The Emergence and Consolidation of Microsimulation Methods in France

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Abstract – The purpose of this paper is to trace the gradual emergence of microsimulation models dedicated to the analysis of tax and social security policies in France since the mid-1960s, as well as their subsequent consolidation since the mid-2000s. A brief outline of these models is given using the static/dynamic distinction. A connection is made between the construction of the Mir model (standing for *Modèle de l'impôt sur le revenu*, an income tax model) and the development of the Household income survey *Revenus fiscaux*. Then we distinguish two periods: An initial period that saw a proliferation of such models and a second period, of standardisation, during which the Ines model has acquired a central position. Besides ongoing evaluations (of minimum income and pension schemes, insurance for long-term care), the most recent expectations in this area relate to the *ex ante* evaluation of measures designed to accelerate the ecological transition and of universal income-type schemes. Finally, we underline that the recent replacement of all the periodic declarations made by employers to various administrations by a unique declaration (the *Déclaration sociale nominative*, or DSN) significantly renews the range of administrative sources capable of feeding into these models.

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The purpose of this paper is to trace how microsimulation models have been developed in France over the past fifty years and how they have come to play an important but overlooked role in tax and social policy analysis. On the one hand, microsimulation methods fulfil a strong demand for the effects of tax and social policies to be evaluated, including, in particular, reforms in the financing of social security, changes in family policies and the future of pensions. On the other hand, barriers to the implementation of these methods have now been completely removed since, on the one hand, individual data are available and, on the other hand, computers are powerful enough to simulate economic and social situations at the individual level.

The article starts with a brief introduction to microsimulation methods in order to provide the reader with a better understanding of the matter at hand. Then a first section, examines the phase of the development of microsimulation models, which resulted in them becoming a fixture in the landscape of social policy analysis. The second section provides a roadmap for microsimulation models to ensure these meet current demands in the *ex ante* assessment of public policies.

Microsimulation methods seek, as part of a bottom-up approach, to trace the behaviours of individual units (individuals, households, companies) at the most disaggregated level possible. The implementation of these methods requires the availability of individual data – that will constitute the starting point of the microsimulation – and computing capacities.

Static Models

The simplest microsimulation models are "accounting" models. Take the case of income tax, where the individual unit is the tax household. Based on a representative sample of tax returns, the amount of tax is calculated using the current schedule: all the factors that determine the amount of tax are included in the tax return and the tax schedule is coded in a computational program. A tax reform can thus be evaluated by calculating the tax using a new schedule and comparing, for each taxpayer, the old tax amount and the new tax amount. It is therefore possible to quantify the aggregate cost (or return) of the reform, but also to identify the winners and losers of the reform, i.e. their number, the distribution of gains and losses, etc. It is also possible to assess the redistributive effects of the reform: on the one hand, taxpayers can be broken down according to their standard of living and, on the other hand, the distribution of the average amounts of gains and losses by standard of living can be estimated. For example, we might say that "the last decile of living standards is the decile that stands to lose the most from the reform" and therefore assess the consequences of the reform in terms of reducing or increasing inequalities in living standards.

Microsimulation methods only began to emerge in the 1960s since they require a large amount of individual data (and therefore an information system capable of recording and accessing large volumes of data) and sufficiently powerful computing capabilities. In the case of income tax, it may be tempting to draw on all tax returns and to perform calculations for the 38 million returns currently available to France's revenue authority. Of course, a sample drawn with a good sampling design is sufficient, but we know that advances in computer science open up the possibility of developing a microsimulation model on a one-to-one scale.

"Accounting" models are also known as "static" models since, in these models, individuals do not respond to the new environment resulting from the reform being evaluated. Some reforms only have a financial goal, such as reducing the public or social security deficit, while others seek to limit inequalities or are implemented with the explicit aim of changing behaviours. In all cases, the responses of individuals should be taken into account since otherwise the assessment of the measure would be incomplete. Let us return to the case of income tax and assume, for example, that the ceiling on the tax discount for the employment of a home-based employee is raised. The primary purpose of the reform is not to "make a gift" to individual employers; rather, its objective is to promote employment in the personal services sector. It would therefore be absurd to quantify the cost of the measure as if it did not lead individuals to employ more home-based workers: in other words, the microsimulation model must incorporate behavioural responses. In this example, assumptions must be made about the "intensive margin" (the proportion in which an increase in the ceiling leads private individuals to employ an employee at home for a longer period of time) and the "extensive margin" (the proportion in which individuals will be able to employ an employee when they did not previously). However, to be complete, it is also necessary to model the situation of employees by once again distinguishing between the intensive margin (i.e. the number of employees employed part-time who increase their working time) and the extensive margin (the number of unemployed or inactive people who will be able to find a salaried position as a home worker).

Dynamic Models

Models that incorporate behavioural responses in this way are referred to as "dynamic" models since, in many cases, they are built to make (more or less) long-term forecasts: the method thus seeks to reproduce dynamic sequences by generating the trajectories of all individuals in the sample over the entire period considered.

Perhaps the most suggestive way to understand dynamic microsimulation is to consider the situation of a pension fund seeking, on the one hand, to predict its situation in 20 years' time and, on the other, to assess the consequences, over the same time horizon, of a change in the rules for calculating pension entitlements. The fund can implement an aggregated method by estimating what could be, on the one hand, the growth rate of the mass of contributions available to it for the next 20 years and, on the other, the growth rate of the mass of pensions that it will have to pay over the same period. There are several possible scenarios, depending on macroeconomic assumptions relating to growth, unemployment, inflation, etc.

