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French Retirement Reforms and Intragenerational Equity in Retirement Duration

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Abstract:

As most developed countries, France has gone over the last 20 years through a process of pension system reforms, mainly aiming at increasing the average retirement age, through increasing the required number of contribution years or through postponing legal (minimal and/or normal) ages. Public debates over which lever should be preferred have been paramount in France, with concerns focusing on redistribution issues between high wage high life-expectancy and low-wage low life-expectancy workers.

In this paper, we empirically address this issue by simulating the differentiated impacts of the past French reforms on average retirement ages across wage quartiles. Our simulations show that increasing the required duration criterion –as was done by the 1993 and 2003 reforms– have redistributive impact as regards retirement age, while increasing the normal age –as was done by the 2010 reform– has a counter-distributive impact. The redistributive impact on average of the required duration criterion however only holds thanks to the fact that disabled workers –most of them in the lowest wage quartile– are exempted from it. Last, increasing minimal age has ambiguous impacts according to gender: redistributive among women but counter-distributive among men.

Key words: retirement behaviour, pensions, microsimulation

JEL code: H55, J26

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■ Introduction

As most developed countries, France has been going through a process of reforming public pension systems over the last 20 years, in order to overcome deficits encountered in most pension schemes on the short run and restore sustainability on the long run. As is well-known, France faces an ageing problem, as baby-boomers progressively achieve retirement age. In 2008, population over age 65 accounted for 28.2% of working-age population (23.6% on average in OECD countries – see OECD 2011) and public pension spending amounted 12.6% of GDP (7% on average in OECD countries). The more recent projections of the French Pension Advisory Council (COR, 2012) also show that the ratio between working-age population and inactive population of age 60 and over will decrease from 2.1 in 2010 to 1.5 in 2060. This will translate in rising public pension spending, which will increase from 13.8% of GDP in 2011 to about 14.2% in 2020, and potentially –under the more pessimistic hypotheses– to 15.8% in 2060.

This concern has already led to three major retirement reforms in 1993, 2003 and 2010, and to other minor changes in pension legislation and parameters throughout the 2000s. Those reforms have triggered intense public debate and have met a strong opposition, especially from unions. In particular, the impact of reforms on intra-generational inequalities in age at retirement has proven very controversial. Indeed, although the three traditional pension parameters (contribution rates, retirement age and amount of pension) have been affected in some way, increasing the average retirement age has been constantly put forward as the main mechanism to restore sustainability and preferred by most policymakers over increasing contributions or decreasing benefits. This preference for rising the retirement age is all the stronger that the latter still remains relatively low in France compared to other countries: on average, men left the labour market at the age of 59.1 and women at the age of 59.5 in 2011, compared to 63.9 for men and 62.8 for women on average in OECD countries². Quite naturally, this aspect has therefore been the most debated and most criticized one.

Criticisms mainly dwelled on the idea that inequalities in life expectancy should be taken into account in retirement reforms. More precisely, the concern was that the retirement age should increase less for low life-expectancy workers –who also often happen to be lower educated, receive lower wages and face harder working conditions– than for high life-expectancy workers, since the latter already enjoy a longer average retirement duration and a larger retirement-over-career duration ratio. Indeed, intra-generational inequalities as regards life expectancy across social groups prove sizeable in France³, according to several studies using different data sources (see table A1 in annex 1). For instance, Aubert and Christel-Andrieux (2010) find that white collars male live on average 3.7 years longer than blue collars male after the age of 55. The gap is 2.8 years for women. This result confirms that of Mesrine

² Comparative OECD figures for period 1970-2011 are available at http://www.oecd.org/els/emp/Summary_1970+values3dec2012.xls.

³ The same result generally holds in most developed countries (see Whitehouse and Zaidi, 2010, for a survey).

(1999), Cambois and Robine (2001) and Desplanques (1993)⁴ on life expectancy gaps after the age of 60. The life expectancy gap varies across studies, but it is never lower than 3 years for men. Comparing groups according to their education level rather than their social category, Aubert and Christel-Andrieux (2010) also find that highly educated people live longer than low educated people. The gap in life expectancy, at the age of 55, between retirees with a university degree and retirees with no degree is about 4 years for men and 2 years for women⁵. Of course, there also exist differences in average retirement age across social or education groups, which may partly compensate differences in life expectancy. However, the former happen to be of a much smaller extent, in such a way that they fail to fully compensate the latter. For this reason, a shorter life expectancy usually implies shorter expected retirement duration.

Inequality in retirement duration is only part of the broader topic of retirement inequalities. Contribution rates and rates of return of the pension system also differ across workers in France. Moreover, those differences imply redistribution from higher incomes to lower incomes (Aubert and Bachelet, 2012). However, very few people in the public debate would argue that this redistribution might justify that low income workers should be given a shorter expected retirement duration, in such a way that decreasing inequalities in retirement duration and performing redistribution through differentiated contribution rates are often regarded as two distinct goals that should be both aimed for. This justifies focusing on the topic of inequalities in age at retirement and in retirement duration as an issue of interest *per se*.

Although it usually proves paramount in public debates accompanying retirement reforms, this issue has, up to now, received little attention in the economic literature. Several papers focus on some intra-generational effects of pension reforms, but the literature traditionally focuses on the consequences of reforms on intra-generational income inequalities rather than age or retirement duration inequalities (see for instance Cremer and Pestiau (2003) for the Belgium case, Fehr et al. (2012) for the German case⁶). Boeri and Brugiavini (2008) also study the differential impact of pension reforms in Italy on retirement decisions by gender, showing that gaps in career of women matter to explain the differential impact of reforms from a gender point of view.

This scarce attention given to the issue of intra-generational retirement duration inequalities may stem from the fact that most retirement schemes in the world provide an age-pension rate profile that is homogeneous across categories of workers –in other words, the idea of

⁴ See also Cambois, Laborde and Robin (2008) for life expectancy gap measures at 35 years old.

⁵ Differences in life expectancy across social groups may stem from several causes: differences in life-style (for instance, as regard smoking or eating habits), difference in professions (unhealthy, if not dangerous, working conditions being more frequent among blue collars), income effects on health expenditures, ... The fact that only working condition-related differences should be taken into account by the pension system is quite consensual in the public debate. Unfortunately, *ceteris paribus* impacts of each factor on social differences in life expectancy are not available in the aforementioned studies.

⁶ Fehr *et al.* (2012) simulate the long run impact of the 2007 reform of the German retirement system, in which the retirement age with a pension without financial penalties progressively increases from 65 to 67. They find that this increase will financially penalize more low-skilled workers.

providing differentiated age-pension rate profiles according to workers' characteristics is not a public policy issue. Most schemes allow some workers to retire with a full-rate pension before the normal retirement age, but this is generally possible for a small share of the population only –mainly disabled workers and, in some countries, workers with a very long career (see SG-COR, 2012). Undoubtedly, France represents an exception, since the age-pension rate profile varies a lot across the population, which echoes the fact that redistribution as regards retirement duration is considered a central topic in public debates regarding the pension system.

The French Pension System

In the French Social Security general regime, the retirement pension is calculated using the following formula:

$$Pension = Pension\ rate * \text{Min}\left(\frac{Nb\ of\ contribution\ quarters}{Required\ number\ of\ quarters}; 1\right) * Reference\ wage$$

The reference value for the pension rate –also known as ‘full-rate’– is 50 %. Retiring before the age at which the conditions for a full-rate pension are met is allowed (after a minimal age), but a penalty is then applied to the amount of pension through applying a pension rate that is below 50%⁷. The penalty is determined by the number of quarters missing to the reference age at which full-rate is allowed, in such a way that the latter is sufficient to summarize the whole age-pension rate profile. In what follows, we will hence focus on this reference age, which will be referred to as the ‘full-rate age’.

Up to 1982, the French system was similar to most other countries’, *i.e.* a fixed full-rate age (equal to 65 –the normal retirement age– for non-disabled workers and to 60 for the disabled). However, the specificity of the French retirement framework is now that, since the 1983 retirement reform, full-rate ages do not always correspond to the normal retirement age, but greatly vary among individuals according to their number of contribution quarters⁸. More precisely, retirement with a full-rate pension is possible as soon as the age of 60 (*ie* the minimal retirement age up to 2010) if one satisfies the required insurance duration⁹. For workers with a too small number of quarters at the age of 60, retirement without financial penalties is possible between the ages of 60 and 65 (*ie* the normal retirement age before 2010) as soon as the worker has accumulated the required number of quarters –otherwise the amount of pension is decreased by applying a pension rate lower than 50 %. In all cases, retirement after the age of 65 is always at full-rate (figure 1).

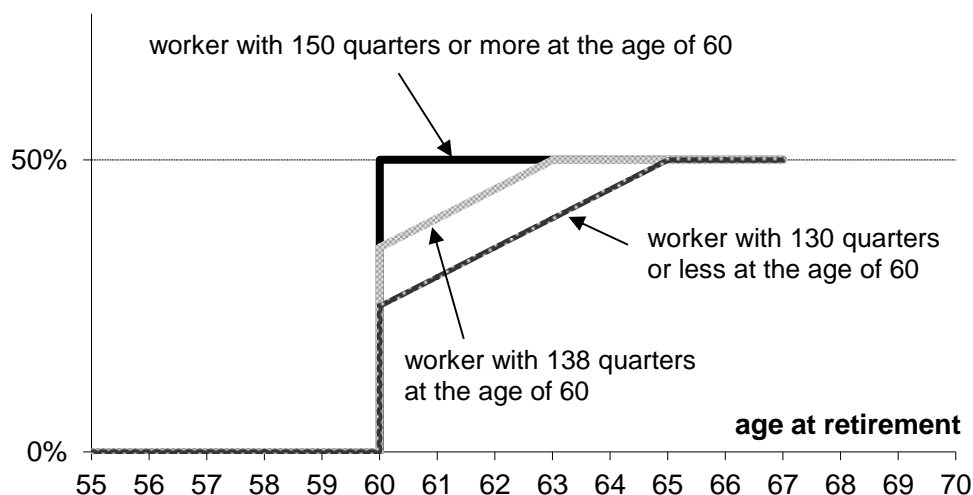
⁷ Since 2003, a bonus is also applied in case of working after the age at which a worker is entitled to a full-rate pension.

