Developing and Using Dynamic Microsimulation Models for Public Policy Analysis

Cathal O’Donoghue
Teagasc Rural Economy and Development Programme
My Modelling Background

1990’s
- SWITCH
- EUROMOD
- LIAM

2000’s
- PENSIM2
- MIDAS x 3
- LIAM2
- Social Genome
- Enviro-SMILE

2010’s
- Farm Level
- Retirement Choice
- Public Choice
- Crisis Modelling

Other
- Brazil
- Pakistan
- Sri Lanka
- Nigeria
- Estonia
- Lithuania

The Irish Agriculture and Food Development Authority
A Dynamic Microsimulation Model

\[ Y_{it}^* = g\left( f\left( BX_{it} + \Omega P_{it} + \varepsilon_{it} \right), C \right) \]

- Dynamic
  - \( t \) - inter-temporal
- Micro
  - \( i \) - micro units
- Simulation
  - \( B \) – parameter estimates – applied to other variables in model \( X \)
  - Almost all variables endogenous to model
  - Can respond to policy \( P \)
  - Incorporates individual heterogeneity \( \varepsilon \)
  - \( f() \) – functional form of regression model
  - \( g() \) – alignment or calibration method using totals \( C \)
Sources of Complexity

- All Models are wrong – some are useful (Box)
  - Multiple dimensions of complexity – models help to manage complexity
  - Move to increase complexity of models
  - However simpler may be better
  - Complexity → More costly, time consuming, harder to interpret
  - Longitudinal versus Cross-section
Dynamic Models

- Database
  - Output Routine
  - Tax-Benefit Routine
    - Behavioural Routine
      - Analytical Routines: RR/METR
      - Model Framework

If Behaviour depends on Tax-Benefit System
• Very many models built
• Few survive into medium term

Li and O'Donoghue, 2012
Model Frameworks

- Microsimulation Model Framework – Model Engine
- Expensive to create – 1 to 2 person years (or more)
- Because of cost, more effort spend on computing environment than policy question
- Specific not general, so models die after initial use
LIAM Objectives

- Construct a dynamic microsimulation model flexible enough to cope with future demands of my research agenda
  - Limited data at the time
- Later objective
  - Potentially usable elsewhere
- Rationale
  - Computing and Other Costs have slowed down development of dynamic microsimulation models over the last 30 years.
  - Model Development still very expensive
- Alternatives:
  - Reusable Code
  - Use of other models as templates
Requirements

- Intra - cohort redistribution of the tax-benefit system.
- Demographic Ageing and the Income Distribution
- Comparisons of welfare state life course redistribution across countries
- Improve behavioural equations
- Improved data
- Savings processes
- Life course labour supply
Desirable Features

- Ease in adding new data
- Ease in new adding behavioural information
- Can run on a PC
- Flexible and Transparent
- Robust to Changes
- Speed
- Allow user to focus more on behaviour than computing
Data Structure

- Use relational database?
- Data storage event driven
- Which, When, Who, What
- Cohort versus cross-section
- Multi-person processes
- Defining and initialising variables
- Duration data
Generalisation - Modularisation

- Modularisation
- Variable Order
- 5 Types of Process Module:
  - transition matrices,
  - regressions,
  - marriage market
  - transformations
  - tax-benefit system
- Discrete time
- Tax-Benefit module
Implementations of Framework

- Irish Tax-Benefit Dynamic Microsimulation Model
  - Life-cycle redistribution
  - Pensions analysis and redistribution
- EU15 Indirect Tax Model
  - Expenditure
  - Indirect Taxation
- MIDAL Models
  - Be, Ge, IT, Lu
  - T-DYMM
LIAM Book - Methodology

- Methodological aspects of dynamic microsimulation models
- The life-cycle income analysis model (LIAM) computing framework
- Simulating histories for dynamic microsimulation models
- Simulating earnings
- Simulating migration
- Alignment and calibration
LIAM Book - Applications

- Intra-personal redistribution over the life-cycle
- Financing higher education
- Modelling Expenditure and Indirect Taxation
- Analysing the Impact of the 2007 Irish Pensions Green Paper
- What are the Consequences of the European AWG-projections on the adequacy of pensions
- Introducing Political Economy into Dynamic Microsimulation Modelling
Benchmark

- Dynamic Microsimulation Model
  - A demographic module, modelling leaving home, births, deaths partnership formation and dissolution, disability, education and broad location.
  - A labour market module containing participation, hours, unemployment and labour income
  - A Tax-Transfer and Wealth module containing capital income and the main tax and transfer instruments
  - A marriage matching module
  - A simple macro-economic model and feedback loops linked with the microsimulation model via alignment.
- Monte Carlo Simulation

