Riach and Rich (2010) use two strategies. The first strategy is to allocate candidates with experience in different fields (unrelated to the post they are applying for) at the beginning of their careers, to equalize the number of experience years between young and senior candidates in the tested occupation. The second is to mention in the application of senior candidate the length of career breaks, for example, in order to care for his children.

tested occupations, women suffer from age discrimination, this is not the case for men. Thirdly, the age discrimination appears more limited in the States where the law against discrimination is more binding: when it is more severe for offenders, the access to employment of the older workers is higher.

**Why does the age matter at the time of the hiring?** There are two dimensions in the age which give a particular value of a job occupied by an age- $a$  worker hired at age  $b$ . Indeed, the age  $a$  contains an information on the worker's experience, i.e. the number of years between the current age and the age at which the worker entered the labor market, and also on the worker's tenure  $a - b$ , i.e. the number of years in the firm since the hiring: these two informations are the "backward dimension" of age, related to the human capital. The current age also contains an information on the number of years that an employer can expect to retain the worker: if the age  $a$  worker remains profitable until retirement age  $R$ , the job duration can be  $R - a$ , but if the worker become unprofitable before  $R$ , she will be fired at the age  $\tilde{a}_D < R$ , shortening her horizon and thus the capitalization value of her hiring. This is the "forward dimension" of the age given by  $R - a$  or  $\tilde{a}_D - a$ .

Even if older workers are still profitable until their retirement age, the existence of fixed costs of hiring can lead to exclude those who are close to their retirement age because it makes impossible to recoup their hiring costs. Empirical support of this argument are discussed in Hairault, Langot and Sopraseuth (2010), and Hairault and Langot (2016). But additional constraints than the "social age" (ie. the distance to the retirement age) can reduce the horizon of the older workers and thus the incentives to hire them.

This is the case of their distance to the technological frontier. If workers are victim of a continuous depreciation of their initial human capital (age increases the gap to the technological frontier) and if there is a downward rigidities of the real wage (labor market institutions), the older workers can become unprofitable before their retirement age. This leads entrepreneurs to discriminate against older workers. For example Aubert, Caroli and Roger (2004) show that both organizational and technological change allows to identify a "technological age" which is a distance between the education of the older workers and the knowledge required to use the new technology. Moreover, in Saint-Paul (2010), it is underlined that the abilities (measured by the dexterity) of the older workers are significantly lower than the ones of the 25-34 year-old workers.<sup>6</sup> But all workers are not affected by a decline of their productivities at the end of their life cycle. So, Garibaldi, Martins, and van Ours (2010) show that older workers are generally considered to be more consistent, cautious, conscientious and less "risky" (fewer accidents, less likely to quit, less absent than younger workers). Furthermore, Garibaldi, Martins, and van Ours (2010) also show that the older workers can maintain their level of productivity to the extent that this only depends on cognitive skills, while they lose some part of productivity depending on physical strength. But,

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<sup>6</sup>The estimates comes from Avolio and Waldman (1994) paper.

this is not the age dynamics of productivity as such that matters for employability, but rather the wage-productivity gap (A competitive labor market leaves no gap). Thus, we focus on situations where the wage is rigid at the end of the life cycle, as it is suggested by Lazear (1979), by an argument of long-term contract, or by Ljungqvist and Sargent (2008), by an argument based on unemployment benefits.<sup>7</sup> Hence, this section focuses on the potential disadvantage of the older workers driven by a productivity-wage gap. But, as in the previous section, all the older workers do not suffer from the same distance to the technology. Hence, the employers must predict the employee specific technological gaps.

Nevertheless, the distance to the technological frontier can be reduced through a learning process. The ability to learn a new production process is at the heart of the labor reallocations since the beginning of the last technological revolution. As it is suggested by Neumark et al (2015) "*a significant share of any increase in employment among seniors would be expected to come from new employment in part-time or shorter-term "partial retirement" or "bridge jobs", rather than continued employment of workers in their long-term career jobs*" (p.1). This phenomena is highly linked to technological change that drives the job polarization described by Autor and Dorn (2013) and Acemoglu and Autor (2011): a large part of experimented workers, in the middle of the wage distribution, see their tasks replaced by new technologies, and must be reallocated toward new activities. Thus, a first characteristic of these workers is the obsolescence of their human capital: the distance to technological frontier increases with the worker age (the gap between the schooling knowledge and the current technology). For these displaced workers, ie. workers who move from their old occupations toward new tasks, there are incentives to learn, because the human capital used in their previous tasks can not be useful for the new ones. Their best reactions consist to accumulate specific skills which are learned by doing their new jobs. Because this human capital is specific, it is not transferable after a reallocation choice. Hence, the hiring process depend on the credibility of the ability to learn on-the-job.

For the "forward dimension" of the job duration, employers have an imperfect information. Concerning the retirement age, if it is possible to know the complete career of a worker, and hence her social security wealth, the implied age at which the worker reaches the full rate pension age can be only considered as an imperfect estimate of the effective retirement age because it is possible for her/him to retire sooner or later than this "rational" age.<sup>8</sup> Concerning the obsolescence of the human capital and the effective distance to the technological frontier, the schooling choices as well as the characteristic of the previous jobs occupied by the candidate can give an information for each applicant, but this information is imperfect because it can not account for the individual quality of the worker knowledge. The same problem occurs with respect to the ability to learn the tasks required on the future job. The employer can then use these information to predict worker-specific characteristics and use them to statistically discriminate older workers.

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<sup>7</sup>For simplicity, these two arguments are summarized by our assumption of a constant wage.

<sup>8</sup>See Hairault, Langot and Zylberberg (2015) for search and matching models where the retirement choices are endogenous, and Bi and Langot (2016) where they are imperfectly observed.

### 3 Isolating the Sources of Age Discrimination

The first subsection is devoted to the analysis of a labor market equilibrium where age discrimination is based on statistical discrimination. In a second part we present foundations for a labor market equilibrium where there exists age discrimination based on subjective tastes.

These two parts share the following assumptions: *(i)* the wages are exogenous<sup>9</sup>, *(ii)* the matching process is not directed per age.<sup>10</sup> Since the Seater (1977)'s pioneer work, a large literature proposes models with endogenous frictions, which are age-specific in order to explain why labor market flows and stocks highly depend on age.<sup>11</sup> With respect to these previous works, our theoretical contribution is to identify the main channels through which the seniors' applications can be discriminated: *(i)* the labor supply channel based on the perception that older workers are at a short distance of their retirement age what lowering the sum of their expected profits, *(ii)* the labor demand channel based on the perception of a negative productivity gap of older workers for tasks requiring the use of new technologies, *(iii)* ad hoc taste. Our approach shows that these channels are exclusive and thus can be lead to a clear testing strategy, described in the last subsection.

#### 3.1 Statistical Discrimination Against Seniors When Hiring

**Job Values by Age.** Aging may decrease worker's productivity through dexterity losses, or depreciation of initial education induced by new technologies.<sup>12</sup> At the opposite, a learning-by-doing process can increase worker's productivity (the tenure's returns). These two opposite forces are summarized in the productivity for an age- $a$  worker recruited at age  $b \leq a$ :

$$y(a, b) = y_0 e^{-\alpha a} e^{\beta(a-b)}, \quad a \geq b \geq 0 \quad (1)$$

where  $a - b$  is the worker's tenure.<sup>13</sup> The first term  $y_0$  represents the worker's productivity when she quits school ( $a = b = 0$ ). This educational knowledge will then becomes progressively

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<sup>9</sup>This simplifying assumption has been retained in order to underline the main forces at work. The results can be easily extended by introducing a bargained wage  $\tilde{w}$  la Hall and Milgrom (2008) which does not depend in the labor market tightness. In this case, one can replace  $w$  by  $w(a, b) = \eta y(a, b) + (1 - \eta)b$ , with  $0 < \eta < 1$ , without changing any results. The crucial point being that a part of the employment opportunity cost must be independant of the age-specific productivity: this is the case of  $w$  in our simplifying case, and will also be the case with  $b$  in the case of a bargained wage.

<sup>10</sup>This means that even if discrimination exists, it can not be posted explicitly on a market. Therefore, the job seekers have access to all vacant positions, but after meetings, the firms can freely select among these candidates.