⁸ The number of contribution quarters is generally qualified as the ‘insurance duration’. It includes contribution periods (*ie* employment periods), but also some periods out of employment (maternity and sick leave, military service, compensated unemployment, etc.)

⁹ Retiring at full-rate at the age of 60 is also possible for disabled people.

Figure 1. Pension rate according to age after the French 1983 reform

Required number of quarters = 150



Note: workers are assumed to work until their retirement age

When this framework was implemented in 1983, the required duration for full-rate was of 150 quarters. At that time, almost all individuals who had stayed on the labour market during their working-age years had an insurance duration above that value at the age of 60. Thus the framework was initially thought as a way to enable workers with a complete career to retire at the minimal age of 60, while maintaining the age of 65 as the full-rate age for workers with an incomplete career¹⁰. Indeed, given the distribution of insurance duration among workers ending their career during the 1980s, there was almost no variability of full-rate ages among individuals, and only two sub-groups were observed – those who reached full-rate at the age of 60 and those who reached full-rate at the age of 65.

However, although it was not explicitly presented as a redistribution tool at the beginning, this framework can prove an efficient way to address inequalities in life expectancy. This goal could be achieved thanks to the correlation between the first employment age and life expectancy. Indeed, high life expectancy workers are higher-educated individuals, who entered the labour market later due to a longer education period. On the opposite, low life-expectancy blue-collar workers usually have lower education, and thus entered the labour market younger. Since an earlier age when entering the labour market implies a longer duration of career, lower life expectancy workers may meet the required duration criterion earlier and thus retire earlier at full-rate¹¹.

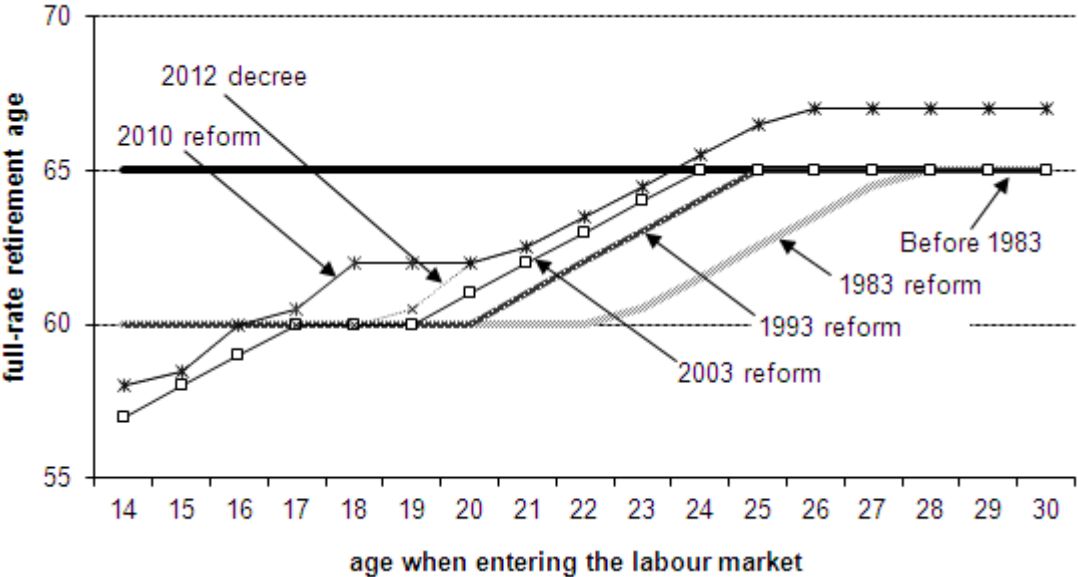
The strength of the correlation between full-rate age and age when entering the labour market in fact depends on the values of the parameters of the pension system (required insurance duration, early retirement age, normal retirement age) and on the distribution of ages when

¹⁰ The initial intent of the 1983 pension reform was to decrease the average retirement age, in the context of high unemployment –at the beginning of the 1980’s, most workers above the age of 60 were already out of employment and receiving unemployment or preretirement benefits. It also met a strong social demand for ‘retirement at 60’ (*“la retraite à 60 ans”*).

¹¹ The disabled people, who also have lower life expectancy, can also retire earlier thanks to the fact that they are allowed to retire at full-rate at the age of 60, regardless of their insurance duration.

entering the labour market. The initial parameters after the 1983 reform were 150 quarters (37.5 years) for the required insurance duration, 60 for the minimal retirement age and 65 for the normal retirement age. As we already stressed it, almost all workers retiring in the 1980's and early 1990's had begun to work before the age of 22.5 –even high-education workers. This implied a small correlation between the full-rate age and the age when entering the labour market, hence a small potential redistributive effect. However, this correlation may have increased over time for at least two reasons: first, the increase of the compulsory school duration and second, the 1993 and 2003 retirement reforms, which increased the required insurance duration¹². The correlation was further increased after the 2003 reform, thanks to the creation of an early retirement age for people who started to work very young (figure 2). The pension rate-age profile was modified again afterwards: the 2010 reform translated it by increasing the early, minimal and normal age by 2 years, while the 2012 decree extended the possibility to retire at the early retirement age for individuals who started to work before the age of 20.

Figure 2. Full-rate age according to the age when entering the labour market (non-disabled workers)



Note: workers are assumed to work continuously from their first employment to their retirement age. The required number of quarters is 150 for the 1983 reform, 160 for the 1993 reform, 164 for the 2003 reform (or 172 for retirement before age 60) and 166 for the 2010 reform (or 174 for retirement before age 62) and the 2012 decree. As mentioned above, we define the full-rate age as the minimal age at which a worker is entitled the 'full' 50% pension rate, given his characteristics.

The issue of a potential redistributive impact as regards retirement duration of the French pension framework became especially vivid during the preparation of the 2010 reform. While increasing the required insurance duration had been chosen in the 1993 and 2003 reforms as the main incentive in order to increase the effective average retirement age, policymakers in 2010 decided to rather increase the minimal and normal age, on the ground that it would entail a faster increase of the effective average retirement age, and thus a faster decrease in pension schemes' deficits. The alleged counter-distributive impacts of this increase were put forward by opponents to the project as one of the reasons why they rejected it.

¹² The number of quarters increases by 1 quarter per generation.

Although the issue is frequently alleged in the French public debate, it actually still has received very little empirical enquiry in the economic literature. The redistributive effect as regards retirement duration of the French pension system relies on the assumption that the number of contribution quarters before the age of 60 is strongly correlated with life expectancy, or at least with social category –which still remains to be proved. In particular, the correlation between the insurance duration and the age when entering the labour market is strong only if all or nearly all quarters between entering the labour market and retiring count as contribution quarters in the insurance duration. Stylized facts show that exceptions may be numerous. For instance, only 60% of men and 40% of women born in the 1940s' and in the beginning of the 1950s' validate 4 contribution quarters per year between 31 and 50 years old (Baraton and Croguennec, 2009). Moreover, most of the young workers do not work enough to validate 4 contribution quarters per year from their first employment: 20% of workers born in 1950 should wait 2 years between their first employment and the first time they accumulate 4 quarters a year. The proportion is above 30% among workers born in the beginning of the 1960s', and above 40% among those born in 1970 (Rapoport, 2009). Moreover, due to the high unemployment rate for young low-skilled workers, the age of the first job might be a weak indicator of social group or income level. For instance, Rapoport (2009) classifies workers according to their wage level at the age of 30. He shows that the first contribution quarter of workers in the lowest decile is registered on average 1.5 year *older* than workers in the intermediate decile of the wage distribution.

Such stylized facts question the (alleged) ability of the French pension system to reduce inequalities in retirement duration –as well as the true impacts of past retirement reforms. Taking into account the complexity of the French pension system, the heterogeneity of workers' characteristics, the evolution of unemployment over time, and the modification of retirement parameters, we cannot conclude without a quantitative analysis. This is what we do in this article, by running simulations using the PROMESS cell-based model. More specifically, we focus on changes in the average retirement age by wage quartile after the 1993, 2003 and 2010 reforms, in order to check whether increasing the required insurance duration, the minimal age and/or the normal age reduced or increased inequalities in retirement duration.

Given the extent of differences in life expectancy across social groups –4 to 5 years between blue-collars and white-collars, see *supra*–, we focus on retirement ages only. We consider that when a reform implies a larger increase in the average retirement age for high-wage workers, it can be considered as redistributive as regards retirement duration –the contrary holding when the reform increases the average retirement age more for low-wage workers. Following this approach, our simulations show that increasing the required duration criterion –as was done by the 1993 and 2003 reforms– seems to have a redistributive impact. For instance, these two reforms increase the average retirement by 21 months for male workers in the highest wage quartile born in 1970, but by 11 months only for male workers in the lowest wage quartile. However, mechanisms behind this redistribution impact do not only rely on the correlation between insurance duration and wage quartile. Actually, non-linearities created by interferences between the required duration, minimal age and normal age rules also happen to be paramount. We also find that creating an early retirement age for workers with a very long career (2003 reform) favoured workers with intermediate wages, not low-wage workers. Both increasing the minimal age and increasing the normal (full-rate) age (2010 reform) increased retirement duration inequalities: for men born in 1970, the 2010 reform increases the average retirement age by 16 months for workers in the higher wage quartile, but by 20 months for workers in the lower wage quartile.

The remaining of the paper is as follows. The second part presents the PROMESS cell-based model. The third part then provides results on the simulated impact of French reforms on retirement age according to wage quartile and gender.

■ The PROMESS Model

PROMESS (MESO Projection of the Retirement System) is a projection model developed by the DREES¹³ to prepare the 2010 reform of the French pension system¹⁴. It is a ‘all schemes and all generations’ model: it covers all the population born in France or abroad, without distinguishing people according to their pension scheme (*e.g.* private sector workers, civil servant, non-wage earners, *etc.*). PROMESS applies the inherent legislation to each generation: the required insurance duration for a full-rate pension, the minimum legal age and the normal age. The model permits to estimate the effect of any reforms modifying one or several of these dimensions.

For the sake of clarity, we only briefly describe, in what follows, the main features of the model. A much thorough technical description is provided in Aubert *et al.* (2013), as well as some insights of the model’s forecasting performance. In addition, Aubert *et al.* (2012) discusses the advantages and disadvantages of the PROMESS model, its main limitations and its planned evolution.