- DYNAMSIM I – Orcutt et al. (1976)
  - Model built in the 1960’s-1970’s
  - Seemingly little progress in field
Constraints and Issues - Hoschka (1986)

- Many of the behavioural hypotheses in micro-simulation models are of insufficient theoretical and/or empirical basis
  - Dynamic changes in the behaviour of the population are mostly not regarded by micro modellers
  - The problems of including more than the primary effects of a policy programme is still unresolved
- Quality and accessibility of the data required by micro models often are restricted severely.
- The development of micro-models frequently needs too much time and its costs are accordingly high
- Running micro models usually requires a lot of computer time
- The prediction quality of micro-models has not yet been systematically evaluated and validated
- Large microsimulation models are so complex that they are difficult to comprehend and control.
Progress

- Speed and Sample Size
  - Hardware
  - Algorithms – DYNACAN, Scott (2001), O’Donoghue et al. (2009), LIAM2
- Validation
  - Caldwell and Morrison
- Micro-econometrics
  - Better micro models
- Spread of Use
- Generic Models
  - ModGen (Wolfson and Rowe, 1998),
  - UMDBS (Sauerbier, 2002),
  - GENESIS (Edwards, 2004)
  - LIAM (O’Donoghue, 2011) and
  - LIAM2
Alignment
Alignment

- Constrain model outcomes to hit external control totals
- Alignment may be used
  - To ‘repair’ the unfortunate consequences of insufficient estimation data by incorporating additional information in the simulations.
  - To adjust for poor predictive performance of the micro model or its misspecification. Even with perfect data, relationships between dependent variables and explanatory variables may change considerably in countries where substantial structural changes are taking place.
  - To produce scenarios based on different assumptions.
  - To establish links between microsimulation models of the household sector and the macro models.
  - To reduce Monte Carlo variability though its deterministic calculation (Neufeld, 2000). This is particularly useful for small samples to confine the variability of aggregate statistics.
Alignment

- "Microsimulation models usually fail to simulate known time-series data. By aligning the model, goodness of fit to an observed time series can be guaranteed.
- Opinions vary as to the admissibility of this procedure. Most microsimulation modellers accept alignment as an unfortunate, but unavoidable necessity while other thermodynamic modellers (myself among them) consider it to be an indefensible fiddle which, to use Popper's celebrated phrase, effectively "immunises the model against empirical refutation".
- the only way microsimulation modellers can predict the future is by persuading someone who knows more than they do to tell them what's going to happen
- thermodynamic models are non-alignment microsimulation models and aligned microsimulation models are irreconcilable”

- Winder (2000)

• Cannot hope to predict the future well
• Is it worth trying to find this “Holy Grail”?
“Failure” to achieve objectives

- Perception of failure of earlier models
- However
  - Expectations to high
  - Predictive Capacity of Models → weak
Added Value

- Term Forecasting should not be used
  - Dynamic Microsimulation Models cannot forecast
  - Not possible to forecast 2008 crisis in 2006 → what hope over 50 years
  - Don’t oversell
  - Recreate realistic expectations
- Utilise as part of foresighting rather than forecasting
- Rather Alignment is a mechanism for Scenario Analysis
  - Main advantage is that DMM has plausible cross-sectional and longitudinal distributions
- Better to focus attention on
  - How different macro-economic environments affect these distributions
  - Improve functioning of Alignment
  - How to combine Alignment with Behavioural Response to policy and economic changes
  - Very limited research on alignment – mainly ad hoc solutions to modelling requirements → big scientific gaps
Behavioural Response
Behavioural Feedback

Count of Use of Behavioural Equations

Li and O'Donoghue, 2012

The Irish Agriculture and Food Development Authority
Behavioural Response

- Behavioural Response to Policy Change
  - Progress ➔ cross-sectional labour supply
- Use dynamic microsimulation models to generate budget constraints for use as an input into life-cycle behavioural choice modelling
- Important Areas
  - Retirement Choice
  - Life-course decision making
    - Fertility
    - Education
    - Savings
Governmental Budget Constraint
Macro-economic Feedback

- Dynamic Models
  - Currently no macro feedback
  - “Flexible” Government Budget Constraint
  - Not really a
- As population ages
  - Pressure on financial sustainability
  - What about wider macro effects
- Useful to consider a link to a macro-economic framework with different “closure” assumptions
Ageing and Political Preferences