<sup>11</sup>See among others, Ljungqvist and Sargent (2008), Hahn (2009), Hairault et al. (2010), Cheron et al (2010, 2011, 2013), Esteban-Pretel and Fujimoto (2014), Choi et al. (2015), Menzio et al. (2016) or Cajner et al. (2021).

<sup>12</sup>Borsch-Supan et al. (2005), Boockmann and Zwick (2004) and Saint-Paul (2010) argue that aging is related to slower information processing, lower learning aptitude, and lower flexibility. Weinberg (2004) shows that the ability to learn how to use new technologies declines with age. Angelini (2020) shows that the problem-solving ability in technology-rich environments declines with age.

<sup>13</sup>The worker enters the labor market at age 0 (by convention). The parameters  $\alpha$  and  $\beta$  can be viewed as specific to each worker. Hence, given the distributions of  $\alpha$  and  $\beta$ , the employer can predict the worker's productivity.



obsolete at rate  $\alpha$  (the term  $e^{-\alpha a}$ ). But the worker will also get more experienced, accumulated at rate  $\beta$  (the term  $e^{\beta(a-b)}$ ). The present value of a job for an age- $a$  worker hired at age  $b$ , denoted  $J(a, b)$ , is the solution of:

$$rJ(a, b) = y(a, b) - w - \delta J(a, b) + \dot{J}(a, b) \quad (2)$$

where  $r$  is the interest rate,  $w$  the wage and  $\delta$  the exogenous separation rate.

**Proposition 1.** *If  $\alpha > \beta$ , it exists an age limit for worker hired at age  $b$  above which her value for the firm is always negative. This age limit  $a_L(b)$  decreases with the age  $b$  at which the worker was hired.*

*If  $\alpha < \beta$ , the worker's age limit can only be an exogenous retirement age  $R$ .*

*Proof.* See appendix A. □

Life-cycle implies that  $J(a, b)$  is non-stationary because the horizon of the match is bounded. When learning is dominated obsolescence ( $\alpha > \beta$ ), this bound is related to the decrease in  $J(a, b)$  with age. This leads firm to fire worker at age  $a_L(b)$ , which then defines the limit age for employment.<sup>14</sup> When  $\beta > \alpha$ , then the horizon of  $J(a, b)$  is bounded by the labor supply, i.e. the worker's decision to retire at age  $R$ . In the two cases, discrimination against seniors when hiring can occur because these workers have a shorter horizon on the job than a youngest worker.

**Non-Directed Matching Process.** The rate of job matching is  $h(v, u)$ , where  $v$  are vacancies and  $u$  the unemployment.  $h$  is homogeneous of degree one and labor market tightness is defined as  $\theta = v/u$ . Unemployment is composed by unemployed workers of each generations:  $u = \int_0^R u(a) da$  where  $a$  is age and  $u(a)$  unemployment for the people aged  $a$ . The ratio  $u(a)/u$  represents the weight of generation  $a$  in the unemployment. The non-directed search assumption is in accordance with the laws prohibiting any job announcement that would explicitly post any criteria based on a age discrimination.<sup>15</sup>

**Hiring Decision and Candidates' Selection.** The vacancies are filled at a rate  $q(\theta) = v^{-1}h(v, u) = h(1, \theta^{-1})$ . The value of a vacancy  $V$  is given by  $rV = q(\theta)(\bar{J} - V) - \gamma$ , where  $\gamma$  is the cost per unit of time of vacant job and  $\bar{J}$  the expected profit from an occupied job. Assuming free-entry condition on the mabor market ( $V = 0$ ), we deduce the "job creation" curve  $\bar{J} = \frac{\gamma}{q(\theta)}$ , showing that expected profit from a vacancy equals is expected costs. After having met a job seeker of age  $a$ , with the probability  $q(\theta)\frac{u(a)}{u}$ , the employer must select among them, those who

<sup>14</sup>A high hiring age ( $b$ ) reduces  $a_L(b)$ , which can then be such that  $a_L(b) < R$ .

<sup>15</sup>For example, The European Union has since 2000 a directive banning discrimination on the basis of age in employment and occupation: "You are protected by the law if, for example, you think you are being treated unfairly when applying for a job because you are a(n) young/older person" See

<https://ec.europa.eu/info/policies/justice-and-fundamental-rights/combating-discrimination>.

have a value allowing them to cover the fixed costs of hiring  $K$ . Therefore, the expected profits of a vacancy are

$$\bar{J} = \int_0^R \frac{u(a)}{u} \max\{J(a, a) - K, 0\} da$$

where  $R$  is the maximum age of workers. The crucial point is that expected profits are computed using  $\max\{J(a, a) - K, 0\}$  that indicates that only workers with  $J(a, a) > K$  will be selected during the hiring process. The propositions 2 and 3 will isolate the two reasons that can lead firm to not recall an applicant because of her/his age.

**Proposition 2.** *If  $K > 0$ , and  $\beta \geq \alpha$ , the firms discriminate older workers because their ages signal a shorter distance between their current ages and their retirement ages.*

*Proof.* See Appendix B □

As deduced from the Proposition 1, the restriction  $\beta \geq \alpha$  ensures that there is no firing before age  $R$ , because a strong efficiency of the learning-by-doing process will lead workers to be selected on the basis of their labor supply choices, reflected by their retirement age  $R$ . Under this restriction, Proposition 2 says that if  $K > 0$  then the signal of a short horizon can be a source of a statistical discrimination because a minimal duration of the job is necessary to recoup the fix costs  $K$ . In order to be recalled by the entrepreneur for a same job, a worker able to retire soon will be required to candidate sooner than a worker having a longer distance to retirement age.<sup>16</sup> To test this proposition, take two jobs where there are training costs in the former but not in the latter, and where the gaps between learning-by-doing and obsolescence processes are identical. By comparing these two types of jobs, theory predicts that only those supporting training costs will be characterized by a discrimination against seniors when hiring.

**Proposition 3.** *If  $K > 0$ , and  $\beta < \alpha$ , obsolescence leads firms to fire workers before the retirement age: (i) the distance to retirement does not matter and (ii) the age at which firms decide to exclude the older workers from the hiring process is still lower than the age at which workers are fired.*

*Proof.* See Appendix C □

Proposition 3 shows that the obsolescence leads to (i) to fire the workers sooner than their desired retirement age  $R$ , and (ii) to discriminate more strongly against senior when hiring. Indeed, firms hire workers younger than the age at which they will be fired, this "firing age" being itself lower than the retirement age  $R$ .<sup>17</sup> To test age based discrimination induced by human capital

<sup>16</sup>The individual paths in the labor market can lead to heterogeneous  $R$  between same age workers, due to differences in the eligibility at the full-rate pension.

<sup>17</sup>Remark that if an exogenous separation hits a worker after the maximal age of hiring, it is not possible for him to find another job

obsolescence hypothesis, take two occupations requiring similar skills and without relationship with customers<sup>18</sup>, and distinguishing themselves by the fact the initial human capital can be viewed as obsolete by the first, but not by the second. If the model's predictions are not wrong, then one should observe a more severe hiring selection for those presumably victims of human capital obsolescence.

### 3.2 Taste Based Discrimination Against Seniors When Hiring

In a search-matching framework where workers' heterogeneity does not matter for the firms' profits, a discrimination process can occur at the equilibrium when firms receive more than one application, and decide to rank them based on an ad hoc criterion. If this criterion is the old age of workers, then the employer will always rank in the first position the younger worker for each of their vacant jobs that have received several applications with at least one coming from a younger worker.<sup>19</sup> In this context, the number of young and old workers matches per period are respectively  $h_Y = v \left(1 - e^{-\frac{u_Y}{v}}\right)$  and  $h_O = v \left(e^{-\frac{u_Y}{v}} - e^{-\frac{u}{v}}\right)$ . The matching function which gives the total number of matches per period is then  $h(u, v) = h_Y + h_O = v \left(1 - e^{-\frac{1}{\theta}}\right)$  where  $\theta = v/u$ . Therefore, each vacancy meets a job seeker with a probability  $q(\theta) = \left(1 - e^{-\frac{1}{\theta}}\right)$  which is obviously the same one as in an economy without discrimination against older workers.<sup>20</sup> With only two groups ( $Y$  and  $O$ ) in the economy, the value of a vacancy  $rV = -\gamma + q(\theta)(y - w)$ , and the free-entry condition  $V = 0$ , lead to  $\frac{\gamma}{q(\theta)} = y - w$  that gives the unique value of  $\theta$ . Nevertheless, the hiring probabilities for each group are different:  $\frac{h_O}{u_O} = \theta \frac{u}{u_O} \left(e^{-\frac{u_Y}{u} \frac{1}{\theta}} - e^{-\frac{1}{\theta}}\right)$  and  $\frac{h_Y}{u_Y} = \theta \frac{u}{u_Y} \left(1 - e^{-\frac{u_Y}{u} \frac{1}{\theta}}\right)$ .

