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BUILDING AND INTERPRETING MACRO/MICRO ESTIMATES OF ACCRUED-TO-DATE PENSION LIABILITIES: FRENCH REFORMS AS A CASE STUDY

BY DIDIER BLANCHET,* SYLVIE LE MINEZ AND ANTHONY MARINO

Institut National de la Statistique et des Études Économiques (Insee)

Estimates of accrued-to-date pension liabilities (ADL) should become more widely accessible to statisticians and decision makers in the near future, in application of new SNA requirements. This raises two questions: how can such estimates be routinely produced, and what for? Microsimulation helps in answering the first question of the "how." It allows ADL computations that take into account the complexity of pension rules. Concerning the "what for" question, it is known that ADL are not an indicator of global financial sustainability. Messages they convey are more interesting at the micro level, from a household perspective. This fosters the case for microsimulation which spontaneously generates consistent micro/macro results. We illustrate these points using the French situation as a case study. We emphasize one aspect of French reforms that may concern other countries as well: the move to price indexation and the connection it creates between sustainability and growth assumptions.

JEL Codes: C53, H55, J26

Keywords: accrued-to-date liabilities, microsimulation, pension reforms

INTRODUCTION

The relevance of implicit pension liabilities (IPL) for the monitoring of pension reforms has been recurrently debated over the last decades (e.g., Franco, 1995; Disney, 2001; Holzmann *et al*., 2004; Kune, 2006; Werding, 2006; Blanchet and Ouvrard, 2007; Eurostat/ECB, 2011). To sum up briefly the difficulty of interpreting such indicators, one must first recall that IPL can be declined in three main different versions that need to be very clearly differentiated. The most comprehensive interpretation of the concept consists in its "open system" (OS) version. It takes into account all the future flows of benefits and contributions to be paid or to be received by the pension system. The two others are more restrictive. They focus on commitments toward people already present in the system: the "accrued-to-date liabilities" (ADL) approach, restricted to benefits to be paid on the basis of past contributions;[1]

Note: This paper is based on work initiated while the first two authors belonged to Insee's Department of General Economic Studies (D3E). Earlier versions have been presented at the 30th IARIW conference, Portoroz, September 2008, at a D3E seminar in December 2009, and at the Netspar International Pension Workshop, Paris, June 2012. The authors thank participants to these meetings and more particularly Stijn Lefebure, Selma Mahfouz, and Patrick Aubert. Comments by the two referees and the editor have also been very helpful. Results and their interpretations are those of the authors and do not reflect official positions by Insee.

*Correspondence to: Didier Blanchet, Institut National de la Statistique et des Études Économiques, 18 Bd Adolphe Pinard, 75675 Paris Cedex 14, France (didier.blanchet@insee.fr).

[1]See also Beltrametti and Della Valle (2011) for a still more restrictive version, concerning pensions remaining to be paid to people currently retired.

and the "closed group" (CG) approach, that also incorporates contributions to be paid by currently active participants until the end of their active lives, balanced with the additional benefits that these future contributions will generate.

Among these three versions of the concept, it is only the OS approach that can directly inform us about the long run sustainability or unsustainability of a pay-as-you-go (PAYG) pension system: the sign of OS liabilities directly tells us whether future expected contributions are enough or not to cover future expected expenditures, that is, whether the system is in need of reform. Such is not the case with ADL and CG indicators. These indicators are always positive by nature, and their magnitude does not inform us about long run financial prospects for the pension system. A given pension system can have very high IPL in the ADL and CG senses of the term while being perfectly sustainable with OS liabilities equal to zero: this will be the case for a large mature pension scheme which is in steady state equilibrium. However, a system that distributes low benefits but faces unfavorable demographic or economic prospects will be unsustainable, while being unduly judged in good standing by naive observers taking low levels of ADL or CG liabilities as proof of financial health.

Despite this limit, expanding the use of ADL for the follow-up of pension reforms has been an important question for national accountants in recent years, following new requirements introduced in the 2008 System of National Accounts (SNA). The main motivation for this change has been the harmonization of treatments of private pension funds and public pension systems. Computing ADL for private schemes was already part of the core system of accounts, and ADL have indeed a clear interpretation for such schemes. Being private, these schemes necessarily require full funding, and their ADL measure the reserves required to honor all their commitments in the event of a sudden interruption of contribution flows. Such a scenario is in principle ruled out for public unfunded pension schemes, yet the same kind of information will soon have to be produced regularly for these schemes in EU member states, according to the 2010 version of the European System of Accounts (ESA 2010, see regulation 549/20133 of the European Parliament and Council and Eurostat/ECB, 2011).

This raises two questions that are the topic of the current paper.

The first one is the question of "how?" Computing ADL is easier than computing full OS indicators, because it does not entail a complete long run projection of all expenditures and receipts by the pension system: it focuses on elements of the pension contract that are predominantly rooted in the past, and here lies the basic reason why accountants favor this particular concept of IPLs. But this computation remains nevertheless difficult when pension rules are complex. One way to address this complexity of pension rules is microsimulation, because it allows a detailed account of all the legislation at the individual level. Microsimulation models are indeed widely used for pension projections. Consequently, it is natural to wonder whether this same technique can also be one of the ways to routinely fulfill new SNA requirements. One possible objection to this solution is that microsimulation results are subject to stochastic variability, a characteristic that appears problematic for their introduction in NA statistics. This is all the more true now that new SNA requirements ask not only for some snapshot figures of ADL, but also for year-to-year changes in these ADL and their components. The first contribution of this paper will be to show that this problem of stochastic variability does not preclude relying on this technique for routine production. We shall see that, even with a microsimulation model running on a relatively limited sample, it seems possible to produce ADL indicators that look stable enough to be included in SNA tables. In other words, microsimulation is indeed one possible answer to the question of "how?"

The second question addressed by this paper is the question of "what for?" What will be the most relevant way to use these indicators once regularly produced? For instance, how should we use the information they will deliver concerning future pension reforms? Relying on our microsimulation results, we shall examine this question, taking recent French reforms as an illustration. We shall confirm that they remain poorly informative concerning the contribution of reforms to restoring pension sustainability. The information they provide is clearly more relevant when looked at from the point of view of households, as indicators of prospective pension entitlements. Restoring sustainability generally entails cuts in these entitlements, either through reduced benefits at given retirement ages, or through a shortening of the retirement period at given replacement levels. The advantage of the ADL approach is to produce a synthetic view of how these two kinds of changes affect individuals or households.

Now, it immediately stands out that such information is much more interesting at the micro level than at the macro level. One additional limit of ADL computed at the very global level is that they give a predominant weight to people who are close to retirement who, in general, are not the ones who are the most strongly affected by reforms. Hence the importance of looking *within* the indicator. This will give an additional argument in favor of microsimulation whose principle is precisely to produce consistent results at both the macro and micro levels. Such a perspective is in line with current attempts to develop household accounts disaggregated by socio-demographic categories (Fesseau *et al.*, 2008).

The paper is organized as follows. The first section will describe the features of the French pension system and of its main reforms that need to be known in order to understand the rest of the paper. Section 2 will briefly present the main characteristics of the microsimulation model used in this paper, the Destinie 2 model (Blanchet *et al.*, 2011) and how it has been used for building ADL estimates. Sections 3 and 4 will discuss macro results. Section 5 will be devoted to some illustrative micro results. Two online appendices are devoted, respectively, to a more precise description of the French pension system and to the demonstration of some analytical properties concerning steady state values of ADL. These analytical properties will be used in the paper to help interpret microsimulation results.

1. Pension Reforms: The French Example

The French pension system is often presented as complex, and as having undergone no large scale reform in recent decades.

The first half of this judgment is undoubtedly correct. For historical reasons, this pension system still combines many components with heterogeneous rules. More details of this complexity are provided in Appendix A. We shall just summarize here what needs to be known to follow the rest of the paper. Wage earners in the private sector are covered by two and sometimes three schemes: the basic General Regime operating up to a Social Security ceiling that is roughly equal to the average wage; and one or two complementary pensions delivered by the two regimes *Arrco* and *Agirc*, the latter one being specific to highly skilled workers. All these schemes are PAYG, but with different ways to compute pensions. In the General Regime, the amount depends in a relatively complex way on age and on the length of the person's career, and of her average wage over the best years of her career. Complementary schemes are more strictly contributive, the pension being proportional to the number of "points" accumulated throughout the retiring person's career. Self-employed workers benefit from the same kind of dual organization, but with a complementary tier that is generally less generous. Public sector employees, on the other hand, draw benefits from a single pension system: their pension level is connected to their last wages (excluding bonuses), but again with a complex proportionality rule involving both age and the length of their career.

