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Abstract[1]

During the last twenty years, microsimulation models have been increasingly applied in qualitative and quantitative analysis of public policies. This paper provides a discussion on microsimulation techniques and their theoretical background as a tool for the analysis of public policies with particular attention to redistribution and social policies. Basic principles in using microsimulation models and interpreting their results are analyzed, with particular emphasis on tax incidence, redistribution and poverty analysis. Social welfare analysis permitted by microsimulation techniques is also discussed. Finally, the paper points to limits of present approaches and directions for future research.

Key Words: Microsimulation; Evaluation of Public Policies; Optimal Taxation; Poverty and Inequality.

JEL Classification: C81; D31; H21; H23; H31

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Introduction

Microsimulation models (msm) are tools that allow the simulation of the effects of a policy, on a sample of economic agents (individual, households, firms) at the individual level. This approach to policy evaluation is based on the representation of the economic environment of individual agents, their budget constraint in particular, and, possibly, their behaviour. A 'policy simulation' then consists of evaluating the consequences of a change in the economic environment induced by a policy reform on a vector of indicators of the activity and/or welfare for each individual agent in a sample of observations.

The microsimulation approach in economics imitates the experimental approach in biology or psychology. Yet, a major difference is that experimentation in the latter disciplines relies on the comparison of observed state and behaviour of the agents being studied before and after a change in their environment has been imposed to them. In economics, the simulation bears only on the change in the environment and on 'imputed' changes in behaviour or welfare. The comparison is thus made on an ex-ante basis rather than ex-post. To be sure, ex-post evaluations are also possible in economics and the field of 'impact evaluation' is growing quickly – see Duflo (2003). However, this approach often is too cumbersome, costly and time consuming for real time policy analysis. Even though much more handy, the use of *msm* in economics as a tool for the analysis and support for public decision-making processes started to developing only recently. In 1957, Orcutt[2] planted the seed of microsimulation as an instrument for economic analysis, but it is only since the early 1980s that the use of *msm* developed, undoubtedly as a consequence of the increasing availability of large and detailed datasets on individual agents and the continuous increase in, and falling cost of, computing power[3].

The importance and usefulness of microsimulation techniques in the analysis of public policies comes from two aspects. First and foremost, is the possibility of fully taking into account the heterogeneity of economic agents as they are observed in micro-data sets. Working with some "typical agents" (i.e. typical households or typical firms) often is the first approach to evaluating the impact of fiscal and social policies. It certainly gives a general idea about the consequences of the reform being analysed but it can hide unexpected effects arising with

[2] See Orcutt (1957), Orcutt, Greenberger, Korbel and Rivlin (1961), Orcutt, Merz and Quinke (1986).
[3] For a detailed description of the "history" and developments of microsimulation in economic analysis, see Atkinson and Sutherland (1988), Merz (1991), Citro and Hanusheck (1991), Harding (1996), Gupta and Kapur (2000).

certain combinations of individual characteristics that could not be apprehended through 'typical cases'. In addition, even when various 'typical cases' are considered, it is never clear how representative they actually are. Working with thousands of actual economic agents rather than a few hypothetical ones permits avoiding these two difficulties. In particular, it permits identifying with precision who are likely to be the winners and losers of a reform. Such information is indeed crucial to evaluate the overall welfare effect of the reform as well as political economy factors that may hamper its implementation. The second aspect concerns the possibility of accurately evaluating the aggregate financial cost/benefit of a reform. The results obtained with an *msm* at the level of individual agents can be aggregated at the macro level allowing the analyst to evaluate the effect of the policy on the government budget constraint. Clearly, the standard 'typical case' approach could not permit such an accurate evaluation of the budgetary cost of a policy reform.

Because of these strong advantages over the 'representative agent' approach, and also because of continuing progresses in data availability and computing facility, the microsimulation approach to economic policy analysis is bound to intensify and to deepen. At the same time, better data and more powerful machines and software enabling analysts to conduct more and more complicated calculations are likely to modify the nature of microsimulation exercises. This process is indeed under way. Not only do micro-data occupy today a space in applied economic analysis that has become considerable but also they are giving rise to more and more sophisticated treatment. The purpose of this paper is to review that evolution and to point to the most promising directions for further development of microsimulation techniques. It does so by focusing on redistribution policies, a domain of application of microsimulation that has been particularly active during the last two decades.

1. A taxonomy of microsimulation models applied to redistribution policies

The common structure of *msm* in redistribution analysis comprises three elements: 1) a micro dataset, containing the economic and socio-demographic characteristics of a sample of individuals or households; 2) the rules of the policies to be simulated - i.e. the budget constraint faced by each agent; 3) a theoretical model of the behavioural response of agents. Existing *msm* differ essentially with respect to this last dimension. Behavioural responses which may be of relevance in connection with redistribution policies, include labour supply, savings and household family composition –i.e. marriage/partnership, cohabitation of children, fertility. A clear taxonomy may be established according to whether some of these behavioural responses are included or not in the analysis, the time dimension of these responses and the partial versus general equilibrium focus of the analysis.

Msm that ignore behavioural responses altogether are sometimes called *arithmetical models*. This type of model simply applies the change in the budget constraint that households face because of the reform in redistribution policy without taking into account any change in their market income and in their demographic composition. Based on market incomes and the socio-demographic characteristics of a household, they arithmetically derive its disposable income and net tax payments given the rules for the computation of taxes and benefits in the policy being analysed. The simplicity of these models is rather appealing, even though it must be kept in mind that the computation of taxes and benefits in most advanced redistribution systems requires a few thousands of lines of code.

Behavioural msm include a detailed representation of the behavioural response of individuals and households to changes in their budget constraint. The type of behaviour taken into account differs across models, even though consumption and labour supply are the most frequent focus of interest. Given the system of pre-tax prices and wage rates, and given the shape of the budget constraint, behavioural *msm* compute the optimal consumption demand and labour supply of each agent. To do so, a model of consumption and labour supply must have been estimated, or possibly 'calibrated', and must be incorporated in the *msm* framework. Of course, the availability of such a model allows for a more detailed analysis of household welfare and the aggregate budget constraint of the redistribution authority.

The time dimension of *msm* depends on the object of the analysis and the kind of behavioural response that is incorporated in the model. For instance, evaluating the effects of a reform of the income tax that would modify the treatment of children will have little effects on household composition in the short-run. An arithmetical *msm* will then be sufficient. Long-run effects, however, require simulating the impact on fertility decisions of the tax reform. A dynamic framework may then become necessary where households are followed over time. Likewise, the microsimulation of changes in the parameters of the tax-benefit system that affect inter-temporal consumption allocation, retirement, training, schooling of the children, etc., must be analysed with *dynamic msm* rather than the static models defined earlier.