**Proposition 4.** *There always exists equilibrium with "taste" discrimination.*

*Proof.* See Appendix D. □

Hence, if employers decide to rank the applications via an ad hoc preference for the younger workers, an equilibrium can exist where the hiring rate of the older workers is always lower than for the younger workers ( $\frac{h_O}{u_O} < \frac{h_Y}{u_Y}$ ). To test this model's implication, take occupations which do not need investments in human capital funded by the employer ( $K = 0$ ) and where the age characteristics of the employees must have a potential impact on their production (the belief of

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<sup>18</sup>Let us notice that candidates must also have a sufficient large distance to retirement. Indeed, for the occupation where the human capital obsolescence does not matter, the age based discrimination can occur only through a short distance to retirement.

<sup>19</sup>The standard urn-ball model in discrete time, introduced in the search-matching literature by Butters (1977), Hall (1979), Pissarides (1979). An urn becomes "productive" whenever it has a ball in it. There are  $u$  unemployed workers and  $v$  vacancies. Suppose that each of the  $u$  unemployed visits one employer (or vacancy) chosen at random and takes the job if available. If more than one worker appears, one is chosen at random for employment. A way of formulating this urn-ball model is to use a Binomial distribution.

<sup>20</sup>See Appendix E for more detail on the urn-ball model.

the employers)<sup>21</sup>, the hirng's selection must then be more stringent for elderly.

### 3.3 Econometric Approach

Based on previous theoretical results, we now describe the empirical strategy allowing us to test them using experimental data. For a candidate  $j$  on job ad  $i$  we let  $J_{ij}^*$  be the recruiter's gain associated with a callback:

$$J_{ij}^* = J_{ij}(a, a) - K_i + \alpha_i + \varepsilon_{ij}$$

where  $J_{ij}(a, a) - K_i$  is the theoretical net expected profit for candidate  $j$  on job  $i$  presented in section 3: it depends on each experiment and includes the discriminatory components we wish to estimate. The  $\alpha_i$  term is the job ad correlated effect (or "fixed effect"), since the same recruiter can reply to all the candidates and  $\varepsilon_{ij}$  is the idiosyncratic error term, typically a white noise.<sup>22</sup> We observe the callback dummy:  $v_{ij} = 1$  when recruiter calls the candidate back i.e. if  $J_{ij}^* > 0$ , and  $v_{ij} = 0$  otherwise. If the theoretical callback probability  $F(\cdot)$  is a logistic distribution<sup>23</sup>, i.e.  $F_\varepsilon(\varepsilon) = \frac{1}{1+\exp(-\varepsilon)}$ , then we have  $P_{ij} = \Pr(v_{ij} = 1) = \Pr(J_{ij}^* > 0) = F_\varepsilon(J_{ij}(a, a) - K_i + \alpha_i)$  and thus  $\varepsilon_{ij} = \ln \frac{P_{ij}}{1-P_{ij}} \equiv \ln \rho_{ij}$ . For simplifying exposure, assume that our experimental data allows us to distinguish between 3 types of applicant  $j \in \{a0, a1, a2\}$ . Our theoretical analysis suggests that value of a new hire for a firm  $J_{ij}(a, a) - K_i$  can be decomposed in 3 components: a common value to each job<sup>24</sup>, denoted  $\theta$ , a potential reduction of this value induced by taste based discrimination against older workers, denoted  $\delta_T$ , and an other potential reduction of this value induced by statistical discrimination linked to the lower value of a job occupied by an old worker, denoted  $\delta_S$ . Therefore, our estimated model becomes

$$\left. \begin{aligned} \ln \rho_{i,c0} &= \theta + \alpha_i \\ \ln \rho_{i,c1} &= \theta + \delta_T + \alpha_i \\ \ln \rho_{i,c2} &= \theta + \delta_T + \delta_S + \alpha_i \end{aligned} \right\} \Rightarrow \begin{cases} \Delta_{c1} &= \ln \rho_{i,c1} - \ln \rho_{i,c0} = \delta_T \\ \Delta_{c2} &= \ln \rho_{i,c2} - \ln \rho_{i,c1} = \delta_S \end{cases}$$

$$\Leftrightarrow \pi = A\delta \quad \text{with } \pi = \begin{bmatrix} \Delta_{c1} \\ \Delta_{c2} \end{bmatrix} A = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \delta = \begin{bmatrix} \delta_T \\ \delta_S \end{bmatrix},$$

where the  $\alpha_i$  term is eliminated by comparing the answers to two candidates on the same job ad. In order to get an empirical counterpart to this model, let  $\hat{\pi}$  be the estimate of  $\pi$ . We assume that  $\hat{\pi} = \pi + \omega$  where  $\pi$  is the vector of the theoretical values of the log odds ratio differences

<sup>21</sup>In absence of educational obsolescence, the age of the applicants must also be sufficiently far from the retirement age.

<sup>22</sup>The  $\alpha_i$  term creates a correlation between the answers of different candidates for the same job, because a same recruiter replies to these different candidates. Thus  $\alpha_i$  can be interpreted as an unobservable heterogeneity term, which we allow to be correlated with the characteristics of the candidate.

<sup>23</sup>Notice that the fit of several distributions can be compared with our method. For example, if we assume a uniform distribution,  $F_\varepsilon(\varepsilon) = \varepsilon$ , we get  $\Delta_{ij} = P_{ij} - P_{ij^r}$  and the estimated coefficients can be interpreted as percentage points.

<sup>24</sup>This value can corresponds to the job value in an economy with infinitely-lived agents.

and  $\omega$  the estimation error term. Its variance equals  $V(\omega) = V(\hat{\rho}) \equiv \Omega$ . Our theoretical model becomes  $\hat{\pi} = A\delta + \omega$ . Here one should notice that  $\hat{\pi}$  and  $A$  are observable, and the estimator of  $\Omega$ , denoted  $\hat{\Omega}$ , is directly computed from the data. The optimal estimator of  $\delta$  is obtained in one step:  $\hat{\delta} = (A'\hat{\Omega}^{-1}A)^{-1}A'\hat{\Omega}^{-1}\hat{\pi}$ , with an estimated covariance matrix  $\hat{V}(\hat{\delta}) = (A'\hat{\Omega}^{-1}A)^{-1}$ . An overidentification statistic is given by  $S = \hat{\omega}'\hat{\Omega}^{-1}\hat{\omega}$ , which asymptotically follows a  $\chi_d^2$ , where  $d$  is the number of overidentifying restrictions. Here  $d = 1$ , since there are 3 independent restrictions for estimating 2 interest parameters.<sup>25</sup>

## 4 Empirical Results

We have collected a set of experimental data designed to identify each type age discrimination analyzed in the theoretical part of our study. Thus, for each of them, we present data, the statistical model and the estimation results.

### 4.1 Does the distance to retirement matter?

**Data collection.** In order to analyze the distance from retirement hypothesis, two occupations were tested: call-center agent, and sales assistant. The former involve more often than the latter the funding of a training by the employers, who expect a return on investment. This cost must be larger for the hiring of a called-center agent than for a sales assistant.<sup>26</sup> Hence, by comparing these two types of jobs, we are able to control for an observed training cost (the call-centers agent). For each of the two occupations, three fictitious applications were built and sent to answer the same job offers. They involve two senior men of the same age (56) and a younger man aged 29. The first one entered the labor market at age 15, and thus, is entitled to retire before legal age of 62. He specified in his resume that he has 41 years of experience and specified in his covering letter that he's entitled to retire in about one year. The second one is the same age, but entered the labor market when he was 21. He mentioned in his resume that he has 34 years of experience. The third fictitious applicant is a 29-year-old man who has 13 years of experience. All applications are otherwise similar in all remaining points. In both occupations<sup>27</sup>, the three fictitious applicants hold the same diploma (vocational training certificate). Since they entered the labor market, they have accumulated a significant experience in the occupation they are applying for. The call-center agents have two experiences as call-center agents (the second

<sup>25</sup>The estimation method is detailed in Duguet et al. (2018).