A distinction can be drawn between this aggregate projection method and a microsimulation method based, in this instance, on the following six steps:

1. Calculate the number of incomers, i.e. the number of (a) new contributors: individuals moving into work or out of unemployment; (b) new pensioners: individuals drawing their pension;

2. Within the data, identify the incomers;

3. For each incomer, estimate the amount: (a) In the case of a new contributor, of his or her contributions based on his or her starting salary using an econometric estimation; (b) In the case of a new pensioner, his or her pension based on the applicable regulations but also his or her employment history;

4. Calculate the number of leavers, i.e. the number of (a) outgoing contributors: individuals who change pension funds, become unemployed or even die; (b) retirees who disappear;

5. Within the data, identify the leavers;

6. Estimate changes for current contributors, i.e. (a) the variation of each contributor's salary, again based on a model; (b) the increase in the pension of each retiree, in accordance with the applicable regulations.

Thus, the aim is to project the information system of the pension fund – in other words, to ensure that in twenty years' time it has the same individual data that it currently has. In 20 years' time, it will therefore be possible to calculate the mass of contributions and the mass of pensions for the reference situation but also for the new rules for calculating entitlements.

In dynamic microsimulation, the calculations follow one another. Let us suppose that the time scale of the model is monthly, meaning that, for each individual, the calculations are made month by month. For example, the salary is updated each month based on the individual's characteristics but also based on his or her previous wages. The computer is thus tasked with manufacturing individual trajectories, fictitiously but realistically, for the entire period studied. It is possible to artificially generate trajectories that differ from one individual to another but which, on average, are aligned with macroeconomic developments: we thus arrive at a picture that shows both the diversity of individual situations and the (relative) regularity of aggregate dynamics. This is done using a pseudo-random number generator: the computer provides a sequence of numbers, each of which represents a realisation of the uniform distribution between 0 and 1. These pseudo-random numbers are used to simulate events. Let us suppose that, for a given category of employees, the probability of them losing their job from one month to the next is 1.5%. Let us also suppose that, in the model, the category includes 200 employees: it follows that the event must be simulated for 3 employees on average. Those employees for whom the pseudo-random number is less than 1.5%, i.e. 0.015, will be retained.

Pseudo-random number generators provide a means of generating individual trajectories that artificially reproduce the range of situations of the individual units. The artificial changes are also reproducible since the computer is able to replicate exactly the same sequence of numbers. This is one of the key attractions of the method: two simulations conducted, for example, one week apart will yield exactly the same results while generating non-trivial individual changes.

The opposition between "static" and "dynamic" models also stems from the two different origins of microsimulation methods. The origins of the "dynamic" method can be traced back to Orcutt (1957). For each unit, Orcutt distinguishes between inputs (all the factors that determine the unit's decisions) and outputs, i.e. strictly economic outputs, but also events of "all kinds" – meaning demographic events such as the birth of a child, marriage, divorce, relocation, death, etc. The term "behaviour" is thus used in a very broad sense since it may refer either to a change of state triggered by comparing a pseudo-random draw with an exogenous probability or to a behavioural response within the meaning of standard economic theory, i.e. a decision resulting from the maximisation of a utility function under a set of constraints. Dynamic microsimulation models were thus developed as an alternative to aggregate population projection methods. As we have seen, static models are less ambitious, seeking simply to trace the regulation of compulsory taxes and social transfers by applying it to individual units.

Microsimulation methods will not be discussed further. Interested readers are referred, for example, to Chambaz & Le Minez (2003) and Legendre (2004) for an examination of what these methods can bring to the evaluation of a new measure in terms of estimating its budgetary cost, evaluating its redistributive consequences and estimating its incentive effects (among other things). The reader may also consult the following articles: Blanchet (1998), Legendre *et al*. (2003), Blanchet *et al.* (2015) and Blanchet *et al.* (2016). Another perspective can be found in Bessis (2019), who looks at the history of microsimulation models with an interpretation in terms of the construction of economic knowledge. Here, the aim is to trace how microsimulation models have become irreplaceable tools for *ex ante* evaluations of tax and social policies.

The Emergence and Establishment of Microsimulation Models

To the best of my knowledge, the first static microsimulation model in France, known as Mir (standing for *Modèle de l'impôt sur le revenu*, an income tax model), was developed at the Forecasting department of the Ministry for the Economy and Finance, with the aim of better understanding the redistributive effects of income tax. Three publications have traced the development of this model: Bégin *et al.* (1971), Bonacossa *et al.* (1975) and Coutière *et al.* (1981).

The Strong Link between Microsimulation and Data

One interest of this set of publications is to implicitly trace the history of the Household tax income survey (*enquête Revenus fiscaux*) the assumption being: no microsimulation model without a sufficiently reliable representative sample. The first surveys were conducted on the basis of the population census, based on a sample of dwellings: local tax centres were tasked with collecting the corresponding tax returns and transmitting them, while taking care to exclude personal information, to the National Institute of Statistics and Economic Studies (Insee) in order to ensure statistical and tax secrets remained separate. Because of the cost of collection, surveys were conducted on average every five years. It was only from 1996 onwards that the *Revenus fiscaux* surveys began to draw on the Labour Force surveys and became an annual occurrence: the focus now was on matching tax data, for each individual in the Labour Force surveys, to the data provided by the latter. Collection became automated and tax centres were no longer responsible for collecting the data.

However, the main purpose of these surveys is not to feed into microsimulation models dedicated to social policy analysis. Rather, they are designed to better understand household living standards and, in particular, to produce poverty statistics. The *Revenus fiscaux* survey thus became the *Revenus fiscaux et sociaux* (RFS) survey from 2005 onwards by incorporating, among other data, the social security benefits actually received by households, previously imputed.[1]

This shows that microsimulation methods are demanding in terms of the volume and quality of data they use as inputs and that data are obtained at a considerable cost.

