Pension Reforms and Inequalities in France

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Abstract

This study analyzes the distributional effects of French pension reforms from 1993 to 2014 across different socioeconomic groups. Using administrative data for individuals born between 1934 and 1950, we examine the impact on social security wealth (SSW) across lifetime earnings deciles and genders. Our methodology incorporates differential life expectancy and exploits the PENSIPP model for counterfactual scenarios. Results show that reforms generally decreased SSW across all income groups, with regressive tendencies. The 1993 reform had the most significant impact, reducing SSW by over 15% for men in the lowest earnings decile compared to 5% for the highest. Subsequent reforms had milder effects. These findings contribute to understanding the long-term consequences of pension reforms on inequality and inform future policy decisions in countries facing similar demographic challenges

1 Introduction

Population ageing has prompted many developed countries to reform their pension systems, with France being no exception. Since 1993, successive reforms have significantly impacted pension levels, aiming to increase retirement age and reduce the pension system deficit. These reforms have successfully raised the average retirement age from 60.3 years for the 1948 cohort to 61.7 for the 1954 cohort, leading to a reduction in the expected time in retirement from 25.8 to 24.6 years (Drees 2023). While these changes have helped stabilise public pension spending, their redistributive impact remains largely unexplored.

This paper aims to fill this gap by providing a systematic analysis of the impact of French pension reforms on different socioeconomic groups. We focus on the effects across deciles of lifetime average earnings and gender, offering a comprehensive view of how these reforms have shaped retirement patterns and pension outcomes for various segments of the population.

Our study leverages rich administrative data (EIC-EIR) containing detailed information on labour earnings and pensions for a representative sample of individuals born between 1934 and 1950. We concentrate on private sector pensioners, positioning them within the distribution of lifetime labor earnings. For each decile, we compare key metrics such as claiming age, pension levels at claiming, and social security wealth, measured as the expected flow of pension benefits over the lifetime.

Our approach incorporates differential life expectancy based on lifetime earnings. Recent literature has highlighted significant variations in life expectancy across income groups (Chetty et al. 2016, Milligan & Schirle 2021), which can substantially influence the analysis of pension system redistribution (Haan et al. 2020, Mélard et al. 2023). We address this by utilising data from Mélard et al. (2023) to compute life expectancy by lifetime labour earnings deciles, ensuring a more accurate assessment of social security wealth across different groups.

Our analysis covers the impact of four major pension reforms implemented in France in 1993, 2003, 2010, and 2014. These reforms were primarily parametric, modifying specific "parameters" of the pension system such as early retirement age, normal retirement age, and the career duration required to receive a full pension. For each reform, we compare actual individual trajectories to counterfactual scenarios, accounting for both changes in retirement behaviour and pension levels. We employ the PENSIPP model, a sophisticated pension calculator, to generate counterfactual pension levels under various legislative scenarios. Additionally, we model behavioural responses using a pension claiming model similar to that proposed by Coile & Gruber (2001), which accounts for financial incentives computed from the PENSIPP calculator.

Our findings show that over the last three decades, French pension reforms have generally had a negative impact on social security wealth (SSW) across all income groups. Notably, all reforms tended to be regressive, reducing the SSW of lower lifetime earnings deciles more than higher deciles. However, the magnitude of impact and degree of regressivity varied significantly across reforms. The 1993 reform had the most substantial and regressive effect, leading to a decrease of more than 15% in SSW for men at the bottom of the distribution, compared to a 5% decrease for those at the top. Subsequent reforms had less regressive impacts, ranging from -5% to 0% depending on the lifetime earnings level. Effects for women were similar, though with some important differences due to divergent career patterns and specific provisions in the pension system aimed at compensating for gender differences related to maternity leave.

This paper contributes to the literature by providing a comprehensive analysis of the distributional effects of French pension reforms, incorporating both mechanical and behavioural responses to policy changes. It completes a large literature focusing on French pension reforms (Bonnet et al. 2006, Bridenne & Brossard 2008, Benallah 2010, Bozio 2011, Duc et al. 2018, Rabaté & Rochut 2020, Tréguier 2021). It mainly differ from these papers by proposing a comprehensive approach allows to compare reforms between each other. Our findings have important implications for understanding the long-term consequences of pension reform on inequality and for informing future policy decisions in France and other countries facing similar demographic challenges.

The remainder of this paper is structured as follows: Section 2 provides a detailed overview of the French pension system and the main reforms conducted over the last 30 years. Section 3 introduces the data used in our analysis, while Section 4 describes the evolution of earnings and pension inequality over time. Section 5 details our retirement behaviour model and its estimation. Results regarding the impact of reforms on Social Security Wealth are presented in Section 6. Finally, Section 7 concludes with a discussion of our findings and their policy implications.

2 Pension system and reforms in France since the 1992

Over the last three decades, France implemented four major pension reforms. As already mentioned, these reforms mainly aimed at balancing the pension system. These reforms were mainly *parametric* in the sense that they affected specific parameters of the system without changing the structure of the pension formula. Before providing more details about the reforms, we first describe the functioning of the French pension system for the private sector employees.

2.1 French pension system for private sector employees

We focus on pensions of former employees of the private sector, which corresponds to the large majority of pensioners (the pension scheme for private sector employees is the main pension scheme for 70.6% of French pensionners, according to Drees 2023). For this population, pensions are made of two components: the first (*Régime général*) and the second (*Agirc-Arrco*) pillar pensions. Both regimes are pay-as-you-go and compulsory systems. They mainly differ on their contribution bases and on the pension formula.

Contribution base Contribution bases of both regimes are defined relative to the *Plafond de la Sécurité Sociale* (PSS) which is an institutional threshold indexed on prices used to define contribution bases of different social benefits. In 2023, the monthly PSS was 3,666€, which was slightly more than twice the gross minimum wage. A vast majority of private sector workers have earnings below the PSS.

Contributions to the first pillar are based on labour earnings up to one PSS. The contribution base of the second pillar depends on the occupation of the worker. Agirc and Arrco were historically two separated pension schemes: one for blue and white collar workers (Arrco), and one for executives (Agirc). For non-executives (Arrco), contributions are based on labour earnings up to 3 PSS. This base is divided into two brackets: the first one that goes from 0 to 1 PSS is associated to a low contribution rate, and the second one, going from 1 to 3 PSS is associated to a higher contribution rate.[1] For executives (Agirc), the second bracket is extended up to 8 PSS.[2] The two schemes merged in 2019,

[1] In 2023, the low contribution rate was 6.2% of gross earnings and the high contribution rate was 16.20%. For the first bracket, one has to add the contribution rate associated to the first pillar: 15.45% of gross wages (6.9% of employee contributions and 8.55% of employer contributions).

[2] More precisely, executives face 3 brackets: one below PSS, one between 1 and 4 PSS, and one between 4 to 8. Contributions below the first PSS are administered by the Arrco. Contribution rate of the last two brackets happen to be identitical (16,44%).

and now apply the rules formerly used for executives.

Pension formula The two pillars also differ in terms of pension formula. Here, we focus on the first pillar formula, as most reforms concentrated on this formula, while the second pillar pension formula was little affected by the reforms.[3]

The first pillar pension formula is given by :

$$B = W_{\text{ref}} \times CP \times \tau \tag{1}$$

The pension is proportional to a reference wage W_{ref}, which in the current system is the average of the 25 best annual earnings figures under the Social Security Ceiling (adjusted for inflation). It also depends on a coefficient of proportionality (*coefficient de proratisation*, CP) accounting for the number of years contributed to the pension scheme. This coefficient is capped to 1, and is computed as:

$$CP = \max(1, D/D_{CP}),$$

with D the number on years of contribution in the private sector and D_{CP} a reference duration determined by law. τ corresponds to a reference replacement rate τ_{ref} of 50%, which can either be increased by a bonus in the case of continued activity beyond the full-rate age, or reduced by a penalty in the case of retirement before this age. More formally it can be decomposed as:

$$\tau = \tau_{\text{ref}} \times \Big[1 - p \times N_{pen} + b \times N_{bon}\Big] \tag{2}$$

Here N_{pen} is the number of quarters of penalty and N_{bon} the number of quarters of bonus. The former is calculated as the minimum between the number of quarters missing to reach the normal retirement age (NRA) and the full-rate duration D_{FR} :

$$N_{pen} = \min(\max(NRA - Age, D_{FR} - D), 0), \tag{3}$$

and the latter as the number of quarters worked beyond D_{FR} and after the minimum age of eligibility (SEA). p and b respectively correspond to the rate of penalty and bonus for

[3]The second pillar is a point based system in which contributions are transformed into points according to a price, and then transformed into a pension according to distinct parameters. Both parameters are fixed by trade unions.

each quarter.

The pension accrual associated with one additional year before claiming is then the sum of three effects:

- The change in the W_{ref}, which depends on whereas the additional annual earnings is among the best ones or not.
- The change in CP, which is equal to 0 if the reference duration D_{CP} is reached, and $1/D_{CP}$ otherwise. As we will detail it later, duration for the full rate (D_{FR}) and duration for full proportionality (D_{CP}) were dissociated at some point in the past, but were finally equalised. In this case, workers eligible for a full rate pension often have their CP capped to 1.
- The change in τ, which depends on the distance to the full rate age and the associated bonus and penalty rates. This parameter can be viewed as the actuarial adjustment in the pension system. But one may notice that as duration is taken into account in the formula, this is only true for workers who have short working careers and are closer to full rate age than full career.

Minimum pension The private sector also has a minimum pension (MiCo), which is an important feature of the model to understand the system's redistributivity. This mechanism actually completes the first pillar pension up to the minimum pension (747€ in 2024). This minimum is contributive in the sense that only indviduals getting full rate pensions ($\tau = .5$) are eligible to it. The actual amount of minimum pension individuals are eligible to is finally obtained by multiplying the total amount by the proportionality coefficient (CP parameter).[4]

2.2 Reforms of the first pillar pension scheme since 1993

The major changes induced by pension reforms since the mid-1990s modified key parameters of the pension system previously defined. Four reforms intervened in 1993, 2003, 2010 and 2014. We briefly present the main changes introduced by these reforms.

[4] In practice, the computation of the individual minimum pension also distinguishes the base minimum pension (684€ in 2024) from the bonus (63€ in 2024) which is only given to individuals who worked at least 30 years. Proportionalisation of the base and the bonus are also made differently: base minimum pension is multiplied by the ratio of *insurance duration* over the target duration, and the bonus by the ratio of the *number of contributed years* over the target duration. On top of contributed years, insurance duration also takes into account unemployment, sickness leave and disability periods.

The 1993 pension reform. The 1993 reform[5] was the first to aim to reduce pension liabilities in France. The reform mainly had an impact on pension levels through two parameters of the system. First, the reform changed the computation of the reference wage (W_{ref}) from the best 10 years to the best 25 years, thus lowering reference earnings used for the pension computation. Second, it increased the number of years required to obtain the full-rate (D_{FR}) from 37.5 years to 40 years. The changes were phased-in progressively by adding one year of the reference year, and one quarter to the required contribution length every cohort (see Bozio 2011, for further details about this reform).

The change in reference earnings computation rules decreased pension benefits for everyone, but was potentially worse for people with highest income because they usually have steeper income slopes over their career (Bozio et al. 2019). However, the increase in required duration probably decreased redistributivity because individuals with high income have longer careers, and can more easily remain in the labour force at late ages than those with low income.

Focusing on individuals who were employed in the private sector in the year before their 60th birthday with a contribution record below the requirement for the FR pension, Bozio (2011) shows that an additional quarter of required contributions led to an average increase in the claiming age of 2 months, corresponding to an elasticity of 0.7. Bridenne & Brossard (2008) propose an ex-ante evaluation of the 1993 reform for individuals who retire between 1994 and 2004. They evaluate the effect of the reform on pension benefits along the pension distribution (at claiming). They show that, for former private workers, the reform reduced average pension benefits for all deciles of the pension distribution. The loss is smaller for men than for women. For both men and women, the loss is higher at the bottom of the distribution (-11.5% for men in decile 2 and -15% for women in decile 4 being the most negatively treated groups) than at the top of the distribution (-8.5% and -11% respectively).

The 2003 reform. The aim of the 2003 reform was mainly to extend rules in the private sector set in 1993 to the public sector, which is out of the scope of our analysis. In the public sector, a penalty was introduced for every year missing to the new required contribution length of 40 years. A second pillar pension was also created for public sector workers. The duration parameters were also programmed to be increased up to 41.5 years.

[5] This reforms in commonly named the Balladur reform from the name of the prime minister who introduced it.

However, important changes also have to be highlighted for the private sector. These changes were made in ensure the actuarial fairness of the pension formula. On the one hand, a bonus (b) for contributions above the full rate duration was introduced. On the other hand, the penalty (p) for claiming before the full rate age was reduced. Duration for the full rate (D_{FR}) and for the full proportionality coefficient (D_{CP}) were also equalized and set to 40 years. Finally, a separate provision (known as *retraites anticipées pour carrière longue* (RACL), i.e., long career) was also introduced for workers having started working at early ages (14, 15, and 16) allowing early retirement (from 56 onward depending on the exact starting age and contributions before 18) without penalty.

Thus, the 2003 reforms decreases financial incentives to retire below full rate age, and increases it above. Changes in the computation of the proportionality coefficient also affects those individuals who are further away from the full rate duration, or who would be less able to increase their labour supply.

For private sector workers with a full career, eligible for the bonus from their 60th birthday, Benallah (2010) shows that the introduction of the bonus increased claiming age by 2 months. Using microsimulation techniques, Bonnet et al. (2006) show that the 2003 reform tends to slow down the reduction of the gender pension gap. Overall, the reform has a slightly positive effect on average social security wealth, which is explained by windfall effects due to the reduction of the penalty and the introduction of the bonus (+1.6%–+1.7%, Tréguier 2021). Both papers show that men postponed their retirement age more than women after the reform.

The 2010 pension reform. This reform was introduced just after the 2008 financial crisis when the financial sustainability of the system had appeared severely dented. The main change induced by this reform concerned the age references: the statutory eligibility age (*SEA*) was increased from 60 to 62, while the normal retirement age (*NRA*) was increased from 65 to 67. The reform was phased-in relatively quickly between cohorts 1951 and 1956, and had a very significant impact on the financial balance of the scheme. The two-year increase in SEA had a mechanical effect on pension claiming age and thus affects those individuals who, in absence of the reforms, would have claimed their pension below 62. For those individuals, pension levels are increased if they keep working, mainly through the increase of the second pillar pension. Pension levels of the first pillar pension scheme remained unchanged when claiming at the *SEA*, although it may also have an indirect impact through an increase of the *CP* parameter. Increase in the *NRA* have an impact through financial incentives as penalty on the pension rate driven by this parameters for individuals with low levels of contributions.

Most impacted individuals are thus likely to be those individuals claiming pensions at the *SEA* who are mainly located in the middle of the distributions, as low earners usually have low duration and need to wait until the *NRA* to claim full pension, and high earners more often work later than the *SEA*. On the other hand, people at the bottom of the distribution are more likely to be affected by changes of the *NRA*.

