Chapter 1

New Frontiers in Microsimulation Modelling: Introduction

Paul Williamson / Asghar Zaidi / Ann Harding

1 Introduction

As Michael Wolfson notes in his preface, this volume draws together some of the key contributions made to the first General Conference of the International Microsimulation Association. The conference, held in Vienna in 2007, took as its theme "Celebrating 50 years of Microsimulation", and marked the 50th Anniversary of the paper in which Guy Orcutt first outlined his vision for a new type of socio-economic modelling (Orcutt, 1957).

Orcutt's original vision for microsimulation entailed an empirically-based, multi-agent, micro-macro modelling approach. Initial fulfilment of this vision was hampered by a range of computational and data constraints. The gradual overcoming of these barriers has shaped the subsequent history of microsimulation, resulting in ever-increasing model sophistication and diversity. The outcome, at the risk of over-simplification, is the emergence of three basic types of microsimulation model. The first is the "static" cross-sectional tax-benefit calculator, which allows assessment of the distributional impacts of changes in state fiscal and welfare policies at a given point in time. The focus of such models is moving towards increasingly comprehensive coverage of the tax-benefit system, inter-country comparison and improved modelling of behavioural responses to changes in tax and benefit rates.

The second is the "dynamic" model, in which population characteristics are projected forwards through a process of regular updating of the characteristics of the individuals within the model (typically using an annual time-step). These models have become increasingly ambitious in terms of

the range of population attributes and behaviours updated, and the sample size modelled.[1]

Third is the "micro-macro" model, which uses outputs from microsimulation models as inputs to macro-economic models and vice versa, in order to better capture the interplay between individual behaviours and the macro-economic environment within which they operate. Again these types of models have seen increasing sophistication, including more comprehensive micro- or macro-elements and greater micro-macro integration. A consistent thread running through all three types of model, distinctive to microsimulation, is a commitment to empiricism and policy relevance, and a concern for the distributional impacts of policy decisions.

For those interested in tracking the historical developments in microsimulation, the single best repository of knowledge is the irregular "series" of edited volumes documenting the proceedings from past microsimulation conferences (Orcutt et al., 1986; Harding, 1996; Mitton et al., 2000; Gupta and Kapur, 2000; Gupta and Harding, 2007; Harding and Gupta, 2007). As the latest in the series, this present volume documents the most recent developments. These include advances in spatial modelling (section 2), discrete-choice behavioural modelling (section 3), improvements in the modelling of demographic events, labour supply, life-time earnings and pensions (section 4) and endeavours to more firmly integrate microsimulation models in a broader micro-macro modelling framework (section 5). The advances in each of these areas are summarized in more detail below. We conclude by outlining some likely future trends in microsimulation modelling, and considering the role that the International Microsimulation Association might have to play in helping to shape this future.

2 Spatial modelling

Spatial microsimulation is a fast-growing modelling technique used to develop synthetic datasets describing household characteristics at a local (sub-regional) level (Birkin and Clarke, 1988; Williamson et al., 1998; Voas and Williamson, 2000; Ballas et al., 2005; Chin et al., 2005, 2007; Lymer et al., 2008). Such data construction is often achieved by combining aggregate

1 See Zaidi and Rake (2001) for a review of major dynamic microsimulation models; the paper also discusses pros and cons of alternative empirical choices to be made in building a dynamic microsimulation model. Harding (2007) offers a summary of challenges and opportunities of dynamic microsimulation models.

census data with a detailed sample survey dataset. The method produces detailed portrayals of the household composition and mix of neighbourhoods, which can be used to inform analysis of spatial variations in the impact of policy initiatives in areas such as taxation and benefits, education, and health. Part I of this volume comprises a series of chapters that outline the latest advances in spatial microsimulation modelling. These include refinements in the creation of a plausible spatially-detailed starting population, dealing with within-city moves, modelling shopping flows and their interaction retail development location, and, finally, the forecasting of sub-regional expenditure patterns.

In Chapter 2, *Birkin, Wu and Rees* make the case for producing a spatially-detailed dynamic microsimulation model, specified at a sub-city scale, in order to fill the gaps left by official projections, which are generally either for larger spatial units and/or lacking any more than a rudimentary age/sex breakdown. They then outline the basic structure of Moses, an ambitious attempt to produce such a model. In order to make the problem tractable, Moses limits its ambitions to the modelling of demographic transitions, migration and housing. Even so, a number of methodological challenges are faced, including the integration of migration and household formation, the modelling of housing stock dynamics and the handling of student migration. The chapter highlights these challenges, but concentrates on one: the use of a spatial interaction model to inform the microsimulation of within-city moves or "relocations". Simulation results confirm that the patterns of microsimulated relocations correspond closely to those of the underlying spatial interaction model, which in turn shows broad agreement with observed flows. The chapter finishes, however, on a note of caution. Whilst the potential utility of spatial microsimulation is high, the challenges, not least concerning adequate validation of the results, remain many and significant.