1. This improvement had been recommended by the National Council for Statistical Information, which had noted that knowledge of social benefits was poor since they were often non-taxable, did not always appear in tax returns and were imputed in the survey.

The articles mentioned above also provide a basis for measuring the significant progress made in information processing over the past fifty years. In the 1960s, the data were recorded on punched cards and were therefore difficult to process. Bégin *et al*. (1971) explained that the data were initially transferred to a magnetic tape "in such a way as to render the whole thing more manageable". It should be noted that in terms of its design, microsimulation operates as a recursive system: the period is short enough that the decisions of one unit cannot be considered to influence immediately the decision-making of the other units. For example, Orcutt (1957) refers to periods of one week or one month to justify such a hypothesis. As a result, the microsimulation can be programmed by requiring only sequential access to the data of each unit. Two magnetic tape drives were enough for a dynamic microsimulation. One of the two drives was used to read the data in sequence while the other drive was used to write the data unit by unit; the drives were then made to swap roles and the output data from the previous period became the input data of the new period. Nowadays, magnetic tapes are no longer used, but the idea persists that even in order to describe interactions between units, a system of simultaneous equations is not necessary.

The Development of Static Models

These first static models provide a good illustration of the information that can be obtained with these tools. In the case of income tax, they provide a means of better characterising the tax, but also its properties, including, in particular, its progressiveness. For example, macroeconomic analysis indicates that the share of income tax in total compulsory taxation remains relatively low in France. For its part, microsimulation provides a basis for establishing the distribution of the tax based on a wide range of criteria (size of the tax household, nature of the main income, etc.), but also for showing that income tax is relatively concentrated and that its progressivity is irregular.

From the Tax System...

The Mir model was used to evaluate the effects of changes in tax law, whether *ex post*, for a measure adopted by the Finance Act; or *ex ante*, for a hypothetical measure whose cost (or return) and redistributive consequences are to be calculated. In Bégin *et al*. (1971), the family quotient system was the subject of an initial evaluation at the time, the benefit provided by the scheme was estimated on average at 20% of total tax revenue. In Coutière *et al*. (1981), the focus was on "the separate taxation of married women" (i.e. tax individualisation). We thus see how microsimulation is capable of contributing to the public debate on controversial aspects of the tax system.

The analysis of redistribution had yet to reach stable ground. The breakdowns presented relate to socio-professional categories, the household's income brackets, the household's tax brackets, and even the household's net income deciles. Socio-professional categories was the preferred option in representing social stratification. Presentation in terms of deciles of living standards in total population was not used. It was only later that it would gain currency, providing a better representation of individuals in the standard of living distribution.

Coutière (1983) provides an exemplary illustration of the use of the Mir 4 model, the version of the model based on the 1975 *Revenus fiscaux* survey, by considering different scenarios for increasing income tax so that the structure of the overall tax burden in France appears similar to that observed in comparable Western countries. The author made it clear that the point is not to assess the impact of taxation: "*The problem of tax incidence is, as economists have long known, one of the most formidable problems in economic theory*". The scenario that attracts the most attention is the one where employee social security contributions are reduced by 10 percentage points and income tax revenue is doubled both by removing a number of provisions specific to the French system and by taxing the income supplement following the reduction in contributions. While the total amount levied remains unchanged, taxation is more progressive and less concentrated and the new system is more redistributive. This scenario, which involves broadening income tax, would have provided an alternative to the developments seen at the time, which took the form of the creation of the General Social Contribution (CSG) in 1990.

... to the Tax-Benefit System

In the 1980s, the economic authorities thus had significant expertise in the field of static microsimulation. However, such expertise remained limited to compulsory levies and therefore did not allow for an analysis of the tax and social security system as a whole; however, we know that the reduction of inequalities is achieved, for the most disadvantaged individuals, by means-tested social benefits and, for the most well-off individuals, by progressive contributions. An important impetus for the development of global microsimulation models (known as Tax Benefit Models) was provided in the late 1980s by a team led by François Bourguignon, at the *École des Hautes Études en Sciences Sociales*, in the form of a simple but pioneering and relatively complete model called Sysiff. This period also saw the spread of microcomputers: the rise of microsimulation models was no longer limited by the processing capacity of computers and it became easier for researchers to invest in these methods.

There have been several versions of the Sysiff model. The first, based on the 1975 *Revenus fiscaux* survey, provided a means of comparing the architecture of compulsory taxes in France and Britain (see Atkinson *et al.*, 1988). The second version, based on a sample from the Household income and expenditure survey, represented the French part of the Euromod project (Bourguignon *et al.*, 1988, and Sutherland, 1997). In other words, these initial studies form part of an international, and specifically European, comparative perspective aimed, on the one hand, at clarifying the link between the structure of compulsory taxes and the social security system, particularly the Bismarckian and Beveridgean systems, and, on the other hand, at better assessing the options for changing the way social security is financed in France.

The analysis of family policies is another area where there is a great demand for expertise. On behalf of the French Tax Board, a study on the family quotient of income tax developed simulations presenting different variants such as, for example, capping the benefit provided by the marital quotient (Glaude, 1991). The author then set about promoting the development of a microsimulation model at Insee, with a view, in particular, to obtaining a general overview of family policy.