The final dimension along which *msm* may differ has to do with the partial equilibrium approach implicit in considering that behavioural responses have no impact on the price system. If labour supply effects arising from a reform of the tax-benefit system are large enough, changes in the structure of wages and prices may be expected to take place. Most models ignore these general equilibrium effects and may thus be called 'partial equilibrium' models. However, *msm* that take into account general equilibrium effect are also being developed. Some of them may be related to the now prolific Computable General Equilibrium literature and essentially try to link these sectoral models to a household micro-data base. Others limit themselves to a subset of markets, most often the labour market.

It would also be possible to establish a taxonomy of *msm* on the basis of their field of application in the broad area of redistribution policies: indirect taxation, direct taxation, social security systems, non-contributory benefits, etc. As the objective of the present paper is more methodological than policy oriented, it seemed more effective to hold on to the preceding taxonomy. The rest of this paper is devoted to a review of the preceding types of models and the use made of them, the emphasis being put on the economic assumptions they implicitly or explicitly rely on, and on the appropriate way of interpreting their results.

2. Arithmetical microsimulation and tax incidence analysis.

As said earlier, arithmetical *msm* in the redistribution field simulate the change in the real disposable income, of individuals or households due to a change in the rules for calculating tax or benefit payments *under the assumption that individual behaviour is unchanged*. Thus, the effect of an increase in the indirect tax rate on good *i* for individual *j* is to reduce the 'real' disposable income of *j* by an amount equal to the change in the final price caused by the tax times the consumption of good *i* by that individual. Likewise, the effect of a reform of the income tax is the change in the real disposable income that it generates for constant market income from labour or other sources. Under these assumptions, it is a simple matter, at least conceptually, to identify the winners or losers of any reform of the tax-benefit system and to compute how much every one loses or gains in terms of real disposal income.

The assumption of unchanged behaviour has often been criticised by potential users. It is important to realize, however, that it is not as restrictive as it would appear. Under some conditions, they are fully consistent with the existence of behavioural responses. They simply give an estimate of the first round effect, which is itself a good approximation of final welfare effect if changes are small enough and individuals may be thought to operate in perfect markets. This is in direct application of the well-known envelope theorem as is shown below.

- *Theoretical justification of arithmetical microsimulation*

The familiar utility theory of consumer behaviour provides a simple income metric of a change in welfare due to any modification of the budget constraint. To measure a household's welfare gains and losses from a reform define $V_i(p, y_i)$ as the indirect utility function of that household (indexed *i)* :

$$V_i(p, y_i) = p.x^M(p, y_i) \text{ with } x^M(p, y_i) = Arg\max\left\{U_i(x_i) \text{ s.t. } px_i \leq y_i\right\} \quad (1)$$

where y_i is household *i*'s income, *p* the price vector that it faces, $U_i(x)$ its direct utility function, and $x^M(p, y_i)$ its vector of Marshallian demand functions.

The welfare effect of a public policy affecting marginally household *i*'s income at constant prices *p* is given by $\Delta V_i = V_y^i \Delta y_i$ where V_y^i is its marginal utility of income. Inverting this expression, one may express any change in the welfare of individual *i* in terms of an 'equivalent' variation of income, Δy_i^* :

$$\Delta y_i^* = \Delta V_i / V_y^i \quad (2)$$

In other words, there is complete equivalence between the change in the welfare income metric, Δy_i^*, and the change in welfare once a value has been selected for the marginal utility of income V_y^i. However, the latter is essentially unobserved and has therefore to be chosen arbitrarily on a purely normative basis.

Consider now a policy change that affects the price vector *p*. Differentiating the indirect utility function yields:

$$\Delta V_i = \sum_j V_{ij} \Delta p_j \quad (3)$$

where V_{ij} is the derivative of the indirect utility function with respect to the price p_j. From the envelope theorem, or Sheppard's lemma or Roy theorem, it is known that:

$$V_j = -V_y^i . x_j^M(p, y_i) \quad (4)$$

Replacing in (3) and using the welfare income metric definition (2), it comes that the change in the price vector Δp causes a change in the welfare of individual *i* that is equivalent to a change in income given by:

$$\Delta y_i^* = -\sum_j x_j^i \Delta p_j \tag{5}$$

where x_j^i is the actual consumption of good *j* by household *i*.

The preceding equation fully justifies the arithmetical microsimulation approach. It indeed implies that the change in the welfare income metric due to a change in price is simply equal to the change in the cost of the consumption basket due to the price change, Δp. This result generalizes easily to the case where the 'consumption' vector, *x*, also includes labour supply or possibly the production of certain goods by the household itself. In this more general case, call y_i^0 the income of household *i* which is truly exogenous, that is income not coming from labour or from the sale of goods. The preceding argument implies that:

$$\Delta y_i^* = -\sum_j x_j^i \Delta p_j + \Delta y_i^0 \tag{6}$$

where x_j^i is now to be interpreted as the 'net' demand of good - or labour service - j by the household. Then, imagine a change in the tax-benefit system that affects the price the household receives for the goods and services it sells on the market, its exogenous income y_i^0 and possibly the price of the goods that it consumes. The preceding expression shows that the change in the welfare of agent *i* may be obtained by applying the new price system generated by the reform of the tax-benefit system to the initial bundle of consumption, production and labour supply of the agent. This is exactly the assumption behind the arithmetical microsimulation approach. Since the preceding argument only applies at the margin, it can be shown moreover that the same reasoning applies when the price system is non-linear, as it is practically the case with tax-benefit systems in most developed countries – through instruments like progressive income taxes or means-tested benefits.

According to the preceding argument, it is therefore erroneous to present arithmetical *msm* as based on the assumption that agents' behaviour is totally rigid. In effect, this approach to the evaluation of policy reforms is fully consistent with the existence of behavioural responses. The point is simply that these responses may be ignored when evaluating individual change in welfare levels, provided some specific conditions hold. These include in particular that: a) the reform is causing only 'marginal' changes in the budget constraint faced by agents; b) all agents are optimising under their sole budget constraint, which implies that all markets are perfect in the sense that agents are never rationed.

If the preceding argument justifies that arithmetical *msm* may ignore behavioural responses when evaluating changes in individual and social welfare, it does not offer the same justification when evaluating changes in tax revenues or benefit payments due to a reform. The envelope theorem cannot be invoked in that case and it is simply not true that raising the tax rate on a specific good will increase revenues proportionally to the initial consumption of that good. Thus, arithmetical *msm* do not permit taking rigorously into account the budget constraint of the government, when strong behavioural responses to a reform are expected.

Other sources of inaccuracy are present in the arithmetical *msm* approach[4]. The first comes from the assumption, often made when using arithmetical *msm* for tax-incidence analysis, that tax changes are completely passed on to consumers prices or net wages. This would be true only in the case of a long-run competitive market equilibrium (an hypothesis that may sometimes be far from reality). To be fully rigorous, some type of partial or general equilibrium model taking into account the production side of the economy should be used to determine the way in which a change in the tax system translates into changes in consumer or producer prices and in wage rates.