One of the most substantial challenges usually facing spatial microsimulators is the lack of a spatially detailed starting population. In Chapter 3, *Tanton, McNamara, Harding and Morrison* revisit this challenge, describing the creation of a synthetic population through the reweighting of survey data to local area census benchmarks. The reweighting is undertaken using a generalized regression algorithm, GREGWT, created by the Australian Bureau of Statistics. Whereas Australian census data capture gross household income, the reweighted survey data capture current disposable income (post-tax and transfers). Importantly, disposable, rather than gross,

income is required to identify households living in poverty. The reweighted survey data, therefore, allow the authors to derive headcount estimates of the number of persons living in poor households for small geographical units (Statistical Local Areas) across the South East of Australia. The results confirm previous findings of widespread rural poverty, but also highlight the existence of pockets of poverty within major urban areas, sometimes cheek-by-jowl with pockets of extreme affluence.

In Chapter 4, *Van Leeuwen, Clarke and Rietveld* demonstrate the clear potential of spatial microsimulation for aiding local planning decisions through the development of a model of local retail choice, SIMtown. In particular they emphasize how spatial microsimulation can allow planners to consider a range of possible spatial developments. Their contribution falls into three parts. First, they generate the by now familiar pre-requisite of a spatially-detailed micro-population. In doing so, they demonstrate that the accuracy of the reconstructed population improves with both the size of the survey being reweighted and with the number of local constraints that the reweighting process is required to satisfy. For this reason, restricting the reweighting process to the use of local survey respondents only is shown to be counter-productive. Second, the authors undertake multinomial logistic regression analysis of shopping survey data to derive probabilistic models, for a variety of retail types, of destination choice. In doing so they find that, in contrast to population reconstruction, behavioural models derived using local responses match the reality better than models based upon analysis of all responses. Third, the authors combine their behavioural models and spatially-detailed micro-populations to explore the predicted impacts of contrasting retail developments (including the opening of a supermarket and a retail centre). The model results are shown to allow the sub-regional winners and losers from such a development to be identified, whether in terms of specific urban centres or socio-demographic subgroups.

In Chapter 5, *Anderson, de Agostini, Laidoudi, Weston and Zong* draw together a number of innovative strands to produce spatially-detailed estimates and forecasts of the share of household expenditures allocated to a range of communications and media-related products, measured in terms of both money and time. First, they use survey data to estimate non-linear demand functions for household expenditures upon a range of telephony and media items. Second, they estimate future values for the explanatory variables underpinning these demand functions, using first-order autoregressive functions fitted to time-series data. Third, they substitute these values into

the demand functions to yield forecast expenditure shares. The resulting overall changes in forecast expenditure shares are shown to be theoretically plausible and in line with observed trends. Fourth, the authors identify, for each item of household expenditure, the most closely associated (predictive) set of census-based variables, the values of which are themselves projected forwards, separately, using a constrained linear regression approach, for each small geographic area within the region of study. Fifth, iterative proportional fitting is used to reweight the original expenditure survey data to these projected small-area values. The authors then demonstrate good geographic model fit by comparing survey-based small-area estimates with observations derived independently from the census and from corporate billing information. They conclude by highlighting the utility of information on local market share and revenue for service providers whose costs, infrastructure and revenues are themselves spatially variable.

3 Work incentives and labour supply

A policy issue that has received much greater modelling attention during the past decade is work incentives, with which Part II of this volume engages. Structural population ageing, resulting from lower fertility rates and increased longevity, is expected to have adverse fiscal consequences for modern welfare states. This is partly due to the expected higher outlays in pensions and health and aged care programmes that the growing number of elderly will generate. But it is also due to the slower forecasted growth in taxation revenue and GDP associated with population ageing, with labour supply growth expected to be slower than in recent decades.

In this environment, it is not surprising that the governments have become much more concerned about whether welfare and tax programmes are adversely affecting incentives to work. In many countries, the labour force participation rates of sole parents and partnered mothers have been the subject of extensive scrutiny. Questions have been raised about whether income-tested cash transfers for children have imposed high effective marginal tax rates upon mothers and about the availability and price of child care (Harding et al., 2006). The impact of tax and social security programmes on labour supply and effective tax rates for the working age population has also been placed under the spotlight (Immervol, 2004). Nearer the end of the working life, a particular issue has been whether pension schemes have provided undue incentives to retire early (Cotis, 2003).

One of the key weaknesses of the traditional static microsimulation models is that they only deal with the first-round effects of policy change, before behaviour has adjusted (Bourguignon and Spadaro, 2005). In recent years, the "arithmetic" static microsimulation models have been complemented by discrete choice models simulating behavioural responses in labour supply. Early work in this field includes research by Blundell et al. (2000) on the likely effect of the introduction of the Working Families Tax Credit in the UK and analysis by Aaberge et al. (2000) of the impact of replacing current income taxes with a flat tax in three European countries. Another notable contribution was that of Creedy et al. (2002), who employed discrete choice models to reflect the interaction between tax rates and labour supply. In Part II of this volume more recent developments are charted. This includes extending model coverage to the economically inactive, the introduction of labour market wage-rates dependent upon supply and demand, cross-country analyses and improved modelling of female labour supply decisions.