Rabaté & Rochut (2020) evaluate the effects of the 2010 reform on employment and the take-up of alternative routes to retirement and they find that a one-year increase in the *SEA* led to a +21pp increase in employment, +13pp in unemployment, +1.4pp in sickness, +5.9pp in disability and +6.2pp in inactivity. The ex-ante evaluation of the increase in the SEA shows an increase in average pension benefits (+2%, Duc et al. 2018, graph 12 page 65). The magnitude of the effect increases along the income distribution, but this pattern is driven by women, while the pension variation due to the increase in the SEA remains fairly stable along the men distribution. The increase in the *NRA* has an overall positive impact on average pension benefits (+2%, Duc et al. 2018, graph 12 page 65), which is fairly flat across the income distribution. Only individuals outside the labour market experience a loss (-1%), as individuals may not always postpone claiming in response to the reform. However the increase of both the SEA and NRA by two years decreased retirement duration. This decrease was stronger for the bottom of the income distribution (-20 months) than for the top of the ditribution (-15 months, Duc et al. 2018, graph 5 page 57)

The 2014 pension reform. This reform was more modest in scale than previous ones, but it further increased required length of contribution (D_{FT} and D_{CP}) from 41.5 to 43 years. It also extended the provision of long careers to workers having started working before 18.

The increase in required duration for the full rate increases financial incentives for the population of individuals who are likely to obtain the full rate through this channel, ie. who have longer careers.

The only evaluation of the 2014 reform is ex-ante (Duc et al. 2018, graph 12 page 65) and shows an overall decrease in average pension benefits, which is more important for the bottom of the income distribution (-2%) than for the top of the distribution (almost zero). The increase in the duration required for the full rate also reduced the retirement duration, with a positive gradient along the income distribution (by 1 month for the bottom of the income distribution and by 8 months for the top of the distrbution, Duc et al. 2018, graph 5 page 57).

3 Data

Our main analysis takes advantage of two administrative datasets (EIR and EIC data) gathering information on contributions and pensions for a representative sample of individuals. We also use larger administrative datasets in order to compute differentiated life expectancy by lifetime income decile.

3.1 EIR-EIC data

The main data used for our analysis is administrative data collected from French pension schemes. More specifically we combine two datasets: the *Échantillon Interrégime des Cotisants* (EIC) 2017 and the *Échantillon Interrégime des Retraités* (EIR) 2016.

The 2017 EIC data provides information on contributions for each pension scheme (private sector, public sector, first and second pillar schemes) : for each period, we observe the number of quarter validated in each scheme, the tax base for contribution, and in the case of the second pillar the number of points accumulated. We also observe periods of unemployment, sickness, disability and parental leave, as these give rise to pension rights.

The 2017 EIC data can be merged with the 2016 EIR data which provides information on pensions for those individuals who already claimed their pension. For each scheme, we observe the claiming date, the amount of pension and different variables used to compute pensions (duration, pension rates, etc.). In order to complete information for earlier cohorts, we also use observations from previous waves of the EIC (2001, 2005, 2009, 2013), and from the EIR (2001, 2004, 2008, 2012).

Our final sample of analysis is composed of individuals from 1934, 1938, 1942, 1946 and 1950 cohorts who contributed to the Social Security system. We focus on private sector employees, and further restrict our sample to individuals who were employed at age 54. We also restrict our sample to individuals who are employed at age 54.

Our final sample is composed of 26,269 individuals (15,038 men and 11,231 women) whom we observe from age 60 to claiming age, corresponding to 34,030 observations (18,102 for men and 15,928 for women). For counterfactual analyses, we further extend the sample providing retirement outcomes for individuals for every age between 60 and 70 and we end up with 288,959 observations (equal to 11 x 26,269). We assess inequality with respect to average lifetime earnings (ALTE) deciles. As our data does not allows to observe lifetime earnings for all individuals, especially earlier cohorts, we proxy this quantity from average labour income between 40 and 54 years old. The main outcome variables we use come from the pension data : claiming age, pension level and social security wealth computing from these two variables (see below). Our analysis is also split by gender.

3.2 Agirc-Arrco data

On top of the EIC-EIR data, we also use administrative data from the second pillar pension scheme of the private sector (Agirc-Arrco). This data is mainly used in order to compute life expectancy differentiated by ALTE deciles as defined as before.[6] This data set is exhaustive which allows for precise estimates of mortality coefficients by decile of lifetime earnings.

Computing differentiated life expectancy Computation of life expectancy is made from mortality coefficients up to age 90 computed on 1927 to 1964 cohorts in years 2009-2021. We note δ_{ad}^{AA} the estimated mortality coefficients for individuals aged a from average lifetime income decile d. These coefficients are displayed on figure 1.

Alignment on Insee data One issue with the data used for computation of mortality coefficients, is that it does not allow to observe the evolution of life expectancy over time, and in particular in periods when the first reforms of the pension system happened. To account for that variation in life expectancy, we take advantage of the national mortality coefficients observed at the national level[7].

We thus obtain a mortality coefficient for decile d, age a and year y as a function of estimated mortality coefficients m_{ad}^{AA} and national ones m_{ay}^{Insee} that are not differentiated by deciles. In practice we thus need to align coefficients m_{ad}^{AA} for the 10 deciles on 1 coefficient m_{ay}^{Insee}. There is no unique way to do so, which allows to impose additional restriction on the computation. We choose to keep constant odd ratios.

[6]See Mélard et al. (2023) for more details about the data.

[7]These mortality coefficients are produced by the French national institute of statistics (Insee).

Define $\delta_{ad}^{AA} = \log\left(\frac{m_{ad}^{AA}}{1-m_{ad}^{AA}}\right)$, then alignment consists in finding the parameter α_{ay} such that:

$$\sum_d \frac{\exp\left(\alpha_{ay}\delta_{ad}^{AA}\right)}{1+\exp\left(\alpha_{ay}\delta_{ad}^{AA}\right)} = m_{ay}^{Insee}$$

Then fitted mortality coefficients are simply given by:[8]

$$m_{ady} = \frac{\exp\left(\alpha_{ay}\delta_{ad}^{AA}\right)}{1+\exp\left(\alpha_{ay}\delta_{ad}^{AA}\right)}$$

Note that this choice has important implication in terms of gradients: these are constant over time.

After age 90 after 90 years old, we do not differentiate by decile, so mortality coefficients are directly obtained from Insee mortality tables previously mentioned.

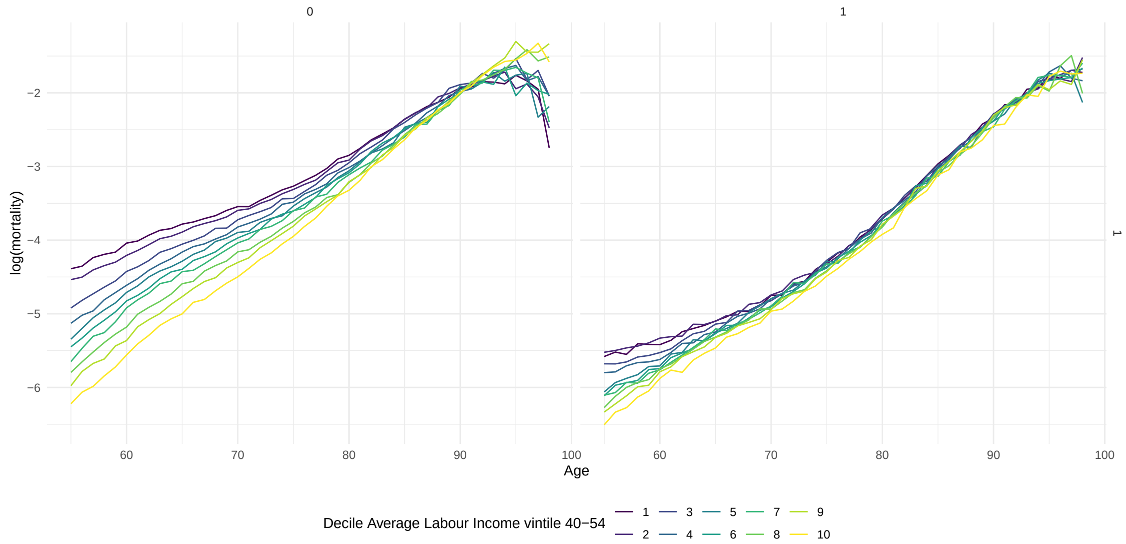
3.3 Life expectancy gradients

Figure 2 shows raw life expectancy obtained from the data. We observe a much larger gradient for men than for women: the interdecile range is 3.73 years for men and 1.65 for women. This difference can be compared to the gradients obtained by Milligan & Schirle (2021) who find a 8 year gap for men and 3.6 for women. Their methodology differs from ours in several dimensions. Most importantly, they first consider life expectancy at age 50 (compared to 55 in our case) conditioning on labour income at age 46 to 50, second they use ventiles instead of deciles. In our case, focusing on ventiles rather than deciles does not affect the gradient, mainly because the change in mortality is flat between the first two deciles.

After alignment (Figure 3), the shape of gradients remains unchanged. By construction, main differences between cohort come from average differences.

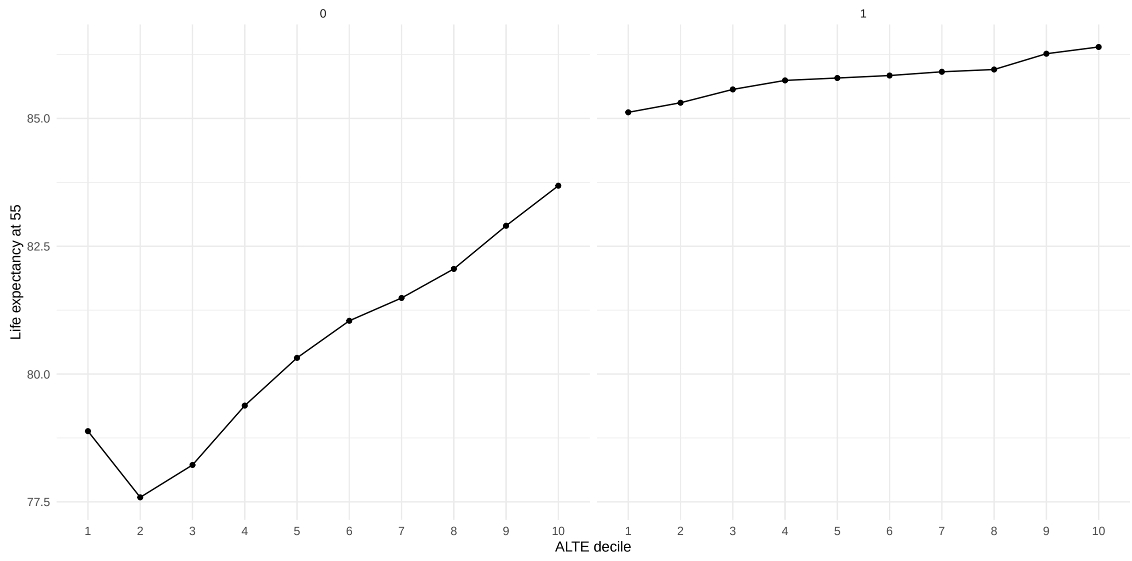
[8] The formula shows that odd ratios defined are constant.

Figure 1: Raw mortality rates



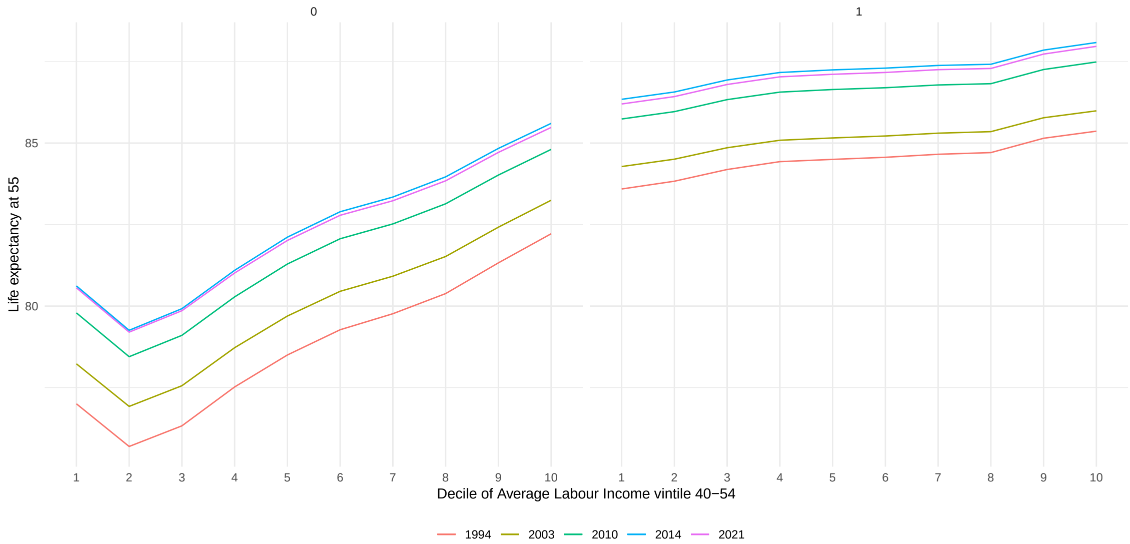
SOURCE: Agirc-Arrco.

Figure 2: Raw mortality rates



SOURCE: Agirc-Arrco.

Figure 3: Aligned Life expectancy



SOURCE: Agirc-Arrco.

4 Descriptive statistics

Career summary Table 1 and 2 provide descriptive statistics for the sample of men and women used for the analysis. The first panel presents summary statistics of individual careers. Unsurprisingly, average lifetime income (ALTE) is increasing for both men and women, and women earnings are much lower than men's. On average, a 10th decile woman would be between the 8th and 9 decile of men's distribution.

For men, we also observe a clear gradient of the probability to experience a sick leave before age 55. At the bottom of the ALTE distribution, men have more than 50% to get pension compensation for sick leaves, while this probability falls to 25% at the top of the distribution. Note that we only observe compensation of sick leaves in the pension system that activate after more than 60 days of paid sick leaves. Thus these period only reflect long work interruptions and neglect shorter ones. For women, the gradient is inverted, probably due to the fact that maternity leaves are administratively recorded as sick leaves as well. The probability to experience at least 50 days of paid unemployment within a year is also negatively correlated with ALTE decile for both men and women. The slope of the gradient is much stronger for men (82.79% for the first decile vs 25.09% for the last one) compared to women (51.39% vs 23.12%).

Retirement behaviour The second panel of tables 1 and 2 decribe the situation of men and women when claiming their pension. In terms, of age, we see a U-shaped pattern for men with an average claiming age of 62.9 years old for the bottom decile, an average of 60.7 years old in the fifth decile and almost 62 years old for the top decile. This pattern can partly be explained by the functioning of the French pension system. Reaching the full rate ($\tau = 50\%$) is considered as a norm in the pension system, and, as explained before, full rate can be obtained either at 65 years old or by contributing a given number year. Individual at the bottom of the ALTE distribution who experience more career interruptions, often need to wait until the full rate age in order to get the full rate, while individuals at higher levels of the distribution have longer career and can often get a full rate before that age. This is reflected in the share of individuals who reached full rate age when claiming and the share of individuals who get full rate duration. At the bottom of the distribution, about 26.5% of individuals reached the full rate age, and only 20.56% of individuals have the required career duration to get full rate. Above decile 5, a large share of individuals get the full rate because of career duration, while less than .5% of individuals reached the full rate age at claiming. A large share of individuals also claim as early as possible at the early retirement age. This share is positively correlated with ALTE deciles.