The Rise of Questions on Social Protection and Employment

Finally, the *Revenu minimum d'insertion*, or RMI (a minimum income scheme) was introduced in late 1988; five years later, a first scheme to reduce employers' social security contributions on low wages was introduced. At the time, employment policies were characterised by both general and targeted measures, as noted by L'Horty (2006). The measures were general insofar as they were not aimed at a particular category of workers or businesses. However, they were also targeted since they depended either on the family configuration and the level of earned income for minimum benefit schemes or on the hourly wage rate for schemes involving reduced contributions. It is thus clear why the economic and social authorities might have been keen to equip themselves with microsimulation models as quickly as possible, thereby reviving the pioneering approach of the Mir model. In short, it had become apparent that such models were necessary for costing and evaluating this type of scheme. In particular, if unemployment results, in part, from labour market failures, is it because of insufficient demand due to excessively high labour costs relative to labour productivity or rather because of a shortage of supply resulting from an excessively low net wage relative to the minimum social benefits? Should companies be given financial incentives to hire low-skilled workers or should workers be encouraged to return to work?

The standard economic analysis posits that a differential mechanism such as the RMI (where one euro more earned at work translates into one euro less of benefits and, therefore, the same disposable income) leads to an "inactivity trap": in other words, this scheme generates marginal tax rates equal to 100%, operating as a disincentive to return to work. It thus became apparent that the advantage of microsimulation models in France was that they provided a basis for estimating distributions of financial work incentives.

A New Generation of Static Models

In addition, the new annual *enquête Revenus fiscaux* (from 1996 onwards) proved essential in providing an informational basis for microsimulation models dedicated to social policy analysis. In other words, the time was ripe for the emergence of a new generation of static models: data and at least three areas of interest – the financing of social security, the analysis of family policies and the evaluation of minimum benefit schemes.

At Insee, the Ines model (standing initially for *Insee Études Sociales*) was developed from the mid-90s onwards (David *et al.*, 1999). The model was soon used as part of the report from Claude Thélot and Michel Villac, commissioned by the then Prime Minister, Lionel Jospin, to respond to the contestation caused by the means testing of family allowances. These then become universal once again in return for a new cap on the benefit provided by the family quotient: here the key role of microsimulation in public decision-making is clear to see.

At the *Caisse nationale des Allocations familiales* (CNAF, the French national family allowance fund), the Myriade model was developed in the early 2000s (Legendre *et al.*, 2001). This model is specifically dedicated to the analysis of family policies. It was used as part of the reform of childcare subsidies, which led to the introduction in 2004 of a childcare benefit designed specifically for infants (the *Prestation d'accueil du jeune enfant*, or PAJE). The model has also been used, together with Ines, to assess *ex ante* different scenarios for the provision of support to young adults on behalf of the *Commission nationale pour l'autonomie des jeunes* (a dedicated Commission of experts – see Foucauld & Roth, 2002). It is particularly difficult to assess the standard of living of young people, especially students (not least because of their increasing numbers following the second "massification" of higher education). Insee's poverty statistics do not take households whose reference person is a student into account. By using the information on family relationships, microsimulation models provide a basis for going further and for assessing students' standard of living based on assumptions about the pooling of resources within an extended notion of family that reintegrates young adults who no longer share the parent's house.

In the mid-2000s, the *Observatoire français des conjonctures économiques* (OFCE), in collaboration with THEMA, a joint research unit that had acquired a degree of expertise in regulation based on standard cases (Hagneré & Trannoy, 2001), began work on the Misme microsimulation model in the mid-2000s. The book by Landais *et al* (2011b) helped to bring microsimulation methods to a wider audience. The model developed by the authors, as an extension of the Sysiff model, was adopted by the Institute for Public Policy (*Institut des politiques publiques*, or IPP) when it was first introduced in 2011; (Landais *et al.*, 2011a; Bozio *et al.*, 2012). The IPP publishes the statutory schedules on its website; these are consistently classified and regularly updated – a considerable task. The tax income schedule has been made available since it was first introduced in 1914. In addition, the Treasury Directorate-General was keen to develop its own expertise, a move that resulted in the development of the Saphir model presented in Amoureux *et al.* (2018). This model is used in preparing the Finance Act and the Social Security Financing Act, which is its main originality.

The potential contributions of microsimulation models to public policy development are well illustrated by the reform of the RMI (the minimum income scheme introduced in the late 1980s), which led to the *Revenu de solidarité active* (RSA). A relatively strong aversion to inequalities, which can be justified, for example, by the difference principle put forward by John Rawls, argues for the introduction of high minimum social benefits to provide the most vulnerable in society with an adequate standard of living. Differential social benefits create a strong disincentive to work. The theory of optimal taxation, developed in the 1970s by Mirrlees (1971), explains the terms of the trade-off between social equity and economic efficiency.

In France, Piketty (1997) argued, based on a very sketchy evaluation conducted by assuming that each decile of the wage distribution constitutes a representative employee, that marginal rates, according to the standard of living, are U-shaped, meaning that they tend to be very high at both ends of the distribution of earned income because of the RMI and housing allowances for the bottom of the distribution and income tax for the top of the distribution. Is this U-shaped profile optimal? It is certainly easy to lend it theoretical substance. To reduce inequalities, average rates must increase with income. A high marginal rate provides a means of increasing the average rate and thus ensuring redistribution; on the other hand, it creates strong disincentives to work. It is therefore preferable to have high marginal rates at the bottom of the distribution since, on the one hand, the number of individuals who are disinclined to work is low and, on the other hand, the number of individuals bearing a higher tax burden is high. Somewhat surprisingly, it is less easy to justify high marginal rates at the top of the distribution: for example, this requires retaining a particular distribution tail for high incomes.