In Chapter 6, *Labeaga, Oliver and Spadaro* extend their earlier work on analysing the impact on income distribution of possible and implemented reforms to the Spanish tax system (Oliver and Spadaro, 2007) to also consider labour supply responses. Much existing work on labour supply behavioural responses excludes those sections of the population who are economically inactive, such as pensioners, students and the disabled. This is because of the difficulty of estimating likely labour supply responses for such groups. The authors argue that this contradicts the basic thrust of microsimulation, which attempts to retain the heterogeneity apparent within the population. Accordingly, Labeaga, Oliver and Spadaro combine behavioural results for those sections of the Spanish population for whom labour supply can be estimated with arithmetic results for the remaining part of the population within their sample. They assess the major structural reforms made to the Spanish income tax system in 1999, as well as the impact of two other possible reform options – first, a reform which replaces the 1999 income tax system with a "vital minimum", consisting of a tax allowance per equivalent adult and a proportional tax on taxable income and, second, a "basic income" reform, which consists of a universal lump-sum transfer allocated to each household plus a flat tax on taxable income. They find that the scenarios simulated have only a limited impact on the efficiency of the economy (as measured by labour supply effects) but that the "basic income" reforms would lead to considerable improvements in the welfare of the poorest households.

In Chapter 7, *Barlet, Blanchet and Le Barbanchon* also seek to push outwards the earlier boundaries of microsimulation. As described above, one of the growth areas for microsimulation in the past decade has been the development of models incorporating changes in labour supply in response to changes in the tax-transfer environment. These models have concentrated upon individuals' decisions to enter the labour market – and/or to supply a larger or smaller number of hours of labour – in the face of the current or possible alternative tax or social transfer programmes. Such models have provided a useful impact to policy debates in an environment when the purpose of policy reform has often been to improve work incentives and raise labour force participation rates. However, one weakness of the labour supply behavioural microsimulation models has been that they typically assume that those who want new jobs or want to increase their working hours will be able to do so – in other words, that the number of jobs will increase so as to match any growth in labour supply.

Barlet, Blanchet and Le Barbanchon take a novel approach in Chapter 7, sketching out a new microsimulation model for simulating labour market demand and supply. The importance of such a new direction has been emphasized by public policy developments in France during the past 15 years, which have been specifically aimed at affecting the demand side of the labour market. The most important of these has been the reduction of employer's social security contributions for those employees on low wages, designed to boost labour demand through the lowering of labour costs. The authors develop a model where the unit on the supply side is an individual and on the demand side is a job. The model is updated every year for such events as aged workers retiring, new workers entering the labour market, the outcomes of "wage negotiations" and a host of other factors. The authors run three experimental simulations to illustrate the capacities of the new model – a 25% increase in the number of new labour market entrants each year (broadly similar to the past impact of the baby boom cohort in the French labour market); an increase in minimum wage; and the elimination of the lower social security employer contribution rates for low wage workers (thus restoring the uniform contribution rates that prevailed at the beginning of the 1990s).

In Chapter 8 the focus upon labour market issues continues, but here the emphasis is upon the role of in-work benefits and their effects upon income redistribution and work incentives. Figari's analysis utilizes EUROMOD, a unique multi-country microsimulation modelling infrastructure developed during the past decade to carry out European comparative social science

research (Sutherland, 2007). The EUROMOD static microsimulation model allows Figari to examine the impact of "policy swapping", introducing two types of in-work benefits into four Southern European counties – Greece, Italy, Portugal and Spain. "In-work" benefits provide cash transfers or tax credits to individuals with low earnings and belong to the "make work pay" group of policies that are conditional on the employment status of the recipient and have been introduced in recent years in the US, the UK and New Zealand. In Italy, Greece and Spain, fewer than 49% of women with low education are in paid employment, raising the possibility that an in-work benefit could raise participation significantly. Figari simulates two policy options – first, a family based in-work benefit, similar in structure to the UK Working Tax Credit and, second, an individually based in-work benefit operating like a low wage subsidy. He finds that there is a trade-off between the redistribution and incentive effects of in-work benefits. The family-based in-work benefits are better targeted at the poorest families – but this comes at the price of the deterioration in work incentives for women in couples. On the other hand, individually-based in-work benefits improve incentives for such women to work – but are less redistributive towards those at the bottom of the income spectrum.