Tax evasion and non take-up of the benefits are other important sources of inaccuracy in arithmetical *msm*. These models are normally built under the hypothesis that taxpayers report all their incomes and that any household entitled to a certain benefit actually cashes it. In reality, tax evasion often is common practice. Likewise, some households do not ask for social assistance even though they are entitled to it by the law[5]. This may occur for multiple reasons including lack of information, social stigma, complexity of the administrative procedures, etc. Reciprocally, some household may be receiving benefits, although they do not qualify for them, because of information problems in the management of the system.[6] Tax evasion and non take-up could be dealt with without too much difficulty if it could be assumed they would not be affected by a reform of the tax-benefit system. It would be sufficient to observe this phenomenon in the database used for the simulation. This is unlikely, however. Increasing

[4] See the list established by Sahn and Younger (2003) for applications of this approach to the incidence of indirect taxation.

[5] About the take-up problem see: Hancock, Pudney and Sutherland, (2003) "*Using Econometric Models of Benefit Take-up by British Pensioners in Microsimulation Models*" paper presented the conference: "International Microsimulation Conference on Population, Ageing and Health: Modelling Our Future" held in Canberra-Australia- in December 2003.

[6] See Duclos 1995a, 1995b, 1997 and Duclos et al. (2004).

income tax rates is making tax evasion more profitable, other things equal, and increasing a benefit is making non take-up more costly. In other words, tax evasion and benefit take-up may be part of the behavioural responses that are ignored in the arithmetical *msm* approach.

- *Examples of application*

There is an extensive literature on the application of arithmetical *msm* techniques to the analysis of reforms of tax-benefit systems. Atkinson and Sutherland (1988), Merz (1991), Citro and Hanusheck (1991), Harding (1996), Sutherland (1998), Gupta and Kapur (2000), among others, offer surveys of *msm* and their use in Europe and United States[7]. Tax incidence analysis, as well as the analysis of the incidence of public spending in areas like education or health also belongs to the arithmetical *msm* tradition. There is an extensive literature in that area (see for instance Creedy, 1999, and Sahn and Younger, 2003 in the case of tax incidence and Demery, 2003, in the case of public spending). Particular attention has been given in Europe to the analysis of policy reforms at national and European level, with a special interest for the issue of the harmonization of tax and social policies. For example, Atkinson, Bourguignon and Chiappori (1988) analyse the effect on a given sample of French households from replacing the French by the British tax-benefit system. De Lathouwer (1996) simulates the implementation of the unemployment benefit scheme enforced in the Netherlands, on a sample of Belgian households, shedding light on the importance of the socio-demographic characteristics of the population for the performance of a redistributive system. Callan and Sutherland (1997) compare the effects of different types of fiscal and social policies on the welfare of households in certain EEC countries. Bourguignon et al. (1997) use a microsimulation model to simulate the effects of the enforcement of the same child benefit scheme on the populations of France, the UK and Italy, whereas Atkinson et al. (2002) analyse the effect of introducing universal minimum old-age income in a larger number of European countries.[8]

By definition, *msm* models provide information on the way every individual or household in a sample is affected by a reform in the redistribution system. This allows identifying precisely the gainers and the losers of a reform, and their characteristics. In general, however,

[7] See also the papers presented at the conference: "International Microsimulation Conference on Population, Ageing and Health: Modelling Our Future" held in Canberra-Australia- in December 2003. The papers can be downloaded at the Web address: http://www.natsem.canberra.edu.au/conference/papers/index.html

[8] The preceding studies all rely on Euromod, an ambitious microsimulation model that covers the 15 EU members For a detailed description and other applications of this model, see Sutherland (2001) and the website: http://www.econ.cam.ac.uk/dae/mu/emod.htm

information at the individual level must be aggregated in order to be of some policy significance. Typically, individuals or households are grouped by socio-demographic characteristics or by initial level of real income or welfare. Changes in their disposable income due to the reform being analysed is given for these various groups. In addition, most models also provide changes in several social welfare indicators computed on the whole population. These include not only the mean disposable income per adult equivalent but also a number of inequality indices (Gini, Theil, Atkinson measures with varying inequality aversion parameters), several poverty measures, and the application of relative or absolute Lorenz dominance criteria.[9] Spadaro (2005) provides a good illustration of international welfare-based comparisons of tax-benefit systems relying on the arithmetical *msm* approach.

Several models also provide information on the distribution of the 'effective marginal tax rates' in the population, defined as the additional disposable income resulting from an additional currency unit of market income after taking into account changes in taxes and benefits. Although no behavioural response is taken into account in the model, these marginal tax rates give information on the labour supply incentives associated with a particular tax-benefit system. Changes in these marginal tax rates are thought to give some rough idea of the effect of a reform on incentives and therefore of the likely size of the behavioural response.[10]

3. Behavioural microsimulation models and social welfare analysis.

As indicated in the previous section, ignoring behavioural reactions can lead to misleading results in several situations. The first part of this section is devoted to a discussion of the way in which behavioural response may be introduced in *msm.* The second part is devoted to several applications of these models to social welfare analysis.

- Building a behavioural msm

As arithmetical models, behavioural *msm* rely on micro household databases. Nevertheless, they add an important component to the analysis. The point is not only to count how much more, or less, everyone is receiving or paying because of a reform in his/her budgets constraint but to take into account the behavioural response of the agents to this change in the budget constraint. This may be done through the estimation of a *structural econometric model* on the cross-section of households available in the survey being used and/or through the *calibration*

[9] For a complete survey on welfare dominance theory, see Lambert (1993).
[10] See Bourguignon, Chiappori and Hugounenq (1993).

of a behavioural model with some predetermined structure so as to make it consistent with behaviour actually observed in the survey, and meant to correspond to the status quo.

Tax-benefit models with labour supply response are the archetypical example of behavioural *msm*. Changes in the tax-benefit system in these models affect the budget constraint of households. They modify their disposable income with unchanged labour supply, but through the corresponding income effects, and also through changes in the after tax price of labour, they also modify labour supply decisions. By how much is determined through simulating a model of labour supply behaviour.

The behavioural *msm* approach thus comprises three steps: specifying the logical economic structure of the model being used, estimating or calibrating the model and simulating it with alternative reforms of the tax-benefit system. These steps are considered in turn.[11]

- The standard continuous modelling of labour supply

The logical economic structure is that of the textbook utility maximizing consumer. An economic agent, i, with characteristics z_i chooses his/her volume of consumption, c_i, and his/her labour supply, L_i, so as to maximize his/her preferences represented by the utility function $u(\ )$ under a budget constraint that incorporates the whole tax-benefit system. Formally, this is represented by:

$$\text{Max } u(c_i, L_i; z_i; \beta, \varepsilon_i) \quad \text{s.t.} \quad c_i \leq y_{0i} + w_i L_i + NT(w_i L_i, L_i, y_{0i}; z_i; \gamma), \ L_i \geq 0 \qquad (7)$$

In the budget constraint, y_{0i} stands for (exogenous) non-labour income, w_i for the wage rate and $NT()$ for the tax-benefit or 'net tax' schedule. Taxes and benefits depend on the characteristics of the agent, his/her non-labour income and his /her labour income, $w_i L_i$. It may also depend directly on the quantity of labour being supplied, as in workfare programs. γ stands for the parameters of the tax-benefit system - various tax rates, means-testing of benefits, etc.. Likewise, β and ε_i are coefficients that parameterise preferences, the latter being idiosyncratic. The solution of that program yields the following labour supply function:

$$L_i = F(w_i, y_{0i}; z_i; \beta, \varepsilon_i; \gamma) \qquad (8)$$

This function is non-linear. In particular, it is equal to zero in some subset of the space of its arguments – i.e. the non-participation solution.

