

The Destinie 2 microsimulation model : overview and illustrative results¹

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ABSTRACT: The Destinie model has been developed and maintained at the French national statistical institute (INSEE) since the mid-1990s. A new version now becomes operational. The main goals of this new version have been the improvement of consistency with official demographic projections, the incorporation of more complex labour market trajectories, and increasing portability and facility to use. The first half of this paper presents the main options that have been retained for this new model. This new model makes a complete separation between two components. One is a generator of demographic and employment biographies, whose results are then stored in two intermediate output files. The other one is a library of subroutines allowing an easy programming of pension projections based on output files produced by this biography generator. The second half of the paper presents some first examples of results obtained with this new model. They consist in simulations of the prospective impact of reforms introduced in France since 1993, and simulations of consequences of large macroeconomic shocks on these long run paths.

1. INTRODUCTION

The Destinie model started being built at the French national statistical institute (INSEE) during the 1990s. It is a dynamic microsimulation model whose main purpose is the long run projection of pension entitlements at the household level. It has been used for the follow-up of pensions reforms that took place in France in 1993 and 2003 (Bardaji et al., 2002), in conjunction with more aggregated models or projections realized by pensions schemes themselves (Conseil d'Orientation des Retraites, 2006). It has been also used for some other exercises, for instance the assessment of the intracohort redistributive properties of pensions (Walraët and Vincent, 2002), or the long run projection of old age disability and of its cost (Duée and Rebillard, 2004), or the consequences of ageing or pension reforms for poverty trends among retirees (see Crenner, in progress). On the whole, the model has been able to partially adapt to the evolution of questionings about the future of pensions or general consequences of ageing. But some problems have also emerged, that have called for a complete rewriting and a partial reorientation of the model.

First of all, Destinie 1 had large entry costs. Even the production of standard variants remained a heavy task, especially for a small team of modelers with strong turnover (typically two to three persons with a complete renewal every third year). The task was still heavier for simulations requiring substantial additions to the basic model, as it is frequently the case: such difficulties have been encountered, for instance, for specific simulations of widows' benefits, or the simulation of changes in incentives to postpone retirement beyond the normal age.

Some other limits have appeared in the quality of projections. Some divergence exist between results provided by the model and more official demographic projections or labour force projections

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performed with the traditional method of components. Adjustment to macro projections was not completely inexistent in Destinie 1, but it remained indirect and relatively loose. This led to inconsistencies, especially concerning trends in labor force participation. Such discrepancies not only matter for the projection of numbers of contributors to the pension system, but could also bias the simulation of retirement decisions: for instance, a systematic underestimation of LFP rates for women will result in an underestimation of the number of years of contributions reached at age 60, a parameter that has a very important role in the French pension system.

Another point of concern for the relevance of projections is the modeling of retirement behavior. The model initially assumed a very simple behavior, consisting in a systematic retirement at the “normal age”, i.e. with a “full rate” pension, which depends both on age and number of years of contributions. After that, the model has been enriched with a behavioral module describing retirement decisions as a prospective income/leisure tradeoff in the spirit of Stock and Wise (Stock and Wise, 1997; Mahieu and Blanchet, 2000). This module has been used to estimate the impact of some aspects of the 2003 reform that intended to introduce more flexibility of individual decisions both before and after the normal retirement age. But the calibration of this model remains very fragile and the model has been frequently criticized for its exclusive emphasis on this specific behavioral assumption. An answer to such a criticism can be to offer a larger menu of behavioral assumptions in the model allowing the multiplication of sensitivity tests.

A third point of concern about the quality of the model has been its short-term properties. As it is the case for many similar tools, Destinie has been essentially developed to shed light on long-term consequences of population ageing and less attention has been paid to the relevance of short-term projections. In a sense one could argue that this reflects a normal specialization of simulation tools: some models can be good for the short-run and bad for long-run projections, and some other ones have the opposite properties. But the logic of such a specialization of models is not always obvious for policymakers, and this is not without reasons: as far as possible, we must therefore try to combine accuracy for the short and the long run.

On top of this, one additional element pushed toward a rewriting and a reorientation of the model. One of the successes of Destinie 1 is that it has stimulated the apparition of similar projects in other administrations. One has been developed by the *Caisse Nationale d'Assurance Vieillesse* for the population of its affiliates (See Berteau-Rapin, Di Porto and Albert, this conference). A parallel project exists at the French ministry of Health and Social Affairs, based on a new data source matching administrative information from all existing French pension schemes for a sample of the French labor force. On the whole, the general trend is certainly toward an appropriation of microsimulation techniques by administrative teams that have the double comparative advantage of having access to more detailed datasources, and of being closer to decision makers. The consequence is that Destinie may become less solicited on pension issues *stricto sensu*. Our answer to this new context is to enlarge the range of topics potentially covered by the model by proposing a new tool allowing a very easy incorporation of additional modules.

The new version of the model that is now becoming operational takes into account this new context and tries to solve some of the problems encountered with the previous Destinie 1 model, while keeping as much as possible of the positive points that made the success of this first version. A general view of these answers is given on table 1. We shall not deal extensively in this document with all the details of these changes, but concentrate on a few points.

As far as the general structure of the model is concerned the main novelty is a complete separation of the model in two subcomponents. The first one is a simulator of individual demographic and labor market trajectories whose results are stored in intermediate files of micro-data. The second component is not a model in the usual sense of the term. It rather consists in libraries of subprograms allowing the easy development of projections based on the micro-files produced during the first step. While the first stage remains relatively heavy, programs developed for the second stage can be very small ones with very rapid execution times. At this stage, this second component essentially consists in a library of

Table 1: The main changes from Destinie 1 to Destinie 2 and their motivations

Main strengths/weaknesses of the initial model	Improvements or corrections brought by Destinie 2
<i>Strength:</i> closed population approach, allowing a simple simulation of family and kinship ties.	Unchanged
<i>Strength:</i> separate simulation of the most important pension schemes (CNAV, ARRCO, AGIRC, Civil Servants)	Maintained, with the additional possibility of simulating heterogeneous careers (mobility between sectors and part/full-time.)
<i>Strength/weakness:</i> a behavioral module for simulating retirement behavior (Stock and Wise model). Better than nothing, but many doubts have been expressed about the empirical relevance of this module.	The existing module has been maintained, but is only one among several possibilities for simulating retirement behavior, with improved facilities for changing preference parameters.
<i>Weaknesses:</i> heaviness, execution time, entry costs, lack of portability/versatility.	The model has been split in two subcomponents: 1. Demographic and labor market events are simulated first, with results stored in intermediate files. 2. Pension projections (or other applications) are made with small <i>ad hoc</i> programs, based on relatively synthetic and easy to use libraries that use these files as inputs.
<i>Weakness:</i> Insufficient consistency with macro projections	Automatic adjustments of transitions probabilities to satisfy some predefined macro-targets
<i>Weakness:</i> short run behavior	Initial conditions are partially imputed to avoid inconsistencies that can exist between initial observations and projected values. This also facilitates the simulation of counterfactual initial conditions (e.g. “what would have been the starting point in 2003 if no reform had taken place in 1993?”)

programs allowing the easy simulation of alternative pensions scenarios, but it will be possible, in the future, to develop similar tools to deal with other socio-economic topics.

The next section will provide the reader with a general, non-technical summary of Destinie 2. The third section will then present examples of results based on this new model.