This concern about female labour supply is also continued in the following chapter, Chapter 9, by *Kalb and Thoresen*. The authors develop broadly comparable behavioural microsimulation models for Australia and Norway and use them to examine the impacts upon parents' labour supply and the costs to government of a substantial reduction in child care centre fees. While the two models are both based on discrete choice labour supply models, they have been adapted to reflect the different institutional arrangements in each country – in particular, the rationing of child care due to supply shortages in Norway. The authors find that mothers' participation in the labour market is strikingly different, with 60% of mothers with a 1-4 year-old child participating in the labour force in Australia compared with 80% in Norway. The authors simulate a 50% reduction in child care fees and find that the change increases the labour supply of both mothers and fathers in both countries, albeit with a greater effect in Norway due to a more elastic labour supply. However, the results also suggest that encouraging labour supply by reducing child care fees for everyone is relatively costly and could have adverse affects on the income distribution, with only modest gains in terms of increased working hours. Thus, once again, there appears to be a trade-off between redistributive goals and improving work incentives.

4 Demographic issues, social security and retirement incomes

Most OECD countries are facing the prospect of rapid demographic change in the decades ahead. Three factors are responsible for this change. The first factor is the ageing of the baby boom generation: this generation was born in 1945 and in the following one to two decades after that, and a large number of these people have been retiring from the early 2000s onwards. The main predicament has been that this phenomenon of the high baby boom did not continue and, instead, it was followed – at least in Europe – by a much lower fertility rate. From one perspective, this can be regarded as a success of societal development, as societies offered much more choice to women – and women had much better control over whether and when to have children and how many children to have in the family. Among the consequences, however, have been either a lower number of births per woman or the postponement of births to a later age. The other key phenomenon associated with demographic change is the rise in life expectancy, particularly at older ages. Today, those who make it to the age of 60 to 65 years have much higher chances of surviving until much later in life. The demographic change observed can be seen as a sign of progress for our societies – but it also raises concerns, in particular, for social security and pension policy. Part III of the book includes chapters that address issues linked with demographic change, social security, earnings and retirement incomes. Also considered are a range of issues relating to the validation and evaluation of model-based estimates of earnings and pensions.

Baroni, Eklöf, Hallberg, Lindh and Žamac, in Chapter 10, illustrate how the agent-based microsimulation model, IFSIM, could be used as an approach to evaluate policy changes that affect fertility decisions. The policy in question is a change to the Swedish parental leave benefit system, in which the minimum level of benefit that is received when no prior earnings are available is increased. The motivation is to see how such a policy change might affect fertility timing and fertility rates. The authors argue that although microsimulation models have come a long way forward in modelling individual heterogeneity, they are not well suited for the study of fertility behaviour. This is principally because the social interactions that are viewed as an important factor in fertility decisions are better captured by the agent-based approach. The main advantage of such a simulation model is that the whole effect of many different social insurance systems

can be accounted for, including the macro feedback on the individual level of other agents' choices. They find that the policy of raising the minimum benefit has a negligible impact on completed fertility – and that this is also true regarding the overall cost to the transfer systems. Thus, Sweden has little to gain or lose by implementing the policy in question. The authors argue that many other issues can be investigated with this agent-based approach, but observe that it is important that such models are validated by appropriate rules of thumb.

In Chapter 11, *Blanchet and Le Minez* describe the main features of the dynamic microsimulation model for France, DESTINIE, which has been progressively developed over the last 15 years at the French National Statistical Institute (INSEE). The authors discuss how the development of DESTINIE has followed the evolution of pension policy issues in France. The authors provide details on pension entitlement rules for a "full rate" pension, that made the use of the microsimulation modelling approach particularly attractive in France. They present results based on this model of retirement behaviour, concerning age at retirement before and after the 1993 and 2003 pension reforms, for both private and public sector workers. They also discuss the relevance and limits of these results, with clear indications on how the model can be further developed.

In Chapter 12, *Morrison* estimates internal rates of return from the Canada Pension Plan (CPP) to subgroups, on the basis of attributes other than the birth year or gender. He makes use of the DYNACAN longitudinal dynamic microsimulation model for Canada. The subgroups of interest are: those with low lifetime earnings, ever-married, immigrants, early retirees, and the disabled. The approach adopted highlights the usefulness of the measure of internal rates of return in evaluating the effectiveness of CPP's existing or possible alternative provisions, to these subgroups. Arguments are presented in favour of using the internal rates of return analyses as a standard part of policy evaluation processes. In a second extension of the author's earlier work, this chapter also presents results for real after-tax internal rates of return for the Canada Pension Plan. The analysis provides a first look at internal rates of return, calculated based on participants' net gains and losses. The findings are that the real after-tax rates of return are lower than the before-tax rates, but are still positive for all cohorts for both men and women, and for all of the examined subgroups by gender. The chapter provides practical, policy-oriented, and policy-relevant results.

Chapter 13, by *Rowe and Moore*, provides an overview of the steps being taken to validate simulations of lifetime employment careers in the

Statistics Canada dynamic microsimulation model, LifePaths. This evaluation serves two purposes: i) to outline the credibility of the simulation of career-long employment and earnings patterns, and to determine how these deficiencies might possibly be remedied; and ii) to document, as far as possible, the degree of realism that might be expected of simulations of the future by examining simulations of the past. One key finding of this validation exercise is that LifePaths is currently generating far too many job transitions. Despite these issues, preliminary validation results show that LifePaths can provide highly credible simulations of career wages. The authors conclude that LifePaths can credibly be used to simulate and evaluate issues relating to the Canadian retirement income system. LifePaths' success is to be attributed to the efforts that went into assembling pertinent data in estimating employment and earnings equations, and to the sophistication of its analytical techniques. In that sense, LifePaths' current success is seen to be a testimony to the value of data integration inherent in all microsimulation modelling work.