Past reforms have indeed done little to reduce this complexity. They have all belonged to the category of "parametric" reforms that only consist in changing numerical values of parameters governing pension levels or age at retirement, without changing the general architecture of the system.

But parametric reforms are not necessarily small reforms: large parametric changes can lead to large changes in pension outcomes, and such has been the case in the French system. Without entering into details, one can say that the French pension system has undergone four major explicit reforms of this kind, plus a more silent implicit one. Implications of these successive reforms for the pensions/GDP ratio are illustrated by Figures 1 and 2 under some of the economic assumptions used in the last report by the Pensions Advisory Committee (*Conseil d'Orientation des Retraites*) which, since 2000, has been in charge of regularly actualizing French pension projections: a "median" scenario for productivity growth, with a long run yearly rate stabilizing at 1.5 percent per year, used for Figure 1, and two variants displayed in Figure 2, a low one at 1 percent and a more optimistic one at 2 percent. These projections have been realized with the microsimulation Destinie 2 model, which will be used throughout the paper; its main characteristics will be presented in the next section.

The "silent" reform has been the first one from the chronological point of view. Until the mid 1980s, most of the monetary parameters of the pension system were indexed on current wages. This applied to the yearly revalorization of pensions for people already retired, but also to the *ex post* reevaluation of past wages when computing the reference wage used in the General Regime. As illustrated in Figure 1 (top curve), the continuation of this rule under rapid population ageing would have led to a considerable rise in the pensions/GDP ratio, bringing it to 18.8 percent in 2060. This would have even exceeded the pure expected consequences of population ageing, meaning that indefinite indexation on wages would have led to some further increases of pensioners' relative standard of living, that was already high in France during this period. But such a large increase will not happen since a shift to indexation on prices started at the end of the 1980s. This new mode of indexation has been confirmed to be the new default rule for private sector employees by the 1993 reform, extended to the public sector in 2003.

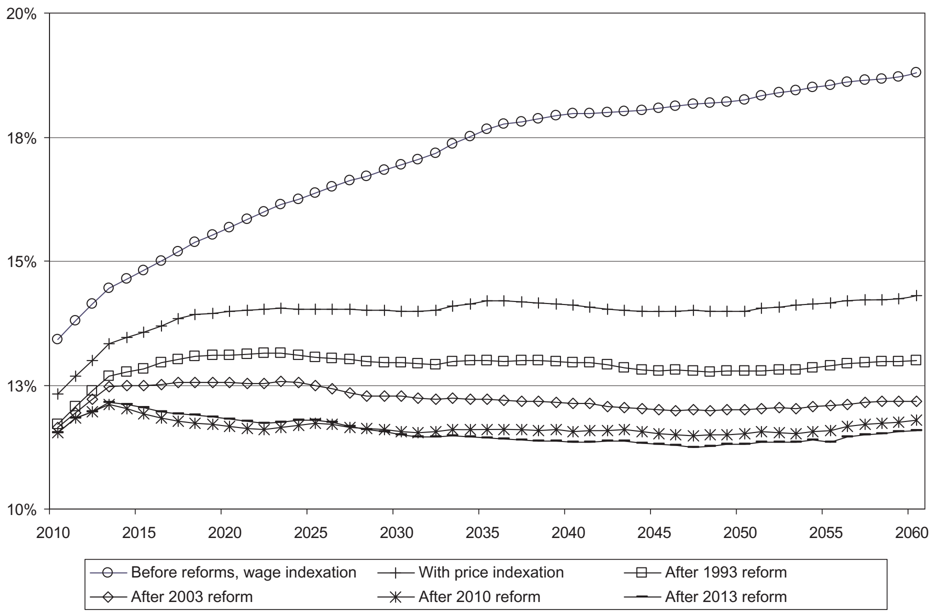


Figure 1. Impact of Successive Reforms on Projected Pensions/GDP Ratios

Notes: Differences between successive scenarios do not only reflect pure effects of the successive reforms, because these scenarios also include the impact of other measures adopted between successive reforms. For instance, the difference between the "after 2013" and "after 2010" reform includes the impact of some favorable dispositions introduced in 2012, including an extension of derogations to the new minimum age of 62.

Source: Destinie 2 model, authors' computations.

As shown by the second curve from the top in Figure 1, this has been a major contributor of reducing the expected growth of the pensions/GDP ratio. In 2010, this ratio was already 1.1 point lower than the value it would have had under the wage-indexation scenario. In 2060, under the median economic scenario of Figure 1, the pensions/GDP ratio will be reduced by 4.5 points under the sole effect of this change in indexation rules.

Other aspects of the reforms have played a lower role taken separately but, when cumulated, fully close the long run financial gap that was expected *ex ante*, at least under the median scenario that is used in Figure 1. They have done so by mobilizing various instruments, applied with varying intensities and various schedules to the different groups of workers:

- First, there have been higher constraints on access to the "full rate" pension within the 60–65 age bracket where retirement was initially possible. In the French system, access to the full rate is automatic once one reaches the upper limit of this bracket, but benefiting from the same full rate before this upper limit requires the additional condition of totalizing a certain number of years of contributions. This number was equal to 37.5 years before 1993, relatively easy to reach as early as 60 for a majority of people within the relevant cohorts, at least for men, hence a *de facto* equivalence between the

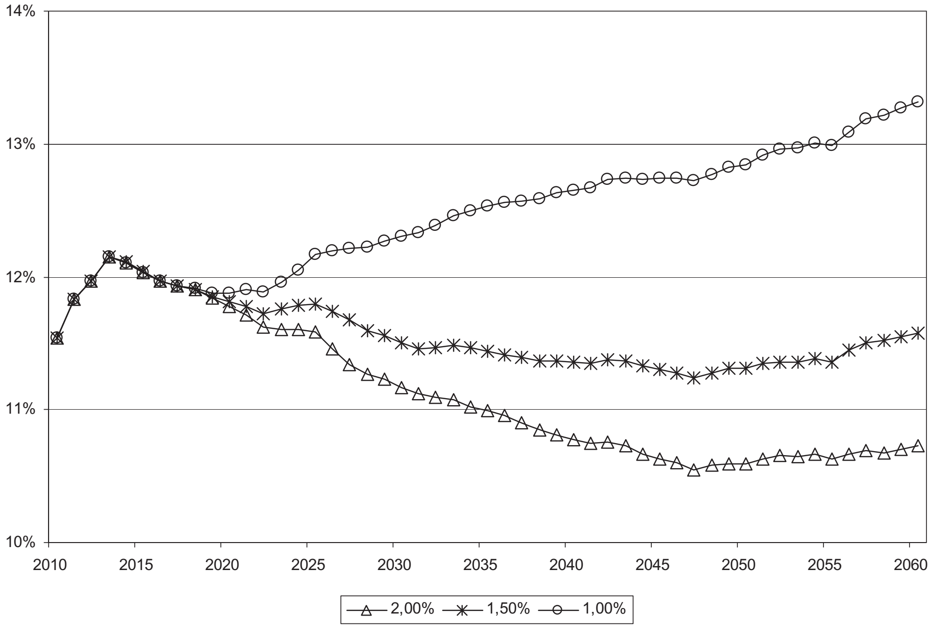


Figure 2. Impact of Various Growth Scenarios on Projected Pensions/GDP Ratios
Source: Destinie 2 model, authors' computations.

minimum age and the actual retirement age. Following the 1993, 2003, and 2013 reforms, this number has started to increase regularly and will do so up to the value of 43 years for people born in 1973. The 1993 reform had changed this parameter only for workers in the private sector but, since the 2003 reform, this parameter is fully identical and moves at the same speed for public sector employees. This should increase the average gap between the minimum age and the age at which the full rate is obtained.