[11] The most basic methodological reference for this approach is the pioneering work by Hausman (1980, 1981, 1985).

Suppose now that a sample of agents is observed in some household survey. The problem is to estimate the function *F( )* above, or, equivalently, the preference parameters, β and ε_i, since all the other individual-specific variables or tax-benefit parameters are actually observed. To do so, preference parameters are broken down into a set of coefficients β common to all agents, and a set ε_i that is idiosyncratic. The latter plays the usual role of the random term in standard regressions.

Estimation proceeds as with standard models, minimizing the role of the idiosyncratic preference term in explaining cross-sectional differences in labour supply. This leads to a set of estimates $\hat{\beta}$ for the common preference parameters and $\hat{\varepsilon}_i$ for the idiosyncratic preference terms. By definition of the latter, it is true for each observation in the sample that:

$$L_i = F(z_i, w_i, y_{0i};\ \hat{\beta}, \hat{\varepsilon}_i; \gamma) \qquad (9)$$

It is now possible to simulate alternative tax–benefit systems. This simply requires modifying the set of parameters γ.[12] In absence of general equilibrium effects, the change in labour supply due to moving to the set of parameters γ^s is given by:

$$L_i^s - L_i = F(z_i, w_i, y_{0i};\ \hat{\beta}, \hat{\varepsilon}_i;\ \gamma^s) - F(z_i, w_i, y_{0i};\ \hat{\beta}, \hat{\varepsilon}_i;\ \gamma) \qquad (10)$$

The change in the disposable income may also be computed for every agent. It is given by:

$$C_i^s - C_i = w_i(L_i^s - L_i) + NT(y_{0i}, w_i L_i^s,\ L_i^s; z_i; \gamma^s) - NT(y_{0i}, w_i L_i,\ L_i; z_i; \gamma) \qquad (11)$$

Then, one may also derive changes in any measure of individual welfare.

Several difficulties in the preceding model must be emphasized at the outset. Its estimation generally is uneasy. It is highly non-linear because of the non-linearity of the budget constraint and possibly its non-convexity due to the tax-benefit schedule, *NT( )*, and corner solutions at $L_i=0$. Functional forms must be chosen for preferences, which may introduce some arbitrariness in the whole procedure. Finally, it may be feared that imposing full economic rationality and a functional form for preferences severely restrict the estimates that are obtained. There has been a debate on this point ever since the first model of this type - due to Hausman (1980) appeared in the literature – see in particular MaCurdy, Green and Paarsch (1990).

[12] Assuming indeed a structural specification of the NT( ) function general enough for all reforms to be represented by a change in parameters γ.

- *Using discrete choice models of labour-supply*

It turns out that simpler and less restrictive specifications may be used, which considerably weaken the preceding critiques. In particular, specifications used in recent work consider labour supply as a discrete variable that may take only a few alternative values, and evaluate the utility of the agent for each of these values and the corresponding disposable income given by the budget constraint. As before, the behavioural rule is then simply that agents choose the value that leads to the highest level of utility. However, the utility function may be specified in a very general way, with practically no restriction. Such a representation is therefore as close as possible to what is revealed by the data.

Formally, a specification that generalizes what is most often found in the recent tax and benefit labour supply literature is the following:

$$L_i = D_j \text{ if } U_i^j = f(z_i; w_i, c_i^j; \beta^j, \varepsilon_i^j) \geq U_i^k = f(z_i; w_i, c_i^k; \beta^k, \varepsilon_i^k) \text{ for all } k \neq j \quad (12)$$

where D_j is the duration of work in the *jth* alternative and U_i^j the utility associated with that alternative, c_i^j being the disposable income given by the budget constraint in (7):

$$c_i^j = y_{0i} + w_i . L_i + NT(w_i D_j, D_j, y_{0i}; z_i; \gamma) \quad (13)$$

When the function *f( )* is linear with respect to its common preference parameters, β^j, additive with respect to the idiosyncratic terms, ε_i^j, and when those terms are iid with a double exponential distribution, this model is the standard multinomial logit. It may also be noted that it encompasses the initial model (7). It is sufficient to make the following substitution:

$$f(z_i; w_i, c_i^j; \beta^j, \varepsilon_i^j) = u(c_i^j, D^j; z_i, \beta, \varepsilon_i^j) \quad (14)$$

This specification, which involves restrictions across the various work duration alternatives, is actually the one that is most often used.[13]

Even under its more general form, the preceding specification might be still found to be restrictive because it relies on some utility maximizing assumption. Two remarks are important at this respect. First, it must be clear that ex-ante incidence analysis of tax-benefit systems cannot dispense with such a basic assumption. *The ex-ante nature of the analysis requires some assumption to be made about the way agents choose between alternatives*. The assumption that

[13] For an extensive discussion of these specifications, see Bargain (2004).

agents maximize some criterion defined in the most flexible way across alternatives is not really restrictive. Second, it must be clear that, if no restriction is imposed across alternatives, then the utility maximizing assumption is compatible with the most flexible representation of the way in which labour supply choices observed in a the survey are related to individual characteristics, including the wage rate and the disposable income defined by the tax-benefit system, *NT( )*.

That model (12) can be interpreted as representing utility maximizing behaviour is to some extent secondary, although this permits of course implementing counterfactual simulations in a simple way. More important is that this model fits the data as closely as possible. Interestingly enough, the only restriction with respect to that objective in the general expression (12) is the assumption that the utility associated with each alternative depends on the wage rate and the non-labour income of an individual only through c_i^j, that is the disposable income given by the budget constraint and the tax-benefit schedule, *NT( )*.[14] The economic structure of this model thus lies essentially in the way in which the income effect is specified. If it were not for that property, it would simply be a reduced from model aimed at fitting the data as well as possible.

In effect, the restriction that the income effect must be proportional to disposable income seems to be a *minimal* assumption to ensure this representation of cross-sectional differences in labour supply behaviour is consistent with elementary rationality. This remark also makes perfectly clear that, within this framework, the simulated effect of a reform of the tax-benefit system, *NT( )*, on individual labour supply is estimated on the basis of observed cross-sectional differences in disposable income in the status quo.

