(towards) A Tax-benefit Agent-Based Model

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Outline

1. Model integration and general equilibrium feedback
   - static
   - dynamic
2. Agent-based models and their relationship to microsimulation
3. Extending ABMs: TBMABMs
4. Specification and estimation

Micro-macro feedback: Relevance

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This is when we have to worry about general equilibrium feedback !

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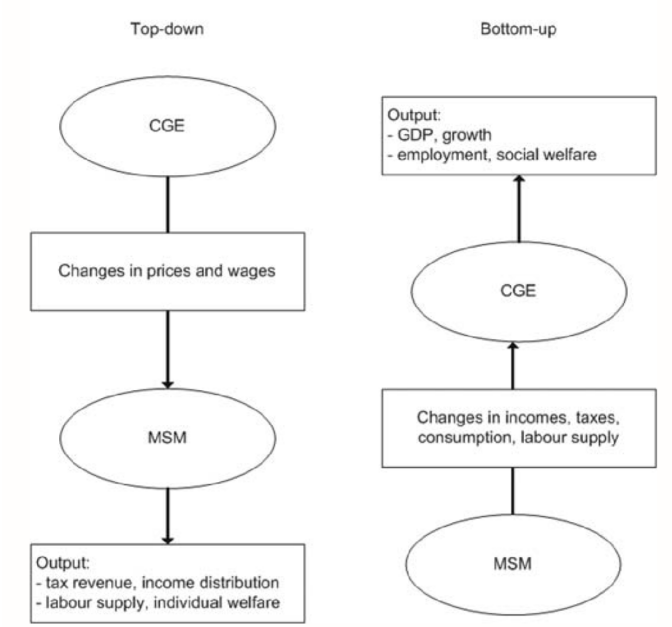

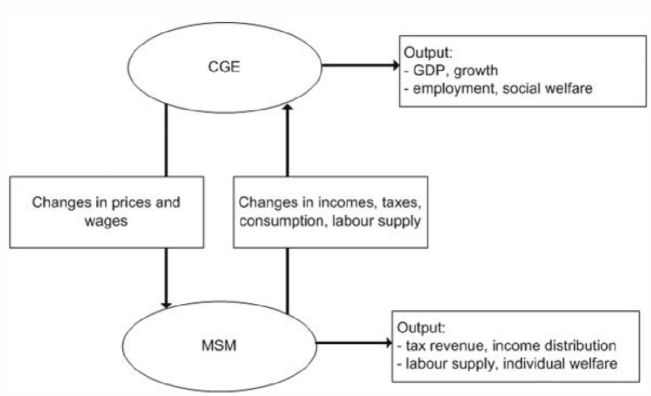

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- Micro model however is required because heterogeneity is deemed important
- Possible inconsistencies
- Aggregation of individual-level functions sometimes possible —e.g. nested multinomial logit spec. for direct utility in individual labour supply aggregates nicely to CES (Verboven 1996; Magnani & Mercenier 2009)

Macro feedback

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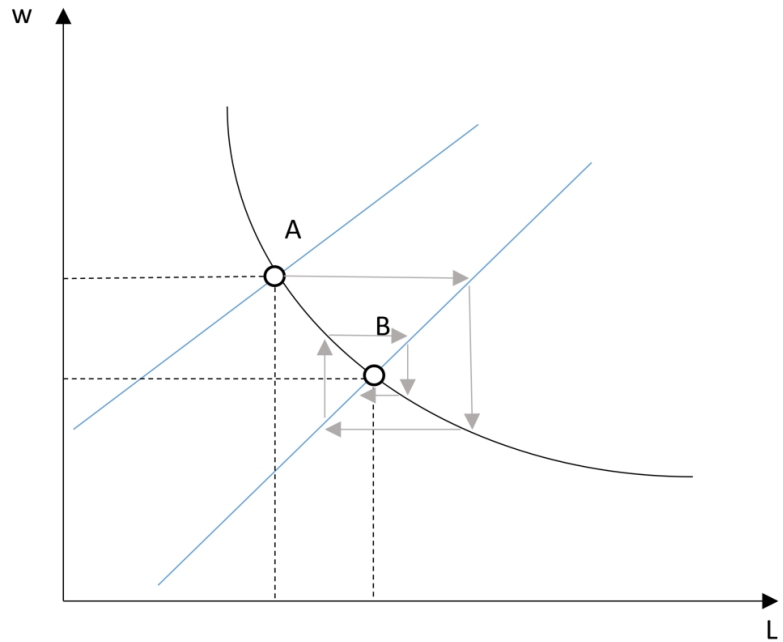

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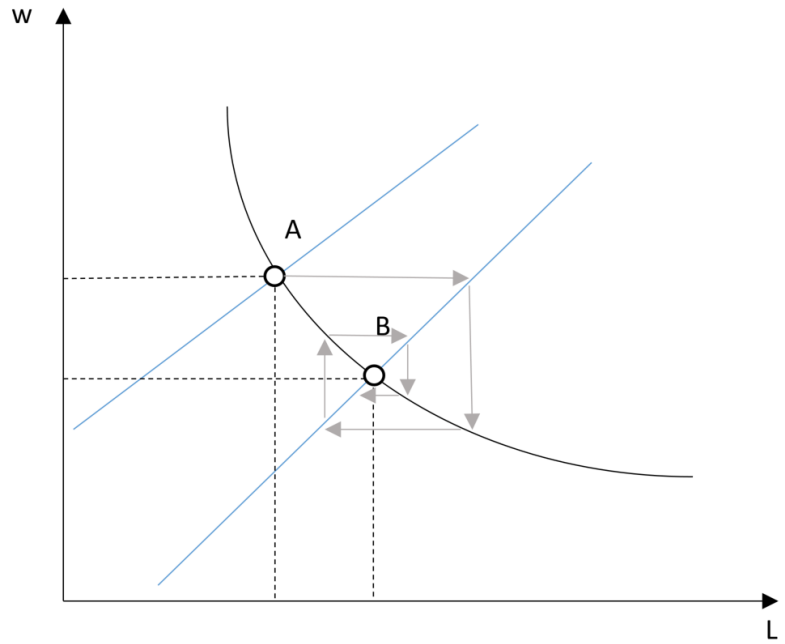