2. MAIN FEATURES OF THE DESTINIE 2 MODEL

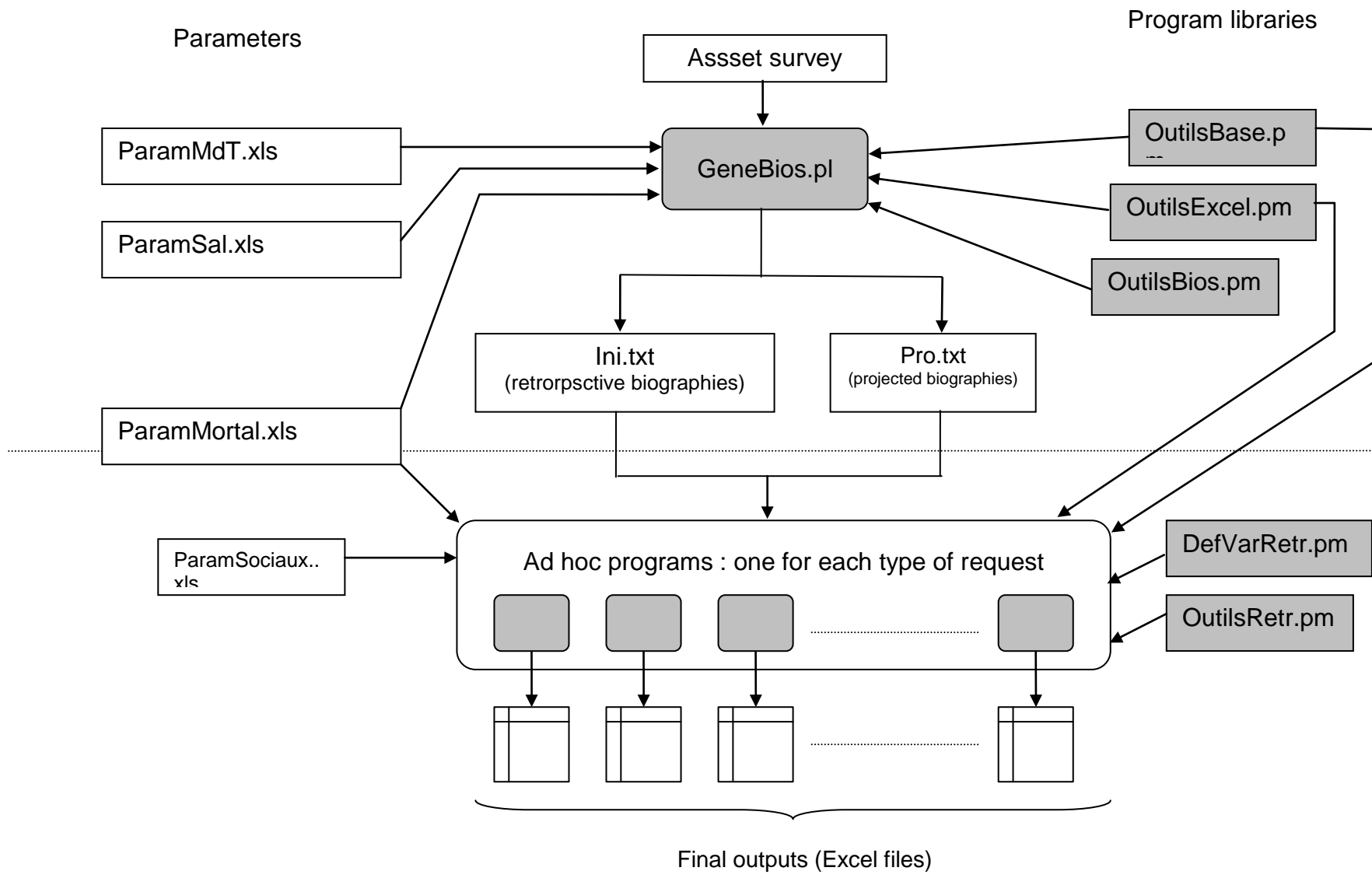
2.1. General organization

The two-tier structure of the new Destinie 2 model is presented on Figure 1. As it was the case for Destinie 1, the main input to the model are data from the Financial Asset survey regularly conducted by INSEE, the latest available version being the one collected in 2003, so that projections use that year as a point of departure.

The biography generator (program GeneBios) starts from this dataset. It does two things: it imputes all the additional historical data that are required for pension projections but that are not available in the survey, and it produces long run projections of demographic and labor market trajectories for all members of this initial dataset. The results are stored in two individual files:

- An ‘Ini’ file that stores demographic information on all individuals present at the beginning of the projection, including links to other individuals of the database that are related to them. This file also stores all the retrospective information on individual’s labor market trajectories,

Figure 1: The Destinie 2 model: general structure



i.e. the yearly succession of labor market statuses since leaving school (inactive, unemployed, employed with a subdivision between different categories of employment) and associated wage levels for each period spent in employment.

- One 'Pro' file storing subsequent changes for all years of projections, including the entry of new individuals in the database, either by birth or in-migration.

At this stage, no information is given neither on pensions nor on retirement status. Notional labor market biographies are artificially continued by GeneBios beyond normal retirement ages in order to leave a complete control of retirement behavior for the second step. This second step ('pension simulator') re-reads the results from this first stage and adds the simulation of retirement behaviour and pension benefits.

A major feature of this second tier of Destinie 2 is that, contrarily to the choice that had been made for Destinie 1, it does not consist in an all-purpose and ready-made model. Our choice has rather been to develop a set of simulation tools that allows building small *ad hoc* simulation programs adjusted to users' requests. This is what is represented in a very stylized fashion in the bottom half of figure 1. Using files generated by the biography generator and libraries of subprograms provided by Destinie, the user builds as many simulation programs as he wishes to, the rule being to have one different program for each application.

When building these programs, a lot of flexibility is offered for changing pension parameters, types of outputs... In practice, this does not imply a heavy programming work, because each program developed for a new application is generally not built from scratch but by reworking a program previously built for another application.

The advantages of this two tier and modular organization are numerous:

- In the development phase, it allowed autonomous work between the two components of the project
- The generation of demographic and labour market histories is fixed once for all, with an improved alignment on 'official' projections. A pension simulation does not require the costly resimulation of all other categories of events. Programs that produce pension results are therefore very compact and their execution is relatively rapid.
- It facilitates detailed analysis of the impact of reforms at the individual level: two runs with different pension rules apply exactly to the same individuals and we can directly compare the individual outcomes after and before the reform.
- The « one simulation/one program » principle leads to a better traceability: all the assumptions behind a given result can be retrieved by returning to the source code that has simulated this result.
- The library of pension modules can be (and has been) used for other applications. Eventually, it can be also be used for microsimulations based on biographies coming from other sources than Destinie's biography generator.

The two next subsections are devoted the demographic and labor-market components of the GeneBios program. Subsection 1.4 then presents the typical contents of a pension projection.

2.2 The demographic component: a relatively complete simulation of kinship ties

Data from the 2003 Assets Survey collected by INSEE used by Destinie are reweighed to account for the demographic structure of the whole French population as known from the 2004 French Census. The initial sample of DESTINIE contains about 20 000 households and 65 000 individuals, but, for development purposes or the production of first results, a lighter sample of only 6500 individuals is also available (it is this smaller sample that has been used for producing results displayed in section 3).

One element that we had been chosen to introduce in DESTINIE 1 and that is fully kept in this new version is a relatively complete simulation of kinship ties, with the idea that simulating such an information can be useful for many questions related to aging, e.g. projections of the level of informal support by relatives in case of old age invalidity (Duée and Rebillard, 2004), or the intergenerational transmission of assets.

How do we generate such a structure? The 2003 Asset survey provides us with relatively rich demographic data. As usual, people who live in surveyed households are known. We also have some demographic information's on children of surveyed persons even if they do not live anymore with their parents. Symmetrically, we know whether people's parents are still alive or not. Given this information, a pseudo-global kinship structure is created in the initial population by linking each person of the sample to some other people in the sample who, when necessary, will play the role of this person's children or surviving parents. These artificial links are created by finding in the sample pseudo-kins whose characteristics are as close as possible to those of real-world kins in terms of age, education level, and labor market status.

Once these pseudo-links have been initialized, their evolution is easy to simulate. We just have to constitute new unions between members of the sample, this sample being renewed only through births issued from these unions (plus an additional flow of in-migrants). Kinship ties for these newborns are automatically generated at birth. The resulting database is only made of individuals, but with some individual variables that identify household and kinship ties. It enables us to reconstitute family circles concentrically from the couple outwards to include all siblings living in other households.

Apart from this specific treatment of kinship ties, the other demographic characteristics of Destinie are relatively standard. The model simulates demographic changes using a mix of deterministic rules, behavioral hypotheses and random components. The demographic events are union, breaking-up, birth of a child, death and migration. The probabilities to have a child, to start or terminate a partnership or to die derive from logit models. In most cases, the probabilities depend, beside other variables, on the school living age, which is the synthetic variable that we use to describe qualification and social status: this variable codetermines labor market and demographic behavior (box 1). Current demographic behaviors are estimated in a quite simple way, and depend on the covariates that have the major influence on each behavior. Probabilities to undergo a demographic event have been estimated by duration spent since the previous event, which is a significant source of demographic heterogeneity. We basically rely on updates of these estimates performed in 2005 for the Destinie 1 (Duée, 2005).

For all these equations, parameters are considered to be constant over time, but, in order to fit every year the long-term demographic projections made by the INSEE, the probabilities predicted by the equations are adjusted to annual macro targets stored in Excel files. These targets are the number of births and deaths by gender, the balance of migrations, etc. In order to reach the targets, the intercepts of the logit models are changed keeping constant the relative chances for an event to occur or not (i.e. the odd ratio) for the different categories of population considered in the model. In practice, those "event alignments" are realized automatically in the model: the user of Destinie only has to know the

Box 1. The school leaving age: a major exogenous covariate

The age at leaving school represents both social changes between generations and social position differences within a generation. This variable is of primary importance for the model as it sums up the social class and the qualification. In the model, the mean age at leaving school is increasing, following past observed trends, and we make the assumption, its mean values remain roughly constant over time after 2010. For people who have not achieved their studies in 2003, the first year of the simulation, for children not yet born and for the in-migrants, the gap between the individual's age at leaving school and the mean age at leaving school of his/her cohort is modeled as a function of the gap observed for his/her parents, allowing for some type of social replication.

probabilities of the event at the individual levels and the target number of events. All the demographic changes by individuals are then stored each year in the “Pro” file (see again Fig.1).

