Lecture 2: Behavioural and Dynamic microsimulation

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Outline of the lecture

I. Behavioural responses in static models

II. Why dynamic microsimulation ?

III. Structure of dynamic microsimulation models

IV. Challenges

I. Behavioural responses

1. Clarifying the issue
2. Labour supply responses
3. Optimal taxation
4. Consumption choices

I. Behavioural responses
Issues

- **Policy interactions**
  (a) Mechanical interactions
  e.g., increase in SSCs reduce taxable income
  (b) Behavioural responses linked to budget constraints
  e.g., increase in income tax reduces either consumption or savings
  (c) Behavioural responses
  e.g., increase in income tax can affect hours of work

- **Behavioural margins**
  - Labour supply (employment, hours, retirement)
  - Consumption patterns
  - Tax optimization, income shifting
  - Mariage, divorce, fertility, etc.

I. Behavioural responses

Labour supply responses

- **Framework (Aaberge and Colombino, 2014)**
  - Opportunity set B_i of labour supply characteristics x (hours of work, net wage, sector, transportation cost, child care cost, etc.)
    e.g., budget set $B_i = x = (c, h), c < f(wh, I)$
  - Decision rules D_i : given B_i, choices x are made

- **Key assumptions**
  (i) Identification of D_i using observations of choice x_i and opportunity set B_i
  (ii) Decisions rules D_i invariant w.r.t policies

- **Microsimulation with behavioural responses**
  1. Compute new option set : B_i^{new}
  2. Produce new choices x_i^{new} based on estimated D_i

I. Behavioural responses

Labour supply responses

- **Modelling labour supply responses**
  - Structural vs reduced-form approaches
  - ETI vs standard labour supply modelling

- **The common problem**
  - Policy changes the non-linear budget set
  - How do individuals responds in different labour supply margins (extensive vs intensive)?

- **Three approaches**
  1. Reduced-form approaches
  2. Structural approaches
  3. Sufficient statistics approaches

I. Behavioural responses
Reduced-form approach

- **The main approach up to the 1970s**
  - Regressing hours of work h

$$h = \alpha + \beta w + \gamma I + \varepsilon$$

  - With h hours of work, w net wage rate, I net other income
  - Identification with exogenous w and I

- **Not a correct modelling**
  - w and h affected by preferences
  - Corner solutions (i.e., $h = 0$) ignored
  - Non-linear budget constraints ignored

I. Behavioural responses

Structural approaches

- **Heckman (JPE, 1974)**
  - Pathbreaking paper
  - Evaluation of a child-care programme on women's labour supply

- **Utility maximisation**
  - Direct utility function $u(c,h)$

$$\max_{c,h} u(c,h) \ s.t. \ c = wh + I$$

  - Individuals have a choice of net wage-hours combinations
  - Use of the duality results to solve the model (indirect utility function, compensated labour supply function)

I. Behavioural responses
Structural approaches

- **Virtual income**
  - Non-linear budget constraints can be seen as piece-wise linear (Burtless and Hausman, 1978)
  - Virtual income : net other income given a net wage rate (i.e., the intercept from the piece-wise linear budget constraint)

- **Solving for the labour supply model**
  - Decompose the budget constraint into each linear section
  - Exclude observations at kinks
  - Estimate labour supply model using virtual income for each section
  - Repeat the procedure for all linear sections

I. Behavioural responses
Structural approaches

- **Unobserved wage for non-workers**
  - Critical aspect of labour supply models
  - Simple solution could be to impute wage to non-workers based on wage equation with observed characteristics
  - Selection bias : unobserved characteristics of non-workers likely to give lower wage distribution

- **Two approaches**
  - Tobit approach (Heckman, 1974) : two equations
  - Multi-step section-correction (Heckman, 1979) : estimate a wage equation with non-random sample section ; impute the systematic part of the wage equation to everyone

I. Behavioural responses
Structural approaches

- **Bourguignon and Magnac (JHR 1990)**
  - One of the first application to French data
  - Data : French LFS 1985
  - Follows closely specification from Hausman (1981) and piece-wise linear estimation
  - Separate estimation for male and female
- **Results**
  - Very small estimates of labour supply elasticities for male (0.1)
  - Larger ones for female (0.3)
  - Bad fit of actual hours with predicted hours from the model without fixed cost

I. Behavioural responses

FIGURE 1: Distributions of predicted hours worked (model without fixed cost)

Weekly Hours	Actual Distribution	Simulated Distribution[a] Without Errors of Measure	Simulated Distribution[a] With Errors of Measure
1–20	11.1%	46.4%	35.5%
20–34	21.5	30.9	30.2
35–38	14.2	5.1	6.0
39	40.6	0.9	1.4
40–44	8.4	5.2	7.4
45–54	3.0	6.7	8.8
>55	1.2	4.7	10.6
Total	100.0	100.0	100.0
Mean	33.4	24.5	29.6

Source : Bourguignon and Magnac (1990), Table 4, p. 376.

I. Behavioural responses
Structural approaches

- **Discrete choice model**
  - Choice over alternative hours of work
  - Conditional multinomial logit model
  - With fixed cost of work (child care, etc.)