<sup>26</sup>Notice that this information is a necessary condition to obtain a significant "horizon effect" for the called-center agents but not for the sales assistants. Nevertheless, it can exist some other fixed hiring costs, different from an explicit period of training. In the appendix F, table 9, we show that the proportion of job offers mentioning the funding of training by the employer is higher for the call-center agents than for the sales assistants. At the same time, the average duration of this training, when it is mentioned in the job offer, is also more important for the call-center agents.

<sup>27</sup>We present, in appendix F, table 9, the main average and modal attributes of individuals working in those two occupations, as extracted from the French Labor Force Survey (Enqu<sup>ête</sup> Emploi-INSEE).

experience being longer than the first one): following Neumark, Burn and Button (2015), we thus give an experience "commensurate with age", but identical whatever the age for the specific task of the job. As for the sales assistants, they only have experiences in retail business.<sup>28</sup>

Table 1: Distance from retirement – callback rates

Index	Contract	Age	Retirement	Call center agent	Sales assistant
$s1$	Short	29	far	17.3%	5.1%
$s2$	Short	56	far	10.6%	2.0%
$s3$	Short	56	close	8.7%	2.0%
At least one callback				20.2%	17.3%
Ads				104	98
$\ell1$	Long	29	far	13.8%	12.8%
$\ell2$	Long	56	far	7.7%	3.0%
$\ell3$	Long	56	close	5.6%	2.0%
At least one callback				16.8%	20.2%
Ads				196	203
Total ads				300	301
At least one callback				18.0%	19.3%

**Statistical model.** We sent three candidates: 29 years old far from retirement 56 years old far from retirement and 56 years old close to retirement. There are also both short term contracts (less than one year), denoted  $s$ , and long term contracts, denoted  $\ell$ . The situation is summarized in Table 1. We distinguish the short term and long term contracts for the following reason: there should be not effect of retirement age on the short term contracts because their term is shorter than the remaining time to retirement. Therefore the difference in the callback rates should be affected by a statistical discrimination based on the short horizon of older workers before their retirement age. As shown in section 3.3, this leads us to estimate the following model:

$$\begin{array}{ll}
 \text{Short term contracts} & \text{Long term contracts} \\
 \ln \rho_{i,s1} = \theta_s + \alpha_i & \ln \rho_{i,\ell1} = \theta_\ell + \alpha_i \\
 \ln \rho_{i,s2} = \theta_s + \delta_A + \alpha_i & \ln \rho_{i,\ell2} = \theta_\ell + \delta_A + \alpha_i \\
 \ln \rho_{i,s3} = \theta_s + \delta_A + \alpha_i & \ln \rho_{i,\ell3} = \theta_\ell + \delta_A + \delta_R + \alpha_i
 \end{array}$$

where  $\theta_x, \forall x \in \{s, \ell\}$  is the common value for short and long term contracts respectively,  $\delta_A$  measures age discrimination when it is negative, and nepotism when it is positive,  $\delta_R$  the discrimination based on the proximity of the retirement age, and  $\alpha_i$  a job post fixed effect. Since short term contracts are not long enough to allow a worker retiring before the end of the contract,

<sup>28</sup>Additions to the protocol are provided in Appendix G. Examples of fictitious applications are available upon request.

the candidate  $s3$  should have the same probability as candidat  $s3$ . By differencing, we obtain:

$$\begin{array}{ll} \text{Short term contracts} & \text{Long term contracts} \\ \Delta_{s2} = \ln \rho_{i,s2} - \ln \rho_{i,s1} = \delta_A & \Delta_{\ell2} = \ln \rho_{i,\ell2} - \ln \rho_{i,\ell1} = \delta_A \\ \Delta_{s3} = \ln \rho_{i,s2} - \ln \rho_{i,s1} = \delta_A & \Delta_{\ell3} = \ln \rho_{i,\ell3} - \ln \rho_{i,\ell1} = \delta_A + \delta_R \end{array}$$

**Estimations Results.** We replied to around 300 job offers for each of both occupations (Table 1). Call center agents and sales assistants had a callback in about one case out of five (respectively 18% and 19.3%). This may reflect a comparable tightness in these two labor markets. We observe that the callback probability is decreasing with the age of the candidate and, slightly with the proximity to retirement.

The discrimination coefficients intervene in the log-odds ratio. Therefore  $\exp(\delta_A)$  represents the odds ratios, the relative callback performance of the old workers compared with the young worker and  $\exp(\delta_R)$  the odds ratio of the old worker close to retirement compared to the other old worker. Let  $\hat{\delta}_k$  the discrimination coefficient (with  $k = A, R$ ). We compute the odds ratio as  $\exp(\hat{\delta}_k)$  and their variance by the delta method.<sup>29</sup>

Table 2: Distance from retirement – discrimination estimates

Statistics	Call center agent		Sales assistant	
	Estimate	Student: $\rho = 1$	Estimate	Student: $\rho = 1$
$\exp(\hat{\delta}_A)$	0.52***	4.61	0.25***	8.57
$\exp(\hat{\delta}_R)$	0.72*	1.63	0.59	1.26
Model constraints (p-value)	0.664		0.702	

$\rho$  : odds ratio. The odds ratio equals 1 when the discrimination coefficient equals 0. \* significant at the 10%, \*\* the 5% and \*\*\* at the 1%

The estimations results are reported in Table 2. The model constraints are never rejected. For both occupations, there is a strong age discrimination. The odds ratio ( $\rho$ ) measures the relative chances of each candidate to be invited to an interview. For call center agents, older workers have half less chances to be called than the young workers. For sales assistants, they have four times less chances to be called. Therefore, the age discrimination seems to be stronger for sales assistant. One potential explanation could be that sales assistants may be face-to-face with the customers while the call-center agents reveal only their voice. We cannot exclude that the employers may transmit a customer discrimination based on the physical appearance. Finally, the table 2 shows that training costs paid by the employers of the call-center agents reduce their callback chances when they are close to the retirement age (horizon effect). This effect of the proximity to retirement is significant only at 10% (This low significance level may be due to our small sample). This confirms the theory: the proximity of the retirement age leads employers to discriminate against workers closer to the retirement only when training costs exist (here, this is the case for the call-center agents).

<sup>29</sup>The variance is compute as follow:  $\hat{V}(g(\hat{\delta}_k)) \simeq g'(\hat{\delta}_k)^2 \hat{V}(\hat{\delta}_k)$  with  $g(x) = \exp(x)$ .

## 4.2 Does the distance to the technological frontier matter?

**Data collection.** In order to test the initial training obsolescence hypothesis, we target two occupations with similar skill levels (Master degree /Executive position) and with no relationship with customers. In order to test the impact of knowledge obsolescence on the hiring selection process, two occupations were selected: the technological gap is more important for Information Technology (IT) project managers/developers than for management accountants and accountants. If the "human obsolescence" does not matter for the management accountants and accountants, then the discrimination in this labor market is driven by the horizon to retirement, described in the previous subsection. Three fictitious applications are submitted in answer to job offers in each of both occupations: three men holding a Master degree, respectively aged 32, 42 and 52. Their experience tends to increase with age. Based on the French Labor Force Survey data (see appendix F, table 10), the applications were made realistic.