2.3. Modelling the labour market

The Asset Survey also provides information about careers until 2003. Indeed, the description of past careers is much more detailed in this new survey than in the previous 1997 Asset Survey that was used by Destinie 1. This should improve the quality of long-term projections of pensions, which remains one of the basic aims of the model. For each year beyond the school-leaving age, we know what has been the status of the individual on the labor market: wage earner in the private or public sector, self-employed, unemployed, retired, inactive. This information is stored in the “Ini” file which includes all current information and past trajectories of individuals alive in 2003. The only modification with respect to the Asset Survey files is that we do not use the information on retirement status: as explained with more details further, this status is imputed later in the model, in order to have a better homogeneity between past and prospective retirement behavior. For individuals of retirement ages, the ‘Ini’ file therefore contains notional projections of continued activity until the current age. The other information from the ‘Ini’ file that does not directly derive from the survey is the sequence of past wages, which are imputed according to wage equations whose main explanatory variables are gender, age at leaving school and tenure.

After 2003, the projection requires the modelization of both activity statuses and wages paths. To model transitions on the labor market, five main statuses are distinguished (the status reached at the age of 60 years being kept constant at this stage until death):

- (1) Wage earner of the private sector
- (2) Wage earner of the public sector
- (3) Self-employed
- (4) Unemployed
- (5) Non participant, inactive

Transitions on the labor market are treated as a first-order Markovian process. Thanks to Labor Force Surveys conducted by Insee between 1992 and 2002, we can estimate transitions probabilities between these statuses depending on individual’s characteristics. Of course, we restrict ourselves to characteristics that are present in the Destinie model. Transitions depend on age at leaving school, on current age and on the interaction between both. They are estimated separately for men and women, for less than 54 years old and for people between 55 and 59 because of labor market specificities at these ages. Transitions beyond the age of 60 are not modeled however: once again, their simulation is left to the pension module that is presented later. Some interaction exists with demographic events, for women. The probability to become a participant on the labor market or to withdraw from the labor market depends on the number and the age of child(ren) and on marital status, which are imputed before the simulation of transitions on the labor market.

Two points are particularly important in this new version of Destinie: the people can move between the public and the private sectors during their careers and the probabilities of the transitions between the different statuses are adjusted in order to:

- be consistent with official labor force forecasts made by INSEE, the annual LFP rates by gender and ages (by 5 years) until 2040
- be consistent with the assumptions made on the macroeconomic environment (the unemployment rates or other targets such as the proportion of public jobs in the economy).

Some of these macro-projections are more important or predominant than other, so this hierarchy imposes the sequence of transitions. More precisely, we first simulate participation to the labor force, then the fact of being employed in the public sector, then the probability of being or remaining unemployed, and at last the probability of being a wage-earner in this private sector (rather than self-employed).

The way to adjust these successive transitions to macroeconomic targets is the following. For each status, transitions equations give *ex ante* figures for the number of people who enter in the status, who remain in this status or who leave it. We have to determine which flows we will constrain in order to reach the targets. Concerning labor force participation rates, we consider that the constraint is on entry rates. In other words, we simulate exits according to the pure *ex ante* probabilities, and we adjust probabilities of entry upwards or downwards depending on the target concerning total LFP.

Once we know who is active, the second step consists determining the people working in the public sector. Several hypotheses can be made, for example to keep constant the proportion among the participants. We choose to keep free the probability to quit the public sector (spontaneous decisions) and we constrain the probability to be hired in the public sector with respect to the target.

In a third step, among active people not employed in the public sector, we have to simulate the flows of people who will be unemployed and of people who, on the contrary, will leave unemployment to take a job in the private sector. We keep first the probabilities free and compare the resulting “spontaneous» unemployment rate with the unemployment target. If the “spontaneous rate” is higher than the target, we constrain the probabilities to quit the status of “unemployed” to be higher (it will be often the case in practice, because standard scenarios for pension projections generally make the voluntary assumption of strong declines in employment rates over the years to come). If the opposite is true, we adjust upwards the probability to become unemployed.

At the end, we have just to compute the status of “self-employed” or “wage earner of the private sector”, in order to respect for each individual the relative odds to belong to one category or the other.

Conditional on labor market status annual wages are finally imputed following the same wage equations as the one used for the retrospective reconstitution of careers: sum of a deterministic component (depending on age at leaving school, tenure -quadratic form- and the product of both) and a stochastic one (including an individual fixed effect and an autocorrelated residual). To take productivity gains into account, we add to these equations a time trend (the current assumption is the one made by the COR in its last report, i.e. 1.8% per year).

At this stage, all these components of the new model are not fully stabilized. We will soon re-estimate the wage equation to take account for the professional changes during the career, mobility between sectors but also between part-time and full-time. At this stage of the development of this new version of Destinie, we also kept the old version of wage equation that was already used for the Destinie 1 model. The deterministic component is simulated with wage equations estimated for each sex and each sector (private or public) according to the standard theory of human capital. The specification implies that the return of one year of schooling is between 4 and 8% (depending on sub-populations) whereas the return on tenure is decreasing from 3% at the beginning of the career to 1%-2% at the end.

To simulate the stochastic components, we draw random variables for every individual: every year for the transitory component (e_{it}), in the first year of employment for the fixed one (u_i). For those in employment in 2003, we used richer information available in the 2003 Asset survey to impute wages in 2003 with a more sophisticated equation (estimations are based on the 2003 Labor Force Survey which contains individual wages) and thus estimate the stochastic components for 2003 (this new version of the Asset survey does not provide labor income of households at the individual level). We derive the past and future components from these 2003 values, thanks to an autoregressive process.

In order to complete the output file used in the retirement module, we have to impute a level of qualification in the private sector (“*cadre*” vs “*non cadre*”), because of differences in complementary pensions for these two categories of workers. This is done through a single equation depending on sex, age, school leaving age and generation in order to reflect the proportion of high levels of qualification in the economy during several periods.

2.4. Deriving a pension projection

The GeneBios module is not expected to be used in a repetitive way. Once some reference sets of demographic and labour market trajectories have been produced and stabilized with this module, the main activity for the Destinie team consists in producing pensions projections based on these datasets. We shall now give a few more details about how such simulations work.

A typical pension projection is realized through an ad-hoc main module that, in the simplest cases, can be limited to 40-50 lines of code, and can then be extended *ad libitum* depending on the number of variants that one wants to simulate and compare, the complexity of these variants and the number of output variables that will be compared across these variants. A typical simulation involves at least six sub-steps. For one pension scenario, these six sub-steps are the following:

- Read initial and retrospective micro-data from the ‘Ini’ file.
- Impute pension variables for the initial conditions. For each individual beyond the minimum retirement age, this means finding at which age he retired, compute the resulting pension at the time he retired and actualize this pension until the initial year of projection, based on indexation rules.
- Read updates of individual variables from the ‘Pro’ file for each year of projection.
- For each year t , update pensions levels in t for all those that were already retired in year $t-1$, and simulate eventual transitions to retirement for those having reached or passed the minimum retired age but still not retired at time $t-1$.
- Compute tabulations that are desired for each year of projection.
- At the end of the projection, store tabulated results. This is directly done in Excel files.

The choice of imputing initial pensions statuses and pension levels instead of using actual values provided by the Asset Survey deserves some justifications. It has two main advantages:

- One is to avoid discontinuities during the first year of projections. Imputations of current pensions or pensions statuses are made in a way that is consistent with the way the projection works. It avoids the declaration bias that may exist of the survey. Of course, it creates another bias due to the fact that the pension simulation module does not exactly describe the reality of pensions, because it neglects some details of these rules or some information on individual determinants of pension levels that are not available in the database. But such a bias, whatever its importance, will remain constant all over the projection period. This is preferable to a simulation where some initial accidents are generated by the shift from one measure of pension levels to another one, or from the shift from actual retirement behavior to behavior proxied by a model that will never be able to fully reflect actual behavior.
- A second interesting property of this approach is that it automatically allows the simulation of scenarios based on counterfactual initial conditions. For instance, a typical demand is the comparison of a scenario decomposing changes in future pensions between what is due to the 1993 and 2003 pension reforms and what would have happened without reforms. To do this, we need a counterfactual projection of what would have been the evolution of pensions without the 1993 reform, including the fact that having had no reform in 1993 would have led to different initial conditions in 2003. This is easily done in the new model through reimputing initial pensions and past ages at retirement on the basis of pre-1993 legislation.