> Assumes labour demand schedule is constant (e.g. invariant to taxation)

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1. there are a multitude of heterogeneous objects (the "agents") that interact with each other and with the environment;
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- Aggregate variables like Consumption, Savings, Investments, Disposable Income, etc., which are the prime units of analysis of Keynesian macroeconomics, cannot be modelled as such in an agent-based framework. They have to be computed by aggregating (averaging) microeconomic agent quantities.

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- Similarly, there is no room for the fictitious representation of a Representative Agent, a cornerstone of Neoclassical economics.

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- When not, it should be thought of simply as a set of variables (e.g interest rates).

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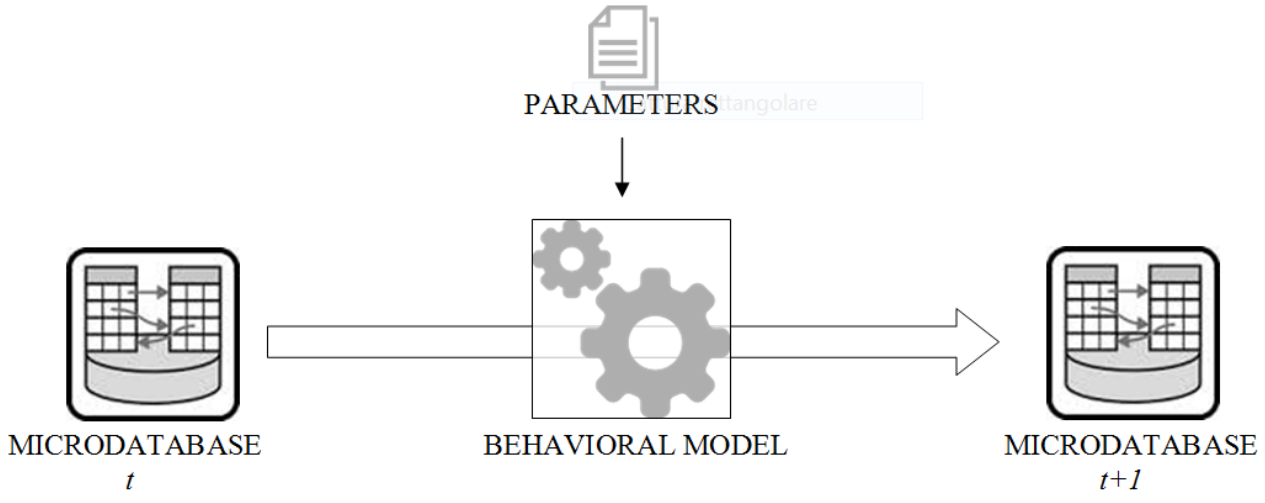
> *This new type of model consists of various sorts of interacting units which receive inputs and generate outputs. The outputs of each unit are, in part, functionally related to prior events and, in part, the result of a series of random drawings from discrete probability distributions.*
> *(Orcutt 1961)*