Table 3: Distance from technology – callback rates

Candidate	Information Technology	Accounting
32	20.5%	4.2%
42	11.3%	1.9%
52	6.6%	1.6%
At least one callback	22.5%	6.5%
Ads	302	308

**Statistical model.** We assume that the candidates aged 32 are the closest the technological frontier. The log odds ratio are written:

$$\begin{aligned}\ln \rho_{i,42} &= \theta + \alpha_i \\ \ln \rho_{i,42} &= \theta + \delta_{10} + \alpha_i \\ \ln \rho_{i,52} &= \theta + \delta_{10} + \delta_{20} + \alpha_i\end{aligned}$$

where  $\theta$  represents the labor market tightness. Therefore, if 32 years old is the closest age from the "technological frontier",  $\delta_{10}$  measures the impact to be at 10 years from the frontier, and  $\delta_{20}$  gives the impact of 10 additional years from the technological frontier. Hence,  $\delta_{10} + \delta_{20}$  measures a 20 years gap from the frontier. We use the following differences and the model puts no restriction on the data:

$$\begin{aligned}\Delta_{42} &= \ln \rho_{i,42} - \ln \rho_{i,32} = \delta_{10} \\ \Delta_{52} &= \ln \rho_{i,52} - \ln \rho_{i,42} = \delta_{10} + \delta_{20}\end{aligned}$$



**Estimation results.** We replied to around 300 job offers for each occupations. IT managers had a callback for a little more than one add out of five (Table 3). Among them we observe that the callback probability is decreasing with the age of the candidate. The fall is comparable for the first 10 years and the additional 10 years. Accounting exhibit a different picture. First, the tightness is smaller in the labor market. Second, the only first 10 years after the initial training exhibit a decrease in the callback probability.

Table 4: Distance from technology – discrimination estimates

Statistics	Information technology		Accounting	
	Estimate	Student: $\rho = 1$	Estimate	Student: $\rho = 1$
$\exp(\hat{\delta}_{10})$	0.49***	4.52	0.45**	2.07
$\exp(\hat{\delta}_{20})$	0.56***	3.10	0.83	0.29

$\rho$  : odds ratio. The odds ratio equals 1 when the discrimination coefficient equals 0. \* significant at 10%, \*\* at 5% and \*\*\* at 1%

Table 4 present the components estimates. The distance from the initial training strongly decrease the callback probability of IT Managers. The relative chances to be called are divided by 2 after 10 years, and by 4 after 20 years.<sup>30</sup> The picture is different for accountant managers. While the chances to be called back are divided by 2 ten years after the initial training, then the chances reaches a plateau up to 20 years after the initial training.

We reach two conclusions. First, there is a discrimination originating in the original training date. Second, the discrimination is stronger where the rate of technological change is higher. The employers may think that, despite a more important experience, older workers are less adaptable to new technologies: their general human capital would become obsolete, despite of their on-the-job training.

### 4.3 Does the ability to learn new tasks can compensate the distance to the technological frontier?

**Data collection.** Three occupations are assessed, which verify low skills and no costly training. These are personal care services: home help (domestic staff, and domestic help), cleaning persons and caretakers. For each job offer, four fictitious applications were built and sent. Each candidate has gone through a long period of unemployment after working for many years in a declining industry: as in the theoretical analysis, these workers experienced an obsolescence of their human capital. Without any opportunities in the labor markets of their previous tasks, they choose to move toward an occupation in tension, implying a the need to learn new tasks. Their expected ability to learn is at the heart of our test. There are two 50-year-old candidates (51 and 52), still far from retirement and two 30-year-old (35 and 36). The only difference between them lies in gender. This gender difference can be used as a signal by the employers, since men are less

<sup>30</sup>The total effect on the odds ratio is  $0.49 \times 0.56 = 0.27$ .

present in this type of activity. Their abilities to learn of men can then be expected to be lower than those of women.

After having neutralized the distance from retirement age, potential obsolescence and training funding, if the senior man has less chances to get a job interview (thus preventing his retraining) than a woman with a similar profile, we can conclude that a stereotype does exist. According to this social standard, a senior man could less be trained in feminized and lower skilled occupations, such as personal care services. Adding two younger applications allows for testing whether the retraining argument is restricted to the senior population.<sup>31</sup>

Table 5: Ability to learn – callback rates

Index	Contract	Age	Gender	Personal care services
$s_1$	Short	30	Man	15.9%
$s_2$	Short	50	Man	12.3%
$s_3$	Short	30	Woman	20.3%
$s_4$	Short	50	Woman	22.5%
Ads				138
At least one callback				33.3%
$\ell_1$	Long	30	Man	15.6%
$\ell_2$	Long	50	Man	9.9%
$\ell_3$	Long	30	Woman	27.6%
$\ell_4$	Long	50	Woman	26.3%
Ads				243
At least one callback				43.2%
Total ads				381
At least one callback				39.6%

**Statistical model.** The log odds ratio for the short term and long term contracts are written:

$$\begin{array}{ll}
 \text{Short term contracts} & \text{Long term contracts} \\
 \ln \rho_{i,s_1} = \theta_s + \alpha_i & \ln \rho_{i,\ell_1} = \theta_\ell + \delta_M + \alpha_i \\
 \ln \rho_{i,s_2} = \theta_s + \delta_A + \alpha_i & \ln \rho_{i,\ell_2} = \theta_\ell + \delta_M + \delta_A + \alpha_i \\
 \ln \rho_{i,s_3} = \theta_s + \delta_W + \alpha_i & \ln \rho_{i,\ell_3} = \theta_\ell + \delta_W + \delta_P + \alpha_i \\
 \ln \rho_{i,s_4} = \theta_s + \delta_A + \delta_W + \alpha_i & \ln \rho_{i,\ell_4} = \theta_\ell + \delta_W + \delta_A + \alpha_i
 \end{array}$$

where the numbers indicate the age,  $M$  men and  $W$  women. The benchmark candidate is the 30 years old man (with no loss of generality). The age discrimination coefficient  $\delta_A$  applies to the two 50 years old candidates (woman and man) and the gender discrimination coefficient  $\delta_W$  applies to all women (30 and 50). Two points are important to mention. First, discrimination happens only when the coefficient is negative. When it is positive, we measure nepotism (a candidate is favored). Second, the  $\delta_W$  coefficient measures both gender discrimination (against women) when it is negative, and discrimination against men when it is positive. For these short

<sup>31</sup>French Labor Force survey data were used to build credible profiles: see appendix F, table 11

term contracts we do not include statistical discrimination against men because the employer can use the short term as a trial period in order to observe the productivity of the candidate. It will be different for the long term contracts, where the imperfection of information about the productivity of the candidates may encourage the employer to rely on the better reputation of women in the field of personal care services as a screening device. A statistical discrimination, that is a discrimination originating in the imperfection of information, could appear against men. We denote it  $\delta_M$ . Similarly, the women aged 30 could be pregnant and some firms may be willing to avoid recruiting them on a long term contract (Duguet and Petit, 2005). We denote it  $\delta_P$ . Differencing the two groups of equations from a benchmark candidate  $j = (30, M)$ , we eliminate the fixed effects:<sup>32</sup>

$$\begin{array}{ll}
 \text{Short term contracts} & \text{Long term contracts} \\
 \Delta_{s2} = \ln \rho_{i,s2} - \ln \rho_{i,s1} = \delta_A & \Delta_{\ell2} = \ln \rho_{i,\ell2} - \ln \rho_{i,\ell1} = \delta_A \\
 \Delta_{s3} = \ln \rho_{i,s3} - \ln \rho_{i,s1} = \delta_W & \Delta_{\ell3} = \ln \rho_{i,\ell3} - \ln \rho_{i,\ell1} = \delta_W + \delta_P - \delta_M \\
 \Delta_{s4} = \ln \rho_{i,s4} - \ln \rho_{i,s1} = \delta_A + \delta_W & \Delta_{\ell4} = \ln \rho_{i,\ell4} - \ln \rho_{i,\ell1} = \delta_A + \delta_W - \delta_M
 \end{array}$$

**Estimation results.** 381 job offers were tested in the personal care services occupation. Overall 43.2% of these job offers received a callback, confirming the high tension in this occupation, and a good match between employers' expectations and the profiles of the built applications. Table 5 compares the callback rates of the candidates.

The first results is a clear gap between women and men, on both short and long term contracts. Women have been preferred to men. The age dimension is less present, since the differences between the same gender candidates is small, except for men on the long term contracts. The model offers a practical way to interpret these differences.