The role of idiosyncratic terms, $\hat{\varepsilon}_i$ or $\hat{\varepsilon}_i^j$, in the whole approach must not be downplayed. They represent the unobserved heterogeneity of agents' labour supply behaviour. Thus, they may be responsible for some heterogeneity in responses to a reform of taxes and benefits. It may be seen in (14) that agents who are otherwise identical might react differently to a change in disposable incomes, despite the fact that these changes are the same for all of them. For this, it is sufficient that the idiosyncratic terms, $\hat{\varepsilon}_i^j$, be sufficiently different. Some will modify their work duration due to a tax-benefit reform, wile others will not.

[14] Of course, it is also necessary to check that utility is monotonically increasing with disposable income for this general specification to make any sense.

Estimates of the idiosyncratic terms result directly from the econometric estimation of the common preference parameters, $\hat{\beta}$ in the continuous specification (9) or $\hat{\beta}_i^j$ in the discrete model (12) . These are standard regression residuals in the former case and so-called 'pseudo-residuals' in the latter. However, one may also opt for a “calibration” rather than an econometric estimation approach. With the former, some of the coefficients $\hat{\beta}$ or $\hat{\beta}_i^j$ are not estimated but given arbitrary values deemed reasonable by the analyst. Then, as in the standard estimation procedure, estimates of the idiosyncratic terms are obtained by imposing that predicted choices, under the status quo, coincide with actual choices.

It is important to emphasize that there is some ambiguity about who the “agents” behind the standard labour supply model (7) should be. Traditionally, the literature considers 'individual agents', even though the welfare implications of the analysis concern households. Extending the model to households requires considering simultaneously the labour supply decision of all members at working age. This makes the analysis more complex. It becomes practically intractable with the continuous representation - see, for instance, Hausman and Ruud (1994) - but only lengthens computation time with the discrete approach.

- *Illustrative applications of behavioural msm*

Applications of the preceding models now are numerous. they are surveyed in Blundell and MaCurdy (1999) and in Creedy and Duncan (2002). The discrete approach underlined above is best illustrated by van Soest (1995), Hoynes (1996) or Keane and Moffitt (1998). An application of the 'calibration' approach may be found in Spadaro (2005).

A nice application of behavioural *msm*, that illustrates very well the potential of this approach, is the work of Blundell et al. (2000) that evaluates the likely effect of the introduction of the Working Families Tax Credit (WTFC) in UK. They estimate, separately, a discrete labour supply model for married couples and single parents, on a sample of UK households coming from the Family Resources Survey of 1995 and 1996. Then they use the estimated model to simulate the labour supply responses under the new budget constraint using the TAXBEN *msm* developed at the Institute for Fiscal Studies. The results of the analysis show that the introduction of behavioural responses reduces the estimated cost of the WFTC programme in the purely arithmetical scenario by 14%. This is mostly due to the increase in the labour force participation of single mothers and the subsequent increase in tax receipts.

Similar analysis has been implemented for the evaluation of recent tax reforms in the US (Keane and Moffit 1998 and Hoynes 1996), in the Netherlands (Das and Van Soest 2000), in France (Bargain 2004b), in Germany (Bonin, Kempe and Schneider 2002), in Italy (Aaberge et al. 1998b) and in Spain (Labeaga, Oliver and Spadaro 2005).

In addition to labour supply and consumption patterns[15], there are other dimensions of household behaviour mattering from a welfare point of view and that may be affected by tax-benefit systems. *Oportunidades* in Mexico, *Bolsa Familia* in Brazil and similar "conditional cash transfer programs" in several other countries, offer a clear example of policies in developing countries that can be evaluated ex ante by behavioural *msm*.[16]

To have an idea of the possible application of behavioural *msm* to this type of policies consider the *Bolsa Escola* program in Brazil, a component of the broader program *Bolsa Familia*. It consists of a cash transfer to households whose income per capita is below a threshold of 90 Reais – approximately 45 US $ - per month and with child at schooling age, *conditionally* on these children effectively attending school. The monthly transfer is equal to 15 Reais per child going to school but it is limited to 45 Reais per household. This may be considered as a 'conditional cash transfer program' because it combines cash transfers based on a means-test and some additional conditionality – i.e. having children at school age actually going to school. As the main occupational alternative to school is work, this really is a labour supply problem similar to the one analysed above. Bourguignon, Ferreira and Leite (2003) estimate a multilogit model of schooling and labour supply for all children aged 10 to 15 in households surveyed in the Brazilian household survey, PNAD in a year preceding the implementation of the program. As above, the identification condition in that model is that the way children earnings and the income of other household members enter the utility of the various alternatives is uniquely through the disposable income of the whole family. After estimating the model of labour supply-schooling decision without conditional cash transfers, the *Bolsa Escola* program was simulated on each of the households in *PNAD*. The results show that the program is indeed effective in reducing the number of poor children not going to school, much more than what

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[15] See Symons and Warren (1996).

[16] Those programs may also be evaluated ex-post through impact evaluation techniques. Progresa, the ancestor of Oportunidades, has been the object of very careful evaluation. For detailed information, see the website of the International Food Policy Research Institute: http://www.ifpri.org/themes/progresa.htm

would result from an unconditional means-tested cash transfer. However, its effect on poverty turned out to be rather limited due to the limited overall size of the program.[17]

Before moving to some other possible applications of the preceding framework, some limitations must be stressed. First, it has to be recognized that this approach is difficult to implement because it generally requires the estimation of an original behavioural model that fits the policy to be evaluated or designed, and of course the corresponding micro data. Because of this, it is unlikely that an analysis conducted in a given country for a particular policy can be applied without substantial modification to another country or in the same country to another type of policy. The methodological investment behind this approach may thus be important. This justifies applying first a pure arithmetical microsimulation approach or a simpler behavioural model based on calibration. Second, the fact that the behavioural approach relies necessarily on a structural model that requires some minimal set of assumptions is to be emphasized. In general, there is no way these assumptions may be tested. In the labour supply model with a discrete choice representation, the basic assumption is that wage and non-labour income variables matter for occupational decisions only through the net disposable income they command, as given by the tax-benefit system. On the contrary, a reduced form model would be based independently on wage and non-labour income. Econometrically, the difference may be tenuous but the implications in terms of microsimulation results of specific policies may be huge. Finally, the strongest assumption is that cross-sectional income effects, as estimated on the basis of a standard household survey, coincide with the income effects that will be produced by the program or the reforms under study. In other words, time income effects for a given agent are assumed to coincide with observed cross-sectional income differences. Here again, this is an hypothesis that is hard to test and yet absolutely necessary for ex-ante analysis. Nothing is possible without it. The only test one can think of would be to combine ex-ante and ex-post analysis. For instance, one could try to run some ex-ante analysis on a household survey taken prior to the implementation of the reform and then compare with the results obtained in the ex-post evaluations that have been

[17] A similar exercise has been made to evaluate ex-ante the Progresa program in Mexico by Todd and Volpin (2002) and by Attanasio et al. (2003). In both case, the modelling framework includes dynamic features and is more sophisticated. Earlier attempts at micro-simulating the effects of educational policies on schooling include Gertler and Glewwe (1990) - see also Younger (2002). Overall, however, it is somewhat remarkable that little ex-ante analysis of such programs is performed in developing countries.

made of that program. Coincidence would support the assumption that cross-sectional and time individual specific income effects are identical.[18]

Because of some possibly strong assumptions there unavoidably is some uncertainty about the prediction that come out of ex-ante incidence analysis based on behavioural *msm*. This being said, such a tool is absolutely necessary in order to reflect on the optimal design of policies the most likely to generate strong behavioural responses.