- The second change has been a global shift of this 60–65 age bracket within which retirement was initially possible. This has been the specificity and the principal element of the 2010 reform: following this reform, this age bracket is currently shifting to 62–67, and it is doing so in a relatively rapid way. The move was initially planned to be of +4 months every year, and was accelerated to +5 months per year in 2011.
- Last, but essentially following the 1993 reform for private sector workers, there has been a decline of effective replacement levels offered at the full rate, due to a change in the formula used for computing the "reference wage" to which the pension will be proportional. Initially computed as the average wage of the 10 best years of one's career, this reference wage is now the average of the 25 best years of this career.

All-in-all, under the median growth scenario retained for Figure 1, these reforms seem to have almost entirely eliminated potential deficits in the long run, which was already the case after the 2010 reform. This explains why the 2013 reform remained at a relatively small amplitude, being based upon the assumption that this median growth scenario was credible in the long run.

Yet Figure 2 shows that some non-negligible uncertainty remains concerning the degree to which the long run pension problem is really solved. The level ultimately reached by the pensions/GDP ratio remains significantly dependent upon assumptions that are made concerning future economic growth, ranging from 10.7 percent under the optimistic scenario to 13.3 percent in the pessimistic one. This directly stems from the important role played by the adoption of price indexation. With indexation on prices and pensions computed on the basis of the 25 best years of one's career, pensions do not reflect current real wages but real wages that prevailed over the last 25 last of pensioners' careers. This lag creates a gap between current pensions and current wages whose amplitude is directly linked to the productivity growth rate. This mechanism combined with the expected incidence of reforms on retirement ages almost exactly stabilizes the pensions/GDP ratio under the median scenario but overshoots this target in the optimistic one, and remains far short of fully securing the system in the pessimistic one.

To sum up briefly, as in many other similar countries, past reforms have gone a relatively long way down the road to stabilizing pension expenditures but, and this is perhaps a little more specific to the French case, they have done so with an efficiency that remains dependent upon future economic growth. This is due to the large role played by the move from indexation on wages to indexation on prices. The main question of this paper is to know how far ADL computations are able to restitute this global picture. But, before that, our first question is to know how such indicators can be easily built for a system that remains very complex.

2. Computing ADL with a Microsimulation Model

As a general rule, simulating pension prospects can be done in two principal ways. One is to build relatively aggregated projection models: the minimal disaggregation is by age and also generally by gender. This is enough if we can assume a reasonable degree of homogeneity of pension entitlements within each of the corresponding cells. This had been considered a sufficient approximation in the first projection exercises conducted in France at the turn of the 1990s (e.g., Vernière, 1990), but we very rapidly had to turn to the alternative solution of a maximal disaggregation, that is, the dynamic microsimulation approach, projecting pension entitlements at fully individual levels, this choice resulting from the complexity of the French pension system. This complexity stems not only from the coexistence of several schemes, but also from the complexity of rules that prevail within each of the schemes. Precise simulations of the impact of parametric reforms with such complex rules is almost impossible to do with aggregated or semi-aggregated models.

For instance, even if we limit ourselves to the General Regime, projecting replacement rates requires knowing the full distribution of the number of years of contribution by people reaching the retirement bracket. It also requires a full knowledge of how their career profiles are distributed, if we want to assess the implications of computing pensions over the 25 rather than the 10 best years of these careers. The first of these two elements can eventually be made available in a cell-based model projecting the cross-classification of individuals by age and number of years of contributions (e.g., Aubert *et al.*, 2010). But this would not provide any answer to the second problem. In such a context, there is a strong motivation to rely on microsimulation; this is the strategy that has been followed since the mid 1990s at Insee with the building of the Destinie 1 microsimulation model (Bardaji *et al.*, 2003; Blanchet and Le Minez, 2009) and later on by the General Regime with the Prisme model used for its own projection exercises (Poubelle *et al.*, 2006).

The model that will be used here is the Destinie 2 model whose development started in the mid 2000s and that has recently replaced Destinie 1 (Blanchet *et al.*, 2011; Bachelet *et al.*, 2014). We shall not review here the complete characteristics of this new model, but only the ones that are of interest for the present exercise. This model works in two steps. The first step consists of a projection of demographic characteristics—including family ties—and of labor market trajectories of a sample representative of the French population. This is done starting in 2009, which is the current base year for the model. The choice of this base year is due to the fact that most of the initial information used by the model currently comes from a survey on wealth conducted in 2009, the *Enquête Patrimoine*. The main advantage of this survey is that it provides full retrospective information on past labor market trajectories of individuals.

Another major characteristic of this first component of the model is that it does not deal with pension issues. It reconstructs or projects potential labor market trajectories beyond standard retirement ages, up to the conventional age of 70, based on year to year matrices of labor market transitions. The idea is to make available to the user a set of given potential labor market histories, whose interruptions through retirement will only be simulated during the second step. This second step of the simulation starts from the biographies generated by the first module, and uses them to simulate the consequences of pension scenarios.

Three important points should be mentioned concerning this two-tier structure:

- First, a frequent objection to microsimulation is that results are affected by stochastic variability and may depend in an uncontrolled way upon assumptions made for the very large number of parameters they require, essentially the various transition probabilities used to simulate demographic or labor market events at the individual level. Here, these two objections are taken into account by aligning some of the macro outputs of the first module on results of standard demographic and labor force projections. The projected population structure is therefore made consistent with Insee's demographic and labor force projections (Blanpain and Chardon, 2010; Filatriau, 2011).
- Second, the separation between the two steps means that it is possible to simulate the consequences of pension reforms on a population whose characteristics outside pensions are completely fixed. Such would not necessarily be the case in a model simulating demographics, labor market transitions, and retirement in one single pass where interferences are difficult to avoid between stochastic drawings used to generate the different categories of events. This characteristic of the model allows *ceteris paribus*

comparisons of reform/no reform scenarios that are not polluted by uninformative noise. The only source of imprecision in the comparison is the fact that the basic sample may stochastically under- or over-represent people more or less affected by the reform, but we avoid the uncertainty that would result from stochastic variations between two distinct "reform" and "no reform" samples. One limit of this way of working is that it precludes simulations of how pension reforms may affect demographic or labor market behavior at earlier stages of the life cycle. But this will not be a limit in this paper that focuses on first order effects of these pension reforms.[2]

- Last, the second tier not only projects pension status and pension levels, but also reconstructs them for all the initial stock of retirees. Initially, this choice was made for a purely technical reason: to avoid having results affected by stock/flow discrepancies that are inherent to most projections exercises of this kind. Whatever the qualities of both the initial survey and the projection model, we know that it is never possible for both of them to be fully consistent, and this may lead to inadequate behavior of the model in the short and medium run. Reimputing initial pensions and past ages at retirement for the initial stock of pensioners avoids such discontinuities. For our present topic, it also has one very useful by-product. This systematic imputation of pensions can be done under any form of retrospective pension rules. It is due to this characteristic that the model was able to produce the kind of "what if" scenarios already displayed in Figure 1, that is, what would have been recent evolutions and what would be their continuation into the future if part or the entirety of past reforms had not been enacted, a possibility that we shall continue to exploit throughout the rest of the paper.

Destinie 2 has been used in the following way in this paper:

(a) The basic structure of the simulation program is the same as for any standard projection. We perform a standard simulation of projected retirement ages and pension entitlements using assumptions described in Table 1. The structure of the simulation program is the typical structure of a dynamic microsimulation model working by period, with two nested loops: one primary loop on the time index; and one secondary loop covering all individuals in the population for each time period. Within this second loop, two operations take place for individuals who are present in the population and already retired or reaching retirement age. For those not yet retired, the model simulates whether the individual chooses to retire. The model offers various options for simulating this retirement decision, including individual maximization of utility functions describing income/leisure trade-offs by forward looking individuals

[2]In addition, one can mention that it is not fully excluded to modify *ex post* the simulations provided by the first module to incorporate some impacts of pension reforms on behavior before retirement. In particular, Destinie 2 has been used to test consequences of changes in labor markets transitions before the age of 60 induced by pension reforms, assuming that such transitions are linked to distance to normal retirement ages rather than age *stricto sensu*.