Chapter 14 is contributed by the research team of the UK's ESRC SAGE Research Group. The authors, *Zaidi, Evandrou, Falkingham, Johnson and Scott*, report on the work undertaken in constructing the labour market module in the SAGE dynamic microsimulation model for Great Britain. They emphasize three steps in simulating life course trajectories of employment and earnings: estimation of credible predictors of employment transitions and earnings dynamics from existing datasets; implementation of estimated employment and earnings equations on the base data; and the validation for logic and consistency of simulated results. The chapter provides a meticulous description of work undertaken for these three steps within the SAGE model and points to generic lessons drawn. Authors conclude that the logic testing and statistical evaluation of simulated results showed that the SAGE model produces a realistic distribution of employment and earnings, which was related to individual circumstances in a way that no static or macro model could achieve. Nonetheless, they identify that a further validation of the long-term trajectories of employment and earnings will be necessary. They mention that the absence of period and cohort effects will inevitably entail some degree of doubt about their simulated results. They also caution for the Monte Carlo and other sources of variation, such as sampling and imputation variation in the base data and variation in parameter estimates, and these variations must be accounted for when exploring the effects of different economic and social policy scenarios of the future.

In Chapter 15, *O'Donoghue, Leach and Hynes* analyse how the results from econometric models of earnings are applied to dynamic microsimulation models, using data for Ireland and the UK. The authors provide an in-depth assessment of the effects of different accounting periods and payment mechanisms for recorded earnings. Such differences may lead to inaccuracies in model estimation through the different variance in earnings across groups – and this could subsequently have a significant impact on the simulation of earnings. The authors find that a number of choices that are not usually incorporated into dynamic microsimulation models have very important impacts upon the performance of earnings equations: i) estimating earnings models on a subset of the population that did not enter the labour market in the previous year; ii) splitting the sample into a low-earnings variability and another group to avoid problems associated with heteroscedasticity; and iii) using a narrower definition of income excluding lump-sum payments and using a shorter accounting period such as weekly earnings.

In Chapter 16, *Willekens* emphasizes the fact that the ultimate aim of microsimulation is to produce a virtual population that is representative of a real population – and then to use the virtual population to study characteristics of the real population and to perform experiments that are not possible in real populations. However, one of the major weaknesses of microsimulation is the credibility of the model for the real population and processes. If the model is a weak representation, then the results of microsimulation will lack credibility. The author argues that continuous-time microsimulation modelling has clear advantages over microsimulation in discrete time units. The key advantage is that the dates of events and the sequences of events can be determined accurately using the theory of competing risks and continuous-time multistate transition models. Willekens points out that the *R* programming environment makes it easier to implement continuous-time microsimulation. These developments substantially reduce the programming costs and the computing time is also not substantially larger than in discrete-time microsimulation. These developments are expected to enhance the use of continuous-time microsimulation in the study of life histories.

Capéau, Decoster, De Swerdt and Orsini, in Chapter 17, analyse the distributional impact of lowering social security contributions and compensating for the revenue loss by an increase in indirect taxes. For this empirical

application, a link is made between two existing Belgian microsimulation models – MODÉTÉ for the tax-benefit system, and ASTER for the indirect tax part. The behavioural models were estimated to predict changes in expenditure behaviour and in labour supply (a discrete choice model). The authors simulate the impact of the reform with and without taking into account the labour supply reaction. The authors find that with fixed labour supply there are considerable distributional effects, with the current generation of pensioners being most liable to pay the bill as they do not profit from the reduced tax on labour income, but do pay higher consumption prices. However, this assessment of gain or loss is sensitive to the decision to neglect or integrate leisure in the welfare concept used to assess the effect of the reform. Moving to the second simulation, incorporating labour supply changes, flexible labour supply is assumed for couples only. The results confirm the findings from many other papers: the labour supply effect is mainly found at the extensive margin of labour market participation. For the welfare analysis, the picture of gainers and losers evidently is affected by the weight attached to the lost leisure for individuals who enter the labour market or increase their labour supply.

Blander and Nicaise, in Chapter 18, estimate a joint (Markovian) model of employment and poverty states, taking into account that educational attainment is endogenous. Using this model, the authors evaluate the impact of different policies on poverty alleviation (by ex-post microsimulation). The three policies evaluated are: increasing the coverage of the minimum income; activation of the unemployed poor; and raising the educational level of vulnerable groups. Using the duration of poverty spells or the poverty probability as the evaluation criterion, the authors find that (a) increased coverage of the guaranteed minimum income has adverse effects, (b) activation has large short-term and small long-term positive effects, and (c) raising the educational level of vulnerable groups has lasting positive effects. The dynamic approach adopted in this chapter can be seen to be much more realistic in predicting the impact of such poverty-reducing policies. Given the high degree of mobility into and out of poverty, the net effects of anti-poverty measures appear to be much smaller than a static model would predict. Moreover, depending on the type of policy adopted, long-term effects may be much greater or smaller than short-term effects.