What are the options available to reimpute or project these pension levels and retirement choices? The general-purpose modules written for the simulation of pension allows simulating historical and prospective pension rules for the basic *Regime Général*, the two complementary schemes ARRCO and AGIRC and civil servants. This module also offers a function modeling the choice of the retirement age. This function has five options for the description of retirement behavior. The first one assumes that individuals retire as soon as they reach the so-called full rate (i.e. what is generally considered as the normal pension), access to the full rate depending both on age and the number of years of

contribution through a rather complex non linear formula. The two next options assume some form of utility maximization with an income-leisure trade-off, either instantaneous (people retire as soon as the value of leisure outweighs the immediate income loss) or prospective (the option value model of Stock and Wise that was used in Destinie 1). The two last ones are based on measures of social-security wealth (SSW), i.e. the actualized expected flows of benefits from retirement age until death, with two suboptions: a myopic one under which people postpone retirement as long as delaying by just one year leads to a higher level of SSW and a forward-looking one analogous to the Stock and Wise model where people delay as long as delaying leaves them with the option of getting a higher SSW level at a later age.

The option based on instantaneous utility maximization requires one preference parameter, which is the preference for leisure. The Stock and Wise option is the one that is the most demanding in terms of parameters: preference for leisure, risk aversion, a discount rate and expected survival probabilities. The two options based on the SSW need both a discount rate and survival probabilities. All these parameters can be individual-specific. The problem is of course to calibrate them. At this stage, this calibration exercise has not been fully completed. One of the requirements of this calibration exercise will be to give current retirement behaviors as close as possible to actual ones. But this, in general, will not be enough to determine them very accurately. In practice, our policy will probably be to provide ranges of results using different behavioral assumptions and/or different sets of parameters for each of these behavioral assumptions, to avoid excessive focalization on one set of results, as it has been too frequently the case with the Destinie 1 model.

It is also possible to apply purely exogenous ages at retirement. In particular, a scenario can re-use ages at retirement saved from a previous one simulated within the same program. This allows producing variants with unchanged retirement behavior

Just to give an idea of how such pensions simulations can be performed, Appendixes 1 and 2 gives the full sources codes for the two sets of simulations that will be presented in the next section. The first one simulates different scenarios of reform each of them with two options for retirement behavior. It generates an Excel file of macro results with one sheet for each variant. The second one simulates consequences of alternative economic paths incorporating more or less long lasting effects of the macroeconomic crisis that is currently under way. This second example shows that the two-tier structure of the new model is not that constraining in terms of exogeneity of labor market trajectories. In principle, simulating alternative paths with different macro-economic contexts should have required a full rerunning of the GeneBios module. But a simpler strategy, at least in a first step, is also to marginally change these trajectories *a posteriori*, within the pension projection program and this is what is done in this example of Appendix 2.

In both cases, the code is relatively compact, requiring no more than one page of instructions, thanks to the fact that

- the user has access to a full set of predetermined Destinie variables without needing to redeclare them. New variables that need declarations are only additional micro variables not generated by GeneBios or not directly managed by the pension subroutines, and macro variables (conventionally declared with uppercase letters) that will be used to store time series of macro-results.
- The user has access to a series of modules that allow a fine-tuning of pension rules according to past or future legislations. This is done without restricting *a priori* the scope of what can be simulated: if the modeler needs to simulate a scenario that corresponds to no existing past or prospective legislation, it can directly access the relevant parameters of pension formulas to change them 'by hand' within his projection program.
- The user also has access to a relatively rich and flexible set of imbedded tabulation procedures and also to procedures allowing direct output to Excel files.

As a general rule, the general spirit of this toolkit has been to make simple scenarios as easy as possible to program, while leaving open full possibilities for the programming of more complex scenarios.

3. SOME ILLUSTRATIONS

To provide some illustrations of results that can be obtained with *Destinie 2*, this section will examine two sets of variants, one devoted to the impact on past reforms, one considering the impact on future pensions of various macroeconomic scenarios suggested by recent economic developments. These preliminary results have been established with the smallest of the two samples currently available from GeneBios (about 6500 people), hence the instability of results that appears, in particular, for flow statistics or statistics pertaining to small subpopulations (such as the unemployment rate). For this reason, and also because the model is still under test, they must be taken with caution, but they are sufficient to evaluate the plausibility and interest of results produced by the model.

3.1. Simulating global consequences of French reforms

The two major reforms that have taken place in France over the last 20 years are those of 1993 and 2003. We shall not provide full details for these two reforms but just recall their main characteristics :

- The 1993 reform essentially focussed on the basic pension delivered by the *regime général* to people having worked in the private sector. It had two main aspects: a gradual increase in the number of years of contributions required to get the maximum pension rate, from 37,5 years to 40 years, and a gradual increase in the number of years used for the computation of the reference wage to which this pension rate is applied. This reference wage was initially equal to the average wage over the 10 best years of one's career and the 1993 scheduled the progressive increase of this bracket to the 25 best years of one's career. A third aspect has been a generalisation of a principle of indexation on prices rather than wages, both for pensions already being served, and for the reevaluation of past wages when computing the reference wage. But this principle of double indexation was, *de facto*, in application since the end of 80s so that we do not treat them as being part of this 1993 reform.
- The 2003 reform extended to workers from the public sector the new requirement of having worked at least 40 years to get the full rate, and then scheduled an additional parallel increase of this condition until 41.75 years in 2020. It also changed incentives to retire earlier or later than this full rate, by introducing a bonus for postponement beyond this age, and by reducing the penalty for earlier retirement that, in pre-2003 conditions, was significantly stronger than required by actuarial neutrality.

Consequences of the 1993 and the 1993+2003 packages are compared to a “no-reform” scenario where the pre-1993 status quo would have been maintained. Projections start in 2003, which is the last year for which data from the Asset Survey are available. In the no-reform scenario the model reconstructs initial conditions for 2003 with benefit levels that are significantly higher because they are fully recomputed with the application of the initial rules.

Outcomes are systematically computed under two behavioural assumptions: one assumption is that everybody retires when he reaches the full rate (FR), even after the 2003 reform that has significantly lowered the incentive to retire exactly at this age. The other assumption is the “Stock and Wise” (SW) option where people retire at the age that maximizes an intertemporal utility function. It must be emphasized that this does not mean at all that people are not constrained on the labour market and can freely choose the age at which they quit the labour force. Under the SW option, those who are already excluded from the labour market at age 60 will generally claim for their benefits at this age, especially after the 2003 reform where the penalty for doing so without the appropriate number of years of contribution is weaker than it used to be.

What are the main messages from these simulations?

The option chosen for describing behavior makes very little difference on retirement ages at the beginning of the projection (Figure 2a), and this illustrates the difficulty to infer behavioural parameters from past observations. In a system that generates a strong incentive to retire at the FR, a very large majority of people will retire at exactly this age, whatever the model that governs their behavior. Yet the difference between the two options becomes progressively wider over time. As one could have expected, retirement behavior appears much more sensitive to reforms under the full rate assumption than under the SW one. Further tests will be performed to explore how far this gap is sensitive to changes in the numerical specification of this SW model. But these variants already provide us with a good view of what can be the amount of quantitative uncertainty on these future retirement behaviors.

When the behavioral assumption leads people to retire earlier, this is compensated by lower pension levels. The phenomenon is first observed on the flow of retiring people (Figure 2b) and then diffuses to the stock (Figure 2c). The resulting compensation between length of service and the level of the pension implies that the total pension bill is not that much sensitive to the behavioral assumption, at least in the long run³. The pensions/GDP ratio is in fact quasi-equivalent for both scenarios in the long run (Figure 2.d). From an initial value of about 10.5%⁴, it would have increased to about 14.5% points of GDP in the *status quo* scenario, hence a projected deficit of about 3 points of GDP. The two reforms reduce this projected gap by about 1/3rd each.

The global impact of reforms is therefore relatively large, but cannot be entirely explained by the relatively moderate of these reforms impact on retirement ages. A large part of this impact stems from the decrease in the ratio between the average pension level and average wages. In fact, such a decrease was already scheduled in the no reform scenario, due to the change in indexation rules that had been already introduced at the end of the 1980s: even without reforms, a 20% decline in the pension wage ratio was already to be expected over the projection period (Figure 2e). This order of magnitude can be understood easily. The average pensioner has an age of about 70. Under the initial rule, his pension was computed on the basis of the average of the 10 best years of his career. Let's assume that these 10 best years were the last 10 ones. This means that current average pensions reflect wages that prevailed about 15 years before. Depending upon whether the reevaluation is based on average productivity growth (here 1,8% per year) or only on prices, we get a gap of $(1-0,018)^{15}$ on the pension level, close to 25%.

The pure impact of reforms is to add extra factors of decline to this preexisting trend, especially in the case of the 1993 reform: by shifting the reference period to the 25 rather than the 10 best years, the reform mechanically reduces the pension level, and it worsens the impact of having past wages reevaluated on the basis of prices rather than productivity, since pensions now reflect wages that prevailed about 22.5 years ahead of the current period rather than 15.