For women, the pattern is slightly different, and the gradient of claiming age is monotonic with ALTE, decreasing from 61.82 to 60.9 years old. As for men, full rate is an important feature of retirement behaviour, and claiming at ERA also concerns a majority of women above the third decile of ALTE.

Table 1: Descriptive statistics: men

	ALTE decile									
	1	2	3	4	5	6	7	8	9	10
1. Career summary										
ALTE (100k 2020 euros)	0.3215	0.5617	0.6842	0.7835	0.8789	0.9771	1.0861	1.2279	1.5060	2.1425
Lifetime Q3/Q1 earnings ratio	0.5969	0.3730	0.2503	0.1843	0.1590	0.1530	0.1675	0.2843	0.6248	0.5923
Sick leaves before 55 (%)	0.5066	0.6065	0.5812	0.5301	0.4916	0.4349	0.3506	0.2867	0.2581	0.1411
Unemployment before 55 (%)	0.8279	0.7268	0.5776	0.4542	0.3807	0.3060	0.2542	0.2759	0.2871	0.2509
2. Situation at claiming										
Claiming age	62.8613	61.6534	60.9843	60.7343	60.6715	60.4759	60.5663	60.7771	61.0387	61.9590
Reached full rate age (%)	0.2244	0.0698	0.0193	0.0145	0.0048	0.0036	0.0036	0.0012	0.0024	0.0048
Reached full rate duration (%)	0.2087	0.5054	0.6735	0.7005	0.7428	0.7699	0.7590	0.7000	0.6046	0.4186
At Statutory Eligibility Age (%)	0.3257	0.5211	0.6723	0.6993	0.7379	0.7855	0.7530	0.6747	0.5732	0.3341
SSW	1.0407	1.7680	2.2619	2.6832	3.0787	3.4695	3.8453	4.3491	5.1195	6.8901
3. Financial incentives at claiming										
Accrual	0.0413	0.0280	0.0119	0.0020	-0.0077	-0.0159	-0.0141	-0.0093	-0.0036	0.0121
ITAX	-0.0260	0.0003	0.0013	0.0050	0.0078	0.0037	0.0079	0.0038	-0.0002	-0.0055
Peak value	0.5676	0.5923	0.5886	0.6078	0.6288	0.6442	0.6969	0.7861	0.8283	0.9366
last labour earnings	12.9087	16.5104	19.1154	22.0475	25.0240	29.2303	34.3799	40.9381	49.3563	61.8955

Table 2: Descriptive statistics: women

	ALTE decile									
	1	2	3	4	5	6	7	8	9	10
1. Career summary										
ALTE (100k 2020 euros)	0.0866	0.1835	0.2791	0.3845	0.4888	0.5900	0.7057	0.8386	0.9894	1.3738
Lifetime Q3/Q1 earnings ratio	0.7486	0.7097	0.7389	0.6194	0.5069	0.4347	0.3241	0.2493	0.2396	0.4666
Sick leaves before 55 (%)	0.3319	0.5889	0.6778	0.7556	0.7361	0.7750	0.7830	0.7549	0.7604	0.7298
Unemployment before 55 (%)	0.5139	0.5736	0.6417	0.6597	0.6472	0.5778	0.4618	0.3565	0.2549	0.2312
2. Situation at claiming										
Claiming age	62.8081	62.0028	61.8178	61.3069	61.0250	60.6847	60.5195	60.4875	60.5223	60.9039
Reached full rate age (%)	0.2656	0.1604	0.0862	0.0458	0.0361	0.0139	0.0042	0.0014	0.0000	0.0070
Reached full rate duration (%)	0.2058	0.3835	0.4131	0.5472	0.6250	0.7278	0.7730	0.7744	0.7702	0.6630
At Statutory Eligibility Age (%)	0.3463	0.4979	0.4993	0.5875	0.6472	0.7306	0.7730	0.7702	0.7744	0.6379
SSW	0.9262	1.3397	1.6092	1.9303	2.2269	2.5804	3.0328	3.5854	4.1279	5.3473
3. Financial incentives at claiming										
Accrual	0.0313	0.0223	0.0180	0.0032	0.0005	0.0026	0.0035	-0.0017	0.0001	-0.0100
ITAX	-0.0082	-0.0020	0.0056	0.0067	0.0026	0.0042	0.0003	0.0038	0.0033	0.0068
Peak value	0.5653	0.4389	0.4117	0.4156	0.5137	0.5884	0.7001	0.7911	0.8776	1.0341
last labour earnings	8.0412	10.4884	13.0882	14.7901	17.2900	18.8911	22.6696	25.8579	31.0755	44.6031

Evolution of inequalities over cohorts We now turn to the description of the evolution of labour earnings and pension inequality over cohorts. As already mentioned lifetime labour earnings are proxied from average earnings between age 40 and 54 (including zeros). We also compare pensions at claiming age, and social security wealth (SSW) accounting for differentiated life expectancy.

Social Security Wealth (SSW) is defined as the discounted value of pension flows from a given age to expected death. At a age a, we thus define $SSW(a)$ as:

$$SSW(a) = \sum_{\tau=0}^{\infty} \beta^{\tau} \frac{S(a+\tau)}{S(a)} P(a) \tag{4}$$

Where $P(a)$ is the pension level when claiming at age a, and $S(a)$ is the survival rate at age a. β is a discount factor (set to .97 in practice).

For each individual in the data, we compute SSW at claiming age using potential pension level at claiming, and decile specific life expectancy. As shown by figure 4, the use of differentiated life expectancy compared to using homogeneous ones plays a role in actual inequality. Measured inequalities are accrued for male as high income males live longer than low income ones. For women, inequalities are less sensitive to this given the flatter life expectancy gradient observed.

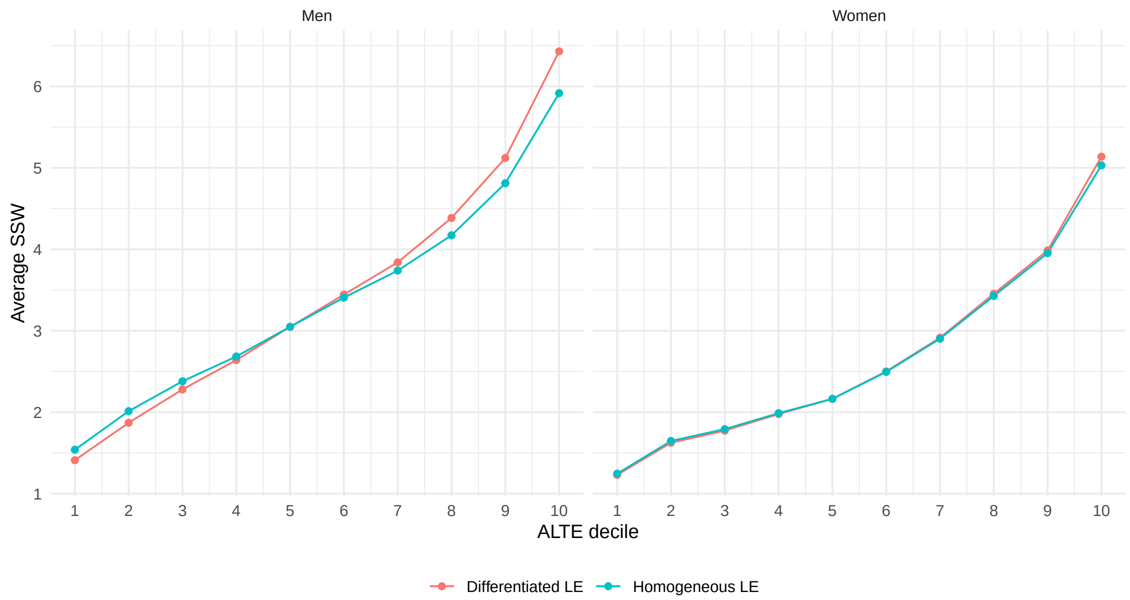


Figure 4: Average SSW by ALTE deciles

Figure 5 shows the evolution of ALTE by deciles and gender. For men, we see that inequality slightly increase as top deciles increase while bottom ones decreased over time. For women, ALTE at the bottom and the top of the distribution remained quite stable (See Bozio et al. 2023, for more details on the evolution of income inequality since 1968). Figure 6 represents the ratio between average D10 and D1 ALTE, SSW, and pension at claiming age.

We can see from this figure that inequality in ALTE slightly increased for men, while Pension and SSW inequality increased faster. On the contrary, ALTE inequality for women remained quite stable, and if anything slightly declined over cohorts, while pension and SSW inequality also decreased.

These inequality can be decomposed as the product of inequality at the top of the distribution (D10/D5) and inequality at the bottom of the distribution (D5/D1). As shown by figure 7 inequality in ALTE for men are mainly driven by the bottom of the distribution, while the increase inequality in pensions and SSW is driven by the top of the distribution. For women the decrease in pension inequality is mainly driven by the bottom of the distribution, probably reflecting the large increase in labour market participation of women over the period.

Finally, figure 8 uses the Gini as alternative way of measuring the evolution of inequality. The pattern is similar than the one observed with the D10/D1 ratio: inequality increase among men while it is slightly decreasing among women.

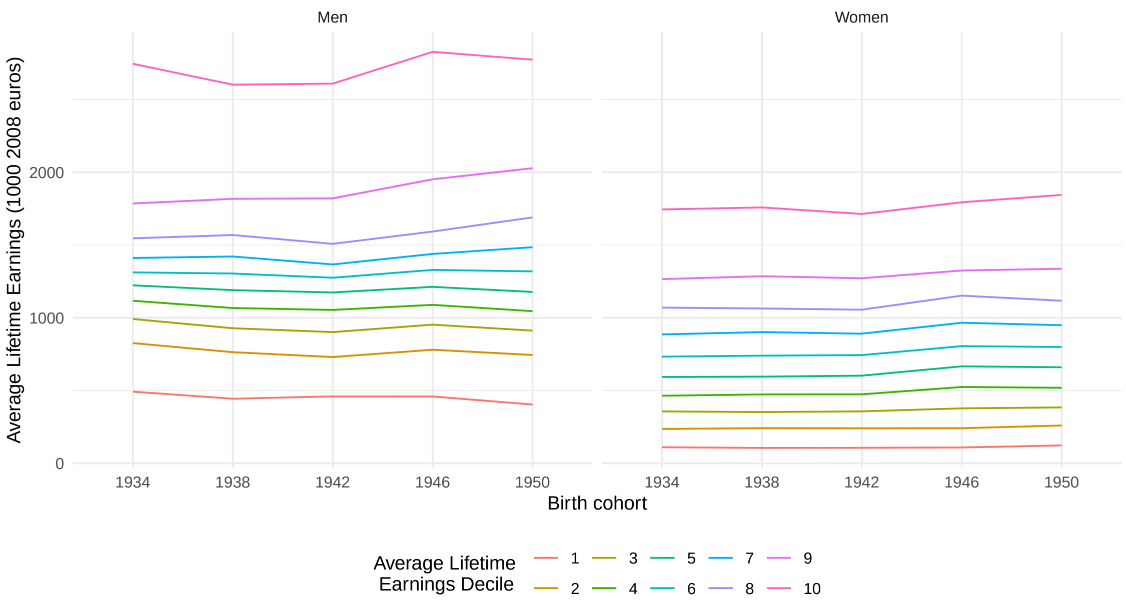


Figure 5: Average Life-time Earnings by cohort

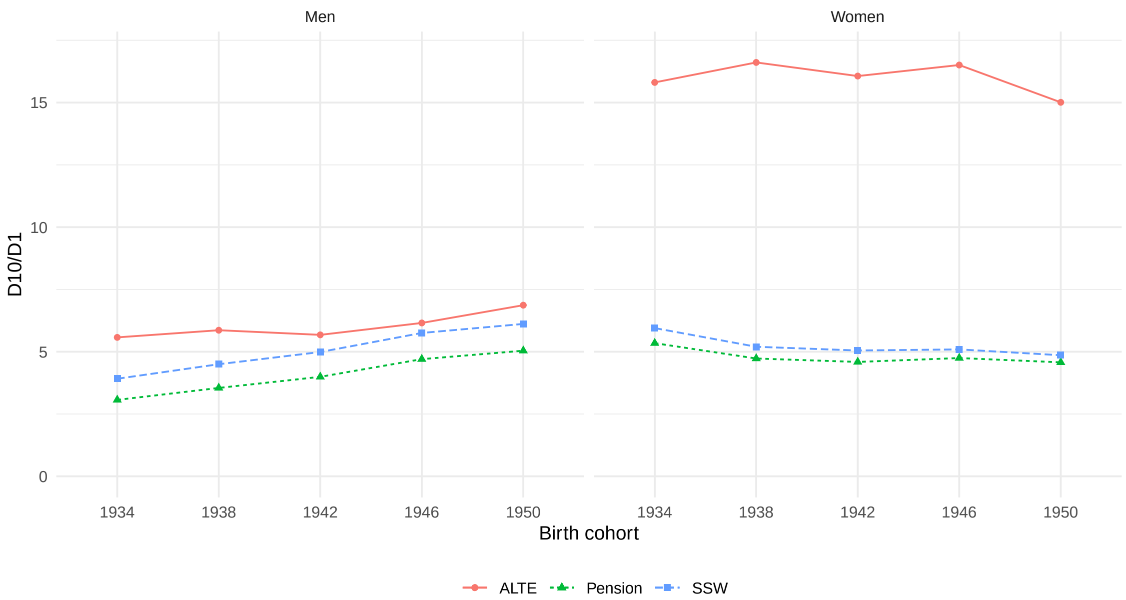
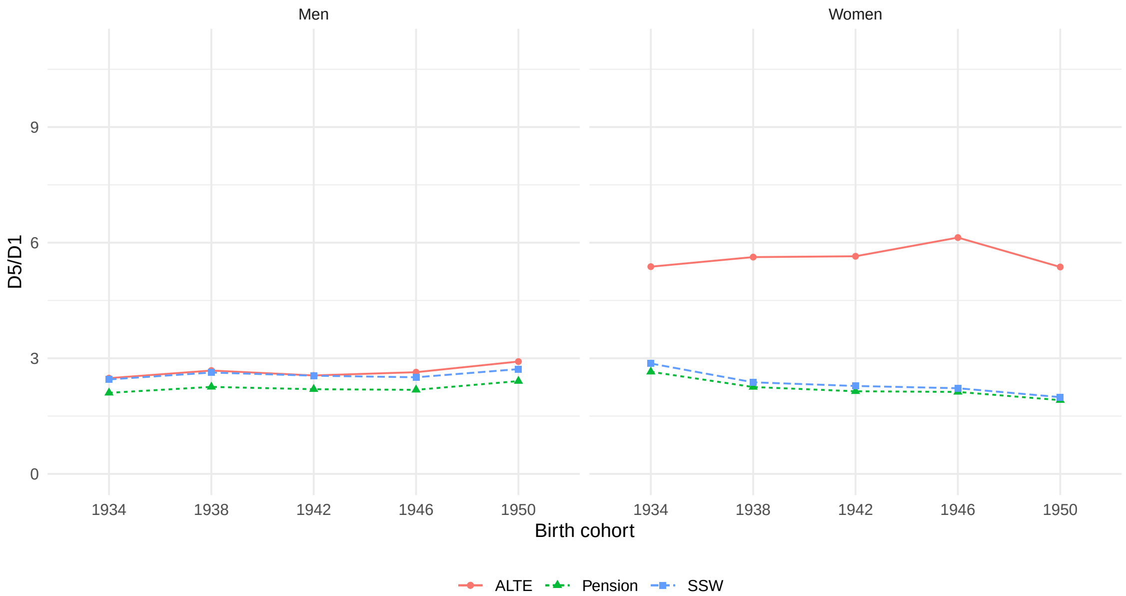