TABLE 1
Projection Assumptions

Scope	Resident population, main regimes: General Regime and complementary schemes Arrco/Agirc for private sector employees, one-pillar scheme for civil servants, basic first pillar schemes for self-employed workers. Only personal entitlements are taken into account. Household level benefits (old age minimum) and survivors' pensions are excluded from the analysis.
Main pension scenarios	Without or with price indexation and the main changes introduced by the 1993, 2003, 2010, and 2013 reforms for the General Regime and public sector employees. Evolutions of rules for complementary schemes, on the other hand, are the same for all scenarios.
Demographic assumptions	According to Insee's demographic projections (Blanpain and Chardon, 2010): total fertility rate stabilizing at 1.95 child per woman, net annual migration flow of +100,000 persons per year, life expectancy at birth increasing from 84.2 to 91.1 years between 2007 and 2060 for women, from 77.2 to 83.5 for men.
Labor force participation	Aligned on Insee's labor force projections for people aged below 55 (Filatriau, 2011). Retirement occurs when a full rate pension can be obtained. Other labor market transitions between 55 and retirement generated by the model with transition probabilities derived from labor force surveys.
Macroeconomic scenarios	Consistent with median and extreme variants retained by the Pensions Advisory Committee (*Conseil d'Orientation des Retraites*, 2012), productivity growth rates of, respectively 1%, 1.5%, and 2% per year.
Real discount rate	3% (with 2% and 4% variants)

(Stock and Wise, 1990). Here, for simplicity, we rather assume that individuals retire when they reach the full rate.[3] Then, when the individual retires, the model modifies their labor market status accordingly, and computes the different components of his pension (there can be up to five components given that the model simulates mixed careers) and their sum.

(b) The simulation of ADL at the individual level then takes place every year within the individual loop. Two cases are considered:
  (b.1) If the individual is already retired, we just have to multiply their current pension by their remaining life expectancy, adjusted for discounting. One possibility in a microsimulation model would have been to use the number of remaining years of life as simulated individually by the model. This is all the more possible here because age at death is simulated *ex ante*, by the first module, and is

[3]Such a behavior has been the norm until the recent past, because of strong financial disincentives to leave before or after this full rate (Blanchet and Pelé, 1999). It could become less widespread in the future, because the 2003 reform and some subsequent measures tried to remove these disincentives by making the system closer to marginal actuarial neutrality around the full rate (Briard and Mahfouz, 2011). The "full rate" assumption has been kept however, for several reasons. First, it is not evident whether people will tend to leave earlier or later than this full rate, since changes in incentives that took place in 2003 play in both directions: the full rate hypothesis remains therefore a realistic median assumption. Second, the importance of very accurately predicting retirement ages is lower here than in other domains. A correct assessment of when people will retire is necessary if we want predictions of labor force participation rates and/or pension levels, but what is at stake here is a projection of global flows of benefits all over the retirement period. In a system that has come closer to actuarial neutrality, potential errors concerning the length of this retirement period are partly offset by errors of the opposite sign affecting pension levels. A last reason for having chosen the full rate hypothesis is, of course, that it is computationally less demanding.

therefore already known when simulating pensions. But this solution could not work for individuals dying after the end of the simulation period, which is here 2060. Furthermore, even if this information on age at death was available for all individuals, using this simulated information would have added irrelevant stochastic noise in the results. We therefore chose to use the standard actuarial formula based on the discounted sum of expected survival probabilities, taking into account the indexation rule for pensions. Theseprobabilities are those derived from current mortality, differentiated by gender only—that is, when we are in year 2015, for example, the projected ADL of a person retired at this period is based on mortality tables of year 2015, not on cohort tables including later gains in life expectancy. But shifting to cohort life tables would have been possible—with the result of increasing the value of liabilities.

(b.2) If the individual is not retired, the computation is more complex. The steps are the following. In order to avoid modifying the characteristics of this individual, we first create a clone of them, whose life path is immediately projected into the future. Two sub-possibilities have been then considered for this projection, corresponding to what is generally described as the "accumulated benefit obligation" (ABO) and "projected benefit obligation" (PBO) approaches (Eurostat/ECB, 2011):

- The "ABO" approach would have been to simulate future entitlements of this individual fully applying the conventional assumption of an immediate closing of the system. In this case, for most people, this would imply arriving at retirement ages with lengths of the contribution period much shorter than the one going to be required for the full rate. As a consequence, the retirement age simulated for the clone would have been generally equal to 65 or up to 67 years, depending upon the simulated legislation. Then, the ADL would have been computed by multiplying the pension reached at this age by the discounted life expectancy at this age, with two additional corrections corresponding to discounting and to the incidence of mortality until this age. Consistent with the choice made for the mortality of people already retired, all the mortality parameters used for this part of the computation would have referred to period mortality, differentiated only by gender.
- The "PBO" method takes advantage of the fact that the model directly provides prospective careers, at least until 2060, that can be easily extended further. We use these simulated prospective biographies to project full career pension entitlements, again under the assumption of retirement at the full rate, but at ages that are now going to be more frequently lower than 67, which sounds more realistic. We then correct these complete pensions to reflect accrued-to-date entitlements through a simple proratization formula. If we are at period t for an individual aged a

expected to retire at age r, their projected pension is multiplied by the number of years of contribution reached at this age a, divided by the total number of years of contribution expected at age r. We then introduce pre- and post-retirement mortality in the same way as with the previous option.

In fact, neither of these two formulae is fully satisfactory: the first because it refers to a highly counterfactual scenario for the pension system—no closing of the system is realistically at stake; the second because the simple proratization formula does not exactly reflect the way entitlements are progressively accumulated for the individual. In practice, however, they give relatively comparable results. Since the incidence of choosing between either of these two options or other possible variants is not decisive for the messages of the current paper, we shall restrict ourselves to presenting results from the second approach.

Once this is done for each reform scenario, we end up with a three-dimensional table whose generic element $ADL(s, i, t)$ gives accrued-to-date liabilities for individual i at time t under scenario s. This allows us to produce many sets of statistics.

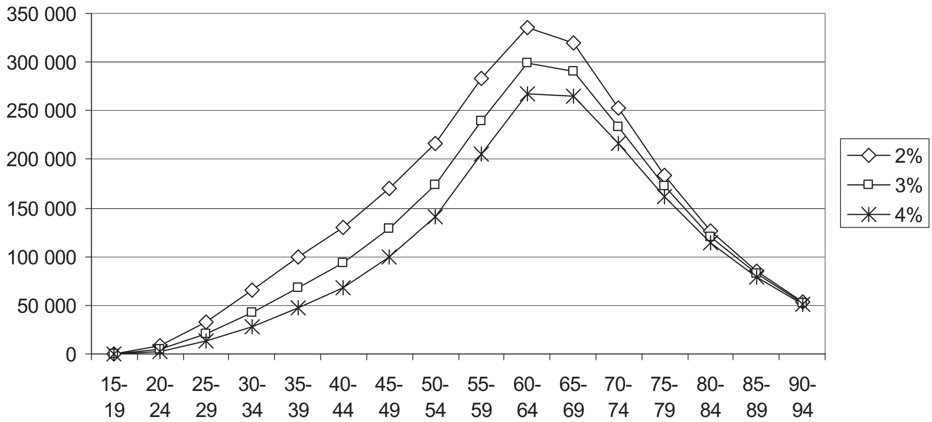
- Global ADL at time t will be produced by simply summing up over i at a given s and t.
- We can compute variations in ADL over time or at given time periods between two distinct scenarios.
- All these computations can be reproduced for specific subgroups, for instance the incidence of reforms on ADL by age or other socio-demographic characteristics.

We also underline the possibility offered by the model to anticipate future changes in ADL: they are computed not only for the current period, but can be projected as far as desired, even if we stopped here in 2020. Such a possibility is quite uncommon among other SNA statistics and is not expected to be used in practice. Tables of accounts do not need to be delivered years in advance. However, being able to build *ex ante* baseline scenarios for these ADL statistics should offer some security for their regular production: we shall be always certain to have at hand one first round estimate of this indicator that, generally, will only require marginal adjustment except in case of new substantial reforms.