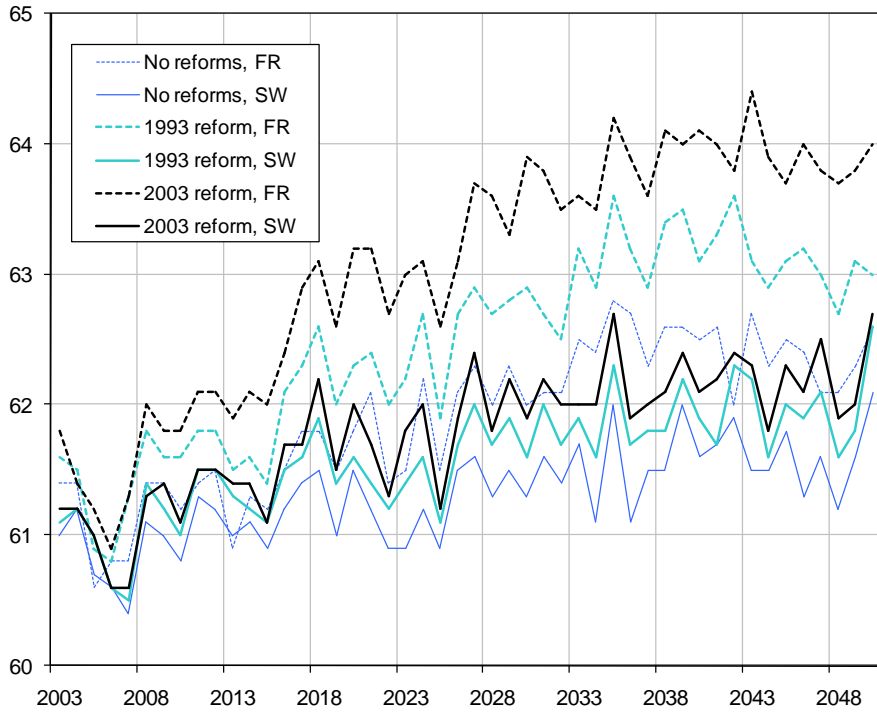
Compared to this impact of the 1993 reform, under the full rate hypothesis, the additional impact of the 2003 reform is almost non-existent: indeed, this reform did not schedule any further significant decrease in pension levels for people retiring at the full rate. On the other hand, a further impact of the 2003 reform on pension levels appears with the SW scenario, but it is due to the arbitrage made by people in favor of only moderate increases in retirement ages.

Figure 2a: Age at retirement with or without reforms

(FR= retirement at the full rate, SW= retirement according to the Stock and Wise model)

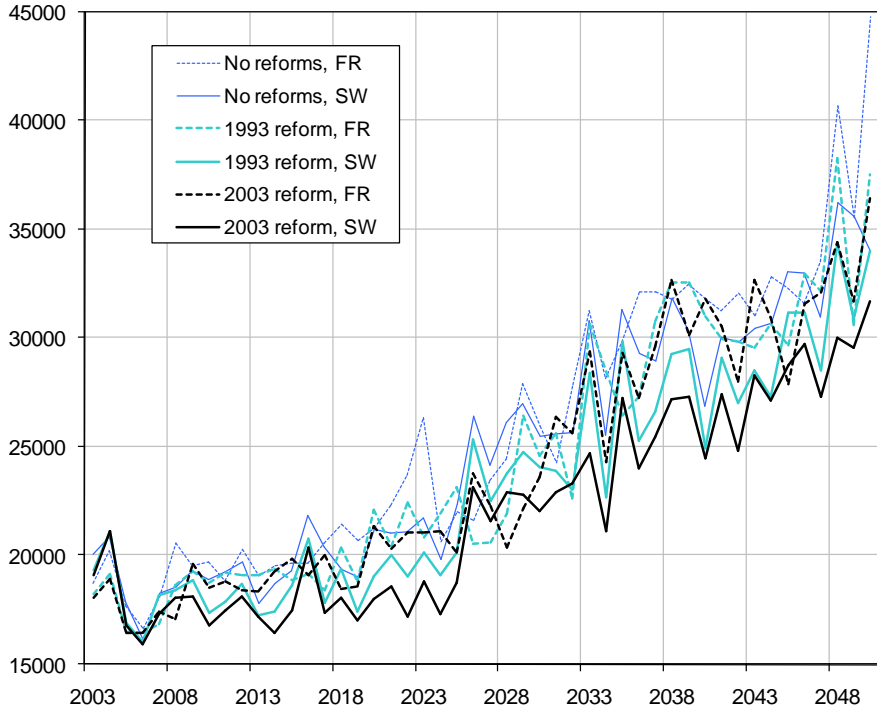
³ In the medium run, the pension bill is higher under the SW scenario run because the compensation is not immediate : people retiring earlier immediately lead to higher global amounts of benefits to be distributed, and it is only progressively that this will depress the average pension level for the whole stock of pensioners.

⁴ This figure is a bit lower than usual figures concerning the pension/GDP ratio for France (12 to 13%) because we restrict ourselves to direct benefits, excluding survivor's pensions and the "minimum vieillesse". But these two categories of pensions can be simulated by the model.



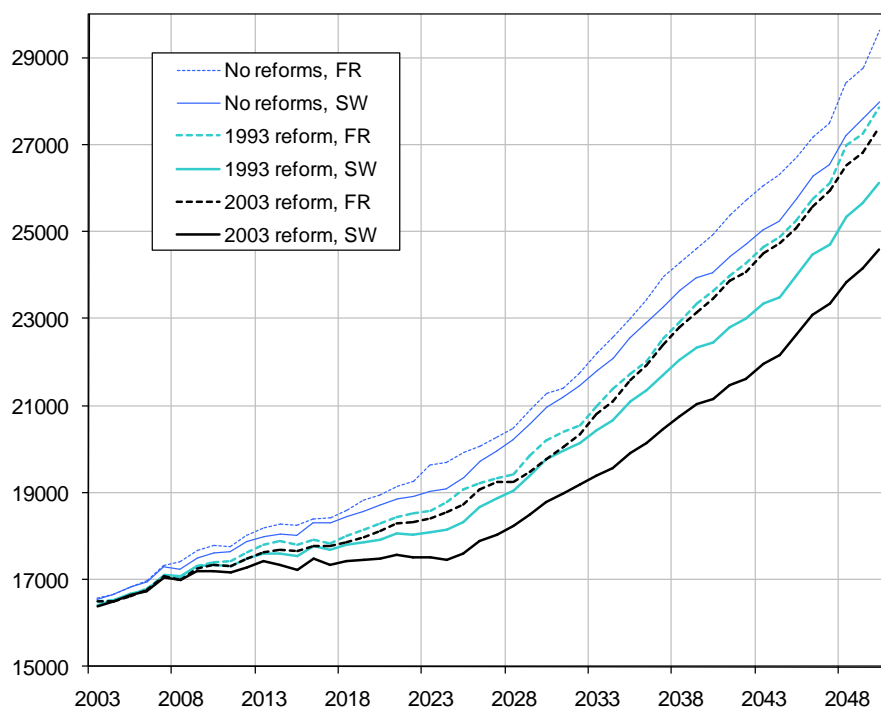
Source : Destinie 2 model. Small sample (≈ 6500 individuals, 20/3/2009 release)

Figure 2b: Average pension level for retiring people, with and without reforms
(FR= retirement at the full rate, SW= retirement according to the Stock and Wise model)



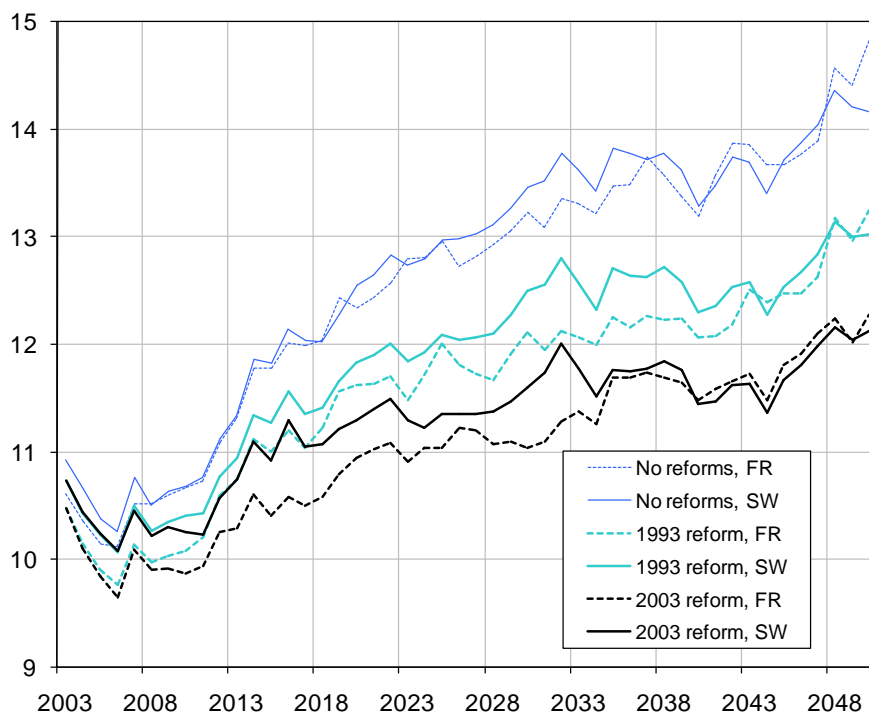
Source : Destinie 2 model. Small sample (≈ 6500 individuals, 20/3/2009 release)