Therefore, can a system that organizes, in a way, the exclusion of low-skilled individuals by pitting them against dissuasive marginal rates of return to work be described as "optimal"? The optimality of the system can be challenged in two very different ways: first, by arguing that the financial benefits of returning to work are probably not the main argument in participation decisions, particularly in a context of job shortages; second, by explaining that the losses for society resulting from the exclusion of the least employable individuals are probably underestimated. The idea that returning to work "doesn't pay enough" gained ground in the 2000s, as shown, for example, by Bourguignon (2001). Moreover, a clearer distinction is made between an intensive margin (marginal effective tax rates) and an extensive margin (effective tax rates on return to work), as argued, in particular, by Saez (2002). Microsimulation models document this question by estimating the profile of marginal tax rates as a function of earned income; see Albouy *et al*. (2002) and Legendre *et al.* (2004).

The implementation of the RSA was largely driven by this vision, putting microsimulation models to use in a different way, this time to quantify *ex ante* the cost of the reform by examining several scenarios on the "slope" of the scheme. The RSA initially provided for a basic minimum income support (RSA-*socle*) and a permanent work incentive scheme, called RSA-*activité*, which allowed beneficiaries to retain 62% of their earned income: the "slope" of the scheme was therefore equal to 0.62. The marginal taxation rates were thus limited to 38% at the bottom of the income distribution. However, the effective marginal tax rates generally remain higher, notably because of housing benefits. The *Prime d'activité* (an in-work tax credit scheme) replaced the RSA-*activité* and the *Prime pour l'emploi* (or PPE, an employment premium) on 1st January 2016 by merging them, allowing beneficiaries to retain 61% of their earned income. The budgetary cost of the RSA-*activité* has been difficult to estimate: the (decreasing) amount is relatively sensitive to its determinants, the basis used to calculate the benefit, which is quarterly, does not appear in the survey on tax and social income (*enquête Revenus fiscaux et sociaux*, ERFS), family configurations are an important factor, etc. Its determination was the subject of a report based on the work carried out with the Ines, Myriade and Saphir models, the subject being all the more burning since a specific tax on financial income had been introduced to finance the replacement of the RMI by the RSA. It then became apparent that the cost had been overestimated, in particular because of a high rate of non take-up. The profile of marginal rates is no longer U-shaped but tilde-shaped, as established, for example, by Sicsic (2018) with the Ines model.

The recent history of low-income support policies is probably better known: the in-work (or "activity") bonus was increased in 2019 following the "yellow vests" (or *gilets jaunes*) movement and the *Revenu universel d'activité* (or RUA, a new scheme of income support) project. Over the last thirty years, static microsimulation models have become indispensable tools for public decision-making. At the same time, dynamic models have enjoyed a similar rise in use.

The Development of Dynamic Models

The distinction between static and dynamic models is not simply a matter of presentational convenience. In fact, the two categories of models focus on relatively different areas, with dynamic models concentrating for the most part on assessing the future of pension systems. In dynamic models, individuals grow older and generational renewal is explicitly addressed. In France, the earliest models were developed at the periphery of the social and economic authorities, with pioneering work conducted by Didier Blanchet at the French Institute for Demographic Studies (INED), then further developed at Insee, in the *Redistribution et politiques sociales* Unit, with the construction of the first comprehensive dynamic model dedicated to the study of pensions in France, the Destinie model. This model was gradually developed from the mid-1990s onwards (Chanut & Blanchet, 1998; Division Redistribution et politiques sociales, 1999).

Demographers soon came to realise the value of microsimulation methods for population projections as an alternative to the component method, which remains the method of choice today. Under the component method, a given population is broken down into groups (e.g. women and men by year group) and changes in group size are monitored over time. For example, the aim may be to predict the number of women aged 50 in t+1; this figure is calculated based on the number of women aged 49 in t by applying the survival rate of women aged 49 in t. Where individual data are available, microsimulation methods are more effective than a projection method since individuals can be tracked over time, thereby generating all the information associated with each individual. The component method allows answering the question: How many women over 80 will there be in 30 years? Microsimulation methods also allow answering the following questions: How many women over 80 years of age will there be in 30 years who (i) are widows? (ii) have at least two children? (iii) own their own homes? And so on. In a dynamic microsimulation, family relationships are subject, like the other characteristics of individuals, to the ageing/renewal process, meaning that they are maintained and updated as necessary. Here we see the value, for social policies that are required to consider possible substitutions between family solidarity and national solidarity, of having at their disposal projections of a representative sample of the resident population incorporating family relationships. This point is explained very clearly in Chanut & Blanchet (1998).

Studies on Pensions

With regard to pensions, the first task was to measure all the effects of the 1993 reform relating to the general scheme, to an increase in the length of the contribution period, to the calculation of the average annual salary on which the pension is based over a longer period (from 10 to 25 years) and to the price-indexation of pensions: What were the savings on pension expenditure generated by the reform? Which measures resulted in the biggest savings? Did the reform lead to a reduction of inequalities in pension income? It is important to have an understanding of trends and changes in the lowest pensions in order to quantify the savings since it is necessary to take into account the minimum pension and the basic old-age pension. Thus, the first version of Destinie, based on the Household Wealth survey (*enquête Patrimoine*), adopted particularly simple assumptions by operating on the basis that the entire population was covered by the general scheme and benefited, in the case of supplementary pensions, from the ARRCO and AGIRC schemes (the two main pension regimes of the private sector).

The evaluation of the gradual transition, for the calculation of the average annual salary used in the computation of pensions, from the best 10 years to the best 25 years is not straightforward. At first sight, upward careers appear to be worst affected by the measure, thus leading to a reduction of inequalities in pension income. However, a review of the relevant regulations is sufficient to show that "multi-pensioners" were particularly affected since the extension of the calculation period was applied in each scheme (the 2003 reform amended this rule to limit the injustice to multi-pensioners). On the other hand, microsimulation highlights the anti-redistributive nature of the measure. In a retrospective microsimulation exercise on the generation born in 1938, Bridenne & Brossard (2008) show that it is the first deciles, depending on the level of the pension, that stand to lose the most from the measure, with the exception of the first decile, where the losses are limited by the minimum pension. In addition, the anti-redistributive impact is more pronounced for women than it is for men, with incomplete careers being a much more common phenomenon among women. This is a good illustration of the lessons provided by microsimulation: in this example, the results of microsimulation contradict the initial intuition.