5 Macro-micro linkages and environmental policies

Another prominent trend in microsimulation in the past decade has been an attempt to link microsimulation models to macro-economic models. The supreme advantage of microsimulation models is that they allow detailed analysis of the winners and losers from a policy reform – but the potential downside is that they ignore the possible economy-wide effects of that reform, such as an increase in interest rates or unemployment. In contrast, the various types of general equilibrium models capture these economy-wide impacts, but at the price of providing no detailed distribution of outcomes, with the household sector typically being represented by a single representative household. Not surprisingly, numerous attempts are now being made to link macro- and micro-models, with the goal of harnessing the power of both types of models. Part IV of the book reports on some of the latest attempts to better integrate the two approaches.

In Chapter 19, *Foertsch and Rector* report on an attempt to capture the second-round effects caused by a series of proposed changes to the US tax system. Their solution involves the use of outputs from a microsimulation of the federal individual income tax system to calibrate a macroeconomic model of the US economy (the "Global Insight" model), and vice versa. The microsimulation model captures changes in the tax system, such as falling marginal tax rates, which lead to changes in macroeconomic behaviours and outcomes (higher levels of investment, jobs growth etc.), which in turn lead to changes in individual behaviour (higher rates of labour market participation, higher post-tax incomes) and so on. Although this iterative calibration process sounds like a potentially computationally very expensive solution, in the example presented only three iterations are required to reduce the gap between microsimulation and macroeconomic model outputs, at the end of a 10-year projection period, to $0.6 billion. The results from the combined models confirm the importance of taking dynamic revenue feedbacks (second-round effects) into account. At face-value, the proposed tax changes are forecast to lead to a loss in tax revenue of $992 billion dollars over the period 2007-16. Allowing for dynamic revenue feedbacks the projected loss in revenues decreases by nearly a third to $696 billion dollars.

Brown, Harris, Picton, Thurecht, Yap, Harding, Dixon and Richardson, in Chapter 20, move the focus on to the micro-level links between health and employment outcomes and wider macro-economic implications that ensue. Specifically, they describe an approach to evaluating a proposed health intervention programme targeted at preventing or ameliorating Type 2

Diabetes – a health challenge of increasing concern not only in Australia but across the developed world. In their work Brown et al. use survey data to first of all produce a cell-based projection of future cases of Type 2 Diabetes. These results are fed into a microsimulation model of future household labour supply, with health status being used as one of the key predictors of labour supply. The outcomes from this model are fed, finally, into a computable general equilibrium model of the macro-economy. Collectively, these linked models allow not only the types of analysis conventionally associated with microsimulation models (such as the estimation of the costs associated with the proposed programme of intervention and of the number of cases of diabetes avoided), but also of the total costs to the economy. The results presented show that this latter contribution is vital. Taken from the viewpoint of health care alone, the costs of intervention are greater than the projected savings in future treatment costs. However, the additional labour supply freed-up by a healthier workforce leads to an estimated AUD $6.4 billion net increase in GDP by the end of the projection period.

In Chapter 21, *Clauss and Schubert* sketch out the structure of the combined CGE/microsimulation model being developed in the Centre for European Economic Research (ZEW) in Germany. ZEW have developed the STSM tax and benefit microsimulation model, for analysis of the impact of taxes, social security contributions and transfers on the private incomes and labour supply of private households in Germany. They have also constructed the PACE-L static general equilibrium model. To link the two models, the authors first run the microsimulation model to derive those parameters which will be subsequently required to run the CGE model, such as the gross wage and disposable income for different types of households. These microsimulation outcomes are fed into the labour supply component of the CGE model, with wages and unemployment rates initially being held constant. In the second round, the labour supply changes arising from policy reform are allowed to affect wages and unemployment. In turn, these then feed back into the labour supply module, with interaction occurring between the two modules until convergence occurs. The authors conclude with some examples of where the availability of both macro- and micro-results has contributed greatly to public policy development.

In Chapter 22, *Stølen, Texmon and Nielsen* outline an integrated micro-macro approach to assessing the future fiscal impact of current and future immigration flows. Using a cohort-component demographic projection model, a series of macro-projections of plausible population futures are first generated, with scenarios ranging from balanced (zero) to constantly high

net immigration. These aggregate projections are used as constraints on the demographic trajectories of the dynamic microsimulation model MOSART. Through MOSART, Stølen et al. are able to disaggregate the tax and benefit histories (and futures) of Norway's immigrant and non-immigrant populations. For immigrants, labour market participation rates are modelled, differentiated by age, sex and point of origin. Alternative labour participation scenarios are also assessed. Through these simulations Stølen et al. are able to demonstrate that future fiscal (pension) and service (education, health) pressures will be attributable almost entirely to demographic ageing. In this context immigration is shown to have the potential to play a small but helpful role in ameliorating these pressures, at least up until the model time-horizon of 2050. Beyond this, as Stølen et al. observe, immigrants from previous decades will themselves start to enter retirement, potentially adding significantly to the existing demographic pressures. Stølen et al conclude by briefly outlining the planned next stage in their analysis, which is to feed their macro-demographic projections and their microsimulation-based estimates of labour supply, pension expenditures and public service demands, as exogenous inputs to Statistics Norway's dynamic computable general equilibrium model, reflecting an overall project arc of linkage from macro to micro and then back to macro.