- *Behavioural msm and applied optimal redistribution theory*

Including behavioural response in a *msm* framework allows for an explicit analysis of the equity-efficiency trade-off in the spirit of standard optimal redistribution analysis. In arithmetical models, that analysis could be performed only in a very indirect way, for instance comparing social welfare indicators and the distribution of marginal effective rates across alternative tax-benefit systems, the latter being taken as an indicator of the disincentives and distortions caused by these systems. A more rigorous treatment can be used once a behavioural model has been specified. This is discussed below in the case where the behaviour of interest is labour supply.

The specification of labour supply behaviour implicitly refers to preferences represented by some utility function, as in (7)-(8) above. With the same notations, let $V(w_i, y_{0i}; z_i; \beta, \varepsilon_i; \gamma)$ be the corresponding indirect utility function for individual i. The social welfare function ($SWF(\gamma)$) corresponding to a tax-benefit system with parameters γ may then be defined as:

$$SWF(\gamma) = \sum_{i=1}^{n} G\left[V(w_i, y_{0i}; z_i; \beta, \varepsilon_i; \gamma)\right] \qquad (15)$$

where n is the number of agents in the population and $G[]$ is the social valuation of individual welfare. $G[]$ is an increasing and concave function, its concavity being an indication of the level of aversion towards inequality of the redistribution authority.

Following a methodology proposed by King (1983), it is often convenient to replace the indirect utility function $V(\,)$ by a money metric, y_e, defined as the non-labour income that must be given to the agent in some benchmark situation to raise his/her utility to the level actually achieved with a given policy. More precisely, use as a benchmark the case where the individual does not work because his/her productivity is too low – say zero – and the tax-benefit system is

[18] Rather satisfactory results have been obtained in that direction by Todd and Wolpin (2002) and Attanasio et al. (2003).

defined by the set of parameters γ^0. Let $V_i = V(w_i, y_{0i}; z_i; \beta, \varepsilon_i; \gamma)$ be the utility actually achieved by individual *i* when the parameters of the tax-benefit system is γ. Then, a money metric $y_e(V_i)$ of V_i using the tax-benefit system γ^0 and the case $w_i = 0$ as a benchmark, is given by the solution to the equation:

$$V\left[0, y_e(V_i); z_i; \beta, \varepsilon_i; \gamma^0\right] = V_i. \qquad (16)$$

The social welfare function may then be defined on the money metric of utility, rather than on the utilities themselves:

$$SWF(\gamma) = \sum_{i=1}^{n} \Gamma\{y_e[V(w_i, y_{0i}; z_i; \beta, \varepsilon_i; \gamma)]\} \qquad (17)$$

where $\Gamma(\ )$ may now be given the usual interpretation of the social utility of individual 'income'. The obvious advantage of that transformation of the initial expression of social welfare is that it does not depend any more on the cardinalization of the utility function used to represent individual preferences.[19]

Within such a framework, it is possible to perform comparative social evaluation of alternative redistribution policies, as summarized by sets of parameters γ^A and γ^B. This only requires being able to compute the indirect utility functions for each individual *i* in the population, inverting it as in (16) thanks to some numerical algorithm, and evaluating the social welfare SWF associated to each system[20].

Equipped with a numerical algorithm that computes the social welfare associated with a tax-benefit system, it becomes possible to consider the issue of optimizing the redistribution, fully taking into account the trade-off between equity and efficiency. The relevant reference here is the optimal taxation literature and the pioneering work of Ramsey (1927) and Diamond and Mirrlees (1971a, 1971b) for indirect taxation, and Mirrlees (1971) for direct taxation. Atkinson and Stiglitz (1980) and Tuomala (1990) offer extensive syntheses of that literature.

Behavioural *msm* and the computation of social welfare according to the equations above make possible some simple application of that literature. The simplest application consists of comparing two tax-benefit systems, as characterized for instance by two sets of parameters, γ^A

[19] An inconvenient is that the equivalent income function is not guaranteed to be concave, which means that, if the function $\Gamma(\ )$ is not concave enough, the *SWF* could favour inequality increasing transfers. Blackorby and Donaldson (1988) show that this will not be the case if the individual utility function is quasi-homothetic.
[20] See, for example, Aaberge et al. (1998a), (1999), (2000), (2001).

and γ^B, and to determine which system leads to the highest level of social welfare. Of course, the comparison makes sense only if the budget of the redistribution authority is the same in the two systems, that is if tax receipts net of transfers are the same with γ^A and γ^B. This corresponds to the standard 'government budget constraint' in optimal taxation models. An example of this approach is provided by Spadaro (2005), where the 1995 French and British tax-benefit systems are micro-simulated respectively on samples of French and UK households in order to find which system is the 'best' for a given level of social aversion to inequality and for each population. As usual in this type of work, the constant net tax receipt constraint is taken care of through the introduction in one of the two systems of an artificial tax that is assumed to be strictly proportional to incomes and ensures budgetary equivalence across the two systems. [21]

A very similar type of application consists of investigating the effects of modifying some subset of the parameters, γ, of a tax-benefit system and to see whether this improves the social welfare function, allowing, of course, for constant government budget. If this exercise is repeated for a broad enough set of alternative definitions of the social welfare function, this is equivalent to investigating 'Pareto-improving' reforms of the initial tax-benefit system. Ahmad and Stern have pioneered this type of application of *msm*'s in the case of indirect taxation – see in particular Ahmad and Stern (1984).

The preceding approaches may be seen as a kind of discrete approach to the original optimal taxation theoretical models. An approach closer to those models would consist in optimizing a tax-benefit system with respect to some subset of its parameters, γ, across some permissible range. In effect, this was the approach developed by Stern (1976) when applying Mirrlees' model to a linear income taxation model.[22] The difference with what could be done today with *msm* is that Stern focussed on hypothetical distributions of individual labour productivities rather than the actual ones, and on hypothetical representations of labour supply behaviour, rather than accurate econometric estimates of that behaviour. Oddly enough, however, there does not seem to be many recent attempts at using existing behavioural *msm* in that way. Is it because such an approach necessarily relies on the specification of a single social welfare

[21] See, for instance, Bourguignon et al. (1997). A proportional income tax is being used as the closest approximation to a 'neutral' tax that would take care of the budget constraint without major distortions of the economy. Practically, however, a proportional tax on income or consumption has an effect on labour supply. Iterating with the whole *msm* is thus necessary to determine the level of the tax rate that will satisfy the budget constraint.