Presentation and limits

PROMESS is a cell-based projection model: it estimates probability distributions for (i) the age of the last year of employment, (ii) the age of the last period taken into account in the insurance duration (*ie* employment, but also compensated unemployment, sick leave ...) and (iii) the age of retirement.

PROMESS is a "meso" (or cell-based) model¹⁵ in this sense that it is based on categories. The latter are defined by the generation, the gender, the country of birth (France / abroad), the insurance duration at the age of 54, the wage quartile and the pension scheme at the end of career¹⁶.

¹³ ‘*Direction de la Recherche, de l’Évaluation, des Études et des Statistiques*’, *i.e.* the statistics and economic studies unit of the French Social Affairs Ministry.

¹⁴ See Aubert, Duc and Ducoudré, (2013) for a detailed presentation of PROMESS.

¹⁵ See Toder et al (2000) for a detailed presentation of cell-based models.

¹⁶ That is the last pension scheme to which the worker is or has been affiliated up to the age of 54. We gather pension schemes in three groups: “public” for civil-servant pension schemes, “special” for special regimes (*i.e.* pension schemes of large public firms) and “private” for private sector schemes (CNAV–*i.e.* the Social Security general regime, covering the largest share of the population– and other smaller schemes covering wage-earners in agriculture and non wage earners). We assume that individuals keep on the same pension scheme affiliation after the age of 54.

PROMESS differs from a "macro" model since the number of cells is very large (several thousands within each cohort). It can then reproduce more precisely population characteristics. Nonetheless, since categories are defined by the insurance duration at the age of 54, some cells could contain only very small number of individuals. In this case we grouped categories to increase the number of individuals¹⁷.

It also differs from a "micro" model insofar as it aggregates all individuals with similar characteristics in homogeneous categories. This choice was made mainly because the model was developed under strong time constraints to prepare the 2010 reform, and this type of models can be build faster.

Moreover, PROMESS differs from a simulation model in that sense that it does not simulate a single and fixed age of retirement for each category of the model depending on a hazard. Instead, it models the entire probability distribution of the age of retirement (or of the age of last employment, etc.) for each cell. This choice implies gains in computational time and smoother results than those of most microsimulation models, as there is no noise associated with a random simulation here¹⁸. On the other side, it prevents from modelling individual agents and interactions within households. This limits the use of PROMESS, since for example the model can't replicate marital retirement strategies.

The model is also not designed to simulate reforms on parameters determining pension levels and to compute financial outcomes on future pension spending¹⁹. Indeed PROMESS is a model focusing on ages (for ceasing employment and receiving retirement benefits), but which does not aim to and does not enable studying the amount of the benefits. These amounts would be difficult to integrate into the model due to an indirect consequence of having chosen a cell-based approach. When dealing with age, consideration of the total number of quarters validated accrued up to age 54 is sufficient –since only the total duration matters for full-rate benefits– which allows disaggregating the total population into a moderate number of categories. An approach enabling an estimation of the retirement benefit level would necessitate considering, in addition, all the heterogeneity linked to the complete chronicle of annual employment revenue, which is not possible within the framework of an aggregated approach. In this case, a micro-simulation approach would be preferable.

In the following parts, we focus on the private sector block of the model, *i.e.* on categories of individuals who terminated their professional career in a sector following the rules of the "private" pension scheme (the "régime général"). They represent roughly 80% of the whole population.

¹⁷ It is the case for example for people definitively ceasing employment before age 50. See Aubert *et al* (2013).

¹⁸ However, a sampling error remains: PROMESS parameters are based on statistical data of the 2004 EIR and the 2005 EIC, which are samples from the entire population of retirees and contributors.

¹⁹ See Aubert *et al.* (2012) for a detailed discussion on the advantages and drawbacks of the PROMESS model.

The Data

PROMESS is based on two statistical databases collected from administrative files of almost all French pension schemes: the Contributors' Inter-scheme sample ('*échantillon interrégimes de cotisants*' or EIC) and the Pensioners' Inter-scheme sample ('*échantillon interrégimes de retraités*' or EIR). These two databases give the most detailed information on French contributors and pensioners.

The EIC contains individual data on professional careers of 247 000 people (for the 2005 vintage). It focuses particularly on all characteristics relevant for the future retirement pensions, especially data on insurance duration²⁰ and their annual wage/revenue (if they are in employment).

The EIR contains individual data on pensions for 252 000 retirees (for the 2008 vintage). This database comes from the same sample of people as EIC. The two databases can then be taken all together to compute precisely the whole career of a retiree since individuals have the same ID in the two databases.

The first year of our simulation is defined by the vintage of the last EIC, that is, the 2005 EIC, which covers one generations of four²¹ born from 1942 until 1974²². Hence data are available for generations 1942, 1946, 1950, 1954, ..., 1974. This choice was constrained by data availability, since EIC and EIR are constructed once every four years. At the time the model was built, EIC 2005 and EIR 2008 were then the more recent databases available²³.

Note that we also use more recent aggregated data from other sources to correct projections of the number of retirees²⁴. But these corrections do not apply to results presented hereafter since we only focus on probability distributions in the paper.

The model

The base component, or cell, of PROMESS is a category c at age a (greater than 54) for generation (*i.e.* year of birth, *i.e.* cohort) g . Each category is composed of individuals born the same year and having the same 'retirement components' characteristics, defined by:

- Sociodemographic variables: gender s_c and country of birth (France vs. Abroad) cb_c

²⁰ It contains quarters accumulated during employment periods, but also all quarters accumulated during career setbacks (the so-called '*périodes assimilées*'): unemployment with Unemployment Insurance benefits, illness interruption and maternity period with an allocation (AVPF), ...

²¹ For each cohort, data on 20 000 people is collected on average, which limits the number of cohorts that can be included in EIC due to data collection costs for each administration concerned.

²² The EIC 2005 dataset also includes data for the 1934 and 1938 cohorts. However, due to the quality of the data for the beginning of the career for those generations, they are not included in the PROMESS model. Nevertheless, these two generations are used to estimate probability to leave the labour market and to retire after 54 years old (cf. *infra*).

²³ EIC 2009 is under construction and should be available in the course of 2013. It would add 4 years of observations on careers for people in the sample (since it is a panel). The building-up of EIR 2012 should start by the end of 2013.

²⁴ For example the EACR database (Enquête Annuelle auprès des Caisses de Retraites) provides every year a global estimate of the number of retirees in France.

– Variables summing up career until the age a : insurance duration accumulated until the age a : $NbQ_{c,a}$, median wage quartile between $a-4$ and a : $w_{c,a}$ (with a specific value $w_{c,a}=5$ for individuals who have already left the labour market at these ages), pension scheme affiliation at the age of 54 (private, public or special): $sect_{c,a}$

$$c(g, a) = \left\{ \begin{array}{l} \text{individuals } i \\ \left. \begin{array}{l} g(i) = g; \\ s(i) = s_c; \\ cb(i) = cb_c; \\ NbQ(i|age\ a) = NbQ_{c,a}; \\ w(i|age\ a) = w_{c,a}; \\ sect(i|age\ a) = sect_{c,a} \end{array} \right\} \end{array} \right.$$

An important input of the model is the legislation ℓ inherent to individuals in category c . In the French pension system, legislation varies across several dimensions: the generation g and the pension scheme $sect_c$. The legislation parameters are the required insurance duration $ReqNbQ$, the minimum legal age of retirement $MinAge$, and the normal age (*i.e.* the age for a pension without financial penalties even if the required insurance duration is not satisfied) $LegAgeFR$.

$$\ell[c, g] = \ell[sect_c, g] = \{ReqNbQ(c, g); MinAge(c, g); LegAgeFR(c, g)\} \quad \forall c, g$$

Note that neither $MinAge$ nor $LegAgeFR$ are completely fixed. Indeed, some categories of the population (*e.g.* disabled people, individuals affiliated to some specific pension schemes, individuals with very long career) can retire before the minimum legal age (early retirement age in case of long career) or retire without financial penalties before the normal age without the required insurance duration (disabled people).

The outputs of the model are the following:

- The number of individuals within all categories c at 54 years old:

$$N_{c,g}(54) = \sum_i 1\{i \in c(g, 54)\} \quad \forall c, g$$

- The number of individuals alive at age a , for all age a above 54 and within all categories c at 54 years old:

$$N_{c,g}(a) = \sum_i 1\{i \in c(g, 54)\} * \Pr(\hat{i} \text{ not dead} | a) \quad \forall c, g; \forall a \geq 54$$

- The probability that an individual i within a category $c(54)$ has left the labour market before age a , for all quarterly age a above 54 and for all categories $c(54)$, under legislation ℓ :

$$P_{c,g}^e(a) = \Pr\left(\text{Max}\{a' | \text{employment at age } a'\} \leq a \mid \begin{array}{l} c(g, 54); \\ \ell[c(54), g] \end{array}\right) \quad \forall c, g; \forall a \geq 54$$

- The probability that an individual i within a category $c(54)$ is accumulating no more quarter at the age of a (*i.e.* is out of all unemployment, sick leave, etc public schemes), for all quarterly age a above 54 and for all categories $c(54)$, under legislation ℓ :

$$P_{c,g}^v(a) = \Pr\left(\text{Max}\{a' | \text{validating quarters at age } a'\} \leq a \mid \begin{array}{l} c(g, 54); \\ \ell[c(54), g] \end{array}\right) \quad \forall c, g; \forall a \geq 54$$

- The probability that an individual i within a category $c(54)$ is **not yet** retired at age a , for all quarterly age a above 54 and for all categories $c(54)$, under legislation ℓ :

$$P_{c,g}^r(a) = \Pr\left(\text{Min}\{a'|\text{retired at age } a'\} > a \mid \begin{matrix} c(g,54) \\ \ell[c(54),g] \end{matrix}\right) \quad \forall c, g; \forall a \geq 54$$

Note that average probabilities over the whole population can be easily estimated by combining the $N_{c,g}(a)$ and $P_{c,g}(a)$ over all cells c .