Dynamic microsimulation /1

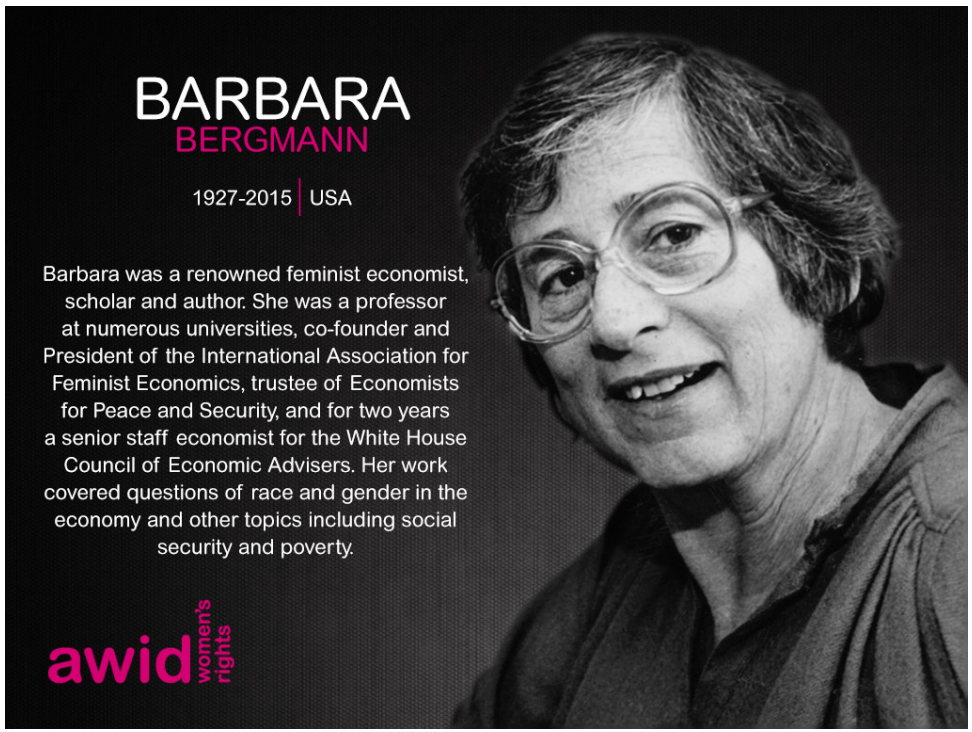


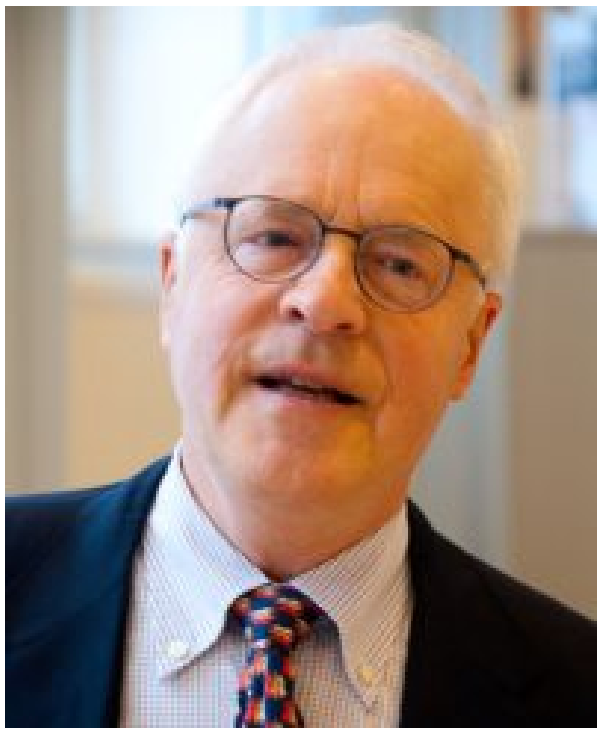
$$y_{k,i,t} = f(y_{1,i,t-1}, \ldots, y_{K,i,t-1}; X_{i,t}, P_t)$$

Dynamic microsimulation /2

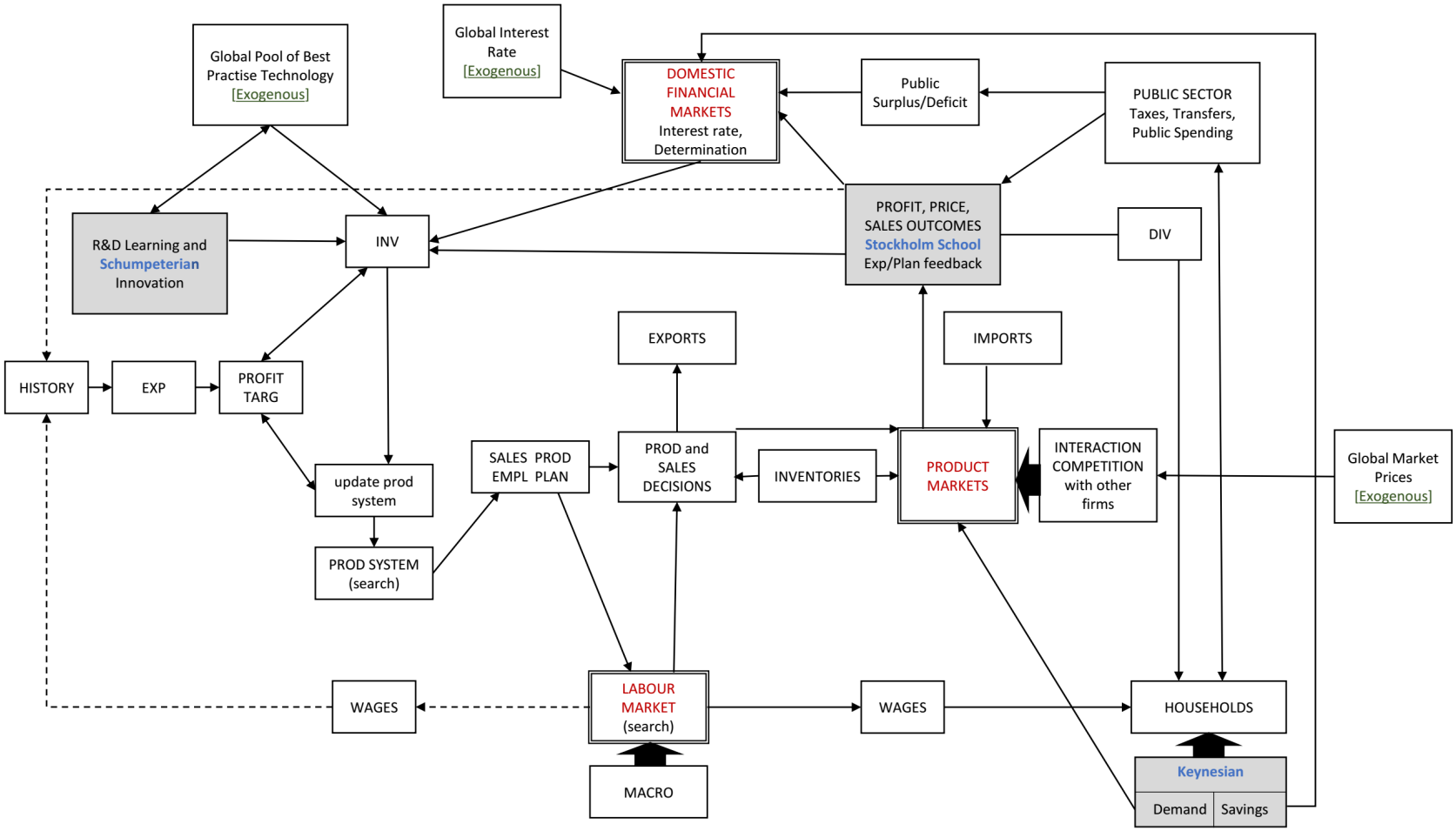
A more structural approach:

- Barbara Bergmann's microsimulation of the US economy (1974)
- Gunnar Eliasson's microsimulation of the Swedish economy (1977).