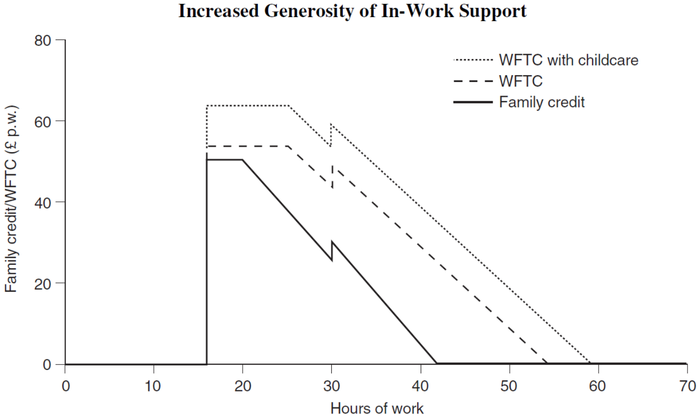
- **Blundell, Duncan, McCrae and Meghir (FS, 2000)**
  - Analysis of the impact of tax-credit reform in the U.K.
  - Apply IFS TAXBEN model
  - Get new budget sets
  - Estimates fixed cost of work
  - Apply discret choice labour supply model
  - Simulate policy with and without behavioural response

I. Behavioural responses
Structural approaches

- **In-work credit in the U.K. in 1998-99**
  - Family credit (FC) replace by Working families' tax credit (WFTC) in 1998
  - Eligibility : families with children, working at least 16 hours per week
  - Reduction in the taper-rate from 70% to 55%
  - Increase in child care credit
- **Potential incentives**
  - Incentives to work more for lone parents
  - Possible disincentives for secondary earners with children

I. Behavioural responses

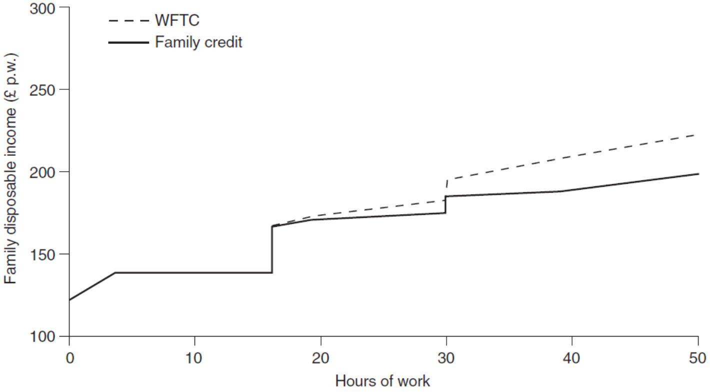
Figure 2: Features of WFTC in the U.K. in 1998-99



Source : Blundell et al. (2000), Fig. 1, p. 78.

I. Behavioural responses

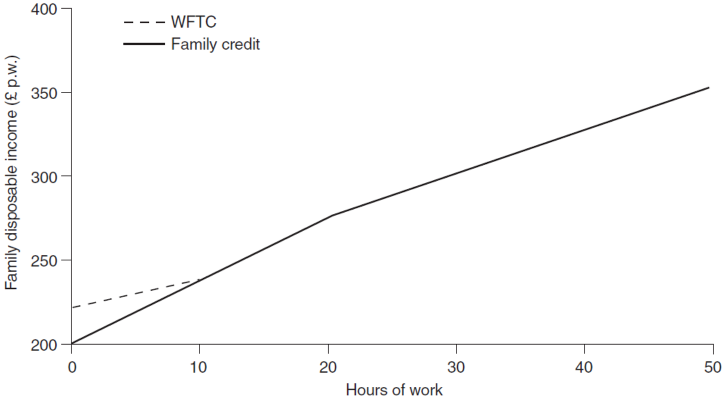
FIGURE 3: Budget Constraint for Lone Parent without Childcare Costs



SOURCE : Blundell et al. (2000), Fig. 3, p. 84.

I. Behavioural responses

FIGURE 4: Budget Constraint for Woman in Couple without Childcare Costs



SOURCE : Blundell et al. (2000), Fig. 6, p. 87.

I. Behavioural responses

Labour supply responses

- **Microsimulation**
  - Use TAXBEN microsimulation model
  - Data : Family Ressources Survey (FRS)
  - 50,000 U.K. households
- **Non behavioural effects**
  - Interactions with other benefits reduce net effects
  - Gains for working lone parents
  - Little gains for married women in part-time jobs : possible negative incentives

I. Behavioural responses

FIGURE 5: Proportion of Gainers from WFTC

Per cent

	Hours of work (banded)					
	0	*1–10*	*11–20*	*21–30*	*31–40*	*41+*
Lone parents						
No pre-school children	.	.	62.1	74.0	52.2	51.1
One or more pre-school children	.	.	75.0	87.9	61.5	61.5
All women	.	.	65.2	78.2	53.8	53.4
Married, partner working						
No pre-school children	30.6	19.0	10.2	4.9	3.6	3.1
One or more pre-school children	35.9	12.7	11.7	5.3	4.4	4.1
All women	33.9	16.2	10.9	5.0	3.9	3.4
Married, partner not working						
No pre-school children	.	.	38.6	53.3	36.7	66.7
One or more pre-school children	.	.	73.1	80.0	45.0	33.3
All women	.	.	51.4	60.0	39.1	61.9

Note: Data are grouped according to observed hours of work for all household members and conditioned on observed childcare expenditure patterns.
Source: TAXBEN, based on Family Resources Survey, 1994–95 and 1995–96.