Figure 2c: Average pension levels, all retirees, with or without reform.
(FR= retirement at the full rate, SW= retirement according to the Stock and Wise model)



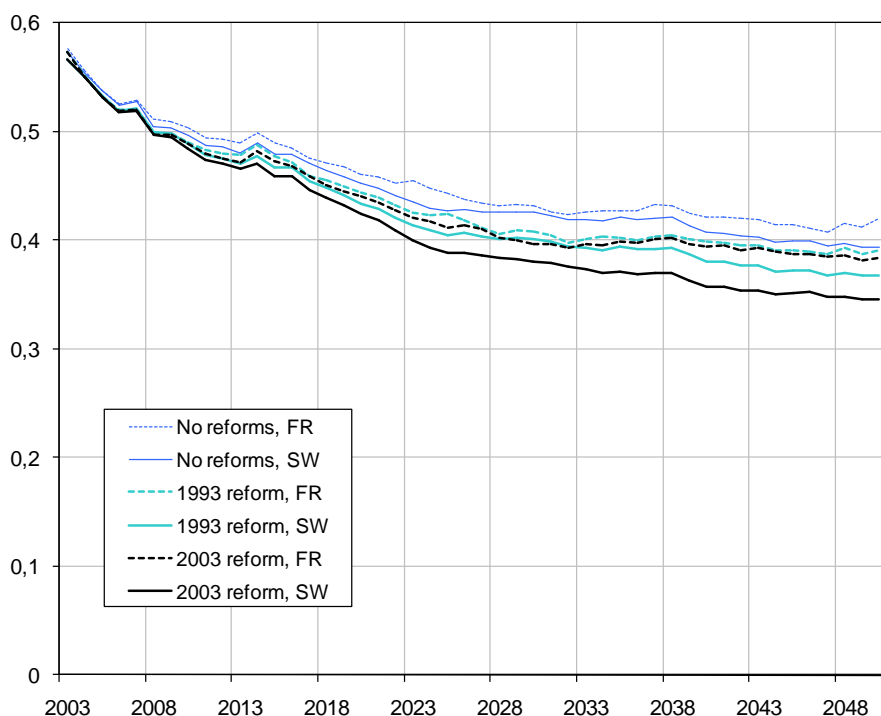
Source : Destinie 2 model. Small sample (≈ 6500 individuals, 20/3/2009 release)

Figure 2d: Projections of the pension/GDP ratio with and without reforms
(FR= retirement at the full rate, SW= retirement according to the Stock and Wise model)



Source : Destinie 2 model. Small sample (≈ 6500 individuals, 20/3/2009 release)

Figure 2e: Ratio of average pensions to the average gross wage, with and without reforms
 (FR= retirement at the full rate, SW= retirement according to the Stock and Wise model)



Source : Destinie 2 model. Small sample (≈ 6500 individuals, 20/3/2009 release)

3.2. Simulating the impact of large macroeconomic crisis

These first simulations were based on the macroeconomic assumptions that have been used by the French Pensions Advisory Committee (COR) for the reference scenario of its latest projections: we have already mentioned the assumption of a continuous rate of productivity growth at 1.8% per year. The other assumption is the assumption of a rapid decline in the unemployment rate to a rate of 7.5%, reached in 2015.

These assumptions have been often considered as relatively optimistic. They are of course strongly challenged by recent economic events, and it is interesting to introduce variants that reflect in a stylized way the possible consequences of these recent macroeconomic developments.

A priori, the two-tier structure of the new model raises a problem for rapidly producing such variants, because unemployment and wages trajectories are determined by the first module that has not been designed for frequent actualizations. But, as mentioned above, it is also possible to produce rapid evaluations of macro-variants integrating new economic information without fully rerunning the whole GeneBios program. To do that, we just have to retreat at the margin the careers simulated by this program, and this can be done within a pension projection program. The source code given in appendix 2 shows that this can be done with only a few additional lines of programming, at least with the stylized assumptions that we have considered here.

More precisely, we complement the reference scenario with three scenarios: a “transitory shock scenario”, a “shock on levels”, and a “shock on trends” scenario. All these scenarios assume that the ongoing crisis results in a temporary increase in unemployment rates, with additional unemployment spells randomly affected to wage-earners in the private sector. This increase lasts until 2014 (figure

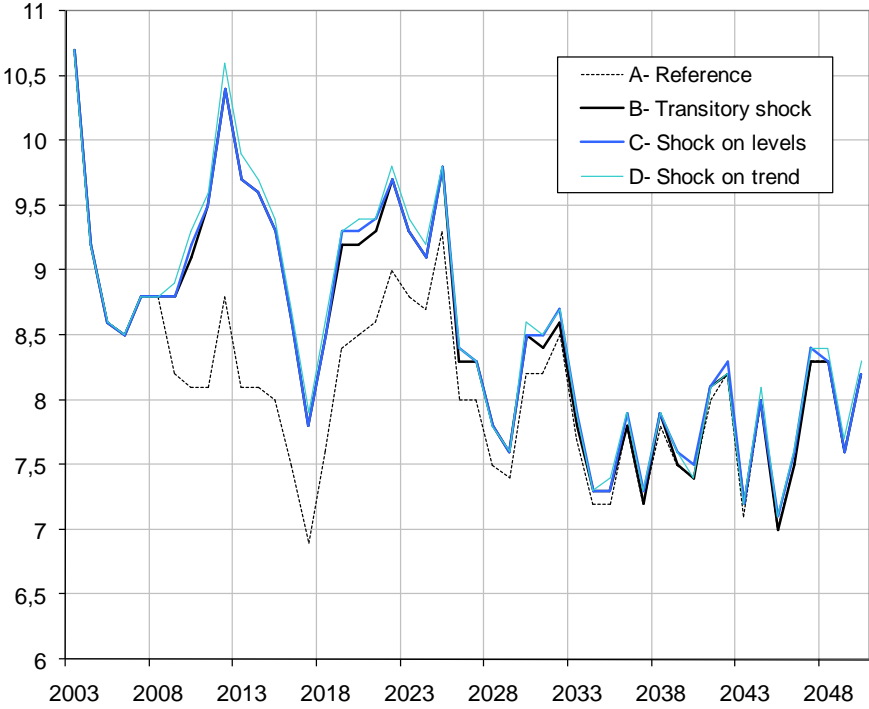
3a). Where the scenarios diverge is in terms of wage trajectories⁵. In the transitory shock scenario, wages temporarily decline beyond their reference path but progressively return to their reference path, this being fully the case in 2014. In the ‘shock on levels’ scenario, we have in 2009 a negative shock of -4% on all wages compared to their ‘normal’ path. Wages then retrieve their initial rate of growth but the 4% loss is definitive: the new path is permanently 4% below the reference one.

At last, the ‘shock on trends’ scenario assumes that the crisis underway not only generates an initial decrease of 4% in wages, but is also the starting point of a new era of much less dynamic economic growth, at only 1.2% per year instead of 1.8%. Needless to say that none of these shocks refer to a well-defined macroeconomic scenario. The exercise is of a purely ‘what if’ character, aiming, at the stage, at assessing the properties of the model.

Resulting profiles for the total wage bill cumulate the change in the unemployment rate –that is always transitory- and the change in average wage, that is more or less permanent depending on the scenario (Figure 3b).