Dynamic microsimulation /3



Structure of the MOSES model of the Swedish economy (Eliasson 1977)

Dynamic microsimulation /4

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  - Two innovations: they explicitly considered the interaction between the supply and demand for labor, and they modeled the behavior of firms and workers in a structural sense.

- Their approach passed relatively unnoticed in the DMS literature, which evolved along the lines identified by Orcutt mainly as reduced form, probabilistic partial equilibrium models, with limited interaction between the micro unit of analysis, and with abundant use of external coordination devices in terms of alignment to exogenously identified control totals.

Dynamic microsimulation /5

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Bergmann B. (1990), "Micro-to-Macro Simulation: A Primer with a Labor Market Example", JEP.

AB models: References

Textbooks

- Epstein & Axtell, **Growing Artificial Societies: Social Science from the Bottom Up**, 1996.
- Billari & Prskawetz, **Agent-Based Computational Demography. Using Simulation to Improve Our Understanding of Demographic Behaviour**, 2003.
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- Epstein, **Generative Social Science: Studies in Agent-Based Computational Modeling**, 2006.
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- Railsback & Grimm, **Agent-Based and Individual-Based Modeling: A Practical Introduction**, 2012.
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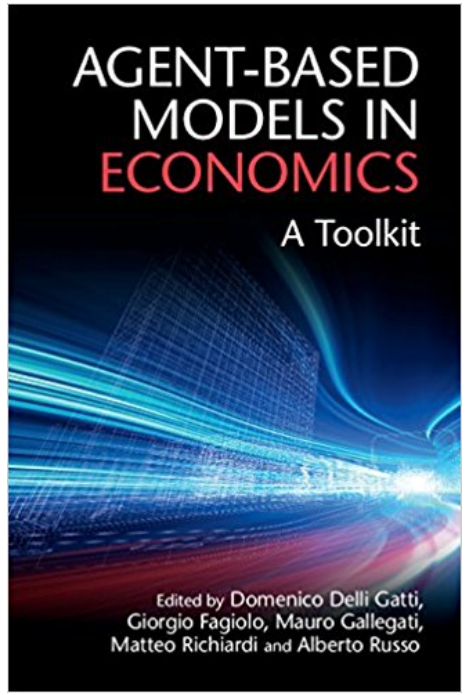
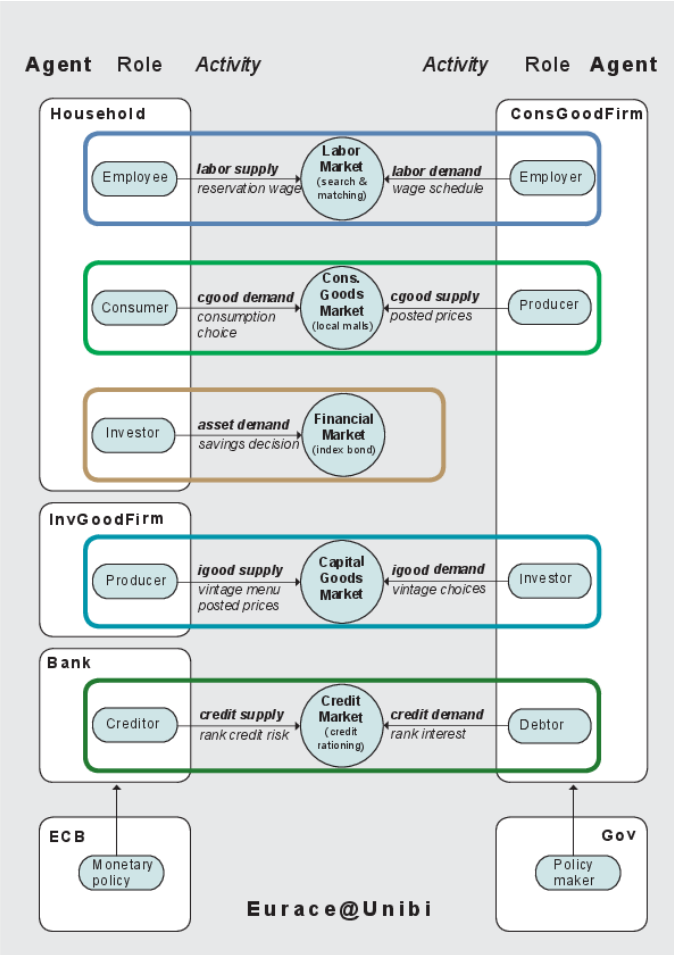