Source : Blundell et al. (2000), Tab. 5, p. 90.

I. Behavioural responses

FIGURE 6: Average Income Gains from WFTC among Gainers

Pounds per week

	Hours of work (banded)					
	0	*1–10*	*11–20*	*21–30*	*31–40*	*41+*
Lone parents						
No pre-school children	.	.	8.70	14.17	18.91	21.74
One or more pre-school children	.	.	12.67	19.59	26.70	20.67
All women	.	.	9.82	16.00	20.48	21.47
Married, partner working						
No pre-school children	19.12	19.32	17.95	17.57	19.86	19.72
One or more pre-school children	23.87	17.57	21.82	19.99	20.60	18.30
All women	22.27	18.73	19.72	18.44	20.13	19.24
Married, partner not working						
No pre-school children	.	.	12.42	16.45	20.57	24.33
One or more pre-school children	.	.	10.99	16.77	18.36	39.65
All women	.	.	11.66	16.56	19.83	25.51

Notes: As for Table 5. Each cell reports average gains (in pounds per week) *among households who gain from WFTC*. To recover average gains over all women, multiply each figure by the probability in the corresponding cell of Table 5.
Source: TAXBEN, based on Family Resources Survey, 1994–95 and 1995–96.

Source : Blundell et al. (2000), Tab. 6, p. 91.

I. Behavioural responses

Labour supply responses

- **Structural labour supply model**
  - joint participation model with discrete hours choices : 0, 10, 20, 30 and 40
  - include fixed costs of work, missing wages, program take-up and childcare demand

- **Estimation**
  - write extended likelihood function
  - get estimates by simulated maximum likelihood

- **Identification**
  - provided by the comparison across different tax/benefit regimes and across different types of individuals with varying eligibility status

I. Behavioural responses

Figure 7: Model Estimates for Single Parents

Variable	*No controls for childcare* Estimate	Std.Err	*with controls for childcare* Estimate	Std.Err
Income^2	-0.1631	0.0503 *	-0.165	0.0536 *
hours^2	0.0334	0.0191	0.0212	0.0195
hours x income	-0.0099	0.0041 *	-0.0087	0.0043 *
Income	2.4705	0.2967 *	2.5995	0.3125 *
x **1**(youngest child 0-2)	-0.2896	0.2928	-0.3747	0.3085
x **1**(youngest child 3-4)	0.1829	0.3119	0.0519	0.3241
x **1**(youngest child 5-10)	0.4032	0.1738 *	0.3473	0.1846
x (age-35)/10	-0.1474	0.1065	-0.1725	0.1157
x (age-35)^2/100	0.0047	0.079	-0.0249	0.0872
x **1**(education<18)	-0.0151	0.1361	0.0155	0.1444
x # children aged 0-1	0.3859	0.3085	0.4325	0.3406
hours	0.008	0.0124	0.0048	0.0127
x **1**(youngest child 0-2)	-0.0554	0.0091 *	-0.0456	0.0089 *
x **1**(youngest child 3-4)	-0.0622	0.0088 *	-0.0584	0.0089 *
x **1**(youngest child 5-10)	-0.0313	0.0054 *	-0.0274	0.0056 *
x (age-35)/10	-0.0036	0.0032	-0.0069	0.0034 *
x (age-35)^2/100	-0.0077	0.0027 *	-0.0087	0.003 *
x **1**(education<18)	-0.0154	0.0046 *	-0.0152	0.0047 *
x # children aged 0-1	-0.0193	0.0093 *	-0.0183	0.0091 *
fixed costs/100	0.6717	0.0752 *	0.6459	0.0714 *
x **1**(Metropolitan area)	-0.0286	0.0506	-0.0324	0.049
x # children aged 0-2	0.2365	0.1368	0.2197	0.1242
x # children aged 3-4	0.0776	0.0973	0.0861	0.0939
x **1**(Greater London)	0.0109	0.0805	0.0064	0.0774
sample size	1807		1807	
log-likelihood	-3358.65		-3740.4	

Source : Blundell et al. (1999), Tab. C1.

I. Behavioural responses

Labour supply responses

- **Behavioural responses**
  - Simulate the WFTC reform using the labour supply model estimates
  - Participation rate for single mothers increases by 2.2 ppt
  - Participation rate for married women with employed partners decreases by 0.57 ppt

- **Overall effects**
  - Total effect : a small increase in overall participation of about 30,000 individuals
  - Behavioural responses reduce the cost estimated in the purely arithmetical scenario by 14%
  - Increase in the labour force participation of single mothers and the subsequent increase in tax receipts

I. Behavioural responses

FIGURE 8: Simulated Transitions among Single Parents

Transitions

Pre-reform	Out of work (*Post-reform*)	Part-time (*Post-reform*)	Full-time (*Post-reform*)	*Pre-reform %*
Out of work	58.0	0.7	1.5	60.2
Part-time	0.0	18.6	0.5	19.1
Full-time	0.0	0.2	20.6	20.7
Post-reform %	58.0	19.4	22.6	100
Change (% points)	–2.2	0.3	1.9	

Summary

	Mean	*Standard deviation*
Change in participation	+2.20%	[0.42%]
Average change in hours (all)	+0.75	[0.16]
Average change in hours (workers only)	+0.22	[0.04]
Average hours before reform (all)	10.20	
Average hours before reform (workers only)	25.70	

Source : Blundell et al. (2000), Tab. 7, p. 94.