In practice, the model has several articulated independent steps. These steps depend on the age: before the age of 54 – as individuals accumulate insurance duration, can shift wage quartile and can shift sector–, the model estimates all $N_{c,g}(a)$. After the age of 54, probabilities $P_{c,g}(a)$ are estimated using two models depending on whether the age is below or above the legal minimum retirement age (see Annex for technical details).

This last point needs some discussion. Some modelling choices are structural and limit the framework in which the model can be used. Firstly, the modelling for ceasing employment gives a primordial place to the age at which one becomes eligible for full-rate retirement benefits. In the private sector, this is a decisive factor, although it does not prevent retirement at other ages from occurring. Secondly, the retirement behaviour is mainly dependent on the contribution history, as is observed in the data. It also depends on gender and wage quartile, but there is no explicit role for other retirement determinants, like financial incentives.

These two limits only represent a minor drawback as long as getting full-rate remains the main determinant for the individuals' retiring decision. We acknowledge that reasons exist why this might be less and less the case in the future. Although up to 2003 the system contained very strong financial incentives to retire at full-rate, this is not true anymore since the 2003 reform. The changes in penalty and bonus rates (the pension penalty in case of retiring earlier than full-rate has been decreased and a pension bonus in case of retiring later has been created) implies that, since the second half of the 2000's, penalty/bonus rates are now almost actuarially neutral (see Briard and Mafhouz, 2011). However, stylised facts show that most workers actually still retire at the age when they can get a full-rate pension. For instance, among new retirees between July, 2010 and June, 2011, only 21% retired at a different age than their full-rate age (7% earlier –with a pension penalty– and 14% later –with a pension bonus) (Barthélémy *et al.*, 2013). Besides, about 70% of working-age individuals state that they plan to retire at the time they get full-rate, not sooner or later (SG-COR, 2013).

On the whole, the hypotheses on behaviour hence imply that the PROMESS projections are pertinent in the study of the current French pension system or of retirement reforms that remain close to it: for example, a modification of the required number of quarters to obtain a full-rate pension, a shift in the minimal retirement age or a shift in the normal retirement age²⁵. Inversely, the model, in its current form, was not designed to study reforms greatly deviating from the current regulatory framework (for example, a huge increase in the age

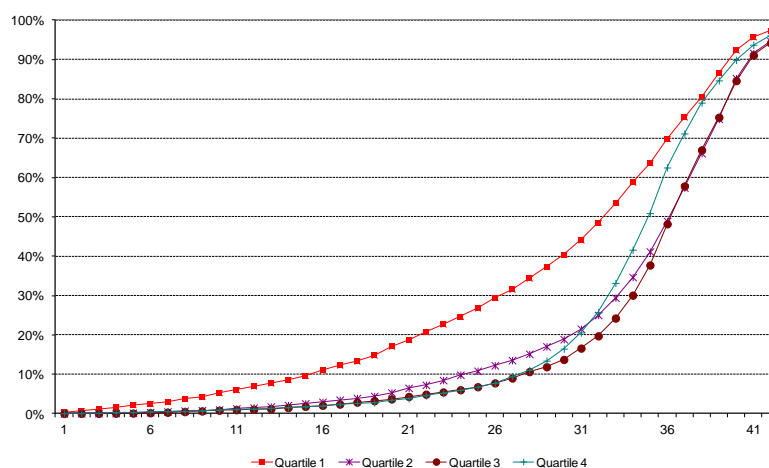
²⁵ The parameters of the model are defined so as to take into account these types of reforms, which can thus be very easily implemented. Some other retirement reforms can also be modelled, but need much more programming. This is the case, for example, of reforms modifying the conditions of eligibility for early retirement measures due to long careers.

limits²⁶), affecting parameters other than the required number of quarters and age (for example, a modification of the discounted rates or premiums) or structurally modifying the conditions for receiving benefits (for example, transitioning to a notional account scheme).

Finally, we obtain, for all generations, the population distributions according to categories defined by generation, gender, country of birth (France / abroad), insurance duration until the age of 54, wage quartile level²⁷ and the pension scheme to which workers have been contributing.

The following figure represents distributions of insurance duration accumulated at the age of 54. An important result of distributions by quartile is that, on average, the first quartile includes a much larger share of workers with a short insurance duration accumulated before the age of 54, compared with other quartiles (figure 3).

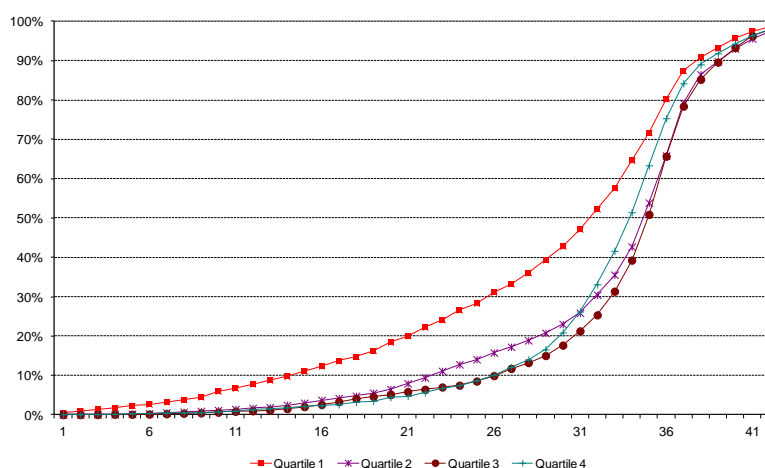
Figure 3. Projected distribution of insurance duration accumulated at 54 years old by wage quartile (number of contribution years)
Generation born in 1950



²⁶ Modelling a scenario with a huge increase in the normal retirement age does not pose technical implementation problems, but it raises questions as to the pertinence of the results. In fact, the model on retirement implies, for example, that a person having validated a sufficient number of quarters for full-rate benefits at the minimum age for receiving benefits has the same probability of remaining employed after said age (and thus to benefit from a premium), regardless of the age. If this hypothesis remains plausible so long as the minimum age for receiving benefits remains close to age 60, it is less so when this age is greatly raised after age 60.

²⁷ In fact, quartiles at 54 years old are observed wage quartiles only for the generation 1950. For younger generations, quartiles at 54 years old result from transition matrices and should better be interpreted as indicators of income level, and not as statistical quartiles.

Generation born in 1962



Source: PROMESS, Drees

We also use the model to project distributions by gender and cohort (not reported here). For men, distributions are quasi-similar across cohorts for short durations, but the weight of longest durations decreases for younger cohorts. These last results can be explained by a later entry in the labour market for the younger generations and by the increase of compulsory schooling age from 14 years old to 16 years old for cohorts born after 1953. Among women, the same result occurs for longest durations accumulated at 54 years old, but the weight of short durations is significantly decreasing for women compared with men due to an increasing participation of women to the labour market.

■ 1993, 2003 and 2010 Reforms: some Results

We use the PROMESS model to assess the differential impact of the 1993, 2003 and 2010 reforms on the projected ages of leaving the labour market and of retiring, by cohort, wage quartile and gender²⁸. As already mentioned in the introduction, we focus here on average ages of labour market leaving and average ages of retirement only. Since life expectancy increases with wage quartile (within a gender group) and given the extent of differences in life expectancy across social groups, we assume that any reform that increases retirement age more for higher-wage workers than for lower-wage workers has redistributive effect as regards retirement duration.

The 1993 reform consists in increasing the required insurance duration from 150 quarters for the generation born in 1933 to 160 quarters for the generation born in 1943. Then, the 2003 reform progressively rises the required duration to 164 quarters for generation 1952. It is also planned to raise it again to 166 quarters for generation 1955 in order to stabilize the average ratio *required insurance duration for full-rate/average expected retirement duration* from one

²⁸ Other results concerning the impact of the 1993, 2003 and 2010 reforms are provided in Aubert *et al.* (2012)

generation to the other²⁹. The 2003 reform also creates an early retirement age, *i.e.* a possibility for workers with a long career to retire before the minimum legal age, with eligibility conditions in terms of required insurance duration changing according to the generation.

With the 2010 reform, all legal ages (early retirement age, minimal age and normal age) progressively increase by two years for generations born after 1950 (with a smoothing over four cohorts). Hence the minimum legal age of retirement is raised from 60 to 62 years old³⁰, and the normal age is raised from 65 to 67.

To assess the intragenerational impact of the 1993, 2003 and 2010 reforms, we compute average ages of labour market leaving and retirement by generation (figure 4). We look separately at the 1993-2003 reforms on one hand and the 2010 reform on the other hand. The 1993 and 2003 reforms both consisted in increasing the required duration and both did not impact the minimum legal age of retirement, so their effect should be very different than the 2010 reform. We first assess the impact of the 1993-2003 reforms compared with the pre-1993 legislation. Then we assess the effect of the 2010 reform compared with the post 2003 legislation.

Results show that the projected variation of **average ages of labour market leaving** due to 1993 and 2003 reforms increase with the quartile of revenue for men. For men born in 1970, the average retirement age would rise by five months for the first quartile, while it would increase by fifteen months for the fourth quartile following the 1993-2003 reforms. The mechanisms behind that result are distinct according to whether we consider quartiles 2 to 4 on the one hand and quartile 1 on the other hand.

Among quarters 2 to 4, people in the upper quartile have shorter insurance durations validated before age 60 than people in the second and third quartile. Due to reforms, they less and less have a sufficient insurance duration compared to the required duration. Thus their probability to stay in employment rises across generations, and this effect is all the larger as quartile increases.

The mechanism is quite different for people in the lower quartile (quartile 1). These people usually have a low insurance duration, due to frequent and long non-employment spells along career³¹. They hence often fail to meet the required duration criterion –even with pre-1993

²⁹ If the ratio exceeds 1.79 the required duration for full-rate pension has to be increased. In fact, with the 2010 reform and the minimum legal age increase, the rule is no longer suited to stabilise the ratio.

³⁰ An exemption was created for some disabled people, who can retire at the age 60 under very strict conditions –such as the degree of disability and the capacity to prove that it was due to a dangerous working environment. This mechanism was not implemented in our simulations since PROMESS cannot account for such specific reform. However this exemption has concerned very few people since 2011 (about 0,3 % of new retirees in 2012) and most disabled workers retire, after the 2010 reform, at the age of 62 instead of 60.