Agent-based macro modelling: A critique



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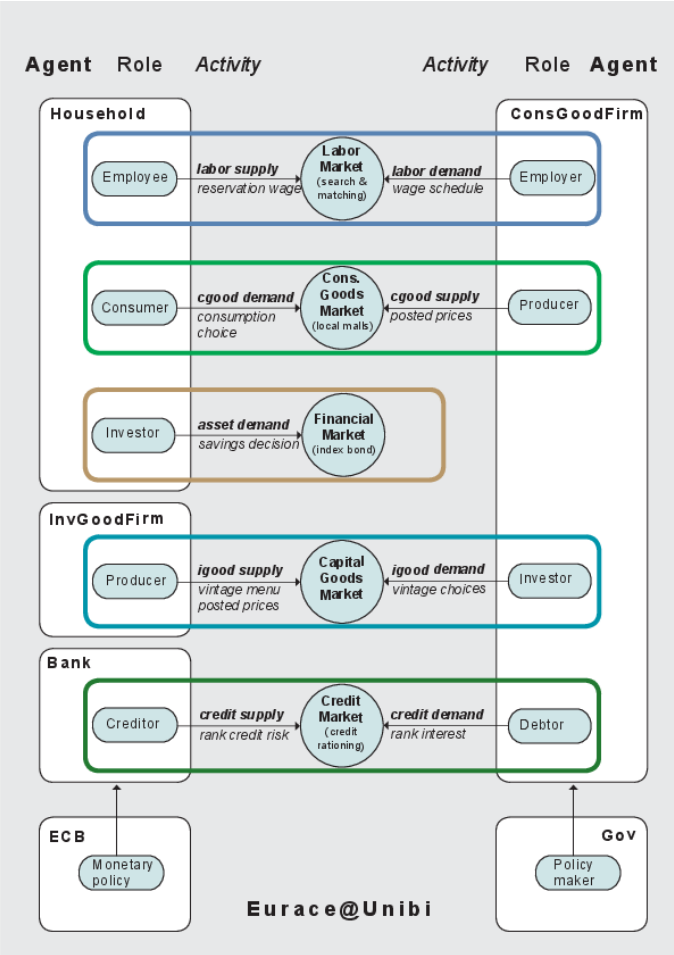

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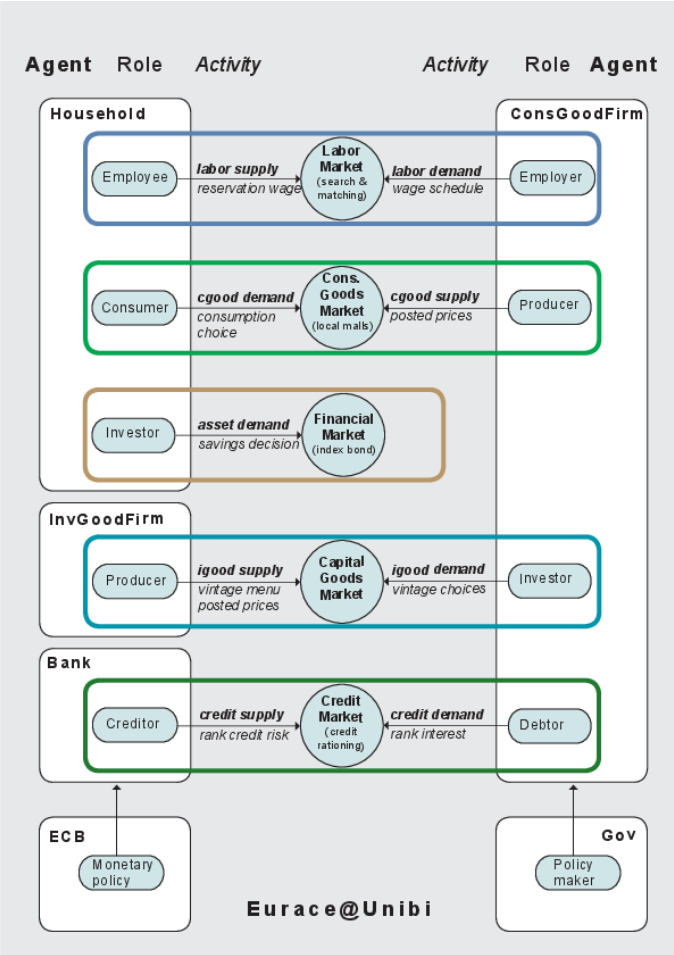

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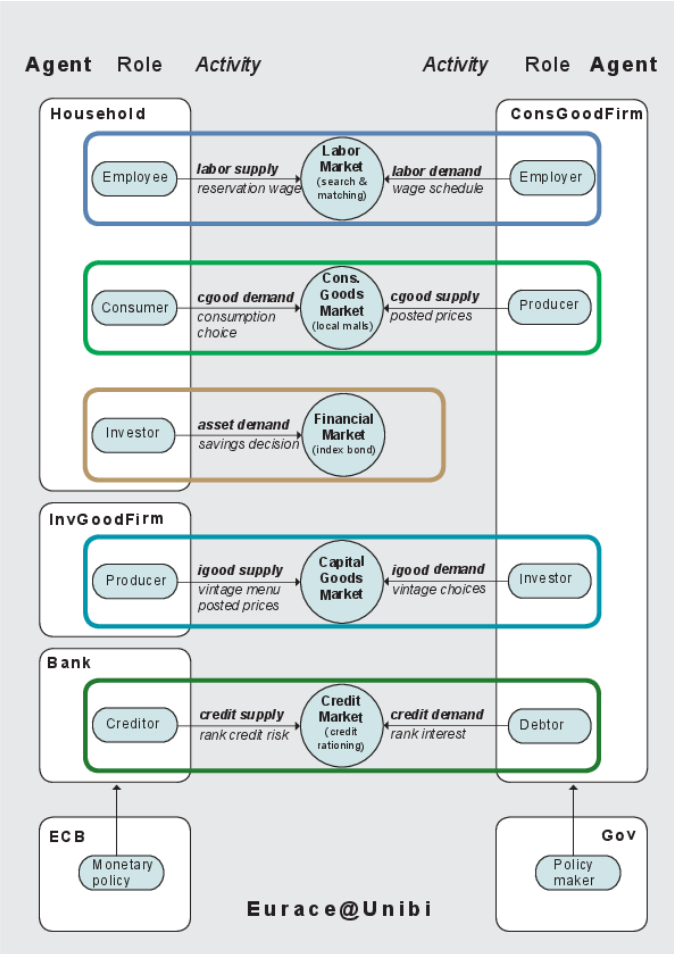