I. Behavioural responses

FIGURE 9: Simulated Transitions among Married Women

Transitions

Pre-reform	*Post-reform* Out of work	Part-time	Full-time	*Pre-reform %*
Out of work	32.2	0.1	0.1	32.4
Part-time	0.3	31.6	0.0	32.0
Full-time	0.4	0.1	35.0	35.6
Post-reform %	33.0	31.8	35.2	100
Change (% points)	0.6	–0.1	–0.4	

Summary

	Mean	*Standard deviation*
Change in participation	–0.57%	[0.06%]
Average change in hours (all)	–0.18	[0.02]
Average change in hours (workers only)	–0.03	[0.005]
Average hours before reform (all)	17.34	
Average hours before reform (workers only)	25.65	

Source : Blundell et al. (2000), Tab. 8, p. 95.

I. Behavioural responses
Sufficient statistics approaches

- **Sufficient statistics**
  - Saez (RESTUD, 2001) : deriving optimal income tax schedule from elasticity of taxable income (ETI)
  - Chetty (AEJ-EP, 2009) : ETI as sufficient statistics
  - Idea : estimate key parameters capturing behavioural responses without estimating structural underlying parameters
  - Applied public economics literature revisiting traditional labour supply lit.

- **Saez (QJE, 2002)**
  - Extensive vs. intensive margin of labour supply
  - Optimal design of transfer programme (traditional vs. in-work credit)

I. Behavioural responses
Sufficient statistics approaches

- **Immervoll, Kleven, Kreiner and Saez (EJ, 2007)**
  - Compare trad. welfare to in-work benefits
  - Model of labour supply with extensive/intensive margins
  - Use EUROMOD microsimulation model to estimate counterfactual reforms on EU countries
  - Calibrate behavioural responses using elasticities from literature

- **Two policy reforms**
  1. Traditional welfare : lump-sum transfer given to everybody (i.e., negative income tax)
  2. Redistribution to working poor : lump-sum transfer given to those working (close to EITC or WFTC)

I. Behavioural responses

Sufficient statistics approaches

- **Static labour supply model**
  - Exogenous productivity w_j
  - Before tax income $w_j l$, consumption c
  - Tax and benefit system $T(y, z)$

$$c = y - T(y, z)$$

  - Assume no income effects

- **Intensive margin**
  - Define intensive margin elasticity ε_j for group j

$$\varepsilon_j = \frac{(1-\tau_j)w_j}{l_j} \frac{\partial l_j}{\partial (1-\tau_j)w_j}$$

I. Behavioural responses
Sufficient statistics approaches

- **Fixed cost of work**
  - Cogan (ECTA, 1981)
  - Fixed cost q distributed according to $F_j(q)$
  - Fraction of group participating in the labour market

$$\int_0^{q_j} f_j(q)dq = F_j(q_j)$$

- **Extensive margin**
  - Consumption when working c_j, when not working c_0
  - Define extensive margin elasticity η_j for group j

$$\eta_j = \frac{c_j - c_0}{F_j} \frac{\partial F_j}{\partial(c_j - c_0)}$$

I. Behavioural responses

Equity-Efficiency trade-off

- **Equity**
  - Ψ, the interpersonal utility trade-off, dL aggregate welfare loss, dG welfare gains

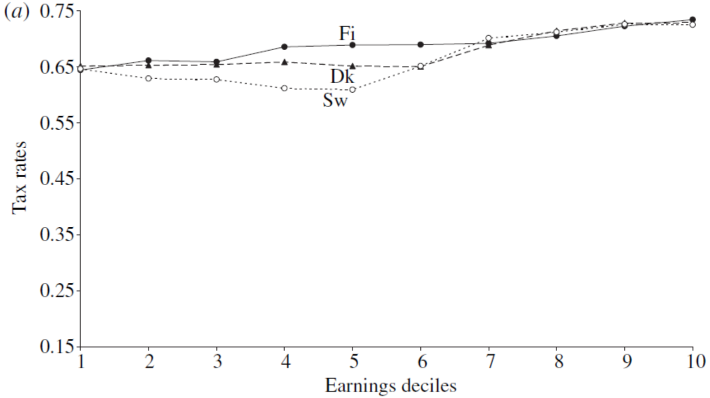
$$\Psi = -\frac{dL}{dG}$$

  - Magnitude of Ψ reflects the degree to which there exists a trade-off between equity and efficiency
  - Ψ gives the welfare cost to the rich of one euro of welfare transfer to the poor (or vice-versa)

- **Efficiency**
  - D fraction of the mechanical tax revenue lost to behavioural responses
  - Tax reforms are considered revenue neutral
  - Mechanical effects vs behavioural effects (intensive and extensive)