³¹ Moreover, a fairly large share of people in the first quartile is made up of immigrants. Most of them entered the French labour market –and thus began to accumulate quarters in French pension schemes– lately, which explains their relatively short duration of career from the point of view of French pension schemes.

values for this parameter— which imply that they are less affected by changes in that criterion. Indeed, the fact that they seldom meet the criterion before the age of 60, whatever the value for this criterion, makes their transition probabilities quite insensitive to reforms. Besides, the fact that they are more often out of employment at age 60 also decreases the impact of the change in required duration on their age at leaving the labour market. Last, a significant share of workers in the first quartile are disabled (see table 2 *infra*), thus exempt from the pension penalty even if they fail to meet the required duration criterion.

For women, reforms have a smaller impact than for men: about three months for women of the first quartile born in 1970, and eight months for women of the fourth quartile. Average ages of labour market leaving for quartiles 2 to 4 increase from one generation to the other, but not in the first quartile: women of the first quartile seldom reach the required duration before the age of 60, even within older generations. Thus the effect is very similar among generations for this quartile.

To summarize, increasing the duration criterion seems to have a differential effect on employment across the quartiles, especially for men. *The lower the quartile, the lesser the career would have to be lengthened before leaving the labour market.* This effect would be higher for younger generations, due to the extinction of early retirements for long career.

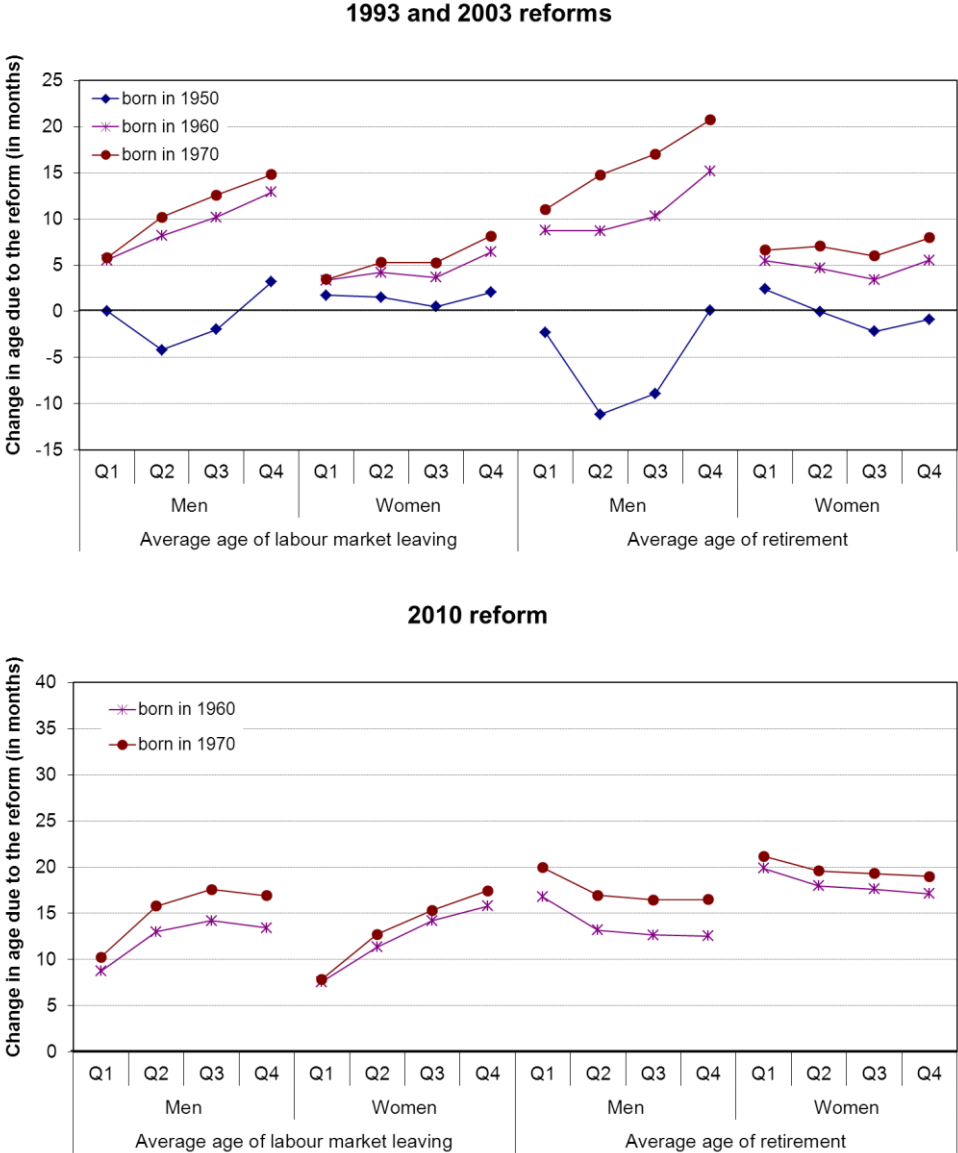
The effect of the 2010 reform on the projected variation of average ages of labour market leaving looks a bit different. The average age increase is higher – from ten months for men in the first quartile to eighteen months for men in the third quartile born in 1970. The slope is even steeper for women (from eight months – first quartile – to seventeen months – fourth quartile – for women born in 1970). The impact is smaller on men in the fourth quartile since they generally stay longer at work due to later entry on the labour market. *In this sense, the 2010 reform seems less redistributive for men than the 1993-2003 reforms, but more redistributive for women.*

Comparing the **average age of retirement** by quartile on figure 4, we also see a differential effect of 1993-2003 reforms across quartiles. The impact differs across generations. For people born in 1950, reforms push down the age of retirement more on average for men of the second and third quartiles (respectively -11 months and -9 months) than for those of the first and fourth quartiles (respectively -2 months and 0 month). This result is due to the possibility to retire earlier than the minimal age for people with a very long career: for example 4% of the men of the second quartile and 3% of men of the third quartile born in 1960 would retire before the age of 60, against 1% for the first and fourth quartiles. The same explanation holds for women of the first quartile compared to the others. On the contrary, the effect for men born in 1970 is increasing with the quartile.

The difference between impacts on the age of leaving the labour market and on the retirement age might be due to some substitution effect between early exit schemes. Workers who retire below 60 thanks to the 2003 reform would probably also have left the labour market below that age, through preretirement schemes or compensated unemployment, had the possibility for early retirement not been given to long-career workers. This substitution between the early retirement scheme and preretirement schemes is likely to explain the fact that, for workers born in 1950 in the second and third quartile, the impact of the 2003 reform has a much larger (negative) extent on retirement age than on age of leaving the labour market.

Figure 4. Variation of the average age of retirement, by gender, quartile and generation

In months



Source: PROMESS, Drees

Concerning the 2010 reform, its impact on average ages of retirement is downward sloping from low to high quartiles. A striking point is that the 2010 reform may have opposite implications on average ages of retirement by quartiles and gender, compared to the 1993-2003 reforms. Looking at gender, women would have to postpone retirement more than men whatever the quartile and the generation (+20 months for women born in 1970 vs. +17.5 months for men on average). By quartile, the 2010 reform also seems to have counter-distributive effects among younger generations, since its impact would be greater the lower the quartile. For men born in 1970, workers in the first quartile would postpone their retirement by twenty months on average, while workers in the fourth quartile would only retire sixteen months and a half later on average. Similar results also holds for women but the slope is less downward sloping.

The larger impact in the first wage quartile comes from the fact that, in this quartile, a larger share of people would have retired at the age of 60 before the 2010 reform thanks to retirement for disability. A larger share also has to wait until 67 to retire with a “full-rate” pension since they seldom reach the required insurance duration before that age. While the end of career of people in the first quartile is less affected by reforms, they have to postpone the most their retirement. These people will then have to rely longer on average –between leaving the labour market and retiring– on other sources of revenue such as unemployment insurance or disability benefits.

Distribution of retirement age

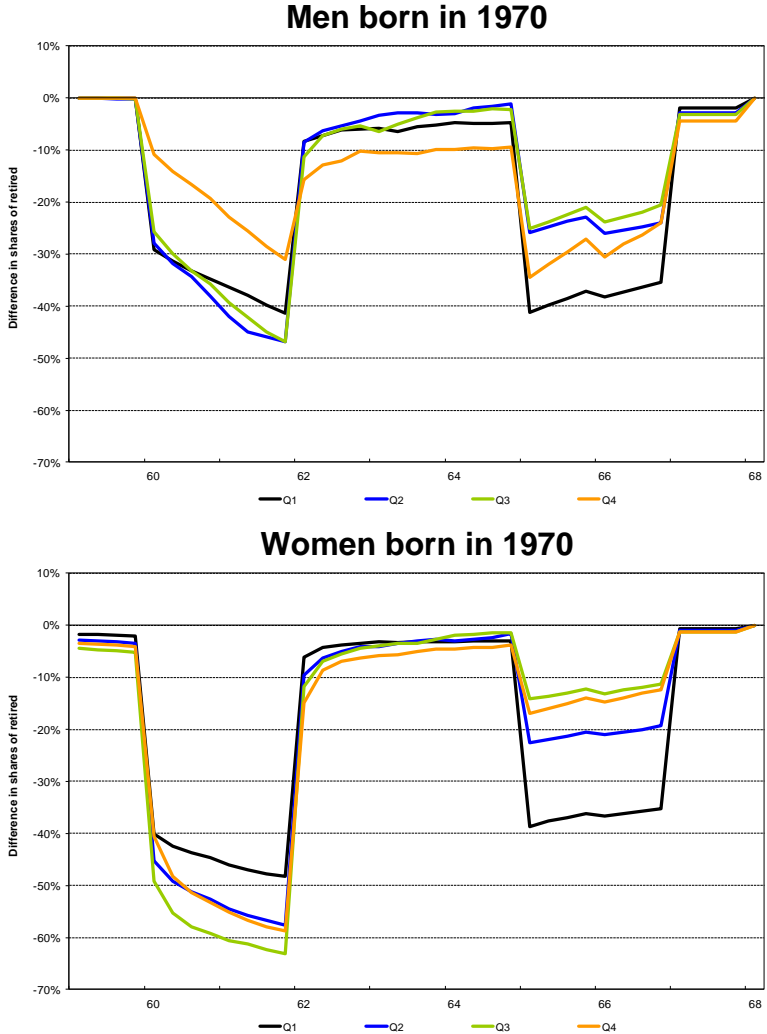
Reforms do not have the same impact among quartiles on the distribution of retirement age. Following the 1993-2003 reforms the share of men retiring at the age of 60 or younger decreases by eighteen percentage points within the first quartile while it decreases by more than thirty-five percentage points within the other quartiles for people born in 1974. This gap is declining with age until the age of full-rate, the slope being larger for quartiles 2 to 4 compared to quartile 1. The lower decrease of the share of people retiring at the age of 60 in the first quartile is likely to be explained by the larger share of disabled³² workers. Before the 2010 reform, such workers could retire at 60 with full-rate pension regardless of their number of quarters, which makes them virtually unaffected by these reforms. The smaller slope may mean that workers in the first quartile who postpone retirement due to the reforms do it by postponing up to age 65. On the contrary, workers within quartiles 2 to 4 who postpone retirement may more often postpone by a few months only, which explains that the fall in the share of retired people according to age decreases with age up to age 65.