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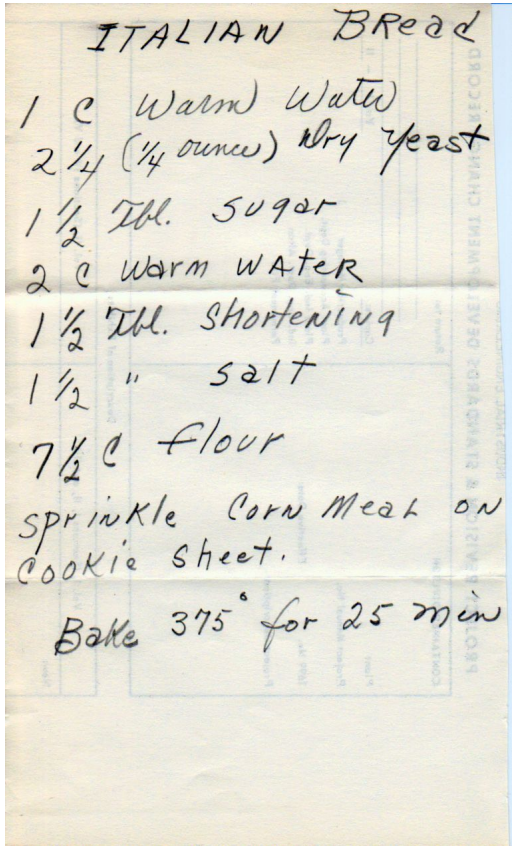
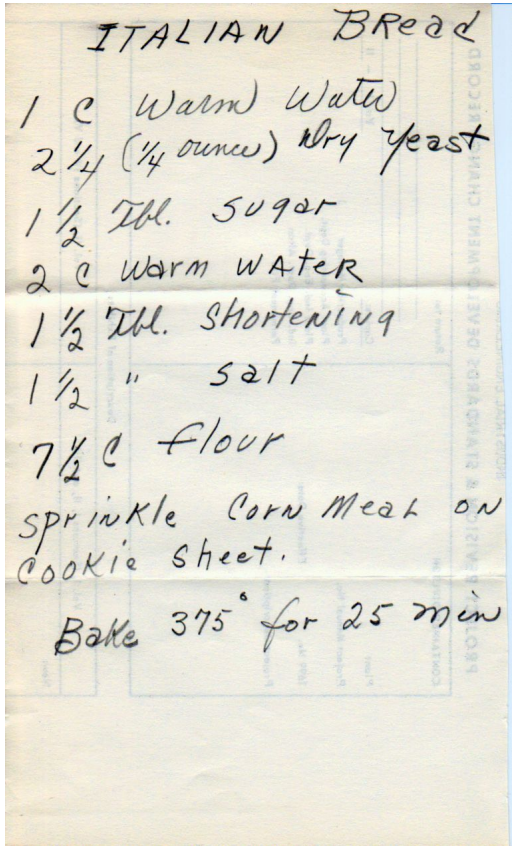
- Individuals typically not structured in households

TBMABM



- Start from a state-of-the-art macro ABM

TBMABM



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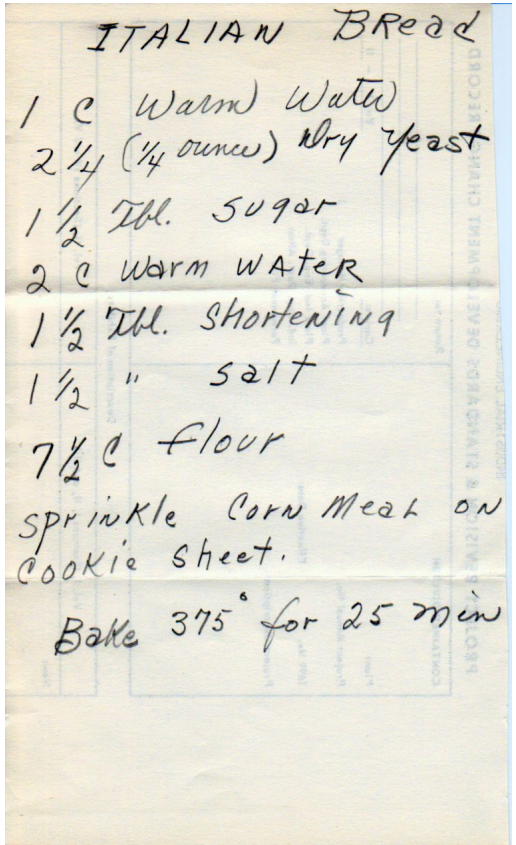
- Add demography

TBMABM


ITALIAN Bread

1 C Warm Water
2 ¼ (¼ ounce) Dry Yeast
1 ½ Tbl. Sugar
2 C Warm WATER
1 ½ Tbl. Shortening
1 ½ " Salt
7 ½ C flour
Sprinkle Corn Meal on Cookie Sheet.
Bake 375° for 25 min