The development of Destinie anticipated the demand for expertise: in the early 2000s, the modelling of retirement decisions was introduced into the model. The 2003 reform, which limited pension reductions (for people retiring early) and introduced the pension premium (for those going beyond the retirement age), gave more importance to the choice of retirement age, whereas in the previous system retirement at the full rate age was the best option. The second version of the Destinie model separates out the public service pension scheme and the model is thus designed to contribute to the evaluation of a universal pension plan. The model will not be discussed further here: Blanchet (2011) presents a detailed history of Destinie, while the second version of the model is examined in detail in Blanchet *et al.* (2011). Destinie was a pioneering model and remains central today since part of its information base[2] was incorporated into pensipp, a microsimulation model designed to project long-term pensions developed by the IPP (*Institut des Politiques Publiques*), and into Aphrodite (Cuvilliez & Laurent, 2018), a model built by the Treasury Directorate General to develop its own expertise, following the example of the static Saphir model. For its part, the department of the Ministry of Labour in

2. The biographies of individuals in the Household Wealth survey based on a comparison with the inter-scheme sample of contributors.

charge of statistics and studies (Drees) developed the Trajectory model (Duc *et al.*, 2016) by relying directly on the data from the all pension schemes sample in order to obtain detailed and reliable information on professional careers. This model was intensively used in 2018 and 2019 to feed the expertise of the High Commission for Pension Reform in charge of proposing a universal pay-as-you-go system. In addition, "sectoral" microsimulation models have been developed at the *Caisse nationale d'Assurance vieillesse* (CNAV, the National old age insurance fund) for the general scheme (Poubelle *et al*., 2006) and at the *Service des retraites de l'État* (the State pension authority) for the public service pension scheme.

Analyses of Ageing and Long-Term Care

One of the advantages of dynamic microsimulation models is to allow for disentangling age and generation effects. This is important, for example in health economics when studying ageing: when considering the use of health services, a distinction must be made between what relates to the state of health proper, which depends mainly on age but also on distance from death, and what relates to the behaviours involved in access to care, where the generation effect plays a key role. A similar capacity to dissociate temporal effects from generational effects is also found in the long-term analysis of pensions. In a defined benefit system (such as the French basic annuity scheme) that protects pensioners from economic and demographic risks, the pension scheme presents necessarily a "dependence on growth" identified by Blanchet *et al.* (2011), the 2008-2009 financial and economic crisis having created the prospect of sustainably weaker growth. Using the Pensipp model, Blanchet *et al.* (2016) discuss three scenarios for reducing this "growth dependence", including a point-based defined contribution pension system.

Finally, dynamic models are particularly used in research on dependency, a risk that could (and should) be covered by social security. Using the Destinie model, Marbot & Roy (2015) outlined the prospects for the *Allocation personnalisée d'autonomie* (APA, an allowance aimed at people aged 60 and in need of care). Comparative work by Bonnet *et al.* (2019) illustrate the use of microsimulation to discuss the prevalence of dependency among the elderly and the associated financing options in nine European countries.

The Consolidation Phase of Microsimulation Models

The somewhat rosy outline provided above requires some qualification. There is no doubt that microsimulation models have come to play a central role in the field of public policy evaluation, but it has also become apparent they are very costly to maintain. To inform the public debate, it is always possible to produce "series of variants", where the main components of the tax and social security system are assessed on the basis of a more or less marginal change to the parameters of their schedule. For example, income tax is assessed by increasing all schedule rates by 1%, before then increasing all tax bracket thresholds by 1%, etc.; each time, the results are presented as a deviation from the reference situation and broken down according to criteria of interest. By proceeding in this way, we are able to shed light on how our tax and transfer system actually operates.[3] However, in many cases, new measures under discussion do not fall within the scope of parametric reforms, instead taking the form of altogether new schemes which, in the microsimulation model, require both searching for the information necessary to determine eligibility for the scheme and programming a new module in the model from scratch. It seems difficult to propose a "push-button" instrument that would allow an imperfectly informed user to really benefit from the model.

After the 2000s, a period marked by a proliferation of models, the 2010s have been a period of consolidation during which Ines has become a central model, not least because of the high maintenance costs of these models, while Destinie has become a reference model.

The Institutionalisation of the Ines and Destinie Models

The institutionalisation of the Ines model occurred in several stages. In the early 2000s, Insee and the Drees (the Directorate of statistics and studies of the ministries of social affairs in charge), agreed to work in collaboration to develop the model, now referred to by the acronym Insee-Drees. The two institutions will pool the costs of developing and maintaining the model.

3. *Since 2018, Insee has made available a series of variants (*cahiers de variantes*) of benefit and tax reforms, based on the Ines model (https://www.insee.fr/fr/statistiques/fichier/3604001/CAHIER_VARIANTES_tableaux.xls, the new versions are available on the Ines page https://www.insee.fr/fr/information/2021951). See Fontaine & Sicsic (2018) for the methodology and variants for 2016, Biotteau & Sicsic (2019) for 2017.*

The second stage saw the CNAF abandon the Myriade model and join the Ines consortium. There were many reasons for this, including, among others, the proximity of the teams that had collaborated on the evaluation of the implementation of the RSA, closer collaboration further upstream to develop the ERFS survey, difficulties in maintaining Myriade, which had been programmed in C++, the persistently high cost of maintaining the models and difficulties in recruiting and motivating data analysts on this type of project.