Regarding effects of the 2010 reform on the distribution of retirement age (see figure 5), we isolate a specific effect at the minimum legal age and one at the normal age:

- First, men in the fourth quartile are significantly less impacted by the reform than others, which is not the case for women.
- Second, a greater proportion of men in the first quartile have to wait until the new minimum legal age to retire for disability. The second and third quartiles are also impacted, but because they have to wait to retire whereas they have validated enough insurance duration.
- Third, a greater proportion of men in the first quartile have to wait until the normal age, since they on average have lower insurance duration, as it is also the case for women.

³² We assume that workers who fail to meet the required duration for a full-rate pension have a higher probability to claim to be recognised as disabled. Hence a retirement reform, which hardens the conditions for a full-rate pension, may result in an increase in the share of (registered) disabled among workers.

Figure 5. Differences of cumulated distributions of retirement ages before and after the 2010 reform, by quartile and gender



Source: PROMESS, Drees
 Note: for men born in 1970 in the first wage quartile, the share of already retired at the age of 60 drops by eleven percentage points under the post 2010 reform legislation, compared to what would have happened under the post 1993-2003 reforms legislation.

Disentangling required insurance duration, legal ages effects and retirement for inability

Another way to look at the impact of the 1993, 2003 and 2010 reforms is to decompose it in a “required insurance duration” effect and “legal ages” effects. First we use the PROMESS model to project retirement ages by gender and quartile simulating only the increase in the required insurance duration. Then we add the possibility for early retirement in the simulation, and the “early retirement age” effect is computed as the difference between the simulated effect and the “required insurance duration” effect. Third we compute the differential impact of the increase in the minimum legal age, and finally the differential effect of the increase in the normal age.

First, for men born in the 1950’ the decomposition shows that “required insurance duration” effects are more pronounced for the first and fourth quartiles (see table 1), whereas the possibility to leave before 60 years old for long career-workers benefits more to people in the

second and third quartile. For men in younger generations, the impact of increasing the required duration is all the larger that the wage quartile is high.

Second, the increase in the minimum legal age has a higher impact on men in low quartiles born in the 1960' and 1970', whereas its effect increases with the quartile for women.

Third, the decomposition confirms that raising the normal age affects more people in the first quartile, both among men and among women. The effect also increases for younger generations.

Table 1. Decomposition of the 1993, 2003 and 2010 reforms into minimum age effects and required duration effects

Cohort of birth	Increase in average retirement age due to...	<i>Effect on retirement age (in months)</i>							
		Men				Women			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1950	Increase in required insurance duration	5.0	4.3	4.5	7.2	4.0	3.4	2.6	3.0
	Early retirement age	-7.7	-16.1	-13.9	-7.4	-1.7	-3.6	-5.1	-4.1
	Increase in minimum legal age (60 -> 62)								
	Increase in normal age (65 -> 67)								
	Total	-2.6	-11.8	-9.5	-0.2	2.3	-0.2	-2.4	-1.1
1960	Increase in required insurance duration	8.9	9.2	10.7	15.4	6.2	5.8	4.8	6.7
	Early retirement age	-0.1	-0.2	-0.2	-0.2	-0.5	-0.5	-0.6	-0.6
	Increase in minimum legal age (60 -> 62)	9.5	9.2	9.1	7.4	11.5	12.9	14.1	13.5
	Increase in normal age (65 -> 67)	7.0	3.3	3.0	5.0	8.0	4.2	2.4	2.9
	Total	25.3	21.5	22.6	27.5	25.2	22.4	20.8	22.5
1970	Increase in required insurance duration	13.1	19.3	21.9	24.9	8.5	9.4	8.9	11.0
	Early retirement age	0.0	0.0	0.0	0.0	-0.3	-0.3	-0.3	-0.3
	Increase in minimum legal age (60 -> 62)	8.5	6.0	5.6	4.7	10.6	12.3	13.3	12.5
	Increase in normal age (65 -> 67)	9.4	6.4	5.9	7.6	8.9	5.1	3.3	3.7
	Total	31.0	31.7	33.4	37.2	27.8	26.5	25.1	26.8

Source: PROMESS, Drees

These results also confirm that intragenerational redistributive effects of reforms are not as clear among generations and gender: people with longest careers are not systematically in the lowest quartiles, and especially in the first one. Moreover, for women, increasing the duration criterion would not be redistributive at all. Therefore the duration criterion *alone* (*i.e.* considered independently from its interferences with age boundaries) is not a way to automatically correct intragenerational inequalities as regards expected life in retirement since it has not the same impact across gender.

Increasing the normal age would not be redistributive at all whatever the gender. On the contrary, increasing the minimum legal age seems to be quite redistributive as regards retirement age for women, but not at all for men.

Nonetheless, the overall effect of the retirement framework might perform redistribution in retirement duration, thanks to the combination of the required duration criterion and the possibility to retire at the minimum age for the disabled. Moreover, a large share of people in the first quartile of wage has been unaffected by the 1993 to 2003 reforms due to the fact that they already had to wait for the normal age (65), even with pre-reform values of parameters

(see table 2). Thus for younger generations, especially for men, the aggregate impact of 1993-2003 reforms seem to be inequality-softening as regards retirement age.

Table 2. Shares of people retiring for disability and of people retiring at the normal age

After the 1993-2003 reforms

Generation	Men				Women			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	people retiring for disability							
1950	19.5	6.1	4.1	2.7	23.0	15.0	7.4	4.3
1960	25.9	10.6	7.3	3.8	23.5	16.8	8.7	6.5
1970	28.4	13.2	9.7	4.3	24.5	18.8	10.4	7.8
	people retiring at the normal age							
1950	22.8	9.8	6.9	10.9	34.3	16.7	9.7	8.9
1960	31.0	15.6	15.0	20.7	34.3	18.8	11.2	12.4
1970	38.1	25.7	24.3	27.7	36.6	21.6	13.5	14.1

After the 2010 reform

Generation	Men				Women			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	people retiring for disability							
1950	19.5	6.1	4.1	2.7	23.0	15.0	7.4	4.3
1960	22.6	7.2	4.7	3.1	22.4	14.6	6.9	4.6
1970	27.7	11.2	8.1	4.0	23.9	17.3	8.9	6.3
	people retiring at the normal age							
1950	22.8	9.8	6.9	10.9	34.3	16.7	9.7	8.9
1960	25.4	10.9	9.2	13.4	30.9	15.3	7.5	9.2
1970	33.5	21.2	17.4	19.6	34.5	18.3	10.1	11.1

Note: the normal age after the 2010 reform is 65 for people born in 1950 and 67 for people born in 1960 and 1970.

Source: PROMESS, Drees

■ Conclusion

The French retirement reforms (1983, 1993, 2003 and 2010) have created a particular legislative framework where the age at which an individual can go into retirement and receive a full-rate pension is conditional to both a legal minimum age and a required insurance duration. In that framework, the required insurance criterion can have a redistributive impact as regards retirement duration.

Indeed, our simulations show that 1993 and 2003 reforms have an intragenerational redistributive impact for men –meaning that they imply a larger increase in the average retirement age of high-wage workers than of low-wage workers. That effect seems to be more and more important across generations, due to the extinction of early retirement for long career for generations born after the 1960'. As far as women are concerned, the redistributive effect is not as clear, but inequalities stemming from differential mortality also seem to be less important among women. For older generations born in the 1950' and early 1960', the

redistributive impact of 1993-2003 reforms holds for quartiles two to four, but not for the first one.

In fact, the required duration criterion *alone* does not really enable low-educated workers to retire earlier. Indeed the modelling of careers with PROMESS confirms that first quartile workers face longer non-employment spells during the career, and thus reach the required insurance duration on average later than higher-educated workers. The existence of a possibility to retire at the minimum legal age without financial penalty for the disabled plays a key role in the French pension system framework, since a greater part of people using this possibility is found in the first wage quartile, according to our PROMESS model.

Analysis of the redistributive effects of the 2010 reform shows ambiguous effects that we tried to unravel. Increasing the minimum legal age seems to have a redistributive impact for women, but not for men. Besides, raising the normal age has counter-distributive effects within both gender groups. Increasing these ages is therefore not a good tool to reduce inequalities stemming from differential mortality, and the rationales for advocating for an increase in the required insurance duration rather than postponing legal (minimum or normal) age seem empirically founded.

Of course, our analysis focusing on retirement ages is only part of the general picture. Our choice to focus on this aspect corresponds to the importance that has been given to this topic in public debates over retirement reforms in France. However, a broader analysis of redistribution performed by the pension system –which is here left for further work– should also involve an analysis of income inequalities and differences in rate of return according to workers' characteristics. It should be noted also that our results depend on labour market outcomes –probabilities to leave employment conditional to workers' characteristics, etc.–, which might be affected in case of changes in legislations apart from retirement legislation (for instance unemployment insurance legislation).

■ References

Aubert P. and M. Bachelet, (2012) « Disparités de montant de pension et redistribution dans le système de retraite français », Insee, *L'économie française, édition 2012*, Insee - Références, pp.45-62

Aubert P. and V. Christel-Andrieux, (2010) "La mortalité différentielle des retraités: estimation à partir de l'échantillon interrégimes de retraités et applications", DREES Working Papers – 'Études et Recherches' series, n°100, July 2010.