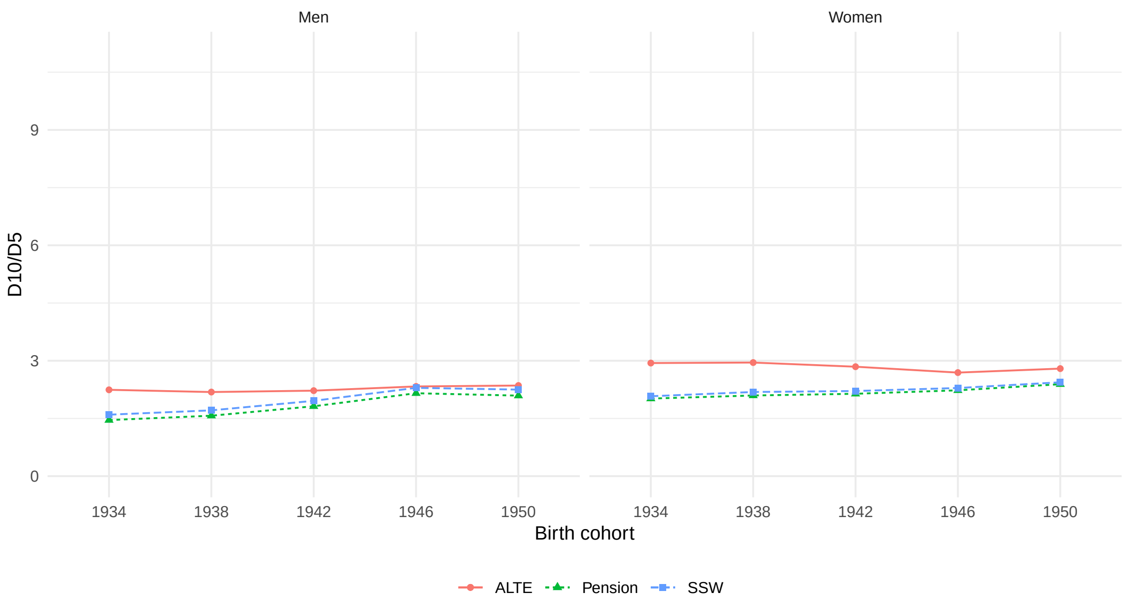
Figure 6: D10-D1 ratio of ALTE, pensions and SSW

Figure 7: Decomposition of inequality

(a) D5/D1

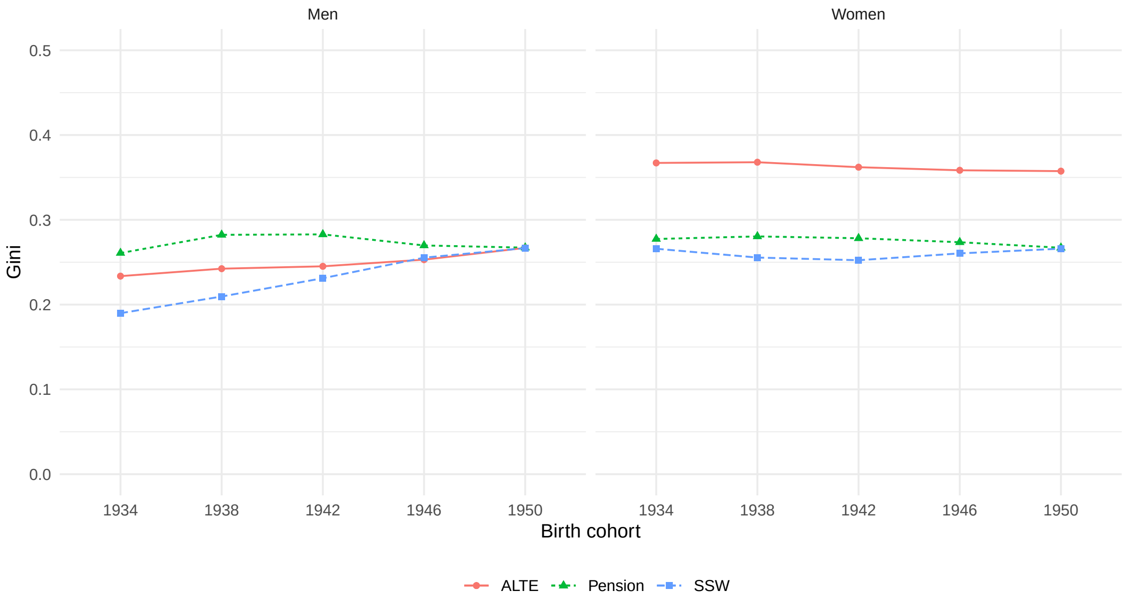


(b) D10/D5



SOURCE: EIR 2001, 2004, 2008 & 2012.

Figure 8: Evolution of Gini coefficient



SOURCE: EIC 2001, 2005, 2009 & 2013 and EIR 2001, 2004, 2008 & 2012.

5 Modelling retirement behaviour

5.1 Model

The analysis of the impact of pension reforms require to account for potential behavioural responses to reforms. To do so, we propose a simple model of pension claiming that accounts for financial incentives, and pension system parameters.

In this model, workers choose whether or not to retire at each period. We follow Coile & Gruber (2001) by including financial incentives as control variables in the specification. Financial incentives are built from the *SSW* concept. We use 3 different concepts:

$$ACC(a) = \beta \frac{S(a+1)}{S(a)} SSW(a+1) - SSW(a) \tag{5}$$

$$ITAX(a) = -\frac{ACC(a)}{y(a)} \tag{6}$$

$$Peak(a) = \max_{\tau \geq t} \beta^{\tau - t} \frac{S(\tau)}{S(t)} SSW(\tau) - SSW(a) \tag{7}$$

The Accrual at age a $[ACC(a)]$ provides the expected increase in *SSW* obtained by waiting one more year before pension claiming. The $ITAX$ simply divides the Accrual by current income $y(a)$. These first two concepts can be viewed as a proxy for financial incentives embedded in dynamic discrete choice models (Stock & Wise 1990) where agents only consider two options: retiring this year or retiring next year. The third concept, the Peak value, incorporates more sophisticated forward looking behaviour by accounting for the largest discounted increase in *SSW* an agent may expect by delaying her retirement age.

We also control for different parameters of the pension system like dummy variables that equal 1 when individuals reach particular ages like the *SEA* or the full rate age. This choice is driven by the fact that these parameters are norms in the French pension system that strongly drive retirement behaviour. In 2017, 54% of individual retiring that year declared that reaching the *SEA* strongly influenced their decision, and 45% mentioned that having the full rate was also a strong motive for retiring (Drees 2023, figure 1, page 168). As many of the reforms implemented since the beginning of the 1990 move parameters like the *SEA* or linked to the full rate (required career length or *NRA*), it seems important to explicitly control for these variables in order to better reflect behavioural responses to reforms.

5.2 Estimation

In practice, we simulate counterfactual pensions and therefore financial incentives using the PENSIPP model. Individual careers as supposed to be known by the individual. For periods outside of the observed labour market trajectory that are used for computation of the accrual, the ITAX of the final period when individuals claim their pension, and for the computation of the Peak value at all period, we simply extrapolated the last observed period before claiming. Thus, this assumption is particularly strong for the computation of the peak value that potentially requires extrapolation over several years.

The population used for the estimation consists of individuals for whom the transition from work to retirement is known. We focus on individuals who are employed at age 54, have strictly positive lifetime earnings, and were either employed, unemployed or on sick leave between age 55 and claiming age. We restrict our sample to individuals who claim their pension from the SEA (we exclude individuals who go on disability before the SEA).

Alternative routes (unemployment and sick leave) are taken into account in SSW, with a replacement income equal to 60% of the individual's reference wage[9] . In other words, SSW(a) is equal to the discounted sum of earnings or replacement income from age a to the claiming age plus the discounted sum of pensions from the claiming age.

The model is estimated using a *logit* model accounting for the different explanatory variables described earlier, on top of controls for age, lifetime earnings, additional variables describing individual careers before 55 (See tables 1 and 2).

In the specification, we allow the effect of financial incentives and pension system parameter to differ by ALTE deciles, in order to better capture the potential heterogeneity in behavioural responses to reforms.

5.3 Parameter estimates

Results of the estimation are summarised in tables 3 and 4. Claiming behaviours are estimated separately for men and women. The first 3 columns of the table corresponds to estimates for men, and the last three for women. The three model corresponds to the use of different financial incentives (Accrual, ITAX or Peak value).

Figure 9 illustrates the fit of these models measured from the distribution of claiming age obtained from model predictions. We compare the predictions of models that include

[9]Reference wage, is the full-time equivalent wage in the previous year. This roughly mimics unemployment benefit rules, although in practice potential duration benefit depends on recent employment time.

different financial incentives, and for each financial incentive, we compare models with and without interactions of these incentives with ALTE deciles.[10]

Non interacted parameters are given at the beginning of table 3. The marginal impact of age on claiming is increasing with a high marginal impact for women compared to men. As expected from a rational choice model, the impact of labour earnings is negative on the probability of claiming pension.

Worse health status, proxied from long periods of sick leave before age 55 is also associated to a higher probability to claim pension at all ages. The impact of periods of unemployment before age 55 is ambiguous as it is negative for male, while positive for women. Note that this variable may proxy different situations on the labour market: it shows that individuals actually got unemployment benefit which require a minimum of time on the labour market. Unemployment benefit also increase contribution duration for pensions.

Table 3 also shows the differentiated impact of financial incentives with ALTE deciles. Figure 10 also gives marginal effects of these variables for the three diferent models.[11] Although we see small differences between models, the overall pattern is similar. For women, financial incentives mainly play a role at the bottom of the ALTE distribution, and the effect is close to 0 and not significantly different from 0 after decile 7. For men, the impact of financial incentives is much more homogeneous. Despite this greated homogeneity for men, one can see that the top of the distribution seems less sensitive to financial incentives as well as the very bottom of the distribution. This is particularly visible when focusing on the accrual model.

It is also interesting to look at the effect of pension system ages. Figure 11 shows these parameters for the Accrual model.[12] The first panel 11a shows the impact of being at the *SEA* by ALTE decile. We see that this impact is positive for males and quite homogeneous, although an inversed U-shaped function can be observed. For female, SEA is only associated to a higher probability to claim at the bottom of the distribution, and to a negative impact at the top. Getting full rate duration is associated to a higher claiming rate for higher female deciles, while an inversed U-shaped pattern is again observed for

[10] Interacted models are the one associated with parameters in table 3 and 4. Parameter estimates of non interacted model are given in appendix Table A.1.

[11] Marginal effect for each decile are taken as the derivative of the probability to claim at the average of other control variables. It thus neutralise composition effect in order to better reflect behavioural differences between ALTE deciles.

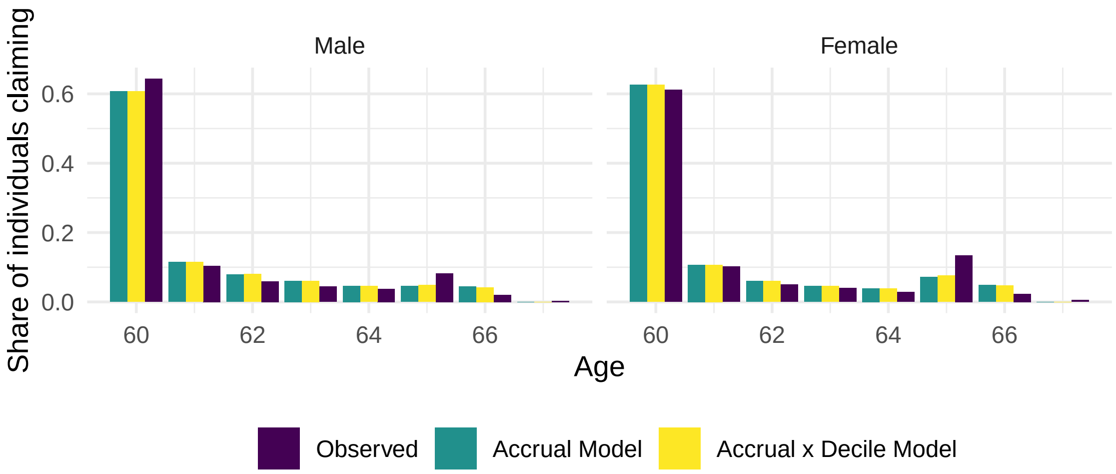
[12] Other models are displayed in appendix Figures A.1 and A.2, the effects are similar. All parameters corresponding to the marginal effects are also displayed in table 4.

men: men at the top and bottom ALTE decile do not seem to be sensitive to that norm. Finally, reaching full rate by age, is only associated to a higher probability to claim for individuals at the bottom of the distribution.

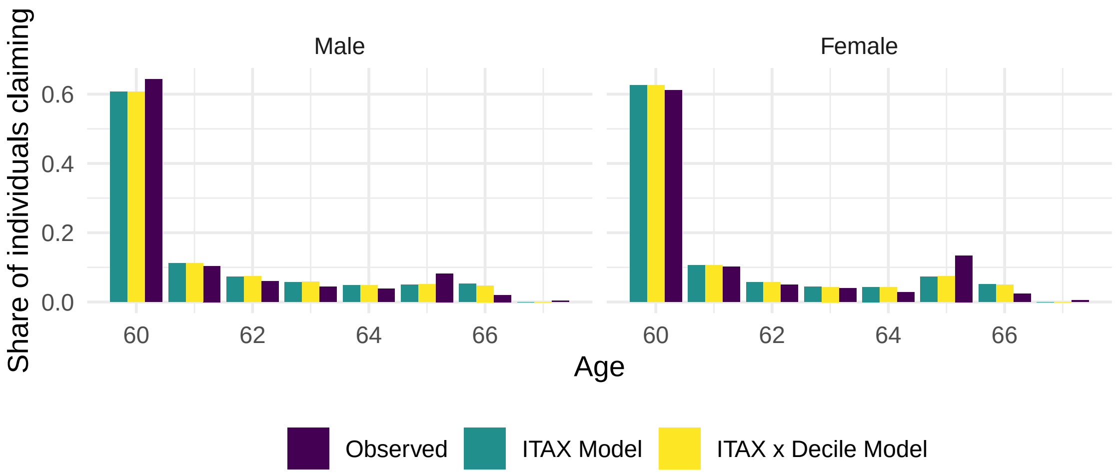
Altogether, these results show quite different behavioural responses to pension system parameters and financial incentives, which it may be important to take into account when analysing the impact of reforms.