In Chapter 23, *Bardazzi, Oropallo and Pazienza* demonstrate how a firm-based microsimulation model (DIECOFIS) can be used to assess the potential for energy taxes – specifically carbon taxes – to encourage a reduction in industrial carbon emissions. Their chapter falls into two parts. First, an ex ante analysis confirms the overall fiscal neutrality of a carbon tax reform introduced in Italy in 1998 – although it also confirms that, as a result, some energy-intensive industrial sectors are likely to experience non-trivial reductions in gross operating surplus. The second part of the chapter reviews what changes in firm behaviour actually arose following the introduction of a watered-down version of the originally proposed carbon tax. This ex post analysis uncovers significant between-firm variations in response. In part this is attributed to sector-specific energy requirements; in part to differing elasticity of demand between large and small firms. The latter finding is thought to reflect the economies of scale and longer time horizons enjoyed by large firms when placing bulk contracts for purchasing energy supplies. The remaining challenge is to close the loop and feed the observed ex post behavioural responses into an ex ante analysis of a next round of possible energy tax reforms.

6 Conclusion

Orcutt's original vision for a fully integrated and comprehensive micro-macro model of the socio-economic system remains unfulfilled. However, as we have shown above, the microsimulation community is making significant strides towards fulfilling this goal. Areas of innovation captured in this volume include improvements in discrete-choice modelling, spatial resolution and micro-macro integration.

Looking towards the future, the pace of development is such that forecasting the advances to be made over the next 50 years would be foolhardy. With more modest ambition, we can at least project forwards current trends. Continued advances in behavioural modelling can be expected, fuelled by the increased provision of longitudinal data, ongoing refinement of existing analytical techniques and growing engagement with the agent-based modelling community. Similar advances are anticipated in the fields of spatial modelling and micro-macro linkage. The "realm" of microsimulation will also continue to expand, having moved well beyond its original tax-transfer focus to embrace arenas such as child support, pharmaceutical benefits and environmental issues (Brown et al. 2004; Harding and Percival, 2007). New application areas are emerging, most notably in the health arena, covering the modelling of both disease (demand) and its treatment (supply). At the same time, microsimulation continues to be embraced by practitioners from an ever-widening range of countries – the most recent notable additions being China and Japan. Finally, we anticipate that microsimulation models of all types will continue to become ever more firmly embedded as key tools in national policy-making, a trend most recently reflected by the planned adoption of dynamic microsimulation to produce official demographic projections for Statistics Canada.

As editors, we trust that this current volume, drawing upon the proceedings of the first General Conference of the International Microsimulation Association (IMA), will go some way towards making this future, and Orcutt's vision, a reality. As the elected serving officers of the association, we also hope that this volume helps fulfil in part the IMA's goal of serving the wider microsimulation community through the dissemination of knowledge. A second General Conference has already been organized, to be held in Ottawa in June 2009, and the publication of this volume is timed to coincide with it. Other dissemination pathways include the association's website, email discussion lists and associated academic journal. For more details of these and other initiatives, please visit the association's website: www.microsimulation.org

References

Aaberge, R./Colombino, U./Strom, S. (2000) 'Welfare Effects of Proportional Taxation: Empirical Evidence from Italy, Norway and Sweden', *Journal of Population Economics,* 13 (4): 595-621.

Ballas, D./Clarke, G.P./Wiemers, E. (2005) 'Building a Dynamic Spatial Microsimulation Model for Ireland', *Population Place and Space*, 11: 157-172.

Birkin, M./Clarke, M. (1988) 'SYNTHESIS – A Synthetic Spatial Information System for Urban and Regional Analysis: Methods and Examples', *Environment and Planning* A, 20: 1645-1671.

Blundell, R./Duncan, A./McCrae, J./Meghir, C. (2000) 'The Labour Market Impact of the Working Families Tax Credit', *Fiscal Studies,* 21: 75-106.

Bourguignon, F./Spadaro, A. (2005) 'Microsimulation as a Tool for Evaluating Redistribution Policies', *Journal of Economic Inequality,* 4 (1): 77-106.

Brown, L./Abello, A./Phillips, B./Harding, A. (2004) 'Moving Towards an Improved Micro-Simulation Model of the Australian Pharmaceutical Benefits Scheme', *Australian Economic Review*, 37 (1): 41-61.