I. Behavioural responses

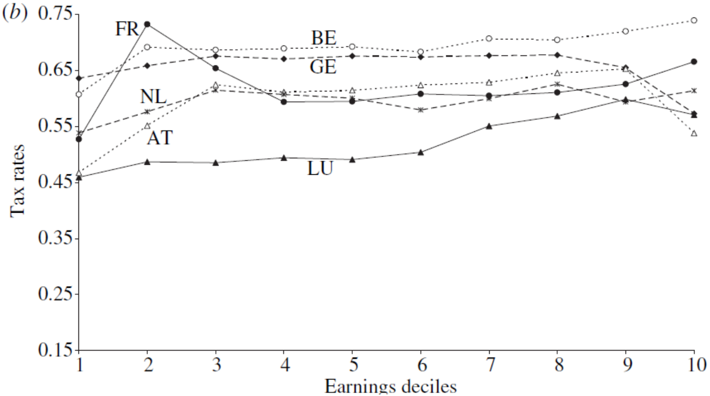
FIGURE 10: Effective Marginal Tax Rates



Source : Immervoll et al. (2007)

I. Behavioural responses

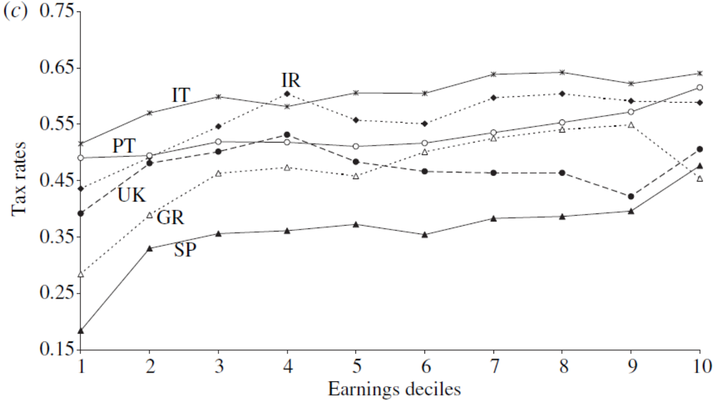
FIGURE 11: Effective Marginal Tax Rates



Source : Immervoll et al. (2007)

I. Behavioural responses

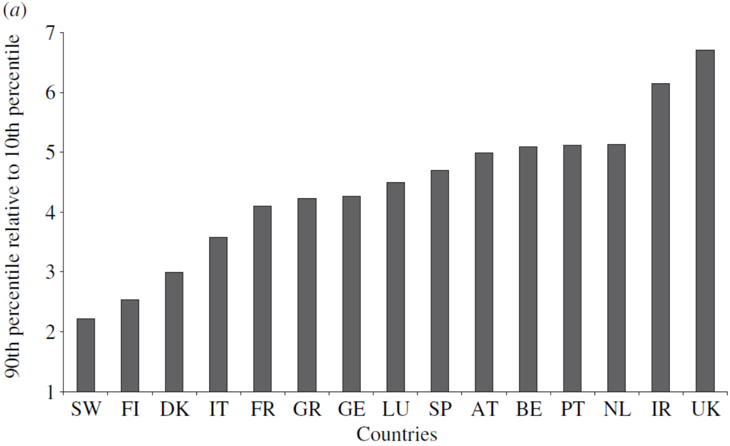
Figure 12: Effective Marginal Tax Rates



Source : Immervoll et al. (2007)

I. Behavioural responses

FIGURE 13: Earnings inequality (P90/P10)



Source : Immervoll et al. (2007)

I. Behavioural responses

Equity-Efficiency trade-off

- **Calibration (benchmark case)**
  - Participation elasticities : $\eta = 0.2$ overall but declining by deciles : $\eta_{D1-D2} = 0.4$, $\eta_{D3-D4} = 0.3$, $\eta_{D5-D6} = 0.2$, $\eta_{D7-D8} = 0.1$
  - Hours-of-work elasticities : $\varepsilon = 0.1$ (with variants from 0 to 0.2)

- **Results**
  - Demogrant policy : trade-offs unfavourable ($\Psi > 1$)
  - Working Poor policy : more favourable ($\Psi < 1$) for some countries
  - Countries with equal earnings distribution lead to unfavourable trade-offs

I. Behavioural responses

FIGURE 14: Welfare Effects from Tax Reform With and Without Participation Responses

	(a)				(b)			
	Benchmark scenario				No participation responses			
	$\eta = 0.2$ (on average) and $\varepsilon = 0.1$				$\eta = 0$ and $\epsilon = 0.1$			
	Demogrant Policy		Working Poor Policy		Demogrant Policy		Working Poor Policy	
Country	Efficiency	Trade-Off	Efficiency	Trade-Off	Efficiency	Trade-Off	Efficiency	Trade-Off
Austria	−0.38	3.04	−0.08	1.50	−0.16	1.57	−0.16	2.16
Belgium	−0.57	4.83	−0.14	1.93	−0.25	1.87	−0.25	3.45
Denmark	−0.82	25.25	1.65	0.00	−0.23	2.31	−0.23	4.75
Finland	−0.58	6.17	−0.21	4.93	−0.24	2.11	−0.24	6.32
France	−0.51	4.32	0.07	0.76	−0.17	1.61	−0.17	2.39
Germany	−0.50	4.38	−0.12	1.89	−0.19	1.72	−0.19	2.67
Greece	−0.21	1.66	−0.05	1.29	−0.10	1.26	−0.10	1.59
Ireland	−0.39	2.73	0.26	0.39	−0.14	1.42	−0.14	1.82
Italy	−0.32	2.07	−0.12	1.96	−0.16	1.43	−0.16	2.62
Luxembourg	−0.26	1.98	−0.06	1.29	−0.12	1.38	−0.12	1.71
Netherlands	−0.36	2.88	−0.07	1.37	−0.15	1.56	−0.15	2.10
Portugal	−0.29	2.34	0.00	0.99	−0.13	1.44	−0.13	1.68
Spain	−0.19	1.52	0.00	0.99	−0.07	1.16	−0.07	1.34
Sweden	−0.62	8.35	−0.17	4.36	−0.22	2.23	−0.22	7.48
United Kingdom	−0.22	1.88	−0.01	1.06	−0.09	1.30	−0.09	1.48

Source : Immervoll et al. (2007), Tab. 2, p. 26.