Table 6: Ability to learn – discrimination estimates

Statistics	Personal care services 1		Personal care services 2	
	Estimate	Student: $\rho = 1$	Estimate	Student: $\rho = 1$
$\exp(\hat{\delta}_A)$	0.89	0.84	0.88	1.45
$\exp(\hat{\delta}_W)$	1.66***	3.08	1.66***	3.08
$\exp(\hat{\delta}_M)$	0.69*	1.84	0.67***	2.39
$\exp(\hat{\delta}_P)$	1.03	0.13	–	–
Model constraints (p-value)	0.208		0.367	

$\rho$  : odds ratio. The odds ratio equals 1 when the discrimination coefficient equals 0. \* significant at 10%, \*\* at 5% and \*\*\* at 1%

The estimates are reported in Table 6. Women clearly benefit from nepotism in this occupation. Compared to men, their chances to be called are 66% higher. In addition, we find that men suffer from a statistical discrimination. Their chances are reduced by an additional 33%. Overall, on the long term contracts, men will have twice less chances to be called than women. We do

<sup>32</sup>Notice that the model implies two constraints since there are 4 parameters to estimated from 6 independent constraints.

not find evidence of age or pregnancy discrimination. Table 6 also presents the estimation with the constraint  $\delta_P = 0 \Leftrightarrow \exp(\delta_P) = 1$ . We did it because the  $\exp(\delta_W)$  was significantly different from 1 at the 10% level only. In order to improve on the accuracy of this estimate, we have deleted the  $\delta_P$  coefficient that was almost equal to 0 (odds ratio equal to 1.03) with a Student of 0.13. This resulted in an estimation with one additional constraint. The constrained model is not rejected by the data (p-value : 0.367) and the  $\exp(\delta_W)$  coefficient is now significantly greater than 1 at the 1% level.

This empirical test suggests that the employers expect that the man's ability to learn a manual task, after an experience on a routine task, is lower than the one of a women. The largest share of the women in these activities gives more credibility to the female candidates.

#### 4.4 Is there age taste discrimination?

**Data collection.** The social norm sends back to Becker's theory of taste discrimination (also called pure discrimination). In our case, this would reduce to an "anti-senior" feeling. In accordance with our theoretical approach, we choose occupations which does not need investments in human capital funded by the employer. The characteristics of the employees must have a potential impact on their production (the belief of the employers). According to these criteria, we kept the sales assistant.

We build and send four fictitious applications on around 300 job ads. The individuals are distinguished from their gender and age: a man and a woman, respectively 49 and 48 years old, a man and a woman respectively 52 and 53 years old. We built their experiences in order to get them as fairly far from retirement, accordingly to their experiences too (like the protocol obsolescence) knowing that the oldest (the one who is 53 years old) is still far from retirement. They entered the labor market at approximately the same period. We verify that the characteristics of the candidates are realistic according to the French Labour Force Survey.<sup>33</sup>

The callback rates are presented in Table 7. We find that the younger candidates have higher callback rates, but the differences are not always important. They are higher in the other dimension: women have higher callback rates than the men of the same age. We estimate a model in order to reveal the discrimination components associated with age, gender and their interaction.

**Statistical model.** The specification of the callback rates for the short term contracts include age discrimination ( $\delta_A$ ), gender discrimination ( $\delta_W$ ) and an interaction term (intersectionality)  $\delta_I$ . When this term is zero, the discriminations act additively, otherwise they can exhibit sub-

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<sup>33</sup>See appendix F and table 12.

Table 7: Age distaste – callback rates

Index	Contract	Age	Gender	Sales assistant
s1	Short	40	Man	4.1%
s2	Short	50	Man	1.0%
s3	Short	40	Woman	8.2%
s4	Short	50	Woman	6.1%
Ads				98
At least one callback				17.3%
ℓ1	Short	40	Man	6.4%
ℓ2	Short	50	Man	4.9%
ℓ3	Short	40	Woman	10.3%
ℓ4	Short	50	Woman	7.9%
Ads				203
At least one callback				20.2%
Total ads				301
At least one callback				19.3%

additivity ( $\delta_I < 0$ ) or superadditivity ( $\delta_I > 0$ ). Thus, ours statistical models are:

Short term contracts	Long term contracts
$\ln \rho_{i,s1} = \theta_s + \alpha_i$	$\ln \rho_{i,\ell1} = \theta_\ell + \alpha_i$
$\ln \rho_{i,s2} = \theta_s + \delta_A + \alpha_i$	$\ln \rho_{i,\ell2} = \theta_\ell + \delta_A + \delta_S + \alpha_i$
$\ln \rho_{i,s3} = \theta_s + \delta_W + \alpha_i$	$\ln \rho_{i,\ell3} = \theta_\ell + \delta_W + \alpha_i$
$\ln \rho_{i,s4} = \theta_s + \delta_W + \delta_A + \delta_I + \alpha_i$	$\ln \rho_{i,\ell4} = \theta_\ell + \delta_W + \delta_A + \delta_I + \delta_S + \alpha_i$

where, for the long term contracts, we may just account for the fact that the older workers could suffer from a statistical discrimination ( $\delta_S$ ) in addition to taste discrimination  $\delta_A$ . After differencing by the (40,  $M$ ) candidate, we get the following equations:

Short term contracts	Long term contracts
$\Delta_{s2} = \ln \rho_{i,s2} - \ln \rho_{i,s1} = \delta_A$	$\Delta_{\ell2} = \ln \rho_{i,\ell2} - \ln \rho_{i,\ell1} = \delta_A + \delta_S$
$\Delta_{s3} = \ln \rho_{i,s3} - \ln \rho_{i,s1} = \delta_W$	$\Delta_{\ell3} = \ln \rho_{i,\ell3} - \ln \rho_{i,\ell1} = \delta_W$
$\Delta_{s4} = \ln \rho_{i,s4} - \ln \rho_{i,s1} = \delta_A + \delta_W + \delta_I$	$\Delta_{\ell4} = \ln \rho_{i,\ell4} - \ln \rho_{i,\ell1} = \delta_A + \delta_W + \delta_I + \delta_S$

**Estimation results.** Following the previous application, we estimate this model by backward elimination (Table 8). The model constraints are never rejected and the accuracy of the estimations increases with the number of (accepted) constraints. We find evidence of age discrimination at the 10% level, despite of the fact that the age difference is lower than 5 years. The relative callback probability is 27% lower for an older worker. We also find nepotism in favour of women, since their relative callback probability is 73% higher than the one of men. Overall there are both age and gender discrimination. Their joint effect is multiplicative on the odds ratios.

Table 8: Age distaste – discrimination estimates

Statistics	Sales assistant 1		Sales assistant 2		Sales assistant 3	
	Estimate	Student $\rho = 1$	Estimate	Student $\rho = 1$	Estimate	Student $\rho = 1$
$\exp(\hat{\delta}_A)$	0.74	0.57	0.76	0.89	0.73*	1.78
$\exp(\hat{\delta}_W)$	1.76	1.60	1.77	1.62	1.73**	2.25
$\exp(\hat{\delta}_I)$	0.96	0.11	0.95	0.12	–	–
$\exp(\hat{\delta}_S)$	1.03	0.06	–	–	–	–
Model constraints (p-value)	0.760		0.907		0.967	

$\rho$  : odds ratio. The odds ratio equals 1 when the discrimination coefficient equals 0. \* significant at 10%, \*\* at 5% and \*\*\* at 1%

## 5 Conclusion

Our study provides theoretical foundations of a labor market equilibrium characterized by age discrimination. As usual, we distinguish statistical and pure taste discrimination. Concerning statistical discrimination, we present theoretical foundations explaining why employers perceive older workers as more risky workers: they can have *(i)* a short horizon before (pre-)retirement, *(ii)* a long distance to the technological frontier, and *(iii)* a high difficulty to learn new tasks. By reducing the future profits of a job occupied by an old worker, these expectations drive the statistical discrimination against older workers. Finally, concerning the discrimination à la Becker, we show that a matching model based on the urn-ball model can support an equilibrium with age discrimination. Based on these theoretical insights, we then construct a set of experimental data allowing us to test each channel of age discrimination. Using the Asymptotic Least Squares method, we show how to identify these channels and test their statistically significant. Empirical results show that all channels can explain age discrimination.

Given that statistical discrimination against older workers can not be rejected, our results suggest that pension reforms that increase labor supply must also be accompanied by a financial supports to the vocational training directed to the older workers, increasing labor demand. Finally, concerning the discrimination à la Becker, the increase of normal retirement age must be accompanied by informational campaign in order to improve *(i)* the image of seniors at work and *(ii)* the knowledge of the composition by age of the workforce of each firm.