Figure 9: Predicted claiming age

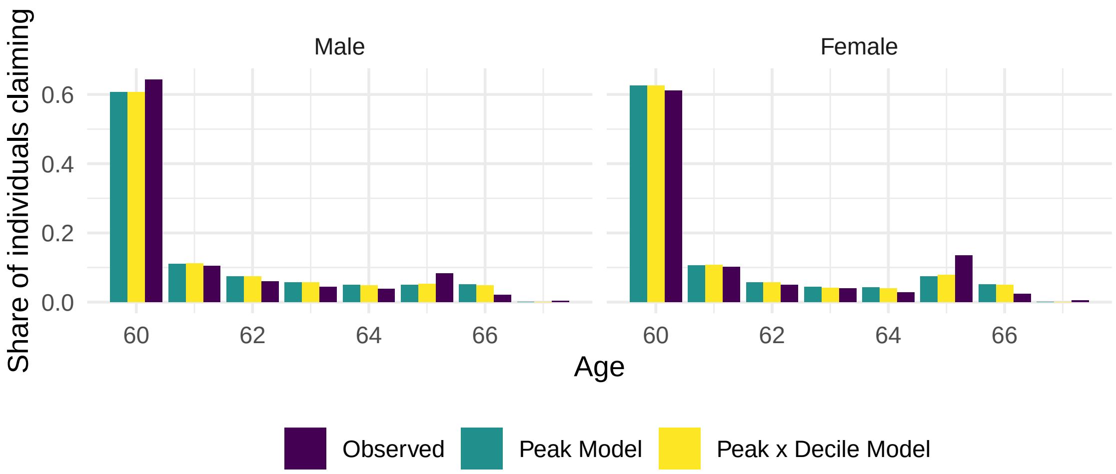
(a) Accrual Models



(b) ITAX Models



(c) Peak value Models



Source: EIC 2001, 2005, 2009, 2013 & 2017 and EIR 2001, 2004, 2008, 2012 & 2016.

Table 3: Parameter estimates of the claiming model (1/2)

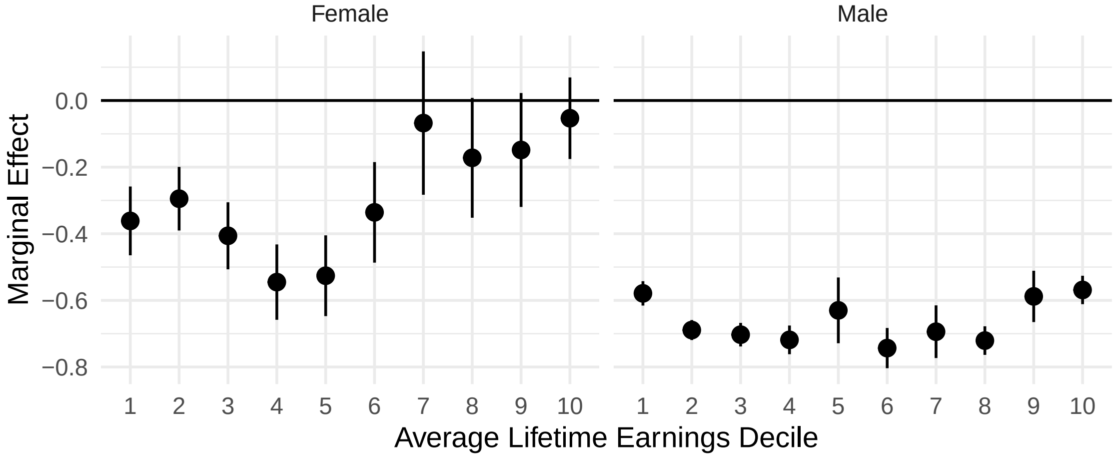
	Men			Women		
	Accrual	ITAX	Peak	Accrual	ITAX	Peak
(Intercept)	−167.579***	−164.074***	−184.096***	−394.766***	−403.694***	−391.403***
	(19.999)	(19.353)	(19.415)	(27.739)	(27.437)	(27.470)
Age	−89.974***	−84.513***	−98.929***	−209.227***	−213.294***	−208.609***
	(10.878)	(10.524)	(10.571)	(15.011)	(14.841)	(14.868)
Age^2	0.071***	0.069***	0.079***	0.167***	0.171***	0.167***
	(0.009)	(0.008)	(0.008)	(0.012)	(0.012)	(0.012)
Q3/Q1 lifetime earnings ratio	−0.093**	−0.023	−0.046	−0.193***	−0.205***	−0.145***
	(0.042)	(0.041)	(0.041)	(0.043)	(0.043)	(0.043)
ALTE	0.003	−0.851***	−1.010***	1.180***	0.899***	0.391
	(0.189)	(0.182)	(0.187)	(0.293)	(0.289)	(0.287)
Labour earnings	−0.019***	−0.033***	−0.014***	−0.046***	−0.055***	−0.037***
	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Unemployment before 55	−0.145***	−0.136***	−0.146***	0.125***	0.112***	0.126***
	(0.041)	(0.040)	(0.041)	(0.041)	(0.041)	(0.041)
Sick leaves before 55	0.238***	0.241***	0.225***	0.365***	0.382***	0.367***
	(0.039)	(0.039)	(0.039)	(0.042)	(0.041)	(0.042)
SSW						
D1 ALTE	−0.041	0.416***	0.417***	0.596***	0.983***	0.233**
	(0.095)	(0.092)	(0.093)	(0.099)	(0.091)	(0.104)
D2 ALTE	0.170**	0.592***	0.644***	0.503***	0.859***	0.204**
	(0.076)	(0.072)	(0.084)	(0.089)	(0.085)	(0.097)
D3 ALTE	0.211***	0.657***	0.619***	0.607***	0.945***	0.371***
	(0.069)	(0.066)	(0.076)	(0.079)	(0.074)	(0.088)
D4 ALTE	0.290***	0.746***	0.635***	0.599***	0.883***	0.408***
	(0.065)	(0.061)	(0.071)	(0.074)	(0.070)	(0.083)
D5 ALTE	0.230***	0.694***	0.581***	0.566***	0.846***	0.384***
	(0.062)	(0.058)	(0.067)	(0.072)	(0.068)	(0.079)
D6 ALTE	0.342***	0.810***	0.729***	0.530***	0.781***	0.399***
	(0.061)	(0.057)	(0.067)	(0.069)	(0.066)	(0.076)
D7 ALTE	0.293***	0.781***	0.618***	0.492***	0.744***	0.363***
	(0.060)	(0.056)	(0.063)	(0.070)	(0.066)	(0.076)
D8 ALTE	0.255***	0.746***	0.591***	0.523***	0.766***	0.465***
	(0.057)	(0.053)	(0.058)	(0.069)	(0.065)	(0.073)
D9 ALTE	0.227***	0.704***	0.537***	0.424***	0.655***	0.387***
	(0.057)	(0.053)	(0.056)	(0.070)	(0.066)	(0.073)
D10 ALTE	0.118**	0.609***	0.502***	0.298***	0.515***	0.310***
	(0.059)	(0.054)	(0.057)	(0.076)	(0.072)	(0.075)
Financial Incentive ×						
D1 ALTE	−11.040***	0.891***	−2.556***	−4.121***	0.935**	−2.178***
	(0.924)	(0.310)	(0.215)	(0.730)	(0.426)	(0.210)
D2 ALTE	−14.341***	1.001	−2.381***	−3.110***	0.626	−2.125***
	(1.117)	(0.651)	(0.217)	(0.593)	(0.515)	(0.221)
D3 ALTE	−9.775***	2.041**	−1.880***	−4.671***	1.049**	−1.747***
	(1.028)	(0.930)	(0.208)	(0.717)	(0.514)	(0.213)
D4 ALTE	−7.669***	1.834*	−1.425***	−6.708***	0.815*	−1.172***
	(1.033)	(0.937)	(0.205)	(0.882)	(0.458)	(0.184)
D5 ALTE	−5.121***	0.986	−1.383***	−6.330***	9.641***	−0.764***
	(0.957)	(1.061)	(0.215)	(0.939)	(3.287)	(0.167)
D6 ALTE	−7.072***	3.147	−1.601***	−3.486***	2.148**	−0.583***
	(1.032)	(3.490)	(0.224)	(0.984)	(1.063)	(0.177)
D7 ALTE	−6.037***	5.656	−1.153***	−0.631	0.149	−0.244
	(0.944)	(4.229)	(0.206)	(1.023)	(0.914)	(0.185)
D8 ALTE	−7.323***	−0.077	−1.121***	−1.623*	0.684	−0.455**
	(0.837)	(0.776)	(0.178)	(0.894)	(1.281)	(0.179)
D9 ALTE	−4.721***	3.036**	−0.959***	−1.399*	0.188	−0.391**
	(0.600)	(1.480)	(0.156)	(0.843)	(1.293)	(0.183)
D10 ALTE	−5.311***	1.442**	−1.454***	−0.501	−1.483	−0.272**
	(0.428)	(0.626)	(0.139)	(0.594)	(1.020)	(0.137)
AIC	18865.262	19555.365	19095.706	16389.582	16597.084	16390.328
BIC	19317.881	20007.984	19548.325	16834.780	17042.282	16835.526
LogLikelihood	−9374.631	−9719.683	−9489.853	−8136.791	−8240.542	−8137.164
Deviance	18749.262	19439.365	18979.706	16273.582	16481.084	16274.328
Num.obs.	18102	18102	18102	15928	15928	15928

Table 4: Parameter estimates of the claiming model (2/2)

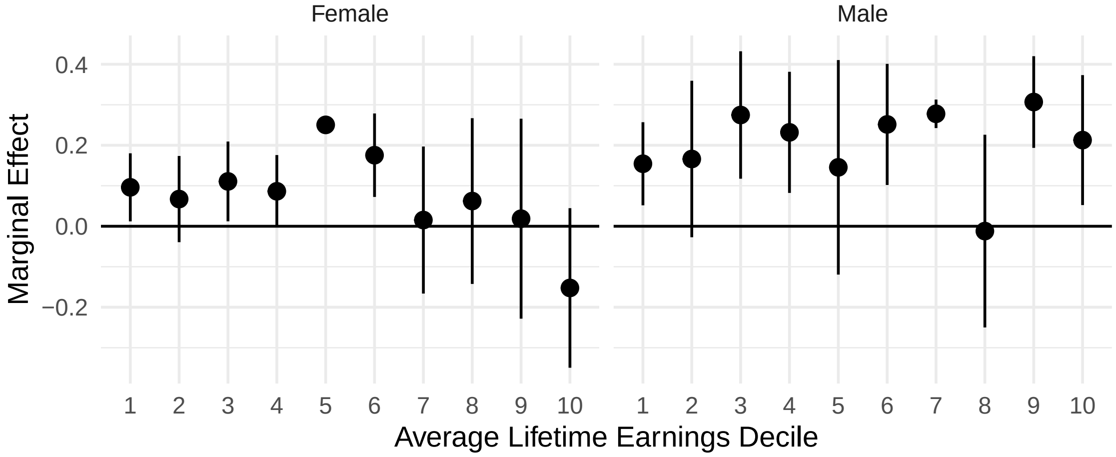
	Men			Women		
	Accrual	ITAX	Peak	Accrual	ITAX	Peak
Full rate by age ×						
D1 ALTE	1.918***	2.041***	1.835***	2.265***	2.324***	2.055***
	(0.164)	(0.160)	(0.163)	(0.189)	(0.188)	(0.190)
D2 ALTE	0.762***	1.635***	1.245***	2.262***	2.312***	2.153***
	(0.281)	(0.263)	(0.269)	(0.249)	(0.249)	(0.250)
D3 ALTE	0.887*	1.372***	1.169**	1.240***	1.306***	1.204***
	(0.506)	(0.497)	(0.496)	(0.260)	(0.255)	(0.261)
D4 ALTE	1.533**	1.855***	1.607**	1.293***	1.491***	1.328***
	(0.692)	(0.673)	(0.671)	(0.390)	(0.382)	(0.383)
D5 ALTE	−0.102	0.119	0.042	0.899**	1.318***	1.260***
	(0.698)	(0.689)	(0.689)	(0.441)	(0.434)	(0.431)
D6 ALTE	0.986	1.497	1.073	1.582*	1.887**	1.708**
	(1.173)	(1.172)	(1.175)	(0.877)	(0.861)	(0.831)
D7 ALTE	0.265	0.267	0.358	0.545	0.638	0.518
	(0.963)	(0.964)	(0.928)	(0.961)	(0.960)	(0.956)
D8 ALTE	10.083	10.560	10.481	−0.932	−0.737	−0.830
	(119.468)	(119.468)	(119.468)	(1.255)	(1.252)	(1.248)
D9 ALTE	0.091	0.041	0.155	−13.550	−13.407	−13.332
	(1.058)	(1.137)	(1.051)	(224.582)	(225.692)	(225.994)
D10 ALTE	−0.297	0.196	0.035	12.981	13.130	12.849
	(0.721)	(0.717)	(0.684)	(141.789)	(140.359)	(142.587)
Full rate by duration ×						
D1 ALTE	0.196	1.052***	0.407**	−0.110	−0.134	−0.786***
	(0.163)	(0.141)	(0.159)	(0.181)	(0.180)	(0.213)
D2 ALTE	0.586***	1.820***	1.410***	0.458***	0.554***	−0.261
	(0.163)	(0.128)	(0.137)	(0.176)	(0.167)	(0.217)
D3 ALTE	1.047***	1.999***	1.663***	0.013	0.409***	−0.044
	(0.181)	(0.146)	(0.153)	(0.174)	(0.152)	(0.186)
D4 ALTE	0.866***	1.717***	1.473***	0.094	0.877***	0.701***
	(0.203)	(0.157)	(0.164)	(0.194)	(0.154)	(0.168)
D5 ALTE	1.201***	1.820***	1.538***	0.452**	1.051***	1.189***
	(0.215)	(0.169)	(0.177)	(0.208)	(0.173)	(0.172)
D6 ALTE	0.371	1.371***	1.054***	1.049***	1.420***	1.407***
	(0.248)	(0.192)	(0.200)	(0.246)	(0.211)	(0.213)
D7 ALTE	0.841***	1.692***	1.542***	1.848***	1.884***	1.898***
	(0.233)	(0.187)	(0.186)	(0.300)	(0.277)	(0.271)
D8 ALTE	0.282	1.413***	1.193***	1.390***	1.572***	1.541***
	(0.207)	(0.166)	(0.169)	(0.335)	(0.310)	(0.309)
D9 ALTE	0.360**	1.060***	0.899***	1.194***	1.363***	1.339***
	(0.168)	(0.140)	(0.141)	(0.320)	(0.286)	(0.288)
D10 ALTE	−0.032	0.858***	0.505***	1.629***	1.700***	1.550***
	(0.136)	(0.114)	(0.117)	(0.252)	(0.234)	(0.231)
SEA ×						
D1 ALTE	0.379***	0.625***	0.762***	0.301*	0.415***	0.960***
	(0.136)	(0.127)	(0.147)	(0.158)	(0.155)	(0.193)
D2 ALTE	0.747***	0.510***	0.635***	0.414**	0.431***	1.106***
	(0.158)	(0.135)	(0.154)	(0.165)	(0.159)	(0.209)
D3 ALTE	0.684***	0.561***	0.607***	0.344**	0.138	0.457**
	(0.177)	(0.152)	(0.172)	(0.172)	(0.159)	(0.188)
D4 ALTE	0.443**	0.341**	0.255	0.367*	−0.071	−0.066
	(0.196)	(0.166)	(0.182)	(0.191)	(0.170)	(0.182)
D5 ALTE	0.383*	0.411**	0.392**	0.263	−0.133	−0.300
	(0.215)	(0.180)	(0.200)	(0.209)	(0.186)	(0.193)
D6 ALTE	0.869***	0.535***	0.616***	−0.066	−0.280	−0.413*
	(0.244)	(0.201)	(0.221)	(0.251)	(0.226)	(0.233)
D7 ALTE	0.470**	0.196	0.117	−0.726**	−0.671**	−0.855***
	(0.235)	(0.196)	(0.209)	(0.308)	(0.288)	(0.287)
D8 ALTE	0.685***	0.086	0.091	−0.742**	−0.866***	−0.873***
	(0.220)	(0.179)	(0.194)	(0.344)	(0.321)	(0.327)
D9 ALTE	0.307*	0.142	0.049	−0.311	−0.411	−0.438
	(0.181)	(0.155)	(0.167)	(0.329)	(0.297)	(0.311)
D10 ALTE	0.129	−0.293**	−0.067	−0.985***	−0.949***	−1.022***
	(0.161)	(0.138)	(0.152)	(0.265)	(0.250)	(0.256)
AIC	18865.262	19555.365	19095.706	16389.582	16597.084	16390.328
BIC	19317.881	20007.984	19548.325	16834.780	17042.282	16835.526
LogLikelihood	−9374.631	−9719.683	−9489.853	−8136.791	−8240.542	−8137.164
Deviance	18749.262	19439.365	18979.706	16273.582	16481.084	16274.328
Num.obs.	18102	18102	18102	15928	15928	15928