I. Behavioural responses

FIGURE 15: Critical Values for the Average Participation Elasticity

Country	(*a*) Identical trade-offs for the two policies ($\Psi_w = \Psi_d$)	(*b*) No efficiency loss for the working poor policy ($\Psi_w = 1$)	(*c*) Pareto improvement for the working poor policy ($\Psi_w \to 0$)
Austria	0.07	0.32	0.57
Belgium	0.10	0.27	0.39
Denmark	0.04	0.13	0.20
Finland	0.17	0.38	0.42
France	0.05	0.17	0.35
Germany	0.08	0.32	0.45
Greece	0.10	0.38	1.15
Ireland	0.03	0.10	0.33
Italy	0.18	0.45	0.80
Luxembourg	0.07	0.33	0.88
Netherlands	0.06	0.28	0.58
Portugal	0.03	0.20	0.62
Spain	0.05	0.19	0.96
Sweden	0.14	0.31	0.36
UK	0.04	0.23	0.83

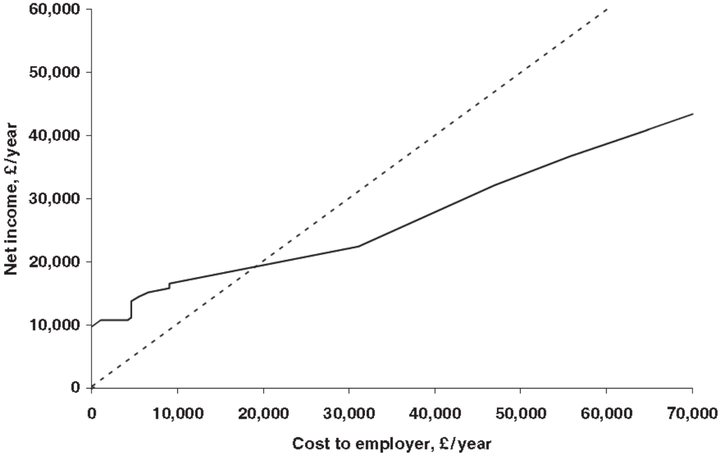
Source : Immervoll et al. (2007), Tab. 3

I. Behavioural responses
Optimal taxation

- **Framework**
  - Mirrlees (1971), Saez (2001, 2002)
  - Maximization of social welfare function
  - Optimal tax schedule depends on elasticity, density and social weight given to redistribution
  - Extensive and intensive elasticities (Saez 2002)
- **Using microsimulation in optimal taxation**
  - Estimate elasticities using past reforms and derive optimal tax schedule (Brewer et al. 2010)
  - Estimate labour supply models with computational approach (Blundell and Shephard, 2012)

I. Behavioural responses

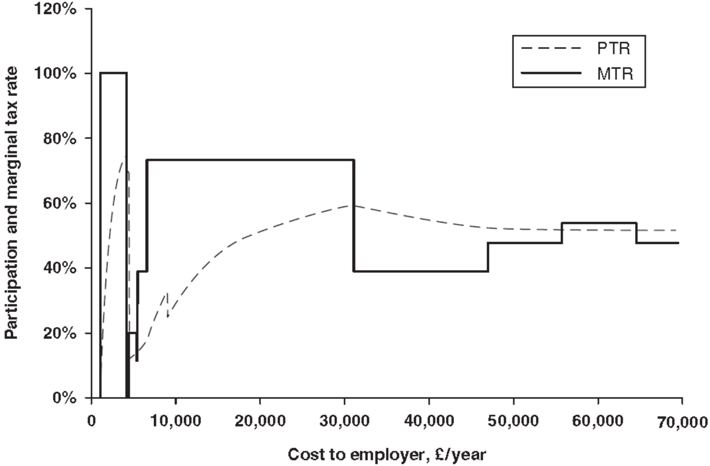
FIGURE 16: Example budget constraint, lone parent



Source : Brewer et al. (2010).

I. Behavioural responses

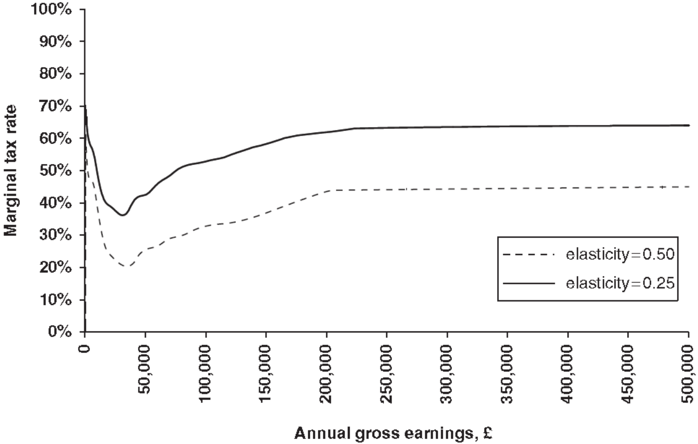
Figure 17: Participation and marginal tax rates, lone parent



Source : Brewer et al. (2010).