[22] See also Slemrod et al. (1994) for an extension to a two tier linear income taxation model. See also Judd et al. (2000) for a computational approach to dynamic optimal taxation.

function, which is essentially debatable? Or because econometric estimates of labour supply behaviour in existing *msm* are simply too imprecise?

Applying the original models of Diamond and Mirrlees (1971a, 1971b) and Mirrlees (1971) without functional restrictions to actual *msm* raises major difficulties when the heterogeneity among individuals or households is multi- rather than uni-dimensional. Indeed, households differ not only by their consumption of various goods or their wage rate but also by some socio-demographic characteristics which create differences in the utility they draw from a given level of consumption, or in non-labour income. These difficulties come on top of the need to ground optimal taxation on the choice of a specific social welfare function. This explains the limited use of optimal taxation analysis in the applied public finance literature.

Another way of using the original optimal taxation models consists of having them reveal the social welfare function implicit in the observed tax-benefit system, given labour supply and consumption behaviour. This is known as the 'optimum inverse' problem and was first analyzed in economics by Kurz (1968). For indirect taxation, one can go back from the observed structure of tax rates across goods and services to the weight of individual households in the social welfare function, depending on their structure of consumption, and under the assumption that the observed indirect taxation system is indeed optimal. For direct taxation, it is also possible to identify the weight of individual households in the social welfare function and to test whether this weight is both positive and decreasing with income, as assumed in the optimal taxation model. Christiansen and Jansen (1978) used that approach to study the Norwegian indirect tax system, whereas Ahmad and Stern (1984) showed that the 1979-80 Indian indirect tax system could not be Pareto optimal and derived from the optimum inverse approach directions for Pareto-improving reforms. More recently, Kaplanoglou and Newbery (2003) used the same type of method to study the Greek indirect tax system. Bourguignon and Spadaro (2002) analyzed the redistribution system in France, UK and Spain using the optimum inverse approach based on the Euromod *msm*, and a calibrated model of labour supply. They found that revealed social preferences satisfy the usual regularity assumption – positive and decreasing marginal social welfare of individual utility – as long as the wage elasticity of labour supply is below some threshold. For Spain and UK, this threshold seems reasonably above the range of available econometric estimates of the wage elasticity of labour supply. In the case of France, however, the threshold is much lower, so that it cannot be ruled out that revealed social preferences are non-Paretian beyond some income level. Using the same type of method, Oliver and Spadaro (2004) analyse how the 1999 reform of the income tax in Spain may be interpreted as resulting from a change in social preferences with respect to inequality.

4. Extensions and directions for future research

The micro-simulation approaches to the evaluation of redistribution policies discussed above were defined within a partial equilibrium and static framework. However, redistribution policies may have powerful general equilibrium effects, for instance by modifying the sectoral structure of the economy in the case of indirect taxation. They may also affect the whole lifetime budget constraint of people and therefore some important decisions in their life-cycle. Several extensions of the basic arithmetical and behavioural *msm* have been proposed or are being researched so as to cover these important dimensions of redistribution policies. This final section briefly outlines them.

- *Micro-macro modelling and microsimulation*

A promising direction of research is the integration of macro models and *msm*, the so-called 'micro-macro' approach to modelling. Numerous economy-wide models, particularly the so-called Computable General Equilibrium models[23], already incorporate several 'representative households' which are used to analyze the distributional effects of economy-wide policies, and possibly the indirect, general equilibrium effects of redistribution policies. The full integration of economy-wide modelling and *msm* consists of replacing these 'representative households' by actual households as they are observed in standard household surveys. Several attempts have been made in that direction that we briefly summarize in what follows.

- *Top-down approaches*

The simplest linkage between economy-wide modelling and the *msm* approach proceeds in a top-down way. A policy is simulated at the macro-level, based on some aggregate representation of household behaviour, possibly using representative households. The simulated changes in prices, wage rates, and self-employment incomes are then passed down to a micro-simulation module as in arithmetical *msm*. In other words, the welfare effects of changes in prices and wage rates are computed according to the envelope theorem for all

[23] See Showen and Walley (1984).

households in a micro-data base. An excellent example of this approach is the analysis of the distributional consequences of China's accession to WTO by Chen and Ravallion (2003).[24]

There are two drawbacks with the preceding linkage of arithmetical *msm* to an economy-wide modelling tool. The first is that the envelope theorem is based on the assumption that all markets are perfectly competitive. The second is that possible economy-wide feedback effects of the distributional consequences of a given policy are not taken into account[25].

Bourguignon, Robilliard and Robinson (2004) generalized the preceding approach to the case where the labour market is imperfect and some individuals are rationed out of formal employment, or out of employment all together. In effect, they combine a CGE model, where wages are assumed to be rigid in the formal sector of the economy, with a *msm* that includes 'behavioural' features. However, the behaviour being modelled there is more the way in which rationing does occur on the labour market than the way in which individual agents freely decide about the sector they want to work in, on the basis of observed remuneration rates on these markets. The main macro-micro linkage thus is the extent of rationing in the labour market and the main use of the *msm* is to select those households or individuals who will actually be barred out of, or let in, the formal sector. In the application considered in that paper, it turns out that the selectivity of labour-market rationing is the channel through which economy-wide policies have the most distributional impact.[26]

-Fully integrated micro-macro models

The second weakness of the top-down micro-macro approach is of course the absence of feedback from the micro to the macro level. Several attempts have now been made to fully integrate a behavioural *msm* into an economy-wide modelling framework. For instance, Gortz et al. (2000) studied the effect of changing opening hours of retail trade in Denmark based on an estimated micro model of time allocation behaviour covering 2000 households. Rutherford, Tarr and Shepotylo (2003) analyzed the effect of Russia's accession to WTO based on a model that included the consumption and labour supply behaviour of 50,000 households. Cogneau and Robilliard (2001) also built an integrated model where some 3,000 Malagasy households

[24] It is true that, by emphasizing changes in relative prices and in the sectoral structure of the economy, this approach is more adapted to developing than developed countries. Yet, there also are applications to developed countries – see for instance Meagher (1993) for Australia. See also the survey on poverty and trade by Hertel and Reimer (2004).

[25] A nice application of an integrated micro-macro analysis is Labandeira, Labeaga and Rodriguez (2004).