Chin, S.F./Harding, A. (2007) 'spatialMSM – NATSEM's Small Area Household Model for Australia', in Gupta, A and Harding, A (eds), *Modelling Our Future: Population Ageing, Health and Aged Care*, Model 22, International Symposia in Economic Theory and Econometrics, Volume 16, Elsevier B. V., Amsterdam, pp. 563-566.

Chin, S.F./Harding, A./Lloyd, R./McNamara, J./Phillips, B./Vu, Q. (2005) 'Spatial Microsimulation Using Synthetic Small Area Estimates of Income, Tax and Social Security Benefits', *Australasian Journal of Regional Studies*, 11 (3): 303-336.

Cotis, J. (2003) 'Population Ageing: Facing the Challenge', *OECD Observer*, September.

Creedy, J./Duncan, A.S./Harris, M./Scutella, R. (2002) *Microsimulation Modelling of Taxation and the Labour Market: The Melbourne Institute Tax and Transfer Simulation.* Cheltenham: Edward Elgar Publishing.

Gupta, A./Kapur, V. (2000) *Microsimulation in Government Policy and Forecasting*. Amsterdam: North-Holland, Elsevier.

Gupta, A./Harding, A. (Eds.) (2007) *Modelling Our Future: Population Ageing, Health and Aged Care*, International Symposia in Economic Theory and Econometrics, Volume 16. Amsterdam: Elsevier B.V.

Harding, A. (2007) Challenges and Opportunities of Dynamic Microsimulation Modelling, Plenary paper presented to the 1st General Conference of the International Microsimulation Association, Vienna, 21 August 2007.

Harding, A. (Ed.) (1996) *Microsimulation and Public Policy*, Contributions to Economic Analysis Series. Amsterdam: North Holland.

Harding, A./Gupta, A. (Eds.) (2007) *Modelling Our Future: Population Ageing, Social Security and Taxation*, International Symposia in Economic Theory and Econometrics, Volume 15. Amsterdam: Elsevier B.V.

Harding, A./Percival, R. (2007) 'The Australian Child Support Reforms: A Case Study of the Use of Microsimulation Modelling in the Policy Development Process', *Australian Journal of Public Administration*, 66 (4): 422-437.

Harding, A./Payne, A./Vu, Q.N./Percival, P. (2006) 'Trends in Effective Marginal Tax Rates, 1996-97 to 2006-07', *AMP NATSEM Income and Wealth Report* Issue 14, September (available from www.amp.com.au/ampnatsemreports).

Immervoll, H. (2004) *Average and Marginal Effective Tax Rates Facing Workers in the EU: A Micro-Level Analysis of Levels, Distributions and Driving Factors*. OECD Social, Employment and Migration Working Paper No 19. Paris: OECD.

Lymer, S./Brown, L./Yap, M./Harding, A. (2008) 'Regional Disability Estimates for New South Wales in 2001 Using Spatial Microsimulation', *Applied Spatial Analysis and Policy*, 1 (2): 99-116

Mitton, L./Sutherland, H./Weeks, M. (2000) *Microsimulation Modelling for Policy Analysis: Challenges and Innovations*. Cambridge: Cambridge University Press.

Oliver, X./Spadaro, A. (2007) 'Basic Income or Vital Minimum? A Note on the Distributive Effects of Possible Reforms of the Spanish Income Tax', pp. 361-387 in: Harding, A./Gupta, A. (Eds.), *Modelling Our Future: Population Ageing, Social Security and Taxation*, International Symposia in Economic Theory and Econometrics, Vol. 15. Amsterdam: Elsevier B. V.

Orcutt, G.H. (1957) 'A New Type of Socio-economic System', *Review of Economics and Statistics* 58 (2): 773-797 (reprinted with permission in *International Journal of Microsimulation* 1 (1): 3-9, Autumn, at http://www.microsimulation.org/IJM/V1_1/IJM_1_1_2.pdf).

Orcutt, G./Merz, J./Quinke, H. (1986) *Microanalytic Simulation Models to Support Social and Financial Policy*. Amsterdam: North-Holland, Elsevier.

Sutherland, H. (2007) 'EUROMOD', pp. 563-566 in Gupta, A./Harding, A. (Eds.), *Modelling Our Future: Population Ageing, Health and Aged Care*, Model 22, International Symposia in Economic Theory and Econometrics, Volume 16. Amsterdam: Elsevier B. V.

Voas, D./Williamson, P. (2000) 'An Evaluation of the Combinatorial Optimisation Approach to the Creation of Synthetic Microdata', *International Journal of Population Geography*, 6: 349-366.

Williamson, P./Birkin, M./Rees, P.H. (1998) 'The Estimation of Population Microdata by Using Data from Small Area Statistics and Samples of Anonymised Records', *Environment and Planning* A, 30 (5): 785-816.

Zaidi, A./Rake, K. (2001) *Dynamic Microsimulation Models: A Review and Some Lessons for SAGE*, ESRC-SAGE discussion Paper no. 2. London: London School of Economics.