I. Behavioural responses

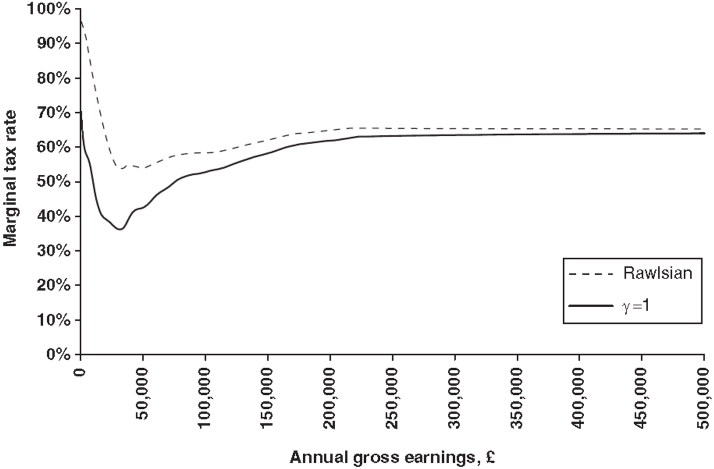
FIGURE 18: Optimal tax sensitivity, labour elasticity



Source : Brewer et al. (2010).

I. Behavioural responses

Figure 19: Optimal tax sensitivity, redistribution preference



Source : Brewer et al. (2010).

I. Behavioural responses

Consumption

- **Indirect taxation microsimulation**
  - Based on expenditure surveys
  - Model sales tax, VAT and excises
  - Need consumption basket of each household
  - Issue of missing prices
- **Incidence**
  - Usually fully on consumers (pre-tax prices fixed)
  - But literature not that clear (Carbonnier, 2007)
- **No behaviour case**
  - Change in budget set for households with expenditure fixed

I. Behavioural responses

Consumption

- **Modelling consumer choices**
  - Engel curve estimation
  - Complete demand system

- **Engel curve**
  - Quantities adjust to change in prices
  - Only income effect of price change taken into account

- **Demand systems**
  - Real income effects and relative price effects taken into account
  - AIDS : Almost ideal demand system (Deaton and Muellbauer, 1980)
  - QUAIDS : Quadratic almost ideal demand system (Banks, Blundell and Lewbel, 1997)

II. Why dynamic microsimulation ?

1. Objectives
2. Macrosimulation
3. Macrosimulation vs microsimulation

II. Why dynamic microsimulation ?
Objectives

- **Policy questions**
  - Pension reforms
  - Lifetime redistribution
  - Elderly care
  - Demographic changes
  - Impact of education policies
- **Key characteristics**
  - Incorporate time dimension
  - Explicitly model dynamic processes

II. Why dynamic microsimulation ?

Dynamic microsimulation

- **Microsimulation**
  - Micro level data

- **Dynamic processes**
  1. Deterministic transitions (e.g., age)

$$AGE_{t+1} = AGE_t + 1$$

  2. Stochastic transitions (e.g., unemployment)
     - Probability of transition p
     - Random draw true/false logic proposition, with p probability of being true
     - Transition if `true`
  3. Behavioural responses (e.g., retirement decision)
     - Microeconomic foundation (optimization)
     - Depends of other variables (e.g., pension level)

II. Why dynamic microsimulation ?

Macrosimulation

- **Cell-based simulation**
  - Classical approach for demographic projections
  - Decomposition of population into cells (e.g. age/sex)
- **The component method**
  - Old method : Wicksell (1926), Leslie (1945)
  - Used with matrix algebra, hence the "Leslie matrix"
- **Principles**
  - Population P_t at time t, split by age and sex
  - Population P_{t+1} is P_t aged by one year : affected by mortality rates, births, and migration

II. Why dynamic microsimulation ?

Macrosimulation

- **Notations**
  - $P_{a,t}$: population age a at time t
  - $q_{a,t}$: age specific mortality rates
  - $f_{a,t}$: age specific fertility rates
  - N_t : births at time t
  - $M_{a,t}$: migration by age a at time t

- **Recurrence equation**

$$P_{a,t} = P_{a-1,t-1}(1 - q_{a,t})$$

- **New cohorts**

$$P_{0,1} = N_t = \sum_{a=15}^{50} f_{a,t} P_{a,t}$$

II. Why dynamic microsimulation ?

Macrosimulation

- **Matrix representation**

$$P_{t+1} = A_t P_t + M_t$$

- **The Leslie matrix**

$$A_t = \begin{bmatrix} 0 & f_{15} \ldots f_{50} & 0 & 0 \\ 1 - q_0 & 0 & 0 & 0 \\ 0 & \ddots & 0 & 0 \\ 0 & 0 & 1 - q_{110} & 0 \end{bmatrix}$$

II. Why dynamic microsimulation ?

Macrosimulation vs microsimulation

- **Macrosimulation vs microsimulation**
  - Macrosimulation limited to few variables
  - Dynamic microsimulation is stochastic by nature