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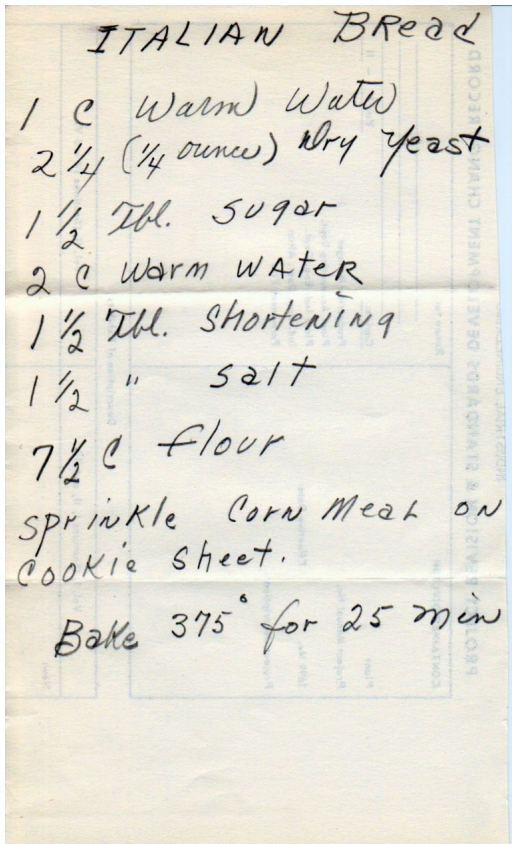
- Add households

TBMABM



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- Add demography
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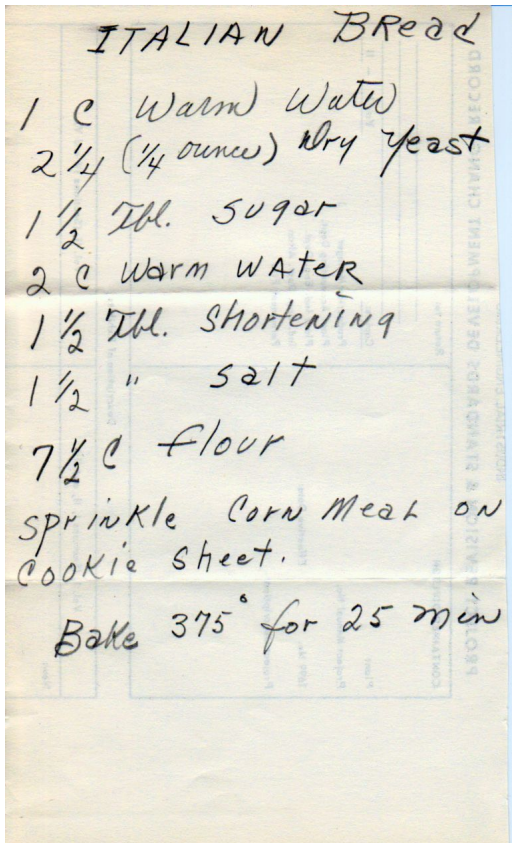

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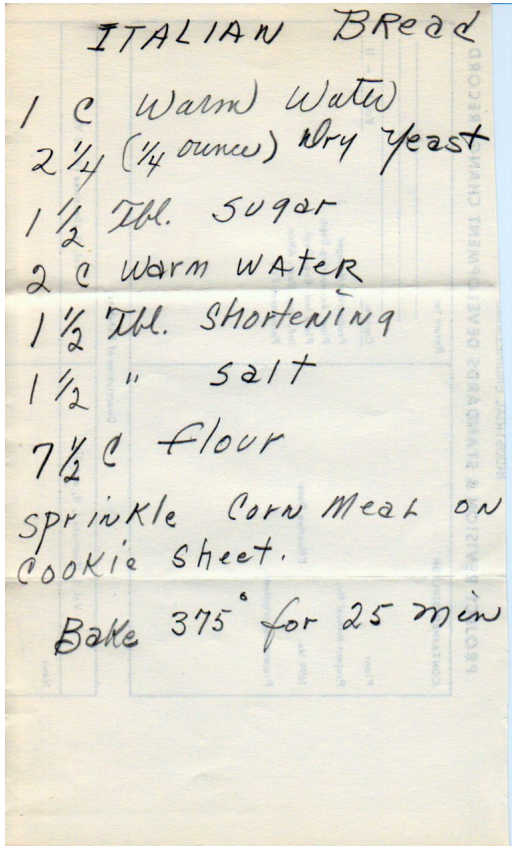
- Add demography
- Add households
- Add T-B system
- Add labour supply module

TBMABM



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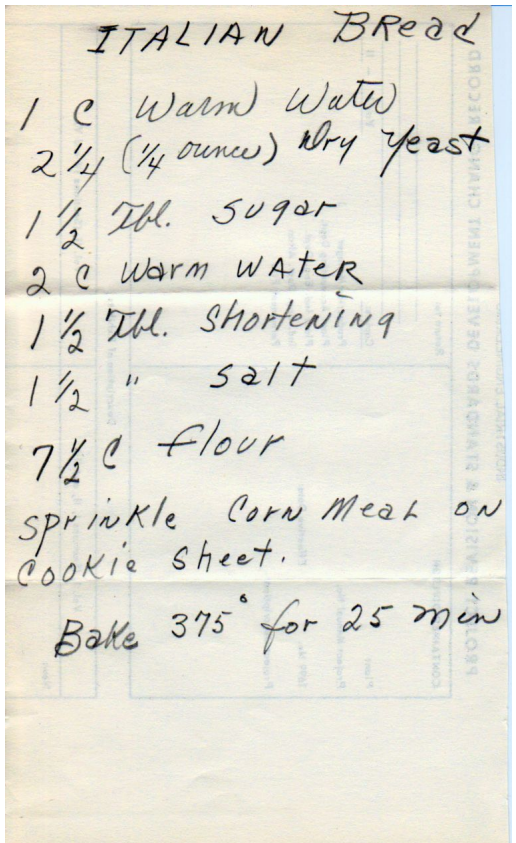
- Top up with any dynamic microsimulation feature of choice (e.g. education, health, etc.)