Figure 10: Marginal effects of financial incentives

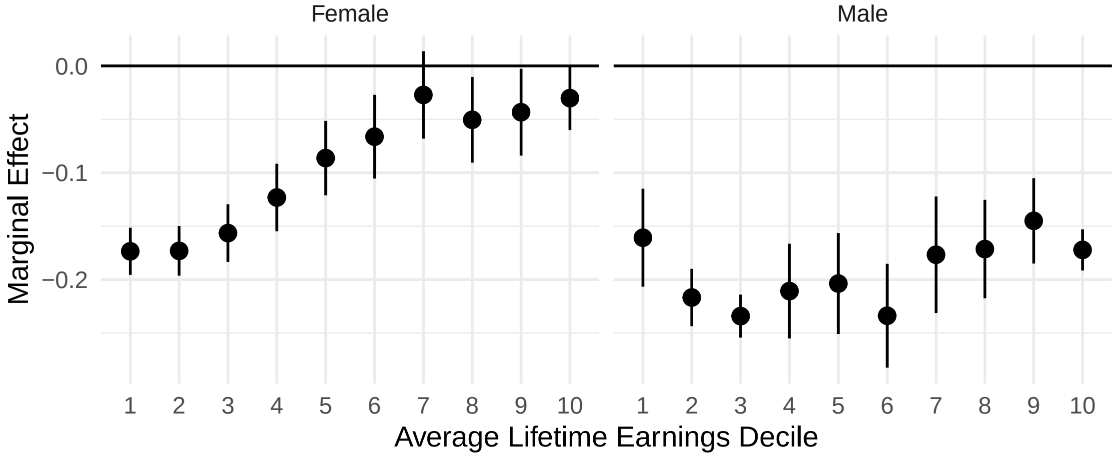
(a) Accrual Models



(b) ITAX Models



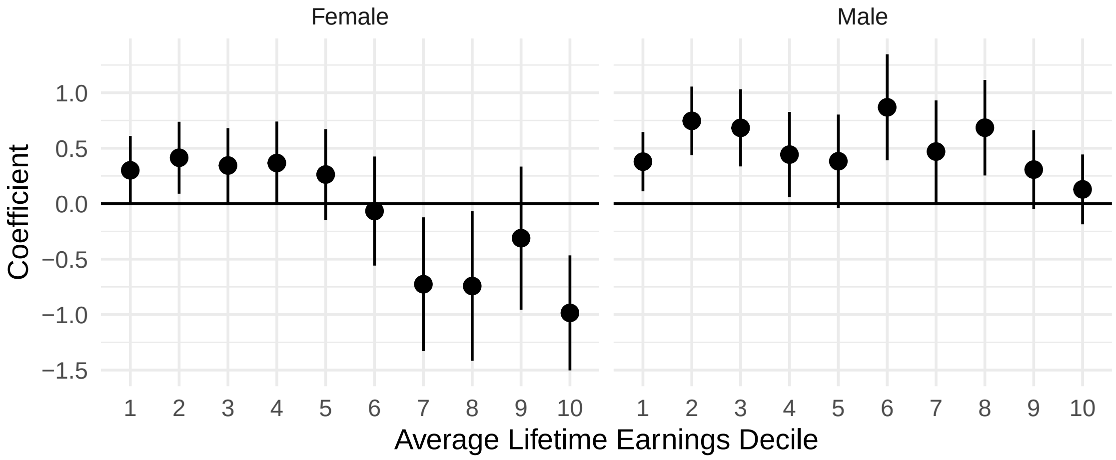
(c) Peak value Models



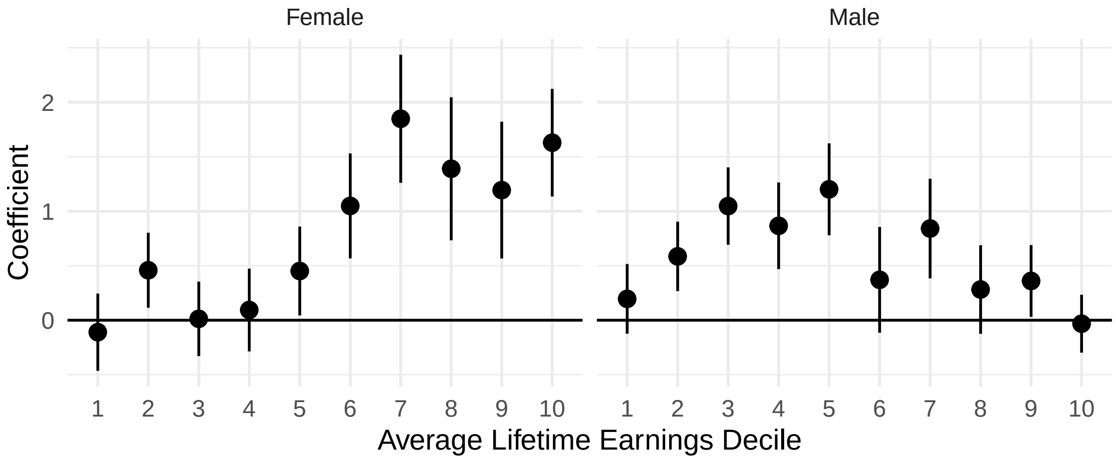
Source: EIC 2001, 2005, 2009, 2013 & 2017 and EIR 2001, 2004, 2008, 2012 & 2016.

Figure 11: Coefficient associated to pension system parameters : Accrual Model

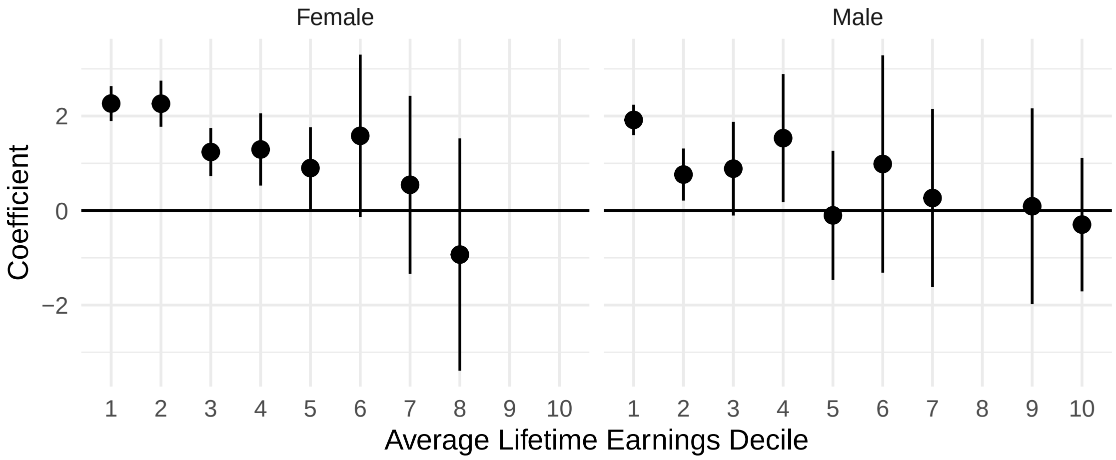
(a) Statutory Eligibility Age



(b) Reached Full rate duration



(c) Reached Full rate age



Source: EIC 2001, 2005, 2009, 2013 & 2017 and EIR 2001, 2004, 2008, 2012 & 2016.

6 The contribution of pension reforms to the evolution of inequality

6.1 Decomposition of the effect of pension reforms

We now turn to the analysis of the impact of pension reforms on inequality. We measure this impact on the expected SSW at age 60 as the minimum SEA possible. This choice is driven by the necessity to distinguish between two different channels in the impact of pension reforms on pension wealth: a *mechanical* one which is due to direct changes in the pension formula measured at a given claiming age, and a *behavioural* component that accounts for changes in claiming age associated to the reform.

We define the expected SSW at age 60 as follow:

$$ESSW_{60} = \sum_{60}^{70} \beta^{a-60} \frac{S(a)}{S(60)} p(R = a) SSW(a),$$

where $p(R = a)$ gives the probability to retire at age a. This concept allows us to compare social security wealth from an identical age for all cohorts.

When considering ages younger than the *SEA* (the 2010 reform increased *SEA* from 60 to 62), potential pensions are 0, but we still compute a SSW by assuming that the individual will leave the labour market and claims her pension as soon as she reaches the *SEA*, without accumulating additional pension rights.

Counterfactual values for $ESSW_{60}$ are obtained by making explicit the dependence of both claiming behaviour and SSW to the pension regime. We note $p(R = a|\ell)$ the probability to retire at age a under legislation ℓ, and $SSW(a, \ell)$ the social security wealth under the same legislation. Counterfactual expected SSW are thus defined as:

$$ESSW_{60}(\ell, \ell') = \sum_{a=60}^{70} \beta^{60} \frac{S(a)}{S(60)} p(R = a|\ell) SSW(a, \ell').$$

For a given population, the total effect of a pension reform changing the legislation from ℓ to $\ell + 1$ is obtained by comparing $ESSW_{60}(\ell, \ell)$ to $ESSW_{60}(\ell + 1, \ell + 1)$. It can further be decomposed into a *mechanical* and a *behavioural* component:

$$\begin{aligned}\tau(\ell,\ell+1) &= ESSW_{60}(\ell+1,\ell+1) - ESSW_{60}(\ell,\ell) \\ &= \underbrace{ESSW_{60}(\ell+1,\ell+1) - ESSW_{60}(\ell,\ell+1)}_{Behavioural} + \underbrace{ESSW_{60,i}(\ell,\ell+1) - ESSW_{60}(\ell,\ell)}_{Mechanical}\end{aligned}$$

6.2 Implementation

Table 5 summarises the parametric changes induced by the 1993, 2003, 2010 and 2014 reforms that we included in the analyses.

We implement the decomposition using the 1950 cohort which is the cohort for which the pension calculator we use is the more accurate, and, more importantly, the data is of better quality. Note that this choice is not innocuous as financial incentives and explanatory variables are linked to individual careers, and that 1950 cohort careers are different from labour market trajectories of other cohorts individuals. The 1950 cohort actually faced the legislation prior to the 2010 reform. Thus, their actual SEA was 60 years old and require duration to get the full rate was 40.5 years of contribution.

Moreover, as for estimation, simulation requires to extrapolate individual careers of individuals above actual claiming age. We do so by simply extrapolating the last observed state before claiming (both labour market status and earnings). This is a strong assumption that has to be taken into account when analysing our results, and comparing it to other results in the literature focusing on the same reforms. Indeed, our methodology may artificially increase the capacity of individuals to remain employed beyond their actual claiming age, which is a key determinant of behavioural responses. An alternative method would require to endogenise labour market status and thus to model unemployment, on top of claiming, but is out of the scope of this paper.

6.3 Results

Figure 12 shows the marginal effect of reforms on the claiming age (Figure 12a), pension level accounting for behavioural responses (Figure 12b), and expected SSW at age 55 (Figure 12c).

The 1993 reform The 1993 reform had a positive effect on claiming age comprised between .25 and .5 years for males, and slightly smaller for females (Figure 12a). The main impact of this reform is on pension level at claiming age, with a large negative effect

Table 5: Parametric changes induced by the French reforms included in the model

Reform	**Parametric changes**
1993	- Computation of the reference wage from best 10 years to 25 best years - Number of years required to obtain the full rate (D_{FR}) from 37.5 years to 40 years
2003	- Duration for the full proportionality coefficient (D_{CP}) from 37.5 years to 40 years - Introduction of a bonus: +5% pension for each additional year of continued activity beyond the full-rate age - Reduction of the penalty from -10% to -5% for each missing year of contribution before the full-rate age
2010	- Statutory eligibility age from 60 to 62 years old - Normal retirement age from 65 to 67 years old
2014	- Number of years required to obtain the full rate (D_{FR}) from 40 years to 43 years - Duration for the full proportionality coefficient (D_{CP}) from 40 years to 43 years

at the bottom of the distribution (about -15%) and a smaller effect at the top (about -3%) for men. Thus computing pensions from the 25 rather than the 15 best years of labour earnings as it was the case before the reform had a stronger effect for low income men, probably due to the fact that they have low career duration, and do not have 25 years of work. The exception is the very first decile, where some men receive the minimum pension, and the average loss due to the reform are somewhat smaller. For women, the impact of pension at claiming age is also negative, but displays a U-shape where the middle deciles are the most impacted (Figure 12b). Women are less affected by the reform in the first deciles, because more of them receive the minimum pension. The impact of the reform in terms on SSW is very similar to the one in terms of claiming (Figure 12c). The effect we find can be compared to other effects found in the literature. Looking at the mechanical effect on older cohorts than ours, Bridenne & Brossard (2008) find effects that have similar orders of magnitude.

When looking at decomposition of the impact of the 1993 reform (Figure 13), we see that the model predicts that the effect of the reform is mainly driven by the mechanical effect, with a very small behavioural response. Only individuals at the very bottom of the distribution have a behavioural response that slightly attenuates the negative effect of the reform for men, and at the first 3 deciles for women.

The impact of the 1993 pension reform might seem counterintuitive, given that it extended the calculation of the reference wage from the 10 best years to the 25 best years. Since high-income individuals often experience more dynamic wage growth, one would expect the reform to affect them more significantly, resulting in a progressive effect of the reform. However, the regressive result we observe can be explained by two factors. First, as mentioned earlier, the wages used to compute the reference pension are capped at one PSS (Plafond de la Sécurité Sociale), which limits the reform's impact on high earners (See Aubert & Duc 2011). Second, our analysis focuses on individuals who were still working at age 54, likely excluding those at the lower end of the income distribution, who may have left the workforce earlier.

The 2003 reform This reform had an impact on claiming age that can be compared to the one of the 1993 reform in terms of magnitude. However, by decile of ALTE, the impact on claiming age was stronger for high income deciles than low income ones (Figure 12a). The impact on pension levels was close to 0 for men, except for the first decile that experienced a negative impact (-5%), and increasing and linear for women from -5% for decile 1 to +2.5% for decile 10 (Figure 12b). The negative impact at the bottom of the distribution can be imputed to the increase in the required duration to get full proportionality. Positive impact can be linked to the introduction of the bonus and the attenuation the penalty for private sector workers. The impact of the reform on SSW is similar to the impact on pension levels. As for the 1993, the total effect of the reform is mainly driven by the mechanical effect, while behavioural responses had no effect at the bottom of the distribution. On the contrary, we note that for women, behavioural responses at the bottom of the distribution partly attenuates the negative impact of the reform.