3. First Results: Point Estimates of Age Specific Profiles and Global Implicit Liabilities

Let us turn to results. Figure 3 shows the age profile of individual ADL, in 2013, that is, after the last pension reform, simulated over a sample of about 60,000 individuals. This profile is presented on a per capita basis in Figure 3a, for three different values of the real discount rate r, and multiplied by the size of the different age groups in Figure 3b, distinguishing liabilities toward current retirees and liabilities toward people still in the contribution phase, for the median value $r = 3$ percent. The profiles have the typical bell-shape that was expected. ADL are close to zero for young contributors because they only have a few years of contributions behind them, and because the limited flow of benefits stemming from these few years

(a) Per Person, for Three Values of the Real Discount Rate (2012 euros)



(b) Aggregate, by Category, Real Discount Rate of 3% (billions of 2012 euros)

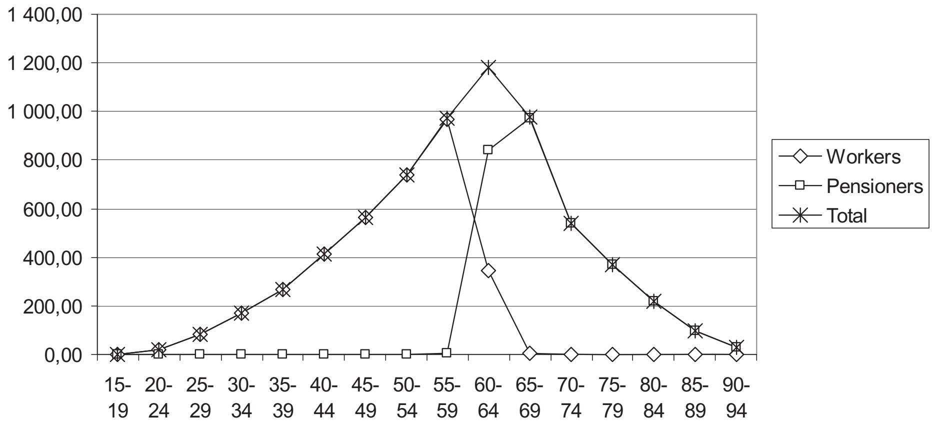


Figure 3. Age Profiles of Liabilities According to the ADL Methodology, in 2013
Source: Destinie 2 model, authors' computation.

of contributions is discounted to a very distant future.[4] Liabilities then increase with age and peak around 60, that is, at an age where people have had the time to accumulate full entitlements, whose actuarial value will be discounted over their entire retirement period. Liabilities decline after that peak because we consider

[4]Such would not be necessarily the case in the closed-group (CG) approach: the discounted sum of future benefits net of contributions for an individual starting to contribute is lower (respectively higher) than zero if we choose a discount rate that is higher (respectively lower) than the internal rate of return on contributions. In steady state, this internal rate of return is equal to the rate of economic growth g. The negative value for $r>g$ means an implicit taxation by the PAYG system which, under such an assumption, is less efficient than the funded system. This non-zero value of net liabilities for younger age groups is the main difference between CG and ADL evaluations. Its impact remains however of second order after aggregation, because of the progressive convergence of CG and ADL liabilities when we progressively come closer to retirement age: for retired people both concepts are fully identical by nature.

TABLE 2
ADL and ADL/GDP Ratios in 2013, Median Economic Scenario

	Real Discount Rate		
	2%	3%	4%
In billions of 2012 Euros			
Workers	4,590	3,575	2,836
Pensioners	3,362	3,078	2,834
Total	7,952	6,653	5,670
In % of GDP			
Workers	230	179	142
Pensioners	168	154	142
Total	398	333	284

Source: Destinie 2 model, authors' calculations.

TABLE 3
ADL/GDP Ratios in 2013, According to Long Run Macroeconomic Scenario

	Real Discount Rate		
Long Run Productivity Growth	2%	3%	4%
1.0%	393	330	281
1.5%	398	333	284
2.0%	403	336	286

Source: Destinie 2 model, authors' calculations.

pensions that remain to be paid for a number of years that itself declines with age. When aggregating, the liabilities of older retirees are further dampened by the fact that the number of surviving retirees is itself decreasing rapidly at older ages. After complete aggregation, we obtain the results of Tables 2 and 3, which show the high magnitude of the ADL/GDP ratio, around 3.33 years of GDP under the median assumption $r = 3$ percent, with substantial variation when this parameter changes, from 3.98 years of GDP with $r = 2$ percent to 2.84 years with $r = 4$ percent.

Results can be compared with other estimates. Some evaluations provided during the 1990s found values comprised between 2.1 and 2.8 years of GDP (Vernière, 1992; Van der Noord and Herd, 1993). Closer to our estimates, Blanchet and Ouvrard (2007), using the earlier and largely independent Destinie 1 model, found an amount comprising between 3.2 and 4.7 years of GDP, using the same values of the discount factor, but with a larger perimeter, since their evaluation also included survivors' pensions. Finally, Durant and Frey (2010), using the cohort based PROST model built by the World Bank, obtained a total amount in 2008 of 7976 current billion euros, with a discount rate of 2 percent. All these estimations are not directly comparable, due to differences in methods and in scope, especially for the oldest ones. But all point to a very large value of these commitments.

To validate such evaluations and their sensitivity to the discount factor, it is useful to refer to some steady state analytical properties of this ADL indicator whose derivation is provided in the technical Appendix B. Of course, the French pension system is currently not in full steady state, even though we have shown that it is no longer very far away from financial stability in the long run. We refer here to steady state properties not to provide a precise validation of the numerical values of Tables 2 or 3, but to show why there is no surprise in getting orders of magnitude representing more than 3 years of GDP.

First, in steady state, that is, with a stable age structure of the population, wages increasing at a constant rate, pension rules fully stabilized, and starting with a discount rate just equal to the growth rate of the economy, our first formula shows that the ADL/GDP ratio is equal to the pensions/GDP ratio, multiplied by the difference between the average age of the pensioner and the average age of the worker/contributor:

$$\frac{ADL}{GDP} = \frac{Pensions}{GDP} \cdot (A_p - A_w).$$

This formula is relatively well-known and has been applied in other contexts (e.g., Settergren and Mikula, 2005).[5] It can be easily understood if we consider ADL as the amount of reserves that should be held at each period by an equivalent funded system. In such a system, the total amount of these reserves would correspond to amounts collected each year, multiplied by their average period of presence in the fund, that is, the difference between the average age at which the worker pays contributions to the fund, and the average age at which he is paid back by the fund under the form of annuities.

This supports the evaluation provided here. Excluding survivors' pensions and means tested benefits, the size of the French system is about 12 percent of GDP over the period of interest, after inclusion of the impact of the last reform. Assume that the gap A_p-A_w is approximately equal to 30 years (i.e., 70 years – 40 years). In case of a discount rate equal to the expected growth rate, this means an ADL indicator representing 3.6 years of GDP. This is consistent with our simulations. This confirms, if necessary, that high values are not, in themselves, sufficient to characterize a situation of disequilibrium for this PAYG scheme. Such high orders of magnitude are not specific of a situation of unsustainability: they also show up in situations of perfect sustainability where inflows of contributions permanently match outflows of benefits.

Analytical computations provided in the Appendix also give a theoretical order of magnitude of how much the indicator is affected by the choice of discount ratio. The formula now involves both the averages and the variances of ages at paying contributions and receiving benefits:

$$\frac{\partial \ln(ADL)}{\partial r} = -\frac{1}{2}\left(\frac{V_p + V_w}{A_p - A_w} + (A_p - A_w)\right).$$

This formula leads to a semi-elasticity of liabilities with respect to r of about −18, that is, a 1 percentage point increase of r leads to an 18 percent decline of ADL. This, again, is roughly in line with differences observed between the successive columns of Tables 2 and 3.

[5]For a much earlier derivation of a similar formula, see Bourgeois-Pichat (1978) and the related paper by Bourgeois-Pichat and Chapron (1979).