Finally, more recently, the opening of the Ines source code in 2016 has reconfigured the landscape. In 2018, the Treasury Directorate General made the Saphir model code available to the public under pressure from the *Commission d'accès aux documents administratifs* (CADA, a body that regulates access to administrative documents). On the other hand, Insee and the Drees, both part of the Official statistical service, had adopted a more open position by promoting the appropriation of the Ines model by third parties. As a result, the Ines model has come to play a central role, as illustrated, for example, by the OFCE's use of the model. Overall, despite the fact that key actors such as Parliament are struggling to develop expertise in the evaluation of public policies (Padirac, 2018), the situation has improved considerably: it is now possible to challenge, on the basis of an internal critique, the evaluations put forward by government and to develop independent expertise more easily than before by taking advantage of free access to the tools developed by the official statistical services. The last remaining obstacle concerns access to data. As things currently stand, "running" the Ines model requires an authorization of access to the data from the ERFS (*enquête Revenus fiscaux et sociaux*).

As noted above, Destinie came to play a particular role in the 2000s, with its information base being reused by others and its modular structure allowing it to be used on topics related to population ageing. The source code was made publicly available in 2018 and the model is very precisely documented for the benefit of both ordinary users and modellers.

The Call for Standardisation

The consequence of the homogenisation of the field was, it seems, a call for standardisation. National accounts have worked tirelessly, albeit at the cost of many conventions, to clarify the content of macroeconomic aggregates: thanks to the 2010 European system of accounts, we know precisely what public debt is "in the Maastricht sense". In other words, microsimulation models should be more aligned to describe the different components of the tax and social security system. For example, it is difficult to count all compulsory levies as taxes since some levies provide individualised benefits. In particular, because of the close link between contributions and benefits, old-age pension contributions should be seen as elements of remuneration.

On the other hand, indirect taxes are often excluded from the analysis of redistribution despite the fact that in the public debate they are often perceived as anti-redistributive. We can mention here a recent study that uses a microsimulation approach to examine the effects of an increase in VAT (André & Biotteau, 2019). Similarly, the degree to which public spending is individualised can vary: such is the case, for example, of education spending. It is thus clear that it is possible to standardise imputations that relate either to indirect taxes or to public expenditure in order to document the situation of social groups that would bear significant indirect taxes but would benefit relatively little from public services.

The issues of non take-up of social benefits and benefit fraud would merit being taken into account in microsimulation models. Non take-up was a key argument used as part of a largely negative evaluation of the RSA. In other words, microsimulation models could be refined to incorporate this particular dimension into the evaluation of social policies. Such models could help in the fight against non take-up by identifying the relevant causes. They would also provide some perspective on the matter by estimating the intensity of non take-up: however serious it may be for a family to be deprived of assistance that could enable it to escape poverty, it is also very easy to see why a family should not request what is effectively very limited assistance (with the minimum amount of the RSA currently standing at 6 euros). Finally, the National Accounts (Hagneré & Mahieu, 2017) seek to take into account illicit work. In social policy making, the possibility of fraud sometimes determines the architecture of the system. Microsimulation models could help to make this type of constraint explicit.

A Roadmap for Microsimulation Models

We now attempt in this last section to present a roadmap for microsimulation models for the coming years. Three important topics are already discussed above: the introduction of universal benefits and certain means-tested benefits with the RUA, work on a universal pension scheme and the insistent question of social insurance for long-term care risk. The use of microsimulation models has been structured around these three topics. These models could also be used to inform public debate on two other issues: climate transition and universal income. We will finish by the perspectives opened up with the consolidation into a single declaration (the *Déclaration sociale nominative*, DSN) of the mandatory declarations that employers must make.

Microsimulations to study policies of ecological transition

It seems to me that the ecological transition will undoubtedly require the expertise provided by microsimulation models. Alongside, of course, the education of individuals and the introduction of strict regulations, it is difficult for economists to disregard the need for a substantial increase in the price of the factors that cause environmental degradation (see also Quinet, this issue). On the one hand, the price of energy, for example, has not seen the increase that would have been required for global warming to be contained. I cannot resist reminding here that after the first oil shock in 1975, the price of a litre of petrol was approximately 2.20 French francs, compared to around 1.60 Euros in 2018. Between those two dates, the gross minimum wage rose from 7.30 French francs per hour to 9.90 Euros. Purchasing a litre of petrol in 1975 required 20 minutes of work, compared to around 10 minutes in 2018. On the other hand, the price of factors that harm the environment is too low to enable investments that could help avoid them to be financially profitable: simply put, what is the point of insulating your home if your annual heating bill only drops by a few hundred Euros? Aligning economic profitability with ecological profitability might involve investment aid. However, it is far more likely to involve a significant increase in the price of all the factors that cause negative externalities on our environment – an increase obtained through taxation. However, a view such as this is socially unacceptable since it amounts to making the most disadvantaged in society pay for the ecological transition. There is, therefore, no “double dividend”: the revenues from such taxation intended to charge a full price (i.e. including negative environmental externalities) must be used to help individuals adapt and change their habits. It is therefore necessary, first, to identify families in “fuel poverty” and, second, to assess different support systems. The range of existing schemes is extremely broad, from the *crédit d’impôt transition énergétique* (CITE, a tax credit aimed at energy transition) to the *chèque énergie* (granted on a means-tested basis). As the price of energy remains low, these schemes are targeted by being reserved for certain investments or families, with many attendant disadvantages, including a partially arbitrary list of investments, the stigma of means-testing, the weakening effect of non-universality on social cohesion and widespread non take-up. With the increase in taxes, aid could be massively increased and much less targeted. If we want to use taxation in this way in order to contribute to the ecological transition and if we want it to be socially acceptable (rather than being perceived as “punitive taxation”), it seems important to inform the public debate with the lessons provided by microsimulation models. Examples include work developed with the Prometheus model (Thao Khamsing *et al.* 2016), or with the Taxipp model (Douenne, 2018). These models may not be capable of predicting social movements, but they do have the potential to identify the anti-redistributive effects of indirect tax policies.