The 2010 reform The impact of this reform is mainly concentrated on claiming age as the reform increased the *SEA* and the *NRA* by 2 years. For men, the actual increase in claiming age ranges between 6 months and 1 year and 3 months depending on the ALTE decile, while for women, the increase was stronger, between 9 month and 1 year and a half (Figure 12a). For both men and women, the impact was inverted U-shaped with low and high deciles less impacted than individuals situated at the middle of the distribution of ALTE. In total, the impact of the reform on pensions was slightly negative and regressive, as shown by the increasing pattern of the impact of the reform on SSW at 55 (Figure 12c). For men, SSW decreased from 2 to 5% and for women from 7.5 to 2.5% with larger decrease at the bottom of the distribution.

The decomposition of the impact of the reform is given Figure 15. First it shows a positive mechanical impact. This can be explained by the fact that in our counterfactual scenario, we mechanically extend careers when increasing *SEA*, individuals thus continue to accumulate pension rights, which increases their pension at claiming. The behavioural responses negatively affect SSW : although individual increase their claiming age, average increase remains below the 2 years increase of the *SEA* and the *NRA*, leading to a negative behavioural impact.

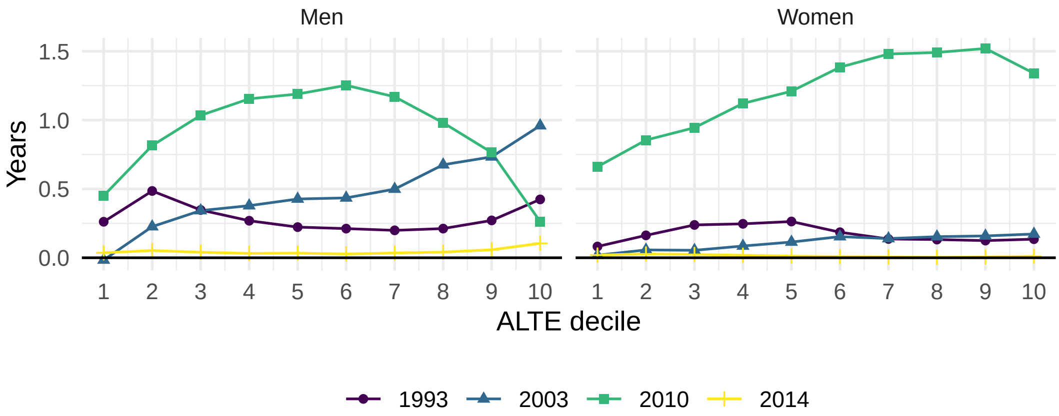
Our findings on the overall impact of the 2010 reform differ from Duc et al. (2018) – who find an overall positive effect – for two main reasons. First, Duc et al. (2018) earlier study did not account for changes in retirement behaviour due to the reform, assuming instead that everyone claimed at the full rate. Our mechanical effect is consistent with this finding. Second, by assuming that the mechanical effect of the reform's shift in the claiming age matches the increase in statutory age, we are led to conclude that the 2010 reform negatively affected SSW compared to a scenario without the reform, as individuals delayed their retirement by less than the increase in statutory age. Overall, our evaluation of the 2010 reform is somewhat imprecise,in order to insure an harmonised approach across all pension reforms.

The 2014 reform The 2014 reform mainly increases required duration to get the full rate. Among the reforms we consider, this reform has the smallest impact on claiming age. This may be due to the fact that moving age bounds has strong mechanical impact on claiming age, and to the fact that increasing required duration may have less impact on financial incentives than the 1993 and 2003 reforms that strongly reduced the reference wage and slope of the penalty and bonus. Moreover, this reform affects less individuals, as pension of individuals who have too low or too large duration at *SEA* will only be affected by the reform through the proportionality coefficient. Nevertheless, this reforms had a comparable negative impact on pensions and SSW to the one the 2010 reform with a large impact (-5%) at the bottom of the distribution and a smaller one at the top (more than -2%) for men, and a similar pattern for women with lower magnitude of the effects.

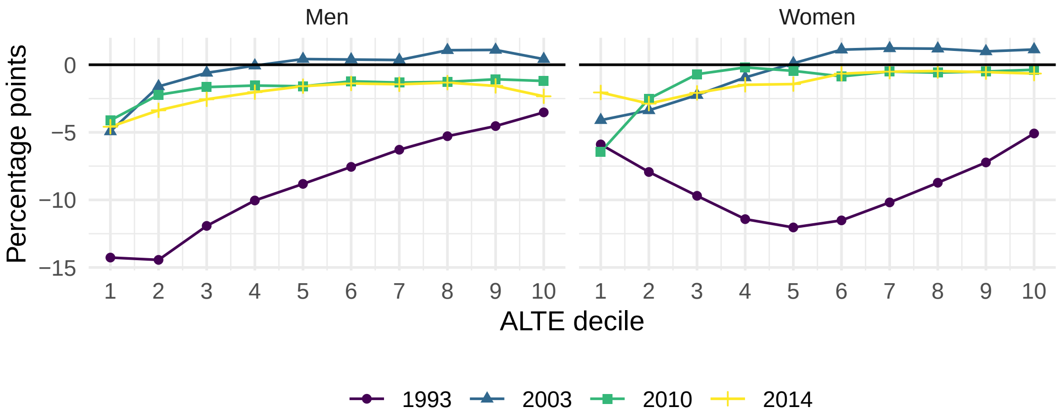
As a consequence, the decomposition of the effect of the reform show that its impact is mainly driven by mechanical aspects. Our results are consistent and of similar magnitude to Duc et al. (2018).

Figure 12: Effects of pension reforms

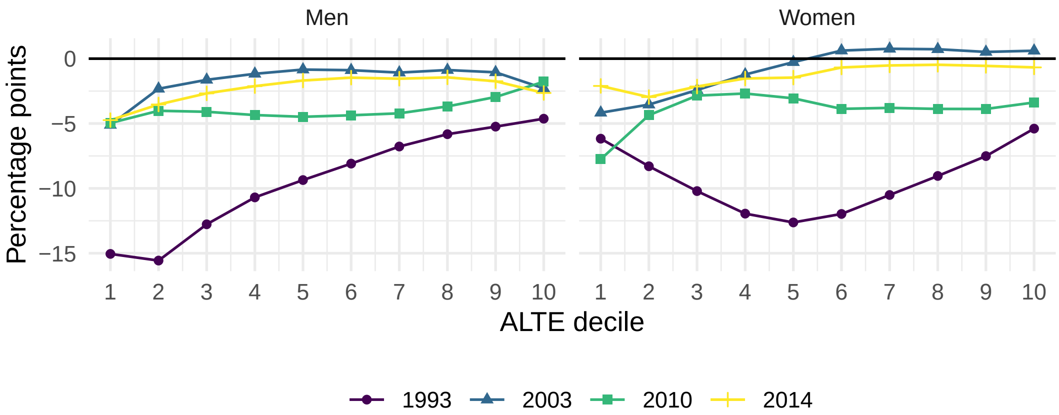
(a) Claiming age



(b) Pension level

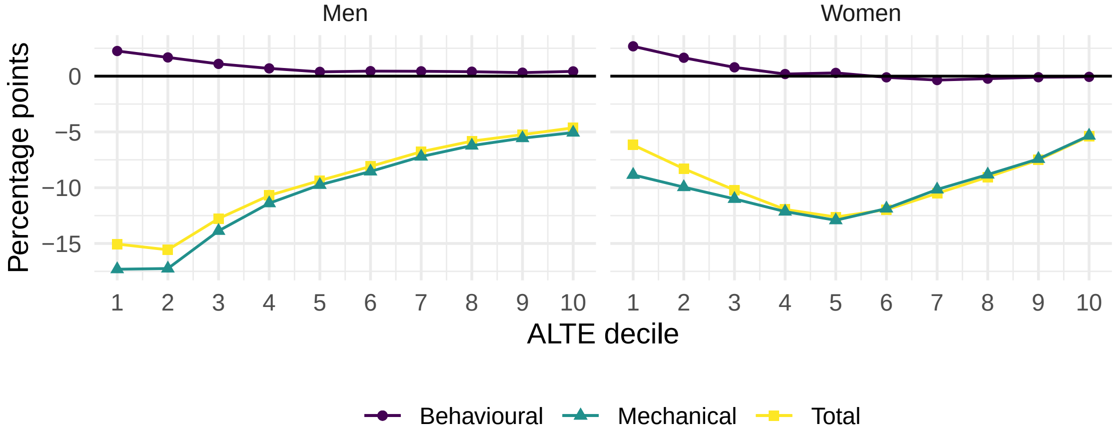


(c) Expected Social Security Wealth at 55



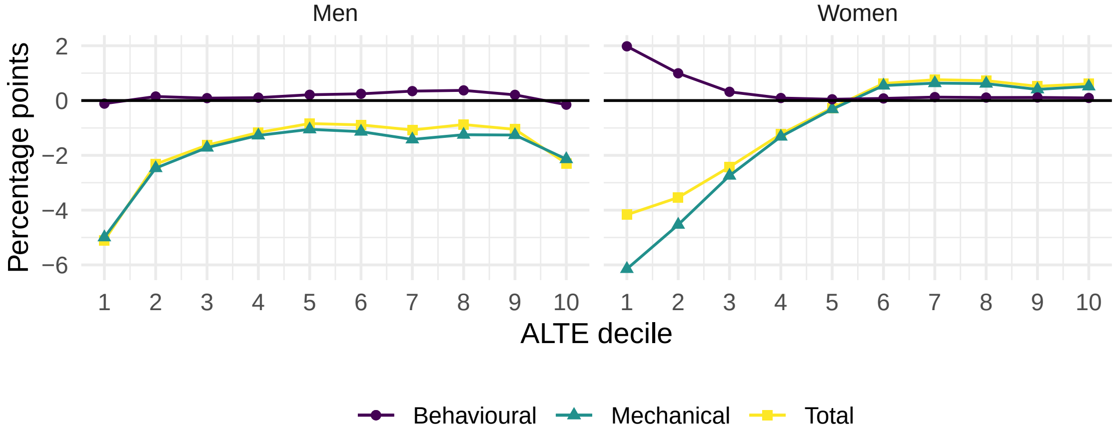
SOURCE: EIC 2001, 2005, 2009 & 2013 and EIR 2001, 2004, 2008 & 2012.

Figure 13: Decomposition of the effect of the 1993 reform on SSW



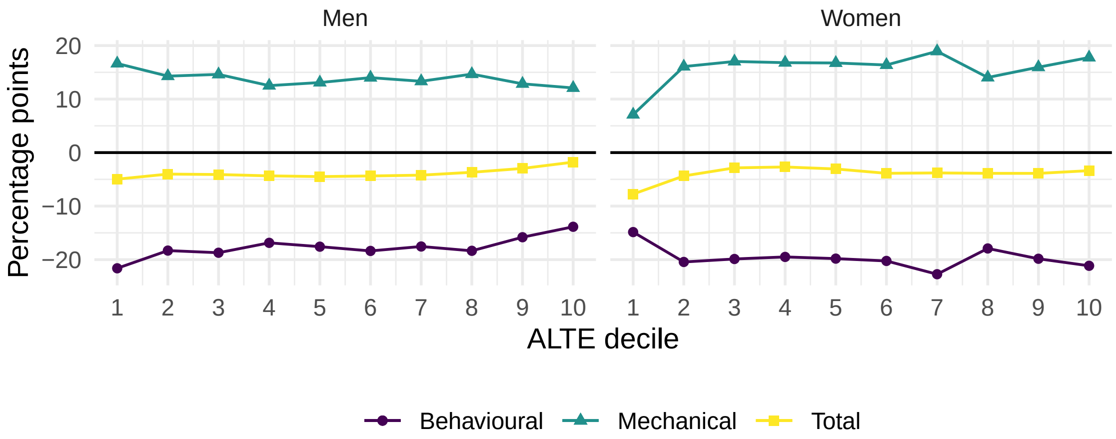
Source: EIC, PENSIPP

Figure 14: Decomposition of the effect of the 2003 reform on SSW



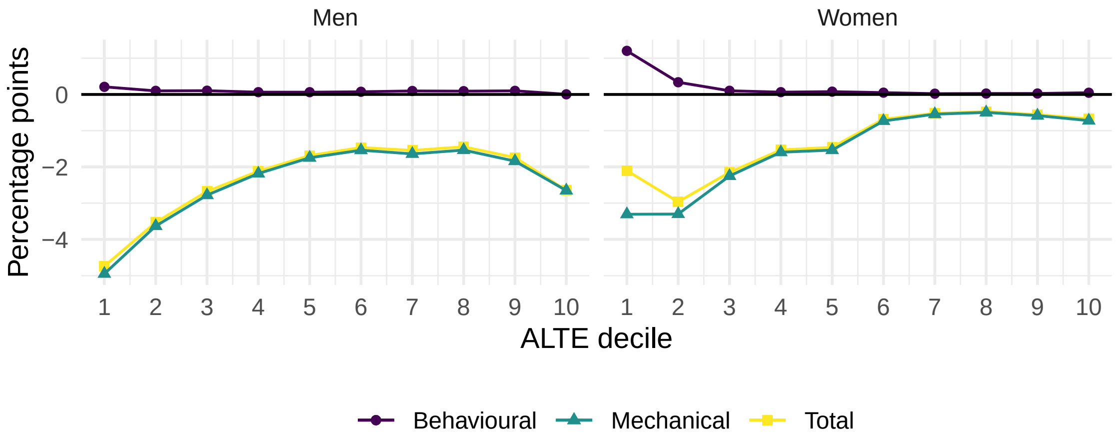
Source: EIC, PENSIPP

Figure 15: Decomposition of the effect of the 2010 reform on SSW



SOURCE: EIC, PENSIPP

Figure 16: Decomposition of the effect of the 2014 reform on SSW



SOURCE: EIC, PENSIPP

7 Conclusion

This paper has analysed the impact of four major pension reforms in France (1993, 2003, 2010, and 2014) on inequality in social security wealth (SSW) across different lifetime earnings deciles and genders. By leveraging administrative data and a retirement behaviour model, we have decomposed the effects of these reforms into mechanical and behavioural components.

Our findings reveal several key insights:

1. Overall, the reforms had a regressive impact, reducing SSW more significantly for lower lifetime earnings deciles than for higher ones. This effect was particularly pronounced for men.

2. The 1993 reform had the most substantial and regressive impact, especially for men, with SSW reductions ranging from over 15% for the lowest decile to about 5% for the highest decile.

3. Subsequent reforms (2003, 2010, and 2014) had smaller but still regressive effects, with SSW reductions generally between 5% and 0% across deciles.

4. Women experienced similar patterns, although with some notable differences. For instance, the 1993 reform had a much smaller impact on women at the bottom of the distribution compared to men, probably due to the introduction of the minimum pension.

5. The decomposition of reform effects showed that mechanical effects generally dominated behavioural responses, particularly for the 1993 and 2014 reforms.

6. The 2010 reform, which increased the statutory eligibility age (SEA) and normal retirement age (NRA), had the most substantial impact on claiming age but a regressive effect on SSW.