[26] See also Bussolo and Lay (2003).

have to allocate their labour to different uses and sectors along the lines of the well-known model by Heckman and Sedlacek (1990) and make consumption choices across different goods and markets. In a dynamic setting, Heckman, Lochner and Taber (1998), Townsend (2002) and others were also able to fully integrate a representation of the labour supply, training and saving behaviour of a heterogeneous population, as observed in household surveys, and macro equilibrium mechanisms in the economy. [27]

Increasing computational power will of course make such integrated micro-macro approaches more and more easy to implement. At the same time, the implementation of these methods raises difficult questions about the way micro behaviour is modelled and, in particular, the way in which individual heterogeneity is entered in the analysis. For instance, it turns out that it makes very much difference whether heterogeneity in preferences is introduced as an additive term in conventional consumption or labour supply functions, or as idiosyncratic price, wage or income elasticities. In the first case, experience seems to show that there is little difference between the top-down and the fully integrated approach – see Hertel and Reimer (2004). This is not true anymore in the second case, as discussed in Browning, Hansen and Heckman (1999).

- *Introducing dynamics*

Much of what precedes about the possible linkage between micro and macro phenomena refers to a static framework. This may often seem inappropriate. Transferring income among agents at a given point of time is not the only function of redistribution systems. They are also responsible for transferring income from a period to another or from a given state of the world to another for a given person. This is, for example, the function of pension systems or unemployment and health insurance schemes. Likewise, economy-wide policies with some distributional impact may affect people in a way that depends on where they stand in their life-cycle. The microsimulation of these policies thus requires the adoption of a dynamic or "life cycle" perspective.

One could think that the basic typology of static *msm*, and in particular the arithmetic-behavioural and the partial-general equilibrium distinction, would apply to dynamic *msm*. This is not totally true, however. For instance, a dynamic arithmetical *msm* should logically rely on

[27] Top-down and fully integrated micro-macro models are not really exclusive. In particular, one may think of resolving fully integrated models in a iterative way going from the macro equilibrium of markets to micro behaviour and then back to the economy-wide model after aggregating total consumption or labour supply at the micro model. See Savard (2003) and Aaberge, R., U. Colombino, E. Holmøy, B. Strøm and T. Wennemo (2004).

the observation of sequential data about individual characteristics like income, employment status, household composition, etc.. . In other words, it should rely on some kind of 'panel data'. However, such data frequently are not available. Moreover, they necessarily are historically dated, and, consequently, may not be of very much relevance for simulating the forward-looking effects of a change in policy. Rather than relying on actual panel data, dynamic arithmetical *msm* thus generally rely on 'synthetic' panel data that simulate individual trajectories in the economic and social space. They are generally obtained by applying to a cross-section of individuals and households observed at a point of time in a household survey, transition probabilities from a set of individual characteristics to another. These probabilities thus generate individual demographic and economic characteristics in the next period and this procedure is repeated sequentially until reaching the time horizon selected for the analysis, or possibly until the individual is simulated as exiting the sample of observations, as in the case of death or retirement. Transition probabilities themselves are obtained from different sources. They are assumed to be constant, so that the society is supposed to be in some kind of steady state and they are supposed to be independent of the policy being analyzed.

In a dynamic setting, arithmetical *msm* thus necessarily incorporate some kind of modelling in order to generate synthetic panel data on which changes in redistribution policies may be applied[28]. Practically, if the socio-economic state of an individual can be described by a vector of characteristics, X_t, the idea is to update this vector to the period $t+1$ according to some exogenous stochastic processes obtained from the appropriate data[29]. For instance, a person may become unemployed with a probability P_t that depends on his/her characteristics X_t. Likewise, he/she may die, get sick, marry or divorce, have children, receive some inheritance, move from a wage bracket to another, etc… The probabilities of these various events taking place between time t and $t+1$ may be given jointly, or they may be assumed independent of each other.

Once such a 'synthetic' panel data set has been put together, it is a simple matter to simulate the effect of changing some particular features of tax-benefit systems, like unemployment insurance, child benefits or the way in which the pension system works. Such models are now being used in a number of countries (DEMOGEN in Canada, SFB3 in Germany, Dynastie in France, etc..) . One precaution that is not always taken when using these synthetic data is that

[28] On dynamic microsimulation of household behaviour, see Harding [1993], O'Donoghue (1999) and Zaidi and Rake (2001). See also Dupont, Hagneré and Touzé (2003) for a survey on dynamic *msm* applied to pensions system analysis.
[29] Caldwell (1990), page 5.

they result from a random drawing procedure, which means that the result of any micro-simulation is itself a random variable. For this reason, it is important, when analyzing the results of a microsimulation, to perform robustness analysis using Monte-Carlo or bootstrapping methods (see Bradley and Tibshirani, 1993).

In a dynamic behavioural *msm*, the transition probabilities, P_t, should partly become endogenous and reactive to the intertemporal budget constraint faced by agents. Depending on what is the behaviour of interest and the parameters of interest in the tax-benefit system, the analyst should thus model the decision making process on labour supply, consumption, savings, marriage, fertility, etc., in function of the budget and other constraints faced by the agent, and his/her expectations about future prices, wages and truly exogenous transition probabilities[30].

This type of models is still relatively scarce in the literature, very much because of their inherent complexity and, in particular, the difficulty of dealing dynamically with uncertainty, expectation formation, and market imperfections. Available models tend to concentrate on some specific behaviour, abstracting from other important components of the demo-economic life-cycle. For instance, Townsend (2002), Townsend and Ueda (2003), Giné and Townsend (2004) concentrate on saving/investment behaviour under uncertainty and in different financial market environments, whereas Heckman, Lochner and Taber (1998) focus on schooling and training behaviour. Although important in their own right, such models are specialized and do not permit analyzing tax-benefit systems in all their dimensions.

Extending these models to a general equilibrium setting requires assumptions about the way in which expectations are formed. Perfect foresight is generally assumed but equilibrium resolution may be difficult. The models already cited are among the few examples of integrated dynamic micro-macro models available at this stage. Yet, it seems likely that dynamic *msm* will become more numerous in the future. A key reason for that is that they are the only tools that allow for the satisfactory analysis of many policy issues that are today in the agenda of any government: demand for tertiary education, savings behaviour and role of the financial sector, pensions and population aging, health, etc.

5. Conclusion

[30] Browning, Hansen and Heckman (1999) and Blundell and McCurdy (1999) contain an excellent discussion about these problems. See also Klevmarken (1997).

This brief survey has shown that micro-simulation techniques have now become relevant practically for the whole of applied economic policy analysis. The increasing availability of large and detailed micro datasets and the foreseeable continuous increase in computing power are drastically modifying our approach to the evaluation of policy reforms. Instead of reasoning in terms of representative agents and of aggregate models of the economy, we now try more and more to take into account the fundamental heterogeneity of agents. By dispensing with the very demanding assumption necessary for perfect aggregation of individual behaviours, such an approach greatly improves the macro analysis of reforms. At the same time, it permits evaluating their full distributional impact. This can easily be done in several instances, under the assumption of no behavioural response. Simple micro-simulation tools are easily developed on that basis and should be used more systematically.

Extending the analysis to cover behavioural responses and the potential general equilibrium and macroeconomic effects of reforms requires investing more in micro-economic and macro-economic modelling. Attempts in that direction, briefly described in this survey, show the difficulty of that approach but also all the benefits that policy making could draw from this kind of instruments.

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