The Evaluation of Universal Income Schemes

A second issue that could come up in the public debate is the question of universal basic income. The weak version of universal basic income involves a simplification of the tax and social security system. The most striking illustration is perhaps to be found in family policies: currently, family allowances are no longer universal, the benefit provided by the family quotient is capped at a relatively low level, the first child does not grant the right to receive allowances but does confer the right to the family quotient so that only taxable families are supported, the back to school allowance is paid based on means testing, etc. Ultimately, it seems more legitimate to replace this set of provisions with a universal allowance granted from the first child, the amount of which would only depend on the age of the child, with half of the allowance being paid to the first parent and the other half going to the other parent. This is the just the kind of proposal put forward, for example, by Régent (2018) on the basis of a careful examination of social legislation. It would be worthwhile applying a microsimulation model to the matter with a view to assessing all the associated consequences. Our tax and social security system could also be simplified by moving to an individualisation of income tax, meaning that married couples or partners in a Civil Solidarity Pact (PACS) would be taxed separately. The twin pressures of the RSA and income tax could be converted into a universal basic income corresponding to the RSA-*socle* and a universal income tax. The purpose of these reforms is not only simplification. They are also designed to reduce the sense of injustice. In other words, the principle is that no one is excluded from the right to universal basic income or from the duty of universal taxation.

The strong version of universal basic income is more a matter of stabilising the income of households in the face of anticipated upheavals in the labour market. It is not necessarily a question of imagining massive job losses as a result of the automation of the economy, which the creation of new jobs would do little to offset. We can at least predict that the content of jobs will change dramatically and that there will be significant pressure on employees to be adaptable. The result will be a strong social demand for a new form of security for individuals, such as a relatively high level of universal basic income. Therefore, static microsimulation models are not necessarily the most appropriate tools for examining the consequences of this kind of reform. Would a universal basic income lead to an increase in the number of people working part-time out of choice (rather than not finding a full-time job)? Would it create upward or downward pressure on the lowest hourly wage rates? Establishing this would require developing a model that gives sufficient consideration to the behaviour of workers and companies to inform the debate.

A New Landscape for Data

The final topic is the matter of data, a crucial factor for microsimulation models. With the *Déclaration sociale nominative* (DSN, replacing all the periodic declarations sent by employers to various administrations) fully in place for most employers since 2017, the landscape has changed profoundly in terms of the range of administrative sources that provide information on household income and serve as a basis for the input sample of a static microsimulation model. The DSN contains monthly data on earned income, which also include a volume/price split (i.e. data on hours worked and total remuneration and, therefore, on the hourly rate of remuneration). First, the new framework places the revenue authority in a special situation: since it also knows all of the occupants of a dwelling, it is able to build a highly representative sample for a microsimulation model. Second, in its current form, the *enquête Revenus fiscaux et sociaux* (ERFS) is clearly becoming secondary: the value of matching it with the Labor Force survey, which provides information on individuals' economic activity, is lessened and its disadvantages are more obvious (such as the scope being limited to ordinary households and the areolar structure of the sample design not allowing for detailed regional statistics). Third, access to the history of the DSN for each individual considerably increases the accuracy of the schedule-based imputations. One of the difficulties encountered by microsimulation models concerns the means-testing used to determine eligibility for most social security benefits. Means can be estimated over a period of one year or one quarter; they are also estimated with a variable time lag. For example, housing benefits are calculated based on a family's annual means but with a two-year lag. In the case of the RSA, the quarterly means of the previous quarter are taken into account. However, it remains very difficult to assess individuals' entitlement to unemployment benefits, calculated on a daily basis based on a history of employment of varying length.

We are thus beginning to see the outline of a major survey made available to researchers that would provide a basis for cooperation and competition in the development of microsimulation models: specifically, cooperation to build a common information base (individual data but also schedule parameters) and competition to ensure a range of expertise in the field of economic and social policy evaluation. The data generated by the DSN would provide the information on working conditions but also on mobility between home and work; tax returns and the information available to the revenue authority would provide the information on other income, including sickness and unemployment benefits, but also on various characteristics relating to housing and the local authority of residence. It would, of course, be necessary to impute a large amount of missing data, but researchers would have a very complete picture of individual situations and circumstances, including, in particular, local benefits (Anne & L'Horty, 2002) and indirect taxes.

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One of the strengths of microsimulation methods is that they allow for a contribution to economic policy debates in a straightforward manner by countering *ad hoc* examples, which are highly unrepresentative, with examples that are truly relevant because they are sufficiently widespread. Despite this potential, microsimulation methods remain somewhat overlooked. Macroeconomic modelling, in conjunction with the improvement of national accounts, has developed a common space for macroeconomists. New-Keynesian models have provided a framework in which controversies have flourished: we need only think of the Phillips curve, the Lucas critique or the Taylor rule. Stochastic dynamic general equilibrium models with nominal or real rigidities have even been seen as a continuation of New-Keynesian models.

However, microsimulation models have not provided a comparable space in which social policy controversies would have developped. The academic world continues to make too little use of these methods. But there is good reason to believe that given the very strong social demand for evaluating social policies, microsimulation methods will come to play a more central role in the toolbox of statisticians and economists. ☐

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