- Fixed Government Budget Constraint
  - How to adjust policies?
- Option – incorporate a public preference model
- As population ages
  - Changed pattern of preferences
  - Transfers to elderly drive fiscal imbalance, but group becomes politically stronger
- Abid Fourati and O’Donoghue (2010)
  - Collect survey on public preferences to pensions policy → Choice experiment
  - Estimate a choice model based around policy attributes and outcomes for different groups
  - Simulate policy preferences at citizen level
  - Scale preferences to social preference → challenge in relation to how voting system works in respect to individual policies
  - Requires multiple run of model
- Observe trade-off between personal return, poverty reduction and cost
- Under status quo → preference for universal pensions but not optimal from poverty perspective
- Under population ageing → preference shift to a lower cost version with later retirement
- Higher incomes prefer earnings related system
Future Directions
Methodological Challenges

- Unit of Analysis
  - Family versus Household
  - Household Formation and Dissolution dynamics
- How to incorporate alignment and behavioural response
- Governmental Budget Constraint
  - Macro-economic constraints
  - Political constraints
- Confidence Intervals
  - Monte Carlo
- Intra-household-Intertemporal-Cross-sectional
- Simulation properties
  - How to generate long term stable employment patterns
  - Understand earnings dynamics
- Validate historical simulations
Base-Sample Size

Count of Size Band

Li and O'Donoghue, 2012
Areas of Analysis

- Big Issues
  - Ageing
  - Climate Change

- New Areas
  - Children
  - Health
  - Environment
  - Short term impacts – Fiscal Crisis
Linking LIAM based models with EUROMOD
EUROMOD

- Financed by EU Commission since 1993
- Tax-Benefit Systems of EU countries
- Focus on Policies to Alleviate Poverty and Social Exclusion
- Consistent Comparative Framework
  - Data
  - Policy
- Comparative Analysis
- Necessary in understanding increased fiscal coordination
- First National MSM in Austria, Greece, Portugal, Lux.
- Challenges
  - Complexity
  - GUI helps – but many systems
Linking LIAM models to EUROMOD

- Convert LIAM Output into EUROMOD input
  - Feasible
  - Requires the same variables
  - May require additional variables
  - Italian model → Bank of Italy Data
  - Possible now
    - Luxembourg model

- Integrate LIAM with EUROMOD
  - Undertaken in LIAM1 – but not available now with simplified EUROMOD code
  - Indirect Tax
  - My PhD
  - Advantage
    - Can call EUROMOD to generate feedbacks from policy to behaviour
  - Would require significant work → Joint project?
Sustainability and Generating Forward Momentum
Reasons for lack of Progress – Tacit Knowledge

- Given that nearly 40 years have passed,
  - the rate of progress it can be argued has been relatively slow
- Knowledge Transfer Mechanism
  - Tacit knowledge
  - Codified knowledge
- Focus on Tacit Knowledge
  - Networks
  - Documentation - aim to facilitate other team members utilising the models
- Where knowledge codified
  - mainly been via books and conference presentations which may have been non-peer reviewed, had limited coverage, often went out of print, may have only been available to those who attended an event and were rarely included in usual citation indices and searchable databases.
  - Where papers were published in peer reviewed formats, they were typically in journals where the focus was on the application rather than the methodology

- A significant proportion of the methods used in the field are not formally codified,
- meaning that new models have had to reinvent the wheel and re-develop existing methods over and over again.
Reasons for lack of Progress – Ownership Model

- Proprietary versus open source
- Proprietary
  - Code or coding consultancy has been sold to potential clients
  - Intellectual property makes sense when an economic return can be gained and incentives private R&D
  - Relatively small demand for these tools by clients with the capacity to pay for them, it seems to be a business model that will stymie intellectual development
- Open source
  - Collective gains
  - Private gains via citation and scientific reputation
  - Peer-review → quality control
  - Emphasis on public good nature of research
    - Funding mechanisms
Business Models

- Large Projects
  - Pensim2, DYNACAN, APPSIM
  - Start from scratch
  - Large resources
- PhD Based
  - LIAM, CORSIM
  - Incremental construction
  - Lots of small resources
- Network Based
  - MIDAL, LIAM2
  - Shared resources
  - Open source
  - Sustainability risk → lack of codification
  - However spread risk
European Microsimulation Meeting

- May 17-19th Dublin, hosted by Teagasc/IZA/UNICEF/NUIM
- Paper submission deadline February 3rd
- Includes meeting of European Dynamic Microsimulation Model network
- Contact Cathal O’Donoghue <cathal.odonoghue@teagasc.ie>
Thank You