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## A Proof of the Proposition 1

- **Case 1.** When  $\alpha > \beta$ , the productivity  $y(a, b)$  is decreasing both with age and the tenure. Therefore there exists an age limit above which the current profit is always negative. Let  $a_L(b)$  this age limit, defined by  $y(a_L(b), b) = w$ . Thus, we get:

$$a_L(b) = b + \frac{1}{\alpha - \beta} \left( \ln \frac{y_0}{w} - \alpha b \right) = b + \frac{\alpha}{\alpha - \beta} (\tilde{a}_F - b)$$

where  $\tilde{a}_F \equiv \frac{1}{\alpha} \ln \left( \frac{y_0}{w} \right) > 0$ , corresponding to  $a_L(\tilde{a}_F) = \tilde{a}_F$  which is the age at which worker is fired. We deduce  $\frac{\partial a_L(b)}{\partial b} = \frac{-\beta}{\alpha - \beta} < 0$ .

- **Case 2.** When  $\alpha \leq \beta$ , the productivity is age-increasing. The value of this job at the age of the hiring  $a$  is given by:

$$J(a, a) = \int_a^R e^{-(r+\delta)(\tau-a)} [y(\tau, a) - w] d\tau$$

Using this value, the threshold age at which firms stop to hire is defined by  $J(\tilde{a}_L, \tilde{a}_L) = K$ . The solution for  $\tilde{a}_L$  is given by:

$$K = \frac{y e^{-\theta \tilde{a}_L}}{r + \delta + \alpha - \beta} \left[ 1 - e^{-(r+\delta+\alpha-\beta)(R-\tilde{a}_L)} \right] - \frac{w}{r + \delta} \left[ 1 - e^{-(r+\delta)(R-\tilde{a}_L)} \right] \quad (3)$$

Equation (3) can be rewritten as follows  $K \equiv H(\tilde{a}_L, \alpha, \beta, R)$ , with  $H'_1 < 0$ ,  $H'_2 < 0$ , and  $H'_3 > 0$ . We deduce from the implicit relation given by  $H$  the relation  $\tilde{a}_L = \Psi(\alpha, \beta | R)$ , with  $\Psi'_1 < 0$  and  $\Psi'_2 > 0$ . Given that the life-cycle is bounded by the retirement age, we have  $\lim_{\beta \rightarrow \infty} \tilde{a}_L = R$ .

## B Proof of the Proposition 2

Using (3) of Appendix A, it is obvious to deduce that  $\frac{d\tilde{a}_L}{dR} > 0$ , showing that a longer horizon (a rise in  $R$ ) increases the maximal age at which firms hire oldest workers ( $\tilde{a}_L$ ).

More intuitively, assume for simplicity that  $\alpha = \beta = 0$ . The value of a job occupied by a worker of age  $a$  is obtained by solving (2):

$$J(a, a) = \frac{y_0 - w}{r + \delta} \left( 1 - e^{-(r+\delta)(R-a)} \right)$$

The last term shows that  $J(a, a)$  is non-stationary: when  $R$  is bounded,  $J(a, a)$  is a decreasing function of age because the capitalization of profits is made on a shorter horizon. There exists

an age  $\tilde{a}(R)$  s.t.  $J(\tilde{a}(R), \tilde{a}(R)) = K$  given by:

$$\tilde{a}(R) = R - \frac{1}{r + \delta} \ln \left( \frac{y - w}{y - w - (r + \delta)K} \right) \quad (4)$$

If  $K \rightarrow 0$  then Equation (4) implies  $\tilde{a}(R) \rightarrow R$  so that the distance to retirement is not used to select workers, all workers can be hired whatever their age. When  $K > 0$ , on the contrary, Equation (4) determines  $R - \tilde{a}(R)$ , the remaining time to work.

## C Proof of the Proposition 3

Assume now that  $\alpha > 0$  and  $\beta = 0$ . A worker hired at age  $b$  will be fired at age  $\tilde{a}_F < R$  (see Appendix 1). The job value equals:

$$J(a, b) = \frac{y_0 e^{-\alpha b}}{r + \delta + \alpha} \left[ 1 - e^{-(r+\delta+\alpha)(a-b)} \right] - \frac{w}{r + \delta} \left[ 1 - e^{-(r+\delta)(a-b)} \right] \quad (5)$$

The threshold age at which firms stop to hire  $b = \tilde{b}_F$  as  $J(\tilde{a}_F, \tilde{b}_F) = K$ .<sup>34</sup> Using  $J(\tilde{a}_F, \tilde{b}_F) = K$ , we can define  $K \equiv F(\tilde{a}_F, \tilde{b}_F, \alpha)$ , with  $F'_1 > 0$ ,  $F'_2 < 0$  and  $F'_3 < 0$ . Then, we have  $\frac{d\tilde{b}_F}{d\alpha} = -\frac{F'_3(z)}{F'_2(z)} - \frac{F'_1(z)}{F'_2(z)} \frac{d\tilde{a}_F}{d\alpha} < 0$  because  $d\tilde{a}_F/d\alpha < 0$ . Finally, notice that  $\tilde{b}_F$  does not depend on  $R$ .

## D Proof of the Proposition 4

At the equilibrium, given the solution for  $\theta$ , and assuming that  $u_Y = \alpha u$  and  $u_O = (1 - \alpha)u$ ,<sup>35</sup> we have

$$\begin{aligned} \frac{h_O}{u_O} &= \theta \frac{u}{u_O} \left( e^{-\frac{u_Y}{u} \frac{1}{\theta}} - e^{-\frac{1}{\theta}} \right) = \theta \frac{1}{1 - \alpha} \left( e^{-\alpha \frac{1}{\theta}} - e^{-\frac{1}{\theta}} \right) \\ \frac{h_Y}{u_Y} &= \theta \frac{u}{u_Y} \left( 1 - e^{-\frac{u_Y}{u} \frac{1}{\theta}} \right) = \theta \frac{1}{\alpha} \left( 1 - e^{-\alpha \frac{1}{\theta}} \right) \end{aligned}$$

Therefore, we have  $\frac{h_O}{u_O} < \frac{h_Y}{u_Y}$  iff  $\frac{e^{\alpha - \alpha}}{1 - \alpha} < e^{\frac{1}{\theta}}$ . Given that  $\theta$  is the solution of  $\frac{\gamma}{q(\theta)} = y - w \Leftrightarrow \frac{1}{\theta} = \log \left( \frac{y - w}{y - w - \gamma} \right)$ , we deduce that the share of the young workers  $\alpha$  must satisfy  $f(\alpha) \equiv \frac{e^{\alpha - \alpha}}{1 - \alpha} < \frac{y - w}{y - w - \gamma}$ . As  $\frac{y - w}{y - w - \gamma} > 1$  and  $f(\alpha) \in (1, \infty)$ , for  $\alpha \in (0, 1)$ , we deduce that  $\alpha$  always exists.

<sup>34</sup>The condition  $J > 0$  implies that we must take  $\tilde{b}_F < \tilde{a}_F$  so that  $\tilde{x} = \tilde{a}_F - \tilde{b}_F > 0$ . In this case  $J(\tilde{a}_F, \tilde{b}_F) > 0$  and thus can be equal to  $K > 0$ .

<sup>35</sup>See Appendix E for more detail on the urn-ball model.