4. What Do ADL Tell Us Concerning the Global Efficiency of Past Reforms?

This strong dependency vis-à-vis the discount rate r is the first point that complicates the interpretation of ADL, since there is no undisputable clear criterion for guiding the choice of r. One possibility is to discuss this choice from the point of view of individuals, which will be adopted in the last section of this paper. Here, the reference to market interest rates has some meaning. A high interest rate indeed means a lower relative value for pension wealth compared to the flows of income that can be generated by explicit wealth. In that case, there are both theoretical and empirical arguments for choosing a long run interest rate that is higher than the expected economic growth rate.[6] Yet another consideration can come into play, since participants to PAYG schemes may consider them as either less risky or more risky than other forms of wealth, depending upon their confidence in the stability of the pension system. Adopting this point of view is therefore inconclusive.

The difficulty to conclude is greater if we view ADL the other way round, as indicators of the pension burden for the collectivity. Here, the fact that ADL depend negatively upon r simply stems from their interpretation as the reserves that would be required by a fully funded equivalent system: "if" we were suddenly shifting to a purely funded system, the required capital stock would effectively be lower with a higher r since we would benefit from higher resources for each unit of capital stored for paying future pensions. But, albeit formally correct, this assertion is of little interest when the question is to appreciate the financial standing of a system that is expected to remain a PAYG system. A last solution is to view the choice of r as a purely normative choice, reflecting the relative weights we want to give to people already retired or close to retirement and young people that have just started to contribute. But this makes the choice of the parameter no less arbitrary.

From now on, we shall leave this inconclusive debate aside and restrict ourselves to a conventional choice for r, the value $r = 3$ percent that was used as the median hypothesis for Table 2 and that is also preconized by Eurostat/ECB (2011). We now turn to the question of how accurately the indicator restitutes what we already know concerning the incidence of past French reforms.

Figure 4 shows evolutions over time of ADL, both in absolute terms and in multiples of GDP under the same retrospective and prospective scenarios used for Figure 1: the "no-reform" scenario, including a continuation of the wage-indexation rule that had prevailed until the mid 1980s; the "price-indexation" scenario applying price indexation without any of the other features of subsequent reforms; then scenarios progressively incorporating the consequences of the 1993, 2003, 2010, and 2013 reforms.

What are the main messages from these different graphs? One first point concerning Figures 4a and b is the very smooth evolution of the indicator, despite

[6]We recall that the identity between r and the economic growth rate g holds only in golden rule economies maximizing the long run level of consumption. It is generally admitted that real economies save below the rate required by this golden rule, hence a lower capital intensity resulting in a better remuneration for capital. For substantial developments around this idea, see Piketty (2014).

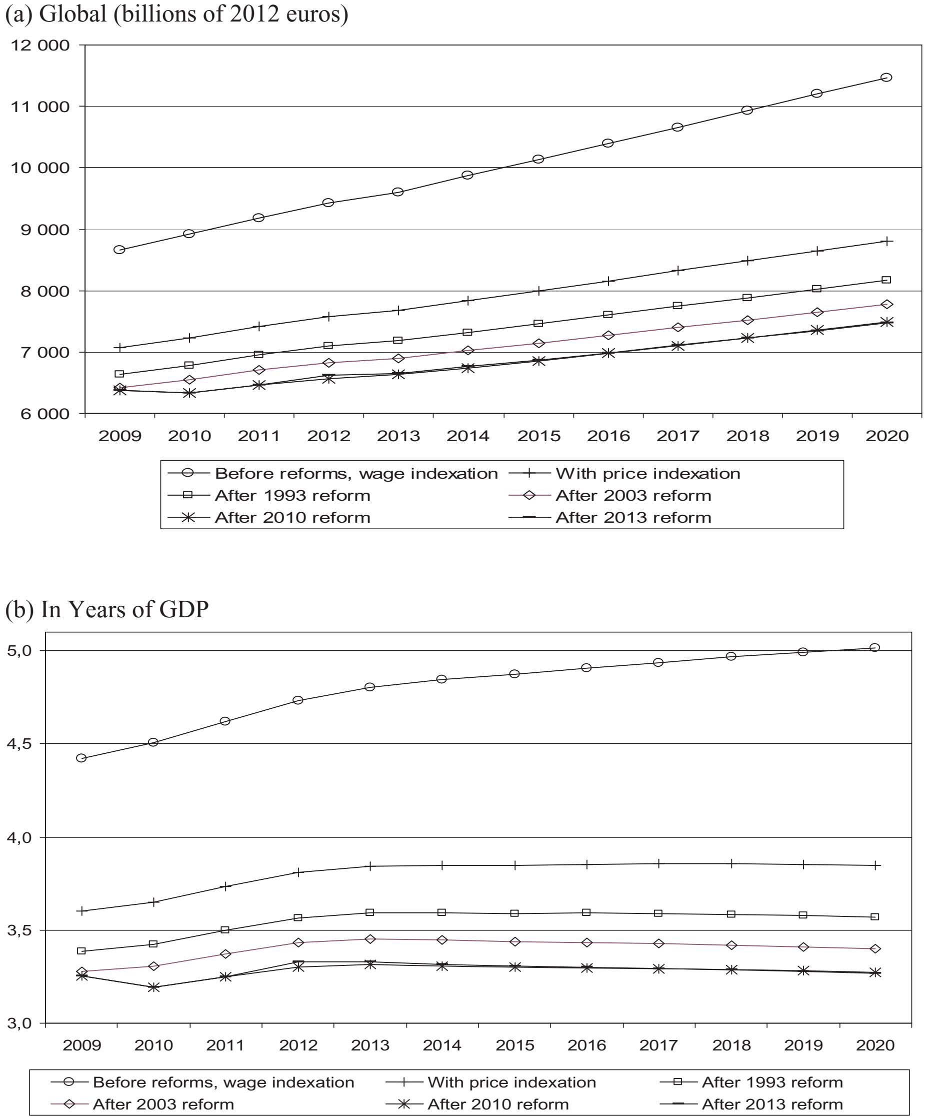


Figure 4. Global ADL According to Reform Scenarios

Notes: See Notes for Figure 1.
Source: Destinie 2 model, authors' computation.

the fact that it is computed on a sample. This can be explained by the fact that it is a very broad aggregate, but also by the way it is simulated. If ADL had been computed at successive periods based on independent samples, year-to-year fluctuations would have probably been much larger. But the principle of dynamic microsimulation is to follow the same individuals from birth to death. Sources of variation between two successive periods will therefore result only from entries and exits from this panel of participants to the pension system, and from changes in individual entitlements for people present in the panel at the two successive periods. Entries and exits are unlikely to generate strong stochastic fluctuations of global ADL, because they concern age groups whose contributions to the global ADL are small: exits only occur in case of death, and predominantly affect people whose individual ADL have already declined significantly since the time they retired. Entries of new contributors, by construction, concern people whose immediate contribution to the global stock of ADL is marginal. The main source of variation for global ADL will be, therefore, year-to-year changes in entitlements of people present at both periods. For people in the accumulation phase, it will be more or less proportional to the global wage bill over the current period, which is itself a relatively stable output of the microsimulation program, especially when wages and global employment are aligned every year on macro projections or assumptions, as is the case here. For people in the decumulation phase, it will correspond to global payments of pensions, which, despite being a bit less stable as a fraction of GDP, still have relatively smooth profiles, even on the sample of limited size that is used throughout this paper.

A second expected property of the indicator is that it approximately reflects the quantitative effects of reforms, with the predominance of disindexation, followed by the more minor impacts of other reforms taken separately. One additional advantage is that, in contrast to the progressive evolutions displayed for the pensions/GDP ratio, it immediately incorporates most of the impact of these reforms. This can be checked here for the 2010 reform. Since the base year of the model is 2009, our simulations illustrate what would have been the message sent by ADL if they had been already used as a follow-up indicator at this period, with a one-shot drop representing approximately 10 percent of current GDP (from 3.3 years of GDP before the reform to 3.2 years after the reform).[7]

However, this reactivity does not mean that the indicator provides self-sufficient information about how far reforms restore sustainability. In total, as assessed in 2013, successive reforms have reduced 2013 liabilities from 9,607 billion euros to 6,653 billion euros, hence a 30 percent decline. A naïve reading of this result would be that reforms have progressed less than one third of the road toward sustainability. Yet such a reading would make sense only if the only road to sustainability was the suppression of the PAYG scheme and its replacement by a funded scheme. Discussing at length the relative merits of the two systems is outside the scope of the present paper.[8] One just needs to recall that, on the one hand, the funded system is indeed more efficient at steady state than the PAYG system; if we accept the $r>g$ relationship that has been mentioned above, this efficiency gain corresponds to the elimination of the implicit tax on labor income generated by the $r–g$ differential. But, on the other hand, this potential gain in long run efficiency has to be compounded with transition costs and consequences in terms of financial risk. It is just the financial stability of the existing PAYG system that is at stake here, not its replacement by a hypothetically more efficient alter-

[7]By contrast such an immediate incidence is not visible for the 2013 reform. This is due to the fact that the profile obtained after including this reform also includes short run consequences of more favorable measures taken in 2012. Graphs presented in Section 5 will allow assessing the pure impact of this 2013 reform.