These findings have important implications for understanding the distributional consequences of pension reforms. While the reforms have helped to address the financial sustainability of the French pension system, they have done so at the cost of increased inequality in retirement wealth. The regressive nature of these reforms suggests that policymakers should consider more carefully the distributional impacts of future pension system changes.

Our analysis also highlights the importance of considering both mechanical and behavioural effects when evaluating pension reforms. While behavioural responses can sometimes mitigate the negative impacts of reforms, particularly for those at the bottom of the earnings distribution, these responses are generally not sufficient to offset the mechanical effects of the policy changes.

Future research could build on this work in several ways. This includes extending the analysis to more recent cohorts and reforms to understand evolving trends in pension inequality, incorporating more sophisticated models of labour market dynamics to better capture the long-term effects of reforms on career trajectories and retirement decisions, and exploring the interaction between pension reforms and other social policies to provide a more comprehensive picture of retirement income inequality. Additionally, investigating the impact of these reforms on specific subgroups, such as those with interrupted careers could help identify best practices in designing pension reforms that balance financial sustainability with distributional concerns.

In conclusion, this paper provides valuable insights into the distributional impacts of pension reforms in France. As countries continue to grapple with the challenges of ageing populations and pension system sustainability, understanding these impacts will be crucial for designing more equitable and effective pension policies in the future.

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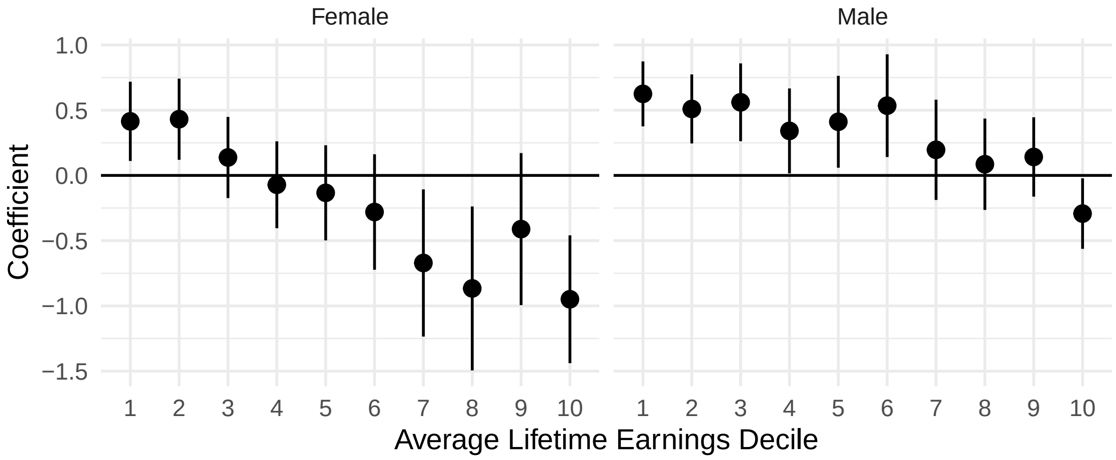
A Appendix

Table A.1: Parameter estimates of the non interacted claiming model

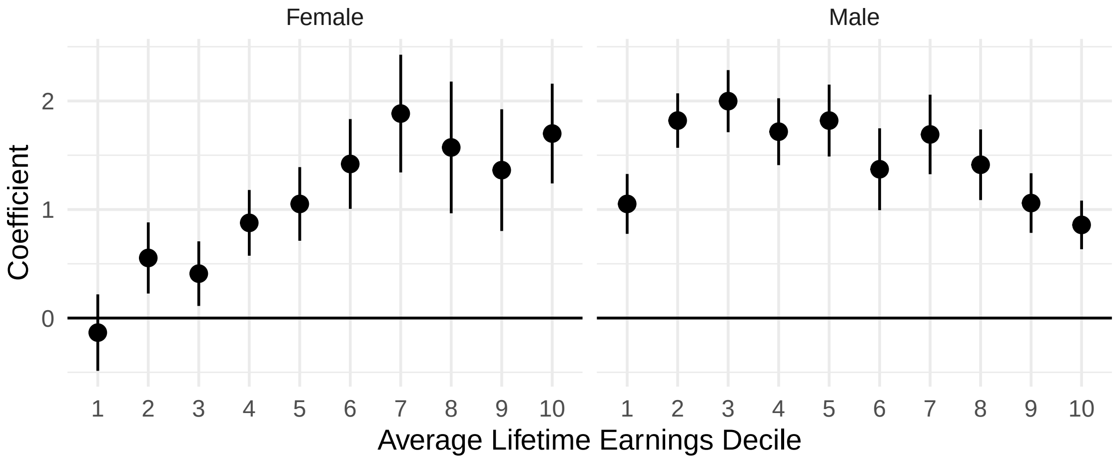
	Men			Women		
	Accrual	ITAX	Peak	Accrual	ITAX	Peak
(Intercept)	-184.022^{***}	-178.647^{***}	-200.776^{***}	-415.824^{***}	-421.282^{***}	-424.215^{***}
	(19.713)	(19.128)	(19.232)	(27.645)	(27.397)	(27.386)
SSW	0.637^{***}	0.939^{***}	0.921^{***}	0.432^{***}	0.690^{***}	0.549^{***}
	(0.053)	(0.050)	(0.051)	(0.055)	(0.051)	(0.054)
Financial Incentive	-5.609^{***}	1.239^{***}	-1.412^{***}	-3.136^{***}	0.979^{***}	-0.601^{***}
	(0.257)	(0.215)	(0.072)	(0.246)	(0.210)	(0.062)
Full rate by age	1.453^{***}	1.507^{***}	1.456^{***}	1.833^{***}	1.892^{***}	1.880^{***}
	(0.123)	(0.122)	(0.121)	(0.120)	(0.120)	(0.119)
Full rate by duration	0.842^{***}	1.438^{***}	1.210^{***}	0.765^{***}	0.990^{***}	0.886^{***}
	(0.053)	(0.046)	(0.047)	(0.063)	(0.060)	(0.061)
SEA	0.451^{***}	0.306^{***}	0.357^{***}	-0.004	-0.100	-0.060
	(0.089)	(0.087)	(0.088)	(0.110)	(0.109)	(0.109)
Age	-98.905^{***}	-93.463^{***}	-108.514^{***}	-220.808^{***}	-223.152^{***}	-225.801^{***}
	(10.717)	(10.399)	(10.467)	(14.952)	(14.814)	(14.810)
Age^2	0.079^{***}	0.075^{***}	0.086^{***}	0.177^{***}	0.179^{***}	0.180^{***}
	(0.008)	(0.008)	(0.008)	(0.012)	(0.012)	(0.012)
Q3/Q1 lifetime earnings ratio	-0.317^{***}	-0.246^{***}	-0.297^{***}	-0.307^{***}	-0.293^{***}	-0.296^{***}
	(0.039)	(0.038)	(0.038)	(0.041)	(0.041)	(0.041)
ALTE	-1.735^{***}	-2.130^{***}	-2.419^{***}	0.539^{***}	-0.059	0.334^{*}
	(0.160)	(0.153)	(0.159)	(0.178)	(0.169)	(0.176)
Labour earnings	-0.023^{***}	-0.033^{***}	-0.016^{***}	-0.044^{***}	-0.053^{***}	-0.041^{***}
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Unemployment before 55	-0.241^{***}	-0.217^{***}	-0.249^{***}	0.157^{***}	0.153^{***}	0.146^{***}
	(0.039)	(0.039)	(0.039)	(0.040)	(0.040)	(0.040)
Sick leaves before 55	0.251^{***}	0.256^{***}	0.242^{***}	0.444^{***}	0.450^{***}	0.449^{***}
	(0.038)	(0.037)	(0.038)	(0.040)	(0.040)	(0.040)
AIC	19595.166	20093.589	19724.995	16631.246	16809.321	16739.081
BIC	19696.615	20195.038	19826.444	16731.032	16909.106	16838.867
LogLikelihood	-9784.583	-10033.794	-9849.497	-8302.623	-8391.660	-8356.541
Deviance	19569.166	20067.589	19698.995	16605.246	16783.321	16713.081
Num.obs.	18102	18102	18102	15928	15928	15928

Figure A.1: Coefficient associated to pension system parameters : ITAX Model

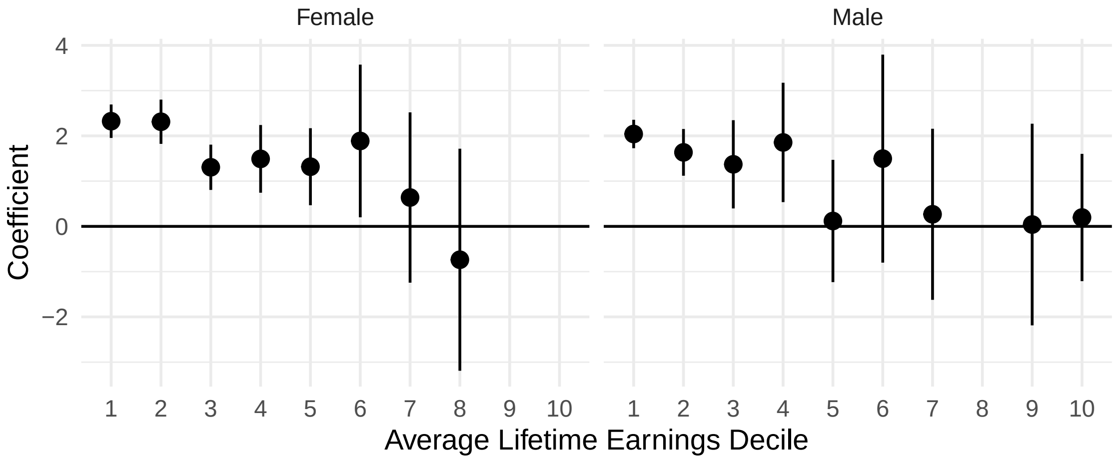
(a) Statutory Eligibility Age



(b) Reached Full rate duration



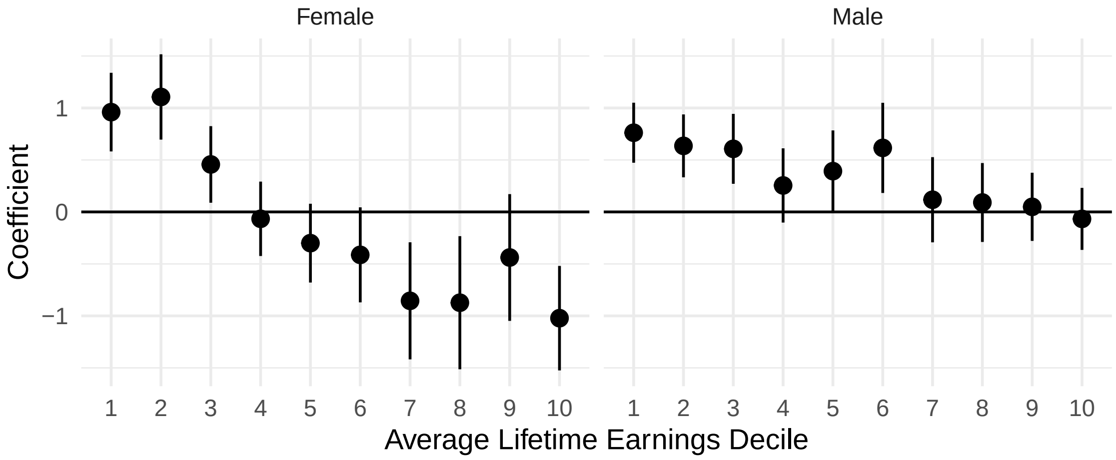
(c) Reached Full rate age



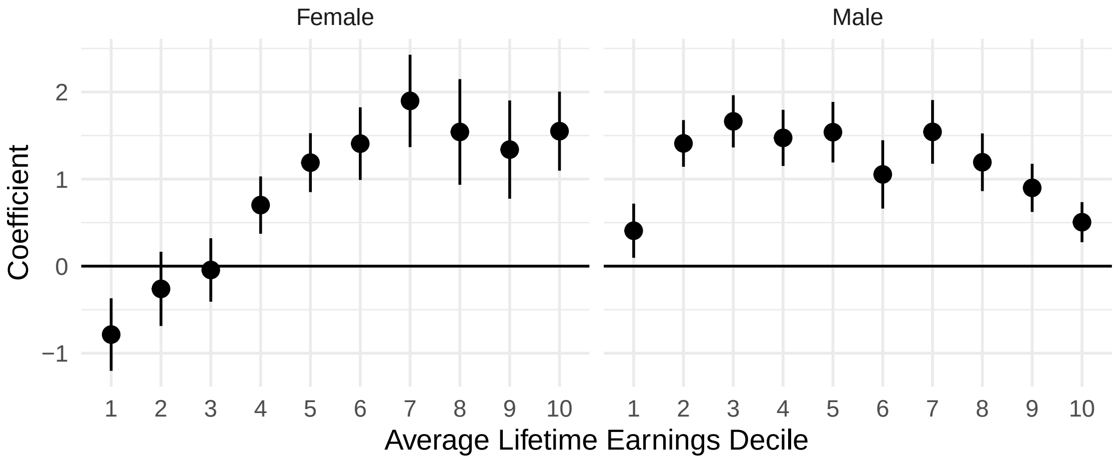
SOURCE: EIC 2001, 2005, 2009, 2013 & 2017 and EIR 2001, 2004, 2008, 2012 & 2016.

Figure A.2: Coefficient associated to pension system parameters : Peak value Model

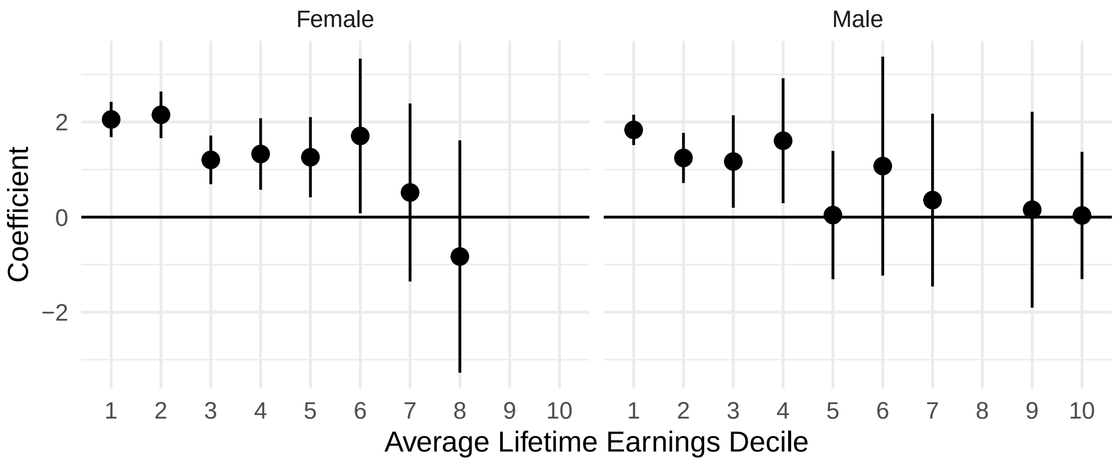
(a) Statutory Eligibility Age



(b) Reached Full rate duration



(c) Reached Full rate age



Source: EIC 2001, 2005, 2009, 2013 & 2017 and EIR 2001, 2004, 2008, 2012 & 2016.