## E Urn-Ball Model

The idea of the urn-ball model consists in representing the firms as urns and the workers as balls. Let us denote by  $u_A$ , for  $A = Y, O$  the unemployment level of older and younger workers respectively. Consider a given vacancy and let  $N_O$  ( $N_Y$ ) be the number of young (old) applicants received in a period of time. Thus  $N_A$ , for  $A = Y, O$  is a random variable that represents the number of older applicants to a firm in the  $u_A$  repeated independent Bernoulli trials. The random variables  $N_O$  and  $N_Y$  are independent. Then,  $N_A$ , for  $A = Y, O$ , follows a Binomial distribution  $B(1/v, u_A)$ , where  $1/v$  is the probability of success, i.e. the probability that a given worker will visit the firm and  $u_A$ , for  $A = Y, O$  is the number of trials, i.e. the number of unemployed. Then,

$$P(N_Y = n) = \binom{u_Y}{n} \left(\frac{1}{v}\right)^n \left(1 - \frac{1}{v}\right)^{u_Y - n}$$

and  $E[N_Y] = \frac{u_Y}{v} = \frac{1}{\theta_Y}$ . Thus, the probability that a given firm will be visited by at least one worker (or, equivalently, the probability that a given firm will receive at least one application) is

$$P(N_Y \geq 1) = 1 - P(N_Y = 0) = 1 - \left(1 - \frac{1}{v}\right)^{u_Y}$$

If  $u_Y$  and  $v$  approach to infinity in such a way that  $u_Y/v = 1/\theta_Y$  remains constant, then we can approximate a Binomial distribution by a Poisson distribution so that

$$\lim_{v \rightarrow \infty, u_Y \rightarrow \infty} P(N_Y = n) = \frac{e^{-\frac{1}{\theta_Y}} \left(\frac{1}{\theta_Y}\right)^n}{n!}$$

Hence, when  $u_Y$  and  $v$ , the probabilities that a vacancy is filled with a young (old) applicant are given by:

$$\begin{aligned} P[N_Y \geq 1] &= 1 - P[N_Y = 0] = 1 - e^{-\frac{u_Y}{v}} \\ P[N_Y = 0 \cap N_O \geq 1] &= P[N_Y = 0] P[N_O \geq 1] = e^{-\frac{u_Y}{v}} - e^{-\frac{u}{v}} \end{aligned}$$

This implies that the number  $M_Y$  ( $M_O$ ) of younger (older) workers matches per period is:

$$h_Y = v \left(1 - e^{-\frac{u_Y}{v}}\right) \quad h_O = v \left(e^{-\frac{u_Y}{v}} - e^{-\frac{u}{v}}\right)$$

As a result, the probabilities to find a job for an old and a young worker are respectively equal to:

$$\frac{h_O}{u_O} = \frac{v}{u_O} \left(e^{-\frac{u_Y}{v}} - e^{-\frac{u}{v}}\right) \quad \frac{h_Y}{u_Y} = \frac{v}{u_Y} \left(1 - e^{-\frac{u_Y}{v}}\right)$$

Finally, the general matching function of the economy which gives the total number of matches per period  $h(u, v) = h_Y + h_O$  is given by:

$$h(u, v) = v \left(1 - e^{-\frac{u}{v}}\right) = v \left(1 - e^{-\frac{1}{\theta}}\right) \Rightarrow q(\theta) = \frac{h}{v} = \left(1 - e^{-\frac{1}{\theta}}\right)$$

which is obviously the same one than in an economy without discrimination against older workers.

## F Descriptive Statistics based on the French Labor Force Survey

Table 9: Average and modal attributes of call-center agents and sales assistants

Characteristics	Call-center agents	Sales assistants
Nationality (mode)	French	French
Region of residence (mode)	Nord-Pas de Calais	Ile-de-France
School leaving age (average)	20 years old	20 years old
Highest qualification obtained (mode)	BTS	BEP
Potential experience, in years (average)	12 years old	16 years old
Rate of women (percentage)	76	75

Source: French Labor Force Survey 2008-2012 (INSEE).

Field: Employed workers having finished their studies.

Sales assistants by correspondence,

Telemarketers: code profession 555a, nomenclature PCS 2003

Non-specialized sales assistants: code profession 553a de la nomenclature PCS 2003

Lecture: Between 2008 and 2012, the call-center agents having finished their studies were most often French women who live in the "Nord-Pas-de-Calais". In average, they are 20 years old at the end of their studies. The highest qualification obtained by these workers is most often the "BTS", (a degree corresponding of the 2 first years of the bachelor). Finally, in average, the surveyed call-center agents have accumulated 12 years of potential experience in the labor market for the end of their initial studies.

## G Data Collection for the 4 protocols

In a same campaign of testing, the fictitious candidates are distinguishing; only, by the attribute whose we want to test the effect on the chances to access to job interview. They are, also, the same characteristics. All of them, are French, the sound of their first name and name indicate a French origin. They are the driving license with a car, and live in Paris and suburbs, in neighborhood similar across socio-economic perspectives. All of them are employed when they apply and explain, in their CVs, have at least a similar experience to that required for tested job offers.

Internet is the main source used to collect the job offers where the fictitious applications have

Table 10: Average and modal characteristics of IT Project managers and management accountants

Characteristics	IT Project managers	Management accountants
Nationality (mode)	French	French
Region of residence (mode)	Ile-de-France	Ile-de-France
School leaving age (average)	23 years old	23 years old
Highest qualification obtained (mode)	master of engineering	masters of accounting
Potential experience, in years (average)	15 years old	15 years old
Part of permanent contract (percentage)	99	98
25-29 years old (percentage)	19	18
30-34 years old	11	25
35-39 years old	17	16
40-44 years old	25	13
45-49 years old	16	12
50-54 years old	5	7
55-59 years old	3	6

Source: French Labor Force Survey 2008-2012 (INSEE)

Field: Employed workers having finished their studies

Table 11: Average and modal characteristics of employed workers in personal care services

Characteristics	Household employee	Household helper	Cleaning person	Caretaker	All
Nationality (mode)	French	French	French	French	French
Region of residence (mode)	Ile-de-France	Ile-de-France	Ile-de-France	Ile-de-France	Ile-de-France
School leaving age (average)	17 years old	18 years old	18 years old	16 years old	17 years old
Highest qualification (mode)	No degree	No degree	No degree	No degree	No degree
Potential experience (average)	32 years old	27 years old	26 years old	33 years old	28 years old
% of women	91	98	70	64	82
Average age	48 years old	45 years old	44 years old	49 years old	45 years old
‡ of days of the unemp. before the actual job	800 (2y & 2m)	664 (1y & 9m)	750 (2y)	577 (1y & 6m)	724 (1y & 11m)
% of unemployed	18	25	27	18	25
Age groups (in %)					
25-29 years old	3	6	7	3	6
30-34 years old	5	7	8	4	7
35-39 years old	9	10	11	8	10
40-44 years old	14	14	16	13	15
45-49 years old	17	17	18	17	18
50-54 years old	19	18	17	18	18
55-59 years old	19	15	13	23	15

French Source: Labour Force Survey 2008-2012 (INSEE)

Field: Employed workers having finished their studies

Table 12: Average and modal attributes on sales assistants

Characteristics	Sales assistants		
	Man	Woman	All
25-29 years old (percentage)	7	15	22
30-34 years old	4	12	15
35-39 years old	3	10	13
40-44 years old	3	8	11
45-49 years old	2	7	9
50-54 years old	1	6	7
55-59 years old	1	5	6

French Source: Labour Force Survey 2008-2012 (INSEE)

Field: Employed workers having finished their studies

been sending. Specialized web-sites have been using for some occupations ("jobanque" for the management accountant, "jobtic" for the computing) as a complement to normal generalists web-sites ("PÃ´le Emploi", "Monster", "cadreemploi", "cadresonline", "keljob", "boncoin", "vivastreet"). For most of the applications have been sent by e-mail either "PÃ´le emploi", or private placement operator, or, directly, company, the same day as the publishing date of the job offers. For a same job offer, the applications have been sent the same day with a different random sending order according to job offers. The collected job offers cover exclusively permanent and fixed-term contracts (full-time and part-time for low-skilled occupations) on the region Ile-de-France.

Table 13: Differences in success rates on the same job offers offering a permanent contract

Tested Occupations	# of build profiles	# of tested job offers	# of sending applications
"Distance of the retirement" hypothesis			
Call-center agent	3	300	900
Sales assistant	3	301	903
Sub-total " distance of the retirement "	6	601	1803
"Obsolescence" hypothesis			
IT project manager and IT developer	3	302	906
Management accountant and accountant	3	308	924
Sub-total " obsolescence "	6	610	1830
"Professional retraining" hypothesis			
Household employee and household helper	4	189	756
Cleaning person	4	169	676
Caretaker	4	23	92
Sub-total " professional retraining "	12	381	1524
"Social norm" hypothesis			
Sales assistant	4	301	1204
Sub-total " social norm "	4	301	1204
General Total	28	1893	6361