[8]For some references on the topic, see Breyer (1989), Sinn (2000), and Barr (2002).

native system. In that case, the target is not to shrink the size of the system to zero; it is only to contain this size to the level compatible with the current contribution rate. Knowing how close we have moved to this target is impossible when just looking at changes in ADL, while it can be done by direct inspection of projected chronicles of the Pension/GDP ratio.

Another limit of ADL appears when we consider the characteristic of French pension reforms that we have underlined above, the fact that their efficiency remains dependent upon the future rate of economic growth. The ADL/GDP ratio sends signals of financial deterioration only in response to *current* changes in GDP growth, through a denominator effect that is fully shared by the pensions/GDP ratio. This explains in particular the rapid increases observed in Figures 1 and 3b for both indicators over the 2009–13 period. But, while Figure 2 shows that the pensions/GDP ratio diverges significantly in the long run according to the rate of productivity growth, no such property exists for the ADL/GDP ratio, as shown in Table 3. For a given value of r, current liabilities in the ADL sense of the term only show a small link with future growth, and this link goes in the wrong direction: this results from the fact that, with the PBO methodology, future growth affects positively future wages and hence pensions, even if the indicator then proratizes these future pensions according to current relative position within people's working lives. The only way for ADL to show how low future growth threatens sustainability would be to present discount rate variants as reflecting different underlying growth hypotheses, in line with some of the arguments proposed in the introduction to the current section. Yet this way of using the indicator is far less straightforward for the user than the simple comparison of pensions/GDP ratios trajectories under explicit economic growth scenarios.

Some similar points could be made about the reaction of the indicator to demographic rather than economic changes, even if no such simulations are proposed here. Durable drops or increases in fertility strongly impact the sustainability of the PAYG system, yet they are fully neutral for current ADL, making them completely uninformative about consequences of these shocks. The same holds true for changes in migration flows. The situation is a bit less problematic concerning mortality changes. Variants affecting long run levels in life expectancy will be reflected in ADL with the correct sign: longer retirement periods result in higher liabilities. But the immediate impact on current ADL remains dampened, because the indicator gives a lower weight to people for whom such variants have the largest prospective impacts, that is, young workers.

All these limits orient toward a different use of ADL. This indicator is not really informative about the degree to which pension reforms improve the sustainability of the pension system, because ADL remain high by nature even in a system that is perfectly sustainable. But its micro components consisting in ADL for various categories of individuals provide a simple way to evaluate how reforms affect these various categories of individuals. The next section intends to illustrate this.

5. How Do Reforms Affect ADL Across Socio-Demographic Groups?

The −30 percent change in 2013 global ADL resulting from successive reforms is a weighted average of the incidence of these reforms for various socio-demographic groups. How has this global change been shared among those groups? The calculation is straightforward given that ADL have been computed, under the different scenarios, at the individual level. It would even be possible to compute fully individualized changes in entitlements since, as explained above, the conception of the model implies that the various reform scenarios are applied in all cases to exactly the same individuals, with exactly the same characteristics from one scenario to the next, except for changes imputable to the reforms themselves. Here, we will not go down to this microeconomic level, but consider average changes for groups of individuals, classified by age/cohort, gender, and level of education. The choice of breaking down results by age is self-evident: reforms generally come into force progressively, and are expected to have a stronger relative impact on younger cohorts. The gender issue is always a matter of particular attention: pension levels remain highly uneven between men and women and we must check whether reforms go or do not go in the direction of reducing this inequality. Education level or more precisely the age at exit from the schooling system, is used here because it is the main variable available in Destinie for describing social stratification. This indicator of social stratification affects labor market trajectories and hence retirement ages or pension levels in several ways: as determinants of age at entry into the labor force, of unemployment risks, and of both the level and slope of wage profiles, determined by standard Mincerian wage equations. Three groups will be considered: people having left school at 18 or before, people having left between 19 and 21, and people having left after 21.

Results are reported in Figures 5 and 6, showing successive relative changes brought by each reform compared to ADL resulting from the previous reform, or from the "no reform" scenario in the case of the initial move to price indexation. Using relative rather than absolute variations neutralizes the impact of discounting or of the correction factor that is applied to young workers to account for their limited past record of contributions. These variations give us quasi-pure measures of entitlements of each age group when they will actually retire, depending on what will be their pension level and the expected length of their retirement period.

These graphs show interesting contrasts between the impact of various reforms. Let's start with results by age and gender provided in Figure 5. The hierarchy of effects of successive reforms is roughly the one that was observed at the macro level, but additional differences emerge. One characteristic of the move to price indexation is not only its very large magnitude, but also the fact that it affects all age groups, not only people who were still working at the time the change took place, that is, aged up to about 85 years in 2013. People already retired when the change takes place "lose" the benefit of future revalorizations according to wage. The indicator reflects this, at least in part: it does not reflect what these people have lost between the reform and today, but the resulting loss in pension flows between today and these people's death.

Subsequent reforms did not have any more impact on people already retired at the time they were enacted, for instance people currently aged 70 or more in the case of the 2003 reform. Among these reforms, the most important element of differentiation by age is the contrast between the 2010 reform on the one side, and all the other reforms on the other. The latter group of reforms essentially tried to change retirement ages, or equivalently pensions levels offered at given ages by

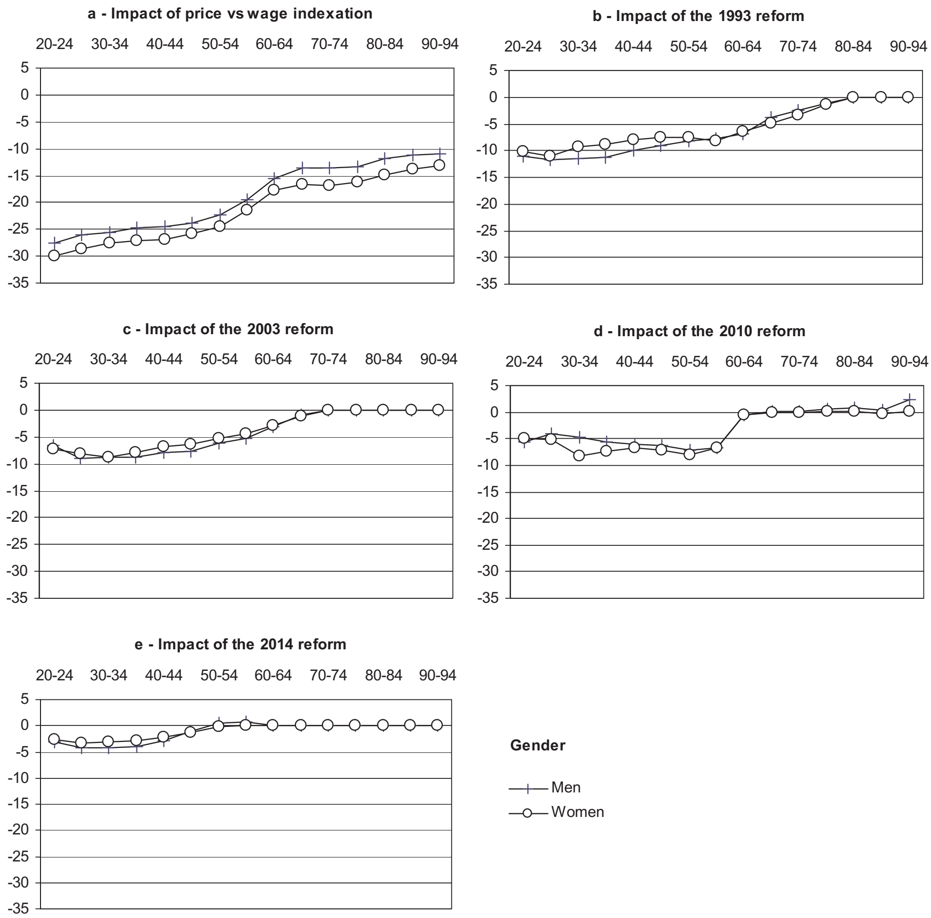


Figure 5. Impact of Successive Reforms on Individual ADL in 2013, by Age and Gender (in percent)

Notes: Relative variations in percent, measuring the pure impact of each reform, excluding the incidence of other measures adopted between successive reforms.