In all cases, transitory evolutions lead to a short run increase in the equilibrium contribution rate, expressed in % of the total wage bill (Figure 3c). In the long run, results are more contrasted. The “transitory” or “shock on levels” scenarios lead to slight reductions in the equilibrium rate at the 2050 horizon, essentially due the fact that people who retire at this time will have pensions slightly below the level they would have had in the absence of economic shock. On the other hand, the “shock on trend” scenario leads to a much higher equilibrium contribution rate. The reason lies in the interaction

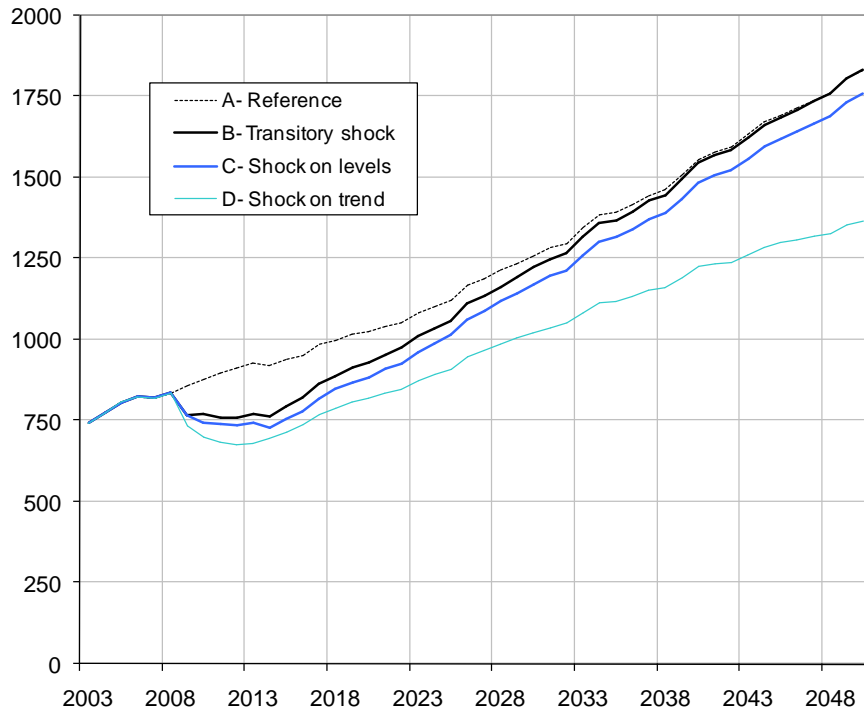
Figure 3a: Unemployment rate, without and with macroeconomic shock



Source : Destinie 2 model. Small sample (≈ 6500 individuals, 20/3/2009 release)

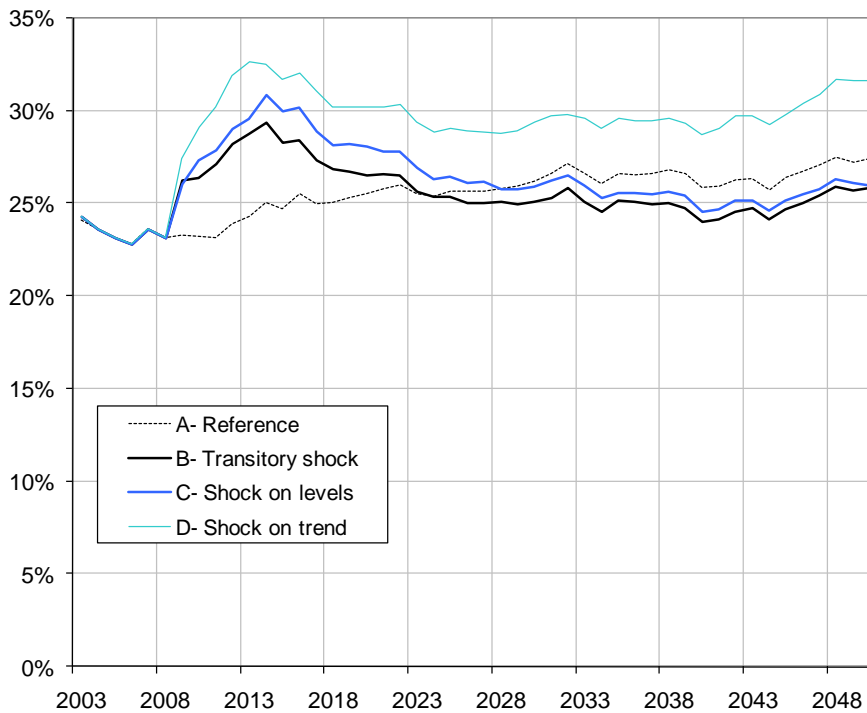
⁵ To keep things simple, impacts are supposed uniform for all categories of workers, belonging either to the private or the public sector –but it would be easy to introduce some differentiation-.

Figure 3b: Total wage bill, according to macroeconomic scenario.



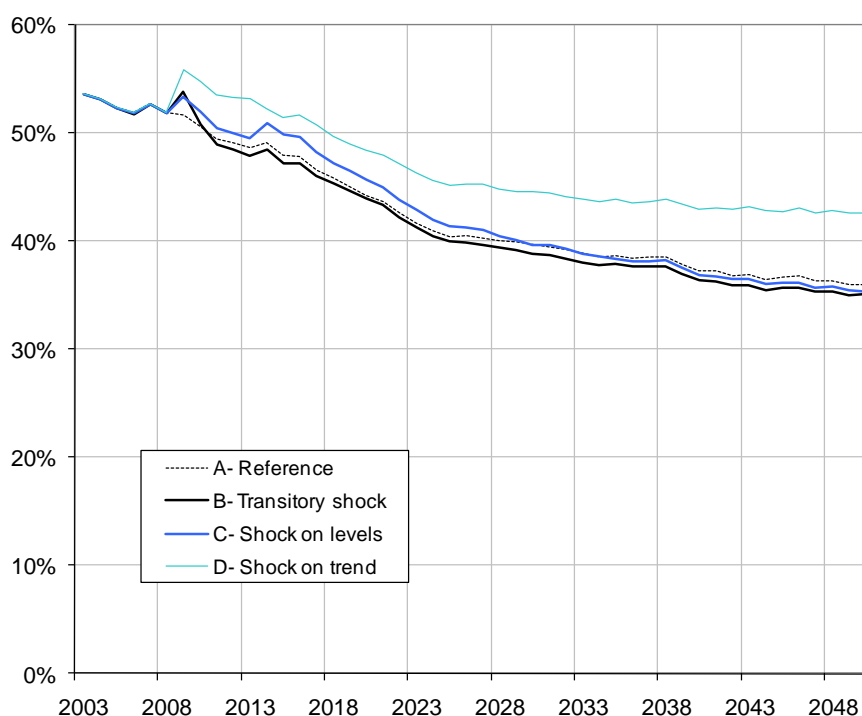
Source : Destinie 2 model. Small sample (≈ 6500 individuals, 20/3/2009 release)

Figure 3c: Ratio of pensions to total wage bill (equilibrium contribution rate)



Source : Destinie 2 model. Small sample (≈ 6500 individuals, 20/3/2009 release)

Figure 3d: Ratio of average pensions to average wages.



Source : *Destinie 2 model. Small sample (≈ 6500 individuals, 20/3/2009 release)*

effect between economic growth and indexation rules. Indexation on prices rather than wages leads to a gap between pensions and current wages that is much less pronounced when the progression of wages is slow. In the limit, if productivity growth was zero, indexation on prices makes no difference compared with indexation on wages. This is the paradox of policies of pension control that essentially play on this indexation instrument. They are all the more efficient that growth is rapid, but it is when growth is slow that the need to control expenditures is likely to be the highest.

Naturally, an exercise such as the one presented in this subsection has to be refined in many directions. In more detailed simulations differentiating the impact of the crisis of different socio-demographic groups, it would be interesting to look at long-term distributional consequences for the standard of living of retirees. One can also mention that, in these simulations, the impact of the crisis is limited by some features of the current system: years spent in unemployment are validated as normal years of contributions –at least as long as people benefit from unemployment insurance, as assumed here–, and the rule of the “25 best years” still protects pensioners against consequences of shocks that have only affected a transitory period of their careers. Outcomes could be different under alternative rules. In particular, a debate starts to take place in France concerning the replacement of the current system with a system of notional accounts, where some of these compensatory mechanisms could disappear. Modules simulating such a system have been already incorporated in *Destinie 2*. More extensively comparing the responses of alternative systems to given economic shocks is one of the possible uses to be considered for the new model.

3. CONCLUSION

The building of the new Destinie 2 model started in 2005 and has occupied a limited team on a very part-time basis over the last two years. The new model now enters its validation phase.

This new model does not have the ambition of becoming the dominant tool for pension analysis in France, for two reasons: more aggregate models are more convenient for general variants and more detailed microsimulation models based on administrative data more relevant for detailed financial projections (eg Prisme at the CNAV).

But this new version of Destinie should keep and even reinforce its comparative advantage for many applications such as variants of retirement behavior or computations involving the household level (pensioners standard of living, means-tested benefits...). And the kind of modular approach that it has applied to the simulation of pensions could easily be extended to the exploration of other domains: disability and health, savings behavior...

AKNOWLEDGEMENTS

Destinie 2 also benefited a lot from all the previous work realized by the successive Destinie 1 teams, in particular Michel Duée for the reestimation of equations determining demographic transitions and Jean-François Foucher for the preparation of the data base derived from the 2003 Asset Survey. Authors also thank Cedric Afsa for his support.