Aubert P., C. Duc and B. Ducoudré (2012), "Projeter l'impact des réformes des retraites sur les sorties d'activité: une illustration par le modèle PROMESS", *Revue française des affaires sociales* 4/2012 (n° 4), p. 84-105.

Aubert P., C. Duc and B. Ducoudré (2013), "The PROMESS model: Meso Projection of Ages for Ceasing Employment and Retiring", DREES Working Papers, Document de travail de la Drees - série Études et Recherches, n° 127, juillet 2013.

Baraton M. and Y. Croguennec (2009), "Les durées d'assurance validées par les actifs pour leur retraite: Une évaluation à partir de l'Échantillon interrégimes de cotisants de 2005", *Études et Résultats* n°692, May.

Barthélémy N., M. Mamache and S. Benallah (2013), « Les motivations de départ à la retraite : stabilité entre 2010 et 2012 », *Études et résultats*, n°838

Boeri, T. and A. Brugiavini (2008). "Pension Reforms and Women Retirement Plans." *Journal of Population Ageing* 1(1): 7-30.

Briard, K. and S. Mahfouz (2011), "Modulations de la retraite selon l'âge de départ : principes directeurs et évolutions depuis les années 1980" *Economie et Statistique*, n°441-442: 15-38.

Cambois E. and J-M. Robine (2001), "Apport des indicateurs d'espérance de vie sans incapacité à l'étude des inégalités sociales de santé" *Société française de santé publique, Santé publique* n° 13, 2001/2.

Cambois E., C. Laborde and J-M. Robine (2008), "La double peine des ouvriers : plus d'années d'incapacité au sein d'une vie plus courte" *Population et sociétés* n° 441, janvier 2008.

COR (2012), "Retraites: perspectives 2020, 2040 et 2060", Onzième rapport du Conseil d'orientation des retraites.

Cremer, H. and P. Pestieau (2003). "The Double Dividend of Postponing Retirement." *International Tax and Public Finance* 10(4): 419-434.

Desplanques G. (1993), "L'inégalité sociale devant la mort", *Insee Données sociales, la société française* 1993.

Fehr, H., M. Kallweit, et al. (2012). "Pension reform with variable retirement age: a simulation analysis for Germany." *Journal of Pension Economics and Finance* 11(03): 389-417.

Mesrine A. (1999), "Les différences de mortalité par milieu social restent fortes", *Insee Données sociales, la société française* 1999.

OECD (2011), "Pensions at a Glance 2011: Retirement-Income Systems in OECD and G20 Countries"

Rapport B. (2009), "En début de carrière, moins d'acquisitions de droits à la retraite pour les jeunes générations", *Dossier Solidarité Santé* n°10-2009, pp. 24-45.

SG-COR (2012), "Les règles d'acquisition des droits et de calcul des pensions à l'étranger", document n°15 de la séance du COR du 25 septembre 2012

SG-COR (2013), "Les évolutions depuis 2000 des attentes et opinions vis-à-vis de la retraite des Français d'âge actif : enseignements du baromètre DREES", document n°6 de la séance du COR du 28 mai 2013

Toder, E., Favreault, M., O'Hare, J., Rogers, D., Sammartino, F., & Smith, K. (2000), "Long Term Model Development for Social Security Policy Analysis." The Urban Institute.

Whitehouse, E. R. and A. Zaidi (2008), "Socio-Economic Differences in Mortality: Implications for Pensions Policy", *OECD Social, Employment and Migration Working Papers*, No. 71, OECD Publishing

Annex 1: recent estimations of the life expectancy gap across social groups in France

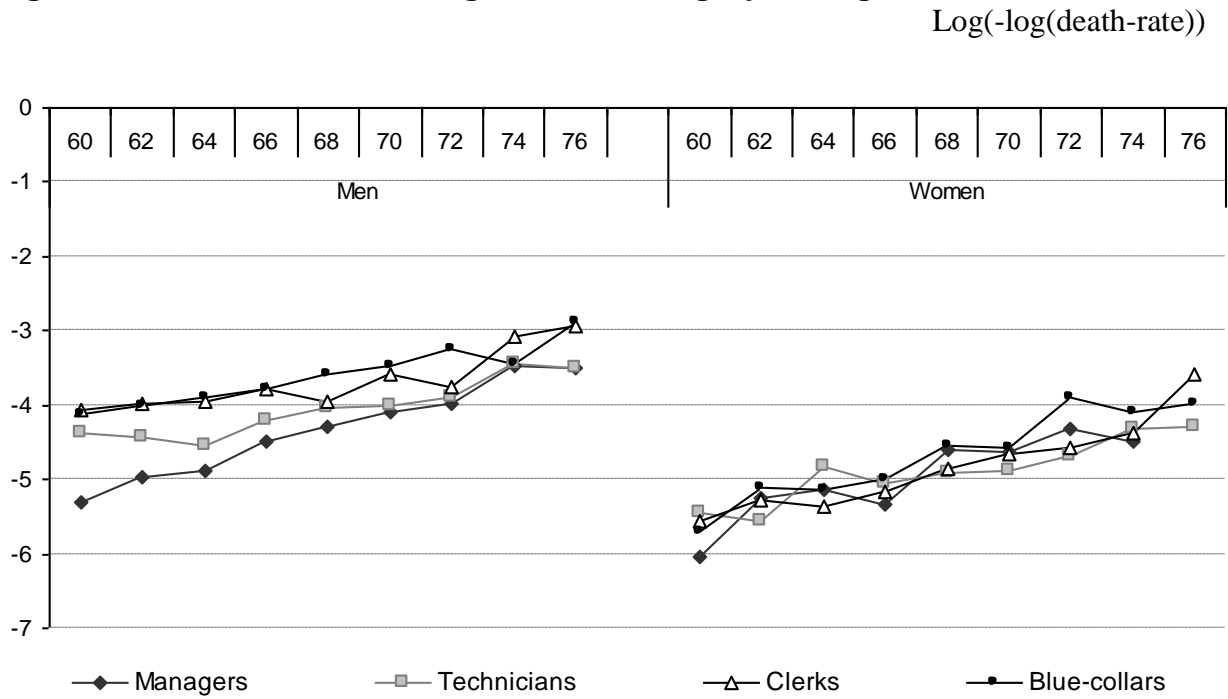
Table A1. Summary of recent estimations of the life expectancy gap across social groups in France

Author	Cambois, Laborde & Robine, 2008	Aubert & Christel Andrieux, 2010	Mesrine, 1999	Cambois & Robine, 2001	Desplanques, 1993
Gap	White / blue-collars workers: +6 years for men +2 years for women	White / blue-collar workers: +3.7 years for men +2.8 years for women	White collars and liberal professions /blue-collar workers: +5.5 years for men +3.5 years for women	White / blue-collar workers: +3.1 years	Teachers, professors of literature and science / body repairmen: +3.8 years for men
Life expectancy	At 35 years old, 1999-2003 period	At 55 years old	At 60 years old, 1982-1996 period	At 60 years old, in 1991	At 60 years old, 1980-1989 period
Source	Permanent demographic sample (EDP)	Pensioners' Inter-scheme samples (EIR) of 1993, 1997, 2001 and 2004	Mortality sample of 1982	Insee, decadal surveys and longitudinal surveys of health mortality	Census / Marital Status

Using the EIR database to look at death-rate gaps by age according to the social level, we see that white collars workers clearly have a smaller death-rate than blue-collars workers at all ages until the 72 years old (figure A1). It is less clear for women, but the death-rate curve for white collars women is generally under that of blue-collar female workers.

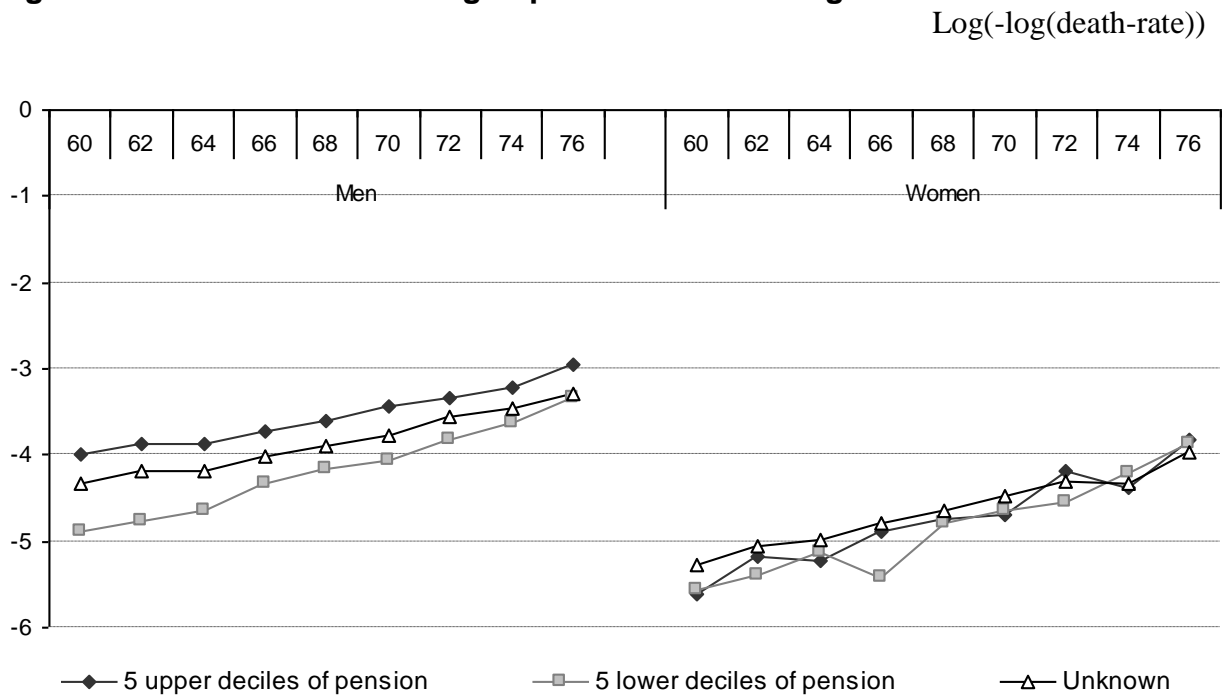
Looking at the death rate curves according to the pension deciles, a notable result for men appears: whatever the age is, retirees in the upper deciles of pension have a lower death-rate than retirees in the lower deciles of pension (figure A2). For women, differences in death-rate are much smaller across social category as well as across pension decile.