Source: Destinie 2 model, authors' computations.

changes in the number of years of contribution required for the full rate. Not only were these changes programmed according to very progressive time schedules, but the impact is also delayed by the fact that they less strongly affect older cohorts that, until the mid 1970s, were still entering the labor market at relatively young ages, allowing an easier accumulation of years of contribution over their active lives. However, the 2010 reform, by imposing a rapid increase of the minimum age at retirement, has relatively similar impacts for people close to retirement and those just starting their working lives. The impact is slightly smaller for the latter, such an increase in the minimum retirement age having a lower impact on people already forced to retire after 60 due to earlier reforms.

Last, as far as gender differentials are concerned, most of the reforms appear to be neutral or sometimes slightly favorable to women with the only exception of

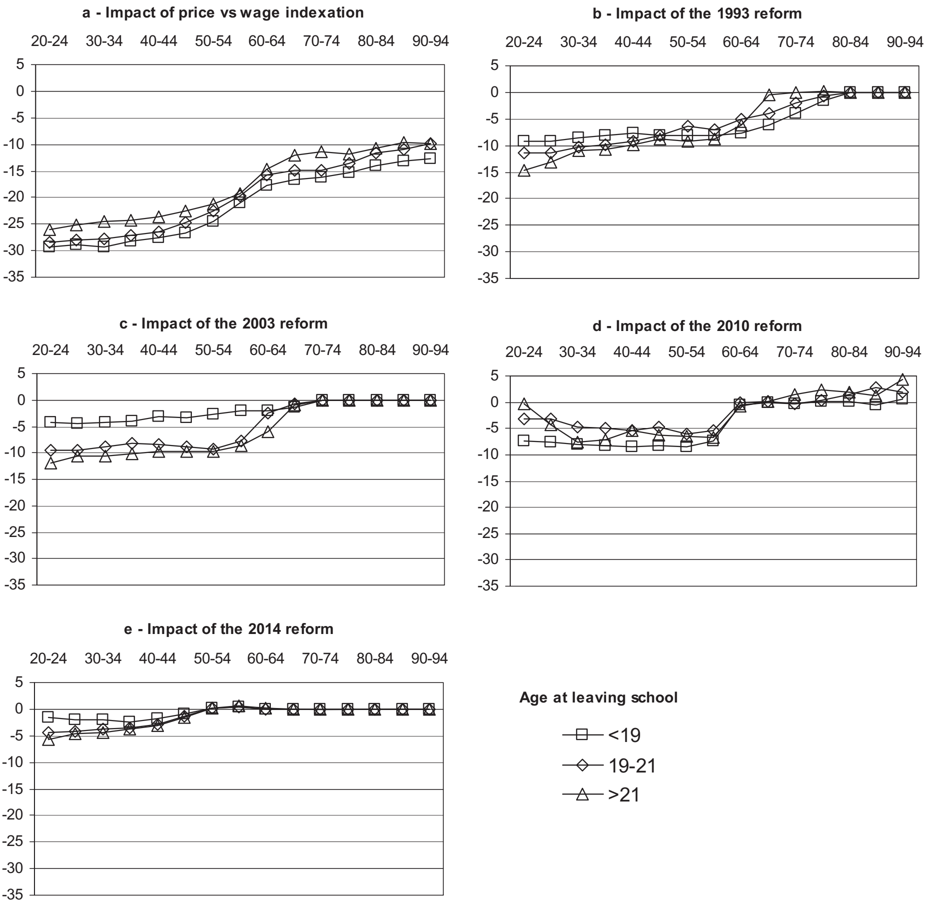


Figure 6. Impact of Successive Reforms on Individual ADL in 2013, by Age and Age at Leaving School (in percent)

Notes: See Notes for Figure 5.
Source: Destinie 2 model, authors' computations.

the 2010 reform for women in their 30s, and more significantly with the impact of indexation on prices, more penalizing for women due to their higher life expectancies: the cumulated incidence of an indexation on prices for pensions that are served all over the retirement period is larger the longer this retirement period is.

One could have expected to find a similar phenomenon concerning the impact of price indexation according to age at leaving school, the penalized group now being the group of more skilled people who live longer. This does not appear in Figure 6a due to one limit of the present simulation that has been mentioned above. Ages at death that are randomly simulated by Destinie account for differential mortality, but it is not those simulated ages at death that are used here—they would have been truncated to year 2060. The computation of liabilities uses instead unadjusted general life expectancies at time of retirement. Differential effects of price indexation according to skill are therefore dominated by other factors, including the younger ages at retirement for people with lower educational attainments. An additional element is the fact that, for private sector workers with higher educational attainment, the pension provided by the General Regime represents a lower share of their total pension income, since it applies only to the share of their past wages that was below the social security ceiling.

Otherwise, for other reforms, we have the same kind of opposition between the 2010 reform on the one side, and all the other reforms on the other side. These latter reforms have been more protective for less skilled people, because these people start working earlier, and are therefore able to reach earlier the length-of-career condition for the full rate.[9] However, the 2010 reform that increased the minimum age did not have this protective feature vis-à-vis less skilled people, and therefore affected them significantly more. If more skilled workers are less affected by this reform, it is essentially because previous reforms were already expected to increase their retirement ages beyond the new minimum age of 62. This is especially the case for the youngest cohorts of people having left school after 21, for whom the impact of the 2010 reform is close to zero.

6. Conclusions

This paper has presented a tentative application of the Destinie 2 microsimulation model to the evaluation of pension liabilities in France. Several lessons can be drawn from this exercise, that are not specific to the French case and may be of general interest to all builders and users of liabilities in the "accrued-to-date" sense of the term.

First, from a technical point of view, it appears that deriving ADL from a microsimulation model is technically easy once such a model is already available for other purposes. It allows the computation of these liabilities under a variety of scenarios, and a consistent estimation of them at the macro and micro levels. The problem of stochastic variability that sometimes complicates the reading of microsimulation results appears, in this specific case, to be relatively limited.

From the point of view of interpreting outputs, the conclusion concerning ADL indicators at the macro level is mixed, at least from the point of view of the follow-up of reforms aiming at restoring sustainability of PAYG pension schemes. These indicators react significantly to reforms, but it is difficult to say whether a given change in ADL is sufficient to restore sustainability. They cannot replace the direct observation of projected pensions/GDP ratios. In the French case, ADL also appear unable to account for one important limit of the reforms that have been enacted up to now, which is the fact that their efficiency depends upon future productivity growth.

It therefore looks more interesting to look at these indicators from the more micro point of view, and Section 5 provided some illustrations of such an application of the ADL methodology. Such an approach is in line with current efforts

[9]This is true even after taking into account their higher exposure to unemployment, as done in the model. The impact of differential exposure to unemployment is mitigated by the fact that periods of registered unemployment are validated as periods of contributions, and therefore do not impact negatively the possibility to retire.

aiming at building more disaggregated household accounts, by socio-demographic groups. However, here also, ADL are only one part of the story. For instance, reductions in entitlements are generally made with the purpose of avoiding increases in contribution efforts. Balancing the two effects implies looking at either life-cycle contributions/benefit balances or rates of return on contributions. Furthermore, a full picture of social consequences of reforms also involves looking at more standard indicators, such as replacement rates, retirees' relative incomes, or exposures to poverty risks.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Appendix A: The French pension system and its reforms
Appendix B: Analytical derivation of ADL indicators under steady-state conditions