REFERENCES

- Bardaji J, Sédillot B and Walraët E (2002) 'Évaluation de trois réformes du Régime Général d'assurance vieillesse à l'aide du modèle de microsimulation DESTINIE', Working paper INSEE/DESE n° G2002/07.
- Bardaji J, Sédillot B and Walraët E (2004) 'Les retraites du secteur public : projections à l'horizon 2040 à l'aide du modèle de microsimulation DESTINIE', Working paper INSEE/DESE n° G2004/14.
- Berteau Rapin C, Di Porto A and Albert, C. (2009) 'PRISME : modèle de microsimulation dynamique pour le régime de pension français', 2nd IMA conference, Ottawa.
- Conseil d'Orientation des Retraites (2006) *Retraites : perspectives 2020 et 2050*. 3rd Report, La Documentation française.
- Crenner E (2007) 'Projecting Living Standards And Poverty Rates For French Pensioners', Paper presented at the first IMA conference, Vienna, 2007.
- Division « Redistribution et Politiques Sociales » (1999) 'Le modèle de microsimulation dynamique DESTINIE', Working paper INSEE/DESE n° G 9913.
- Duée M and Rebillard C (2004) 'La dépendance des personnes âgées : une projection à long terme', Working paper INSEE/DESE n° G2004/02.
- Duée M (2005) 'La modélisation des comportements démographiques dans le modèle de microsimulation Destinie', Working paper INSEE/DESE n° G2005/15.
- Mahieu R and Blanchet D (2004) 'Estimating models of retirement behavior on French data', in *Social Security Programs and Retirement around the world*, J Gruber et DA Wise, Eds, NBER/The University of Chicago Press: 235-284.
- Walraet E and Vincent A (2002) 'Analyse de la redistribution intragénérationnelle dans le système de retraite des salariés du privé : une approche par microsimulation' (English Version: 'Intragenerational distributional analysis in the French private sector pension scheme: a microsimulation approach'), Working paper INSEE/DESE n° G2002/14.

Appendix 1 : Source code for simulations presented in section 3.1

```

# This program simulates pension trajectories with or without taking into account
# the 1993 and 2003 reforms. It does so under two behavioural assumptions :
# departure at the full rate or according to the Stock and Wise model.

use strict;
use lib "..\Outils";
use OutilsBase ;
use OutilsExcel;
use DefVarRetr;
use OutilsRetr;

# Initialisations
my ($sc,$i,$t,$pib2003,$resultats,$hyp_comp,$legislation,@liq,
    %MSAL,%PIB,%TOT,%TOTPIB,%MOYTOT,%MOYTOTLIQ,%AGELIQ,%SALMOY,%PENSREL);
$resultats = ClassOut("ScénarioIMA-1.xls");
UseBios("../V5 (petit ech - 20 mars 2009)\IniMod.txt",
    "../V5 (petit ech - 20 mars 2009)\ProMod.txt",2003);
UseW(9.24694272 ,0.924694272/100000 );
$pib2003=1684; # 2003 GDP in 2006 Euros

# Loop on scenarios
for $sc ("TP-1992","TP-1993","TP-2003","Uact-1992","UAct-1993","UAct-2003")
{
    ($hyp_comp,$legislation) = split(/-/, $sc);
    UseOpt($hyp_comp);
    @liq=();

    # Time loop
    for $t (103..150)
    {

        # Simulation
        Relec($t);

        # Individual loop : simulation of pensions, generation of a dummy variable
        # for individual retiring at the current period
        for $i (1..IMax)
        {
            UseLegRetroMax($legislation);
            UseLeg($legislation,$anaiss[$i]);
            SimDir($i);
            if (($age[$i]==$ageliq[$i]) && ($age[$i]>0)) {$liq[$i]=1} else {$liq[$i]=0};
        }

        # Macro outputs for year $t
        $MSAL{$sc}[$t] = SVar(@salaire)/$Prix[$t];
        if ($t==103)
            {$PIB{$sc}[$t]=$pib2003}
        else
            {$PIB{$sc}[$t]=$PIB{$sc}[103]*$MSAL{$sc}[$t]/$MSAL{$sc}[103]};
        $TOT{$sc}[$t] = SVar (@pension)/$Prix[$t];
        $TOTPIB{$sc}[$t] = 100*$TOT{$sc}[$t]/$PIB{$sc}[$t];
        $MOYTOT{$sc}[$t] = MVar(@pension,sub{$pension[$_]>0 })/$Prix[$t];
        $MOYTOTLIQ{$sc}[$t]= MVar(@pension,sub{$pension[$_]>0 && $liq[$_]==1})/$Prix[$t];
        $AGELIQ{$sc}[$t] = MVar(@age,sub{($pension[$_]>0) && ($liq[$_]==1)});
        $SALMOY{$sc}[$t] = MVar(@salaire,sub{$salaire[$_]>0});
        $PENSREL{$sc}[$t] = $MOYTOT{$sc}[$t]/$SALMOY{$sc}[$t];

    }; # End time loop

SavSer($resultats,$sc,$sc,
    "Masse salariale", @{$MSAL{$sc}},
    "Masse pensions", @{$TOT{$sc}},
    "Pensions/PIB", @{$TOTPIB{$sc}},
    "Pension moyenne", @{$MOYTOT{$sc}},
    "Pension moyenne liquidants", @{$MOYTOTLIQ{$sc}},
    "Age a la liquidation", @{$AGELIQ{$sc}},

```

```
"Salaire moyen          ",@{$SALMOY{$sc}},
"Ratio pension/salaire ",@{$PENSREL{$sc}});

} # End loop on scenarios

CloseOut($resultats);
```

Appendix 2 : Source code for simulations proposed in section 3.2

```
# This programme simulates a reference scenario and two variants with large economic
# shocks starting in 2009, whose consequences on wages are either transitory or permanent

use strict; use lib "..\Outils";
use OutilsBase; use OutilsExcel; use DefVarRetr; use OutilsRetr;

# Declaration of non predetermined variables
my ($s,$i,$t,$out,@deltaUN,%deltaWAGE,
    %UN_RATE,%TOT_WAGES,%REL_PENS,%CONT_RATE);

# Initializations : input files, weights, retirement behavior
UseBios("../V5 (petit ech - 20 mars 2009)\IniMod.txt",
    "../V5 (petit ech - 20 mars 2009)\ProMod.txt",2003);
UseW (9.24694272 ,0.924694272/100000 );
UseOpt ("Uact");

# Aggregate time profiles for shocks
for $t (109..150)
{
    $deltaUN[$t] = Affn($t,109, 0.10,110, 0.10,115,0);
    $deltaWAGE{"B- Transitory shock"}[$t] = Affn($t,109,-0.02,110,-0.02,115,0);
    $deltaWAGE{"C- Shock on levels" }[$t] = -0.04;
    $deltaWAGE{"D- Shock on trend" }[$t] = 0.96*exp(-0.006*( $t-109))-1;
}

# Loop on scénarios
for $s ("A- Reference","B- Transitory shock","C- Shock on levels","D- Shock on trend")
{
    # Time loop
    for $t (103..150)
    {
        Pointage(*STDOUT,"Annee " .($t+1900));
        Relec($t);

        # Individual loop
        for $i (1..IMax)
        {
            # Shocks on wages and employment status
            if (($t>=109) && ($s =~ /shock/i))
            {
                $salaire_[$i][$age[$i]] *= (1+$deltaWAGE{$s}[$t]);
                $salaire[$i] *= (1+$deltaWAGE{$s}[$t]);
                if ((In($statut[$i],$CodeNC,$CodeCad) && ((Alea) < $deltaUN[$t]))
                {
                    {
                        $statut_[$i][$age[$i]] =$CodeCho; $statut[$i]=0;
                        $salaire_[$i][$age[$i]]=0 ; $salaire[$i] = 0;
                    }
                }
            }

            # Simulation of retirement behavior, according to ret. or prosp. legislation
            UseLegRetroMax(2003);
            UseLeg(2003,$anaiss[$i]);
            SimDir($i);

        } # End individual $i

        # Aggregate statistics for year $t
        $UN_RATE{$s}[$t] = Taux (sub{$statut[$_]==$CodeCho},sub{In($statut[$_],@CodesAct)});
        $TOT_WAGES{$s}[$t] = SVar(@salaire)/$Prix[$t];
        $CONT_RATE{$s}[$t] = SVar(@pension)/SVar(@salaire);
        $REL_PENS{$s}[$t] = MVar(@pension, sub{$pension[$_]>0})/
            MVar(@salaire, sub{$salaire[$_]>0});

    } # End year $t
}
```

```
} # End scenario $s

# Output to Excel file
$out = ClassOut("ScenariosIMA-2.xls");
SavHS($out,"UN Rate" ,"Unemployment rate" ,%UN_RATE);
SavHS($out,"Wages" ,"Total wage bill" ,%TOT_WAGES);
SavHS($out,"Cont Rate","Apparent contribution rate",%CONT_RATE);
SavHS($out,"Rel Pens" ,"Relative pension level" ,%REL_PENS);
CloseOut($out);
```