- **Demographic example (Imhoff and Post, 1997)**
  - Simulate number of kids born in one year from 100 000 women aged 25
  - p probability to have a kid, $p = 0,10$
  - Macrosimulation : $100\ 000 * p = 10\ 000$
  - Microsimulation : random draw a at individual level on uniform distribution [0,1], if $a > p$ then a kid is born

II. Why dynamic microsimulation ?

Macrosimulation vs microsimulation

- **Limits of microsimulation**
  - Results are stochastic
  - After random draw, number of kids born could be 9 998, 9 999, 10 001, etc.
  - More variability in results for small samples

- **Limits of macrosimulation**
  - Size of matrices depend on number of variables :

$$M_1 \times M_2 \times M_3 \times M_4 \times M_5 \times M_6$$

  - Demographic example
    - 7 variables (sex, marital status, location etc.)
    - 2 billion cells...

II. Why dynamic microsimulation ?

Static vs dynamic ageing

- **Static vs dynamic ageing**
  - Static : less costly, theoretically close (Dekkers, 2015)
  - Dynamic : more costly, but more natural for long term projections
- **Arguments for dynamic ageing**
  - New individuals different from baseline data
  - Modelling career
  - Modelling reforms depending on cohort, age and period

II. Why dynamic microsimulation ?
Dynamic microsimulation

- **Mostly pension models**
  - 34 dynamic MS models for pensions (Li and O'Donoghue, 2013)
  - 13 models for lifetime redistribution
  - 10 models for demography
- **Costs and platforms**
  - Costs of development of microsimulation models : very high
  - Development of platforms dedicated to dynamic MS
    - LIAM2 : Belgium, Hungary, Luxembourg, etc.
    - ModGen : Statistics Canada,

III. Structure

1. Baseline data
2. Demographic module
3. Earnings module
4. Pension module
5. Retirement decision

III. Structure

Baseline data

- **Representative sample**
  - Need all variables necessary to simulate policy (and predict processes)
  - Need to combine different sources (admin, survey, etc.)
- **Sample size**
  - Bigger the sample, slower the run
  - Bigger the sample, more precise the simulation
  - 44% of models have more than 100'000 obs. (Li and O'Donoghue, 2013)

III. Structure
Demographic module

- **Core of projection**
  - Modelling of birth, death
  - Matching with a partner, mariage, divorce
- **Use external data on demographic projections**
  - Projections Insee/Ined
  - Replication of standard demographic scenarios

III. Structure

Earnings module

- **Past earnings**
  1. Long panel of earnings
  2. Simulation of past earnings

- **Projection of future earnings**
  - Different status
  - Risk of unemployment
  - Earnings/hours of work

- **Earnings**
  - Wage equation + individual fixed effects
  - Earnings history estimations

- **Calibration on macro scenarios**
  - Unemployment rate
  - Productivity growth

III. Structure
Pension module

- **Pension legislation**
  - Formulas and parameters
  - Need to go back in time (pensioners have had pension legislation from 30 years ago !)
- **Checking on case study**
  - Checks
  - Simplification

III. Structure

Retirement decision

- **Model of retirement**
    - Individual decision depends on :
        - Pension level
        - Replacement rate
        - Gains to delay retirement
        - Health
        - Spouse's decision
- **Different models**
    - Full-rate pension rule
    - Stock and Wise model
    - Incentives variables

IV. Challenges

1. Cohort vs population models
2. Discrete vs continuous
3. Open vs closed
4. Alignment

IV. Challenges

Discrete vs continuous

- **Discrete vs continuous**
  - Discrete time : changes between periods (often year)
  - Continuous time : events are simulated at exact date
- **Trade-offs**
  - Discrete version rules out transitions within period (e.g. no unemployment spell within year)
  - Simultaneity of decision over one period (e.g. getting married, pregnant)
  - Practical limitations of continuous models (high requirements on data)
  - Most models known apply discrete time periods (89%)

IV. Challenges

Open vs closed

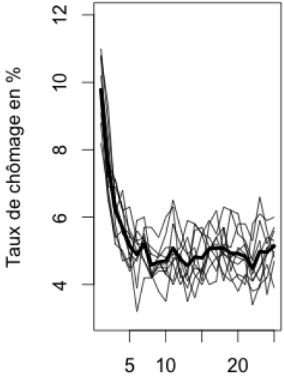
- **Open vs closed**
  - Open : spouses are modelled outside of the sample
  - Closed : spouses are modelled within the sample
- **Trade-offs**
  - Closed : allow to respect structure of population, but implies same weight of individuals within the sample
  - Open : fewer simulation constraints, but harder to reproduce household level structure
  - Most models prefer closed solution (76%)

IV. Challenges
Solutions to stochastic variations

- **Idea**
  - Methods aiming to reduce stochastic nature of results
- **Possible options**
  1. Increase size of sample
  2. Multiple random draws and averaging
- Drawback is the time cost

IV. Challenges
Alignment

Figure 20: Average of multiple draws (left) and larger sample (right)



Source : Blanchet (2014).

IV. Challenges

Solutions to stochastic variations

- **Possible options**
  3. Variance reduction (*sidewalk algorithm*)
  4. Alignment techniques
- **Method**
  - Algorithms which constrain the random draw to hit the target
  - Allow to scale model output to aggregate data or external validity

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