Figure A1. Death-rate according to social category and age



Source: Pensioners' Inter-scheme samples

Figure A2. Death-rate according to pension level and age



Source: Pensioners' Inter-scheme sample

Annex 2: technical notes

Before 54 years old

For cohorts born after 1950, category at 54 years old cannot be directly observed in the EIC data. Categories are available only before this age: 50 years old for the 1954 cohort, 46 years old for the 1958 cohort, *etc.* Then we have $N_{c,1954}(50)$, $N_{c,1958}(46)$, *etc.*

Nevertheless, we can use EIC data to estimate transition probabilities between categories, *i.e.* probabilities to move from one category to another with a four-year step until 54 years old. We use a four-year step because only one cohort over four is observed in EIC (cf. *supra*). At this stage, almost all individuals in EIC born between 1942 and 1974 are included to estimate transition probabilities (about 180 000 people). Note that only three elements defining a category c may change: insurance duration validated NbQ , wage quartile w and/or activity sector $sect$.

$$\Pr_{c \rightarrow c', g}(a \rightarrow a + 4) = \frac{\sum_i 1\{i \in c(g, a) \cap c'(g, a + 4)\}}{\sum_i 1\{i \in c(g, a)\}} \quad \forall c$$

To compute quadrennial transitions, we use the closest generation. For instance we use data of the cohort born in 1970 to compute transition probabilities between 30 and 34 years old, data of the cohort born in 1966 to compute transition probabilities between 34 and 38 years old and so on. This choice implies that empirical probabilities follow the same transitions as they were between 2000 and 2004. Implicitly, the model PROMESS assumes that in projection, the labour market will keep, in average, the same characteristics that the period 2000-2004.

Note that whereas, PROMESS was designed to study the consequences of retirement system reforms, it does not make explicit models and specific parameters of other determiners in senior employment cannot be defined, such as economic conjuncture, public measures relating to unemployment and preretirement, *etc.* These determiners are however not ignored: they appear implicitly in estimated parameters of the models for ceasing employment. But this implicit consideration implies that this model makes the strong hypothesis that these determiners will remain similar to their current level³³ throughout the projection period. This signifies that, firstly, the model does not enable us to study the reforms of one of the determiners other than retirement systems, and secondly, that any modification to the balance of the senior labour market in relation to the current balance is an additional factor of uncertainty on the projections.

The weight of each category at 54 years old for each generation is obtained by multiplying the weight of each category at age a observed in EIC and the transition probabilities.

³³ More precisely at their level at the end of the 1990s and the beginning of the 2000s, being that the parameters for the ceasing employment models were estimated using observations from those years.

For instance, for the 1974 generation $N_{c,1974}(30)$ is observed in the EIC data. Then we have:

$$N_{c,1974}(34) = \sum_{c'} N_{c',1974}(30) * \Pr_{c' \rightarrow c, 1970}(30 \rightarrow 34)$$

then

$$N_{c,1974}(38) = \sum_{c'} N_{c',1974}(34) * \Pr_{c' \rightarrow c, 1966}(34 \rightarrow 38)$$

and so on.

Between 54 years old and the minimum legal age of retirement

In PROMESS, the age of 54 years old was selected as the threshold from which the last year of activity is modeled, that is, both the last employment and the retirement for the last pension scheme. This choice is based on the observation of employment rates by age. They remain roughly stable at a high level until 54 years old, and then begin to decline for men and women. This stylized fact corroborates the idea that it is mainly during the five years preceding the minimum legal age of retirement that the transition from employment to inactivity takes place.

For simplicity reason, we only present the method for the last employment age but, the method is similar for other ages (the age of the last social benefit taking into account for the retirement pension and retirement age). We restrict here to private sector workers still in employment after 50 years old³⁴. Thus we have $P_{c,g}^e(50) = 1, \forall c, g$. We also consider that all transitions between 50 years old and 54 years old occur at some arbitrary age ($=52$). For age a ($54 \leq a \leq \text{MinAg}(c, g)$), probabilities are computed as follows:

$$P_{c,g}(a) = P_{c,g}(52) * \prod_{a'=54}^a \Pr_{c,g}^{inst}(a')$$

where $\Pr_{c,g}^{inst}(a')$ are the instantaneous probabilities that a worker who is still in employment at age a' leaves the labour market at that age:

$$\Pr_{c,g}^{inst}(a') = \Pr(\text{Max}\{a'' | \text{employment at age } a''\} = a' | c, g)$$

They are estimated through a Logit regression on the EIC and the EIR data (about 12 000 men and 9 000 women) for the 1934, 1938 and 1942 cohorts. Separate estimations for all genders and ages are run. Explanatory variables are dummies for all wage quartiles, plus a dummy $1\{\text{Nb}Q_c(54) + 4 * (a' - 54) \geq \text{ReqNb}Q(c, g)\}$ which equals 1 when the required insurance duration is satisfied³⁵.

After the minimum legal age of retirement

³⁴ See Aubert, Duc and Ducoudré (2013) for a presentation of the model as regards civil servants and workers already out of the labour market before 50 years old.

³⁵ Workers who have missing quarters to satisfy the duration criterion and then eligible to a full-rate pension have higher incentive to remain on the labour market and keep on accumulating quarters. On the opposite, workers who know they can pretend to a full-rate pension as soon as they reach the minimum legal age may more often into exit the labour market particularly with preretirement schemes.

Just before the minimum legal age of retirement (*i.e.* at age $MinAge^-$), individuals within a category c can be divided into 4 subgroups: $P_{c,g}^e(MinAge^-)$ which is the share of individuals still in employment (subgroup $c1$), $[P_{c,g}^v(MinAge^-) - P_{c,g}^e(MinAge^-)]$ the share of individuals who have left the labour market but still perceive social benefit taking into account for the retirement pension³⁶ ($c2$), $[P_{c,g}^r(MinAge^-) - P_{c,g}^v(MinAge^-)]$ the share of individuals who are out all social arrangements but not yet retired ($c3$), and $1 - P_{c,g}^r(MinAge^-)$ the share of individuals who are already retired³⁷ ($c4$). Note that the model considers that retired people do not work nor accumulate quarters during their retirement period, so inequality $P_{c,g}^r(MinAge^-) \geq P_{c,g}^v(MinAge^-) \geq P_{c,g}^e(MinAge^-)$ is always fulfilled.

For each subcategory and each age a such as $MinAge(c, g) \leq a \leq LegAgeFR(c, g)$, we estimate probability $PrRetire_{c,g}^{ci}(a)$ that retirement occurs at age a . For individuals still in employment, we assume that they leave the labour market and stop accumulating quarters at the same age. Estimations are run using a Logit model on the EIR and the EIC data for generations 1934 and 1938 (about 2 500 men and 2 500 women). The estimation specification is very simple for individuals already outside the labour market at the minimum legal age, since retirement mainly occurs at the minimum legal age $MinAge$ or at the legal full-rate age $LegAgeFR$. We therefore do not present them here.

A slightly richer specification is considered for workers who are still in employment when they attain the minimum legal age. In that case, the specification for the latent variables is as follows:

$$\begin{aligned}
y^* = & \sum_{a=MinAge(g,c)}^{LegAgeFR(g,c)+1} \sum_{w \in \{1,2,3,4\}} (\tilde{\alpha} \cdot a + \alpha_0 \cdot 1_{a=MinAge}(a) + \alpha_1 \cdot 1_{MinAge < a < LegAgeFR}(a) + \alpha_2 \cdot 1_{a=LegAgeFR}(a) + \alpha_3 \cdot 1_{a > LegAgeFR}(a)) 1_{w=w(c)} \\
& + \sum_{a=MinAge(g,c)}^{LegAgeFR(g,c)+1} (\tilde{\beta} \cdot a + \beta_0 \cdot 1_{a=MinAge}(a) + \beta_1 \cdot 1_{MinAge < a < LegAgeFR}(a) + \beta_2 \cdot 1_{a=LegAgeFR}(a) + \beta_3 \cdot 1_{a > LegAgeFR}(a)) EQUAI(a) \\
& + \sum_{a=MinAge(g,c)}^{LegAgeFR(g,c)+1} (\gamma_0 + \tilde{\gamma} \cdot a) PLUSI(a) + \sum_{a=MinAge(g,c)}^{LegAgeFR(g,c)+1} (\delta_0 + \tilde{\delta} \cdot a) ABOVE(a) \\
& + \varepsilon
\end{aligned}$$

Explanatory variables are the following (estimations are run separately for men and women):

- age a
- dummies $1_{w=w(c)}$ for each wage quartile at 54 years old
- dummies $1_{a=MinAge}(a)$, $1_{MinAge < a < LegAgeFR}(a)$, $1_{a=LegAgeFR}(a)$, $1_{a > LegAgeFR}(a)$ equalling 1 respectively when a equals the minimal legal age, when a is strictly between the minimal legal age and the full-rate pension age, when a equals the full-rate pension age, when a is above the full-rate pension age.

³⁶ Some unemployment and disability schemes enable to accumulate quarters for retirement.

³⁷ In the private sector, this share of the population only includes individuals for whom derogatory schemes allows to retire before the minimum legal age (*e.g.* the so-called ‘long-career’ workers after the 2003 reform).

- a dummy $EQUAL(a)$, equalling 1 at age a when the required insurance duration $ReqNbQ(g,c)$ is reached at age a (strictly)
- a dummy $PLUSI(a)$, equalling 1 at age a when the required insurance duration $ReqNbQ(g,c)$ is reached at age $a-1$ (strictly)
- a dummy $ABOVE(a)$, equalling 1 at age a when the required insurance duration $ReqNbQ(g,c)$ is reached before age $a-1$.

The peak probability of retire occurs when individuals reach the required insurance duration, *i.e.* when $EQUAL(a)=1$. However, the model also takes into account that some individuals retire earlier or later than this age³⁸.

³⁸ All probabilities are normalized so that they add up to 1.