TBMABM



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- (Do not forget a grain of salt)

The macro-donor

Dosi et al. "Keynes-meets-Schumpeter" family of macro-ABMs:

- Dosi, Roventini, Fagiolo (2010), "Schumpeter meeting Keynes: A policy-friendly model of endogenous growth and business cycles", JEDC
- Dosi, Fagiolo, Napoletano, Roventini (2013), "Income distribution, credit and fiscal policies in an agent-based Keynesian model", JEDC
- ...and counting

KMS /1

Agents:

Features:

KMS /1

Agents:

- Individuals

KMS /1

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KMS /1

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KMS /1

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$\Rightarrow$ Endogenous generation and diffusion of supply shock

KMS /2

Stylised facts:

KMS /2

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KMS /2

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  - > Endogenous self-sustained growth with persistent fluctuations

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Research questions:

TBMABM

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- How does the equity vs. efficiency trade-off change when considering macroeconomic effects?
- How is economic insecurity affected by macroeconomic performances, and in particular by macroeconomic instability?
- What policy changes can be devised in order to diminish the level of economic insecurity, and what are their macroeconomic effects?

Microsimulation feature #1: Demography

- Alignment to official demographic projections

Microsimulation feature #2: Households

Process U1: Prob. of entering a union

	Coef.	
Gender (Ref = Women)		
—Men	-0.02	
Age	0.03	***
Age Squared	0.00	***
Lagged self-rated health status	0.04	***
Educational Attainment (Ref = High)		
—Medium	-0.13	***
—Low	-0.16	***
Lagged Employment Status (Ref = Employed)		
—Student	-0.55	***
—Not Employed	-0.05	**
Lagged Household Income Quintile (Ref = 1st Quintile)		
—2nd Quintile	0.00	
—3rd Quintile	0.03	
—4th Quintile	0.03	
—5th Quintile	0.08	***
Time	0.00	
Regional dummies	yes	

Microsimulation feature #2: Households

Assortative mating

Sparse Biproportionate Adjustment Matching (SBAM), Stephensen et al. 2013:

- Based on historical observations of matchings from one or more years, distributed on a set of types (age, gender, education, region etc.)

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1. Sum each row and proportionally adjust to target
2. Sum each col and proportionally adjust to target
3. Repeat 1. and 2. until convergence

Microsimulation feature #2: Households

Process U2: Prob. of exiting a union

	Coef	
Age	-0.03	***
Age Squared	0.00	**
Spouse's Age	-0.06	***
Spouse's Age Squared	0.00	***
Number of Years in Partnership	-0.02	***
Self-rated Health Status	-0.03	*
Spouse's Self-rated Health Status	-0.12	***
Number of Children aged 0-2 in Household	-0.19	***
Educational Attainment (Ref = High)		
—Medium	0.18	***
—Low	0.26	***
Spouse's Educational Attainment (Ref = High)		
—Medium	0.04	
—Low	0.04	
Employment Status (Ref = Employed)		
—Student	0.22	*
—Not Employed	0.09	**
Spouse's Employment Status (Ref = Employed)		
—Student	0.26	*
—Not Employed	0.07	
Household Income Quintile (Ref = 1st Quintile)		
—2nd Quintile	0.01	
—3rd Quintile	-0.01	
—4th Quintile	0.14	**
—5th Quitile	0.04	
Time	0.01	
Regional dummies	yes	

Microsimulation feature #2: Households

Process F1: Fertility

- Model of differential fertility: overall fertility rate aligned to demographic projections

Microsimulation feature #2: Households

Process F1: Fertility

- Model of differential fertility: overall fertility rate aligned to demographic projections
- **Controls**: education, partnership status, number and age of children, health, lagged employment status, lagged hh income, region, avg. fertility rate

Microsimulation feature #3: EUROMOD

Options:

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Microsimulation feature #3: EUROMOD

Options:

1. Model population changes within the tax-benefit model (ie. "dynamising" the tax-benefit calculator).
2. Have a separate dynamic microsimulation environment to update the population, feed this input population into the tax-benefit calculator, and bring the after-tax variables back to the dynamic microsimulation.
3. Use the tax-benefit model (with its own input population) as a donor dataset (missing variables approach).

Static-dynamic linkage

Missing variables approach

hh disposable income (labour supply) and **total labour cost** (labour demand) are missing from the dynamic microsimulation environment

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$\Rightarrow$ use EUROMOD as a donor dataset for the dynamic microsimulation:

- EUROMOD is run prior to simulation, with the chosen tax&benefit parameters.
- This produces as many EUROMOD tables as the number of EUROMOD configurations.
- Imputation is made by minimising the distance between the characteristics of the simulated household, for given levels of labour supply, and the characteristics of the EUROMOD household.
  - **Individual characteristics** (for each partner): sex, age, health status, education, potential earnings (as estimated by a wage equation), work sector, number of hours worked.
  - **Household characteristics**: region, number and age of kids.

Static-dynamic linkage /2

Missing variables approach (cont'd)

Matching:

Static-dynamic linkage /2

Missing variables approach (cont'd)

Matching:

- Most of the matching variables are discrete, allowing for a perfect match. The number of hours worked in EUROMOD needs to be discretised to make it homogeneous with the labour supply module.

Static-dynamic linkage /2

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Static-dynamic linkage /2

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- Minimum distance matching can be implemented for continuous variables (unit wages).
- Disposable hh income and labour cost for the firm observed in EUROMOD need to be corrected to take into consideration the fact that matching in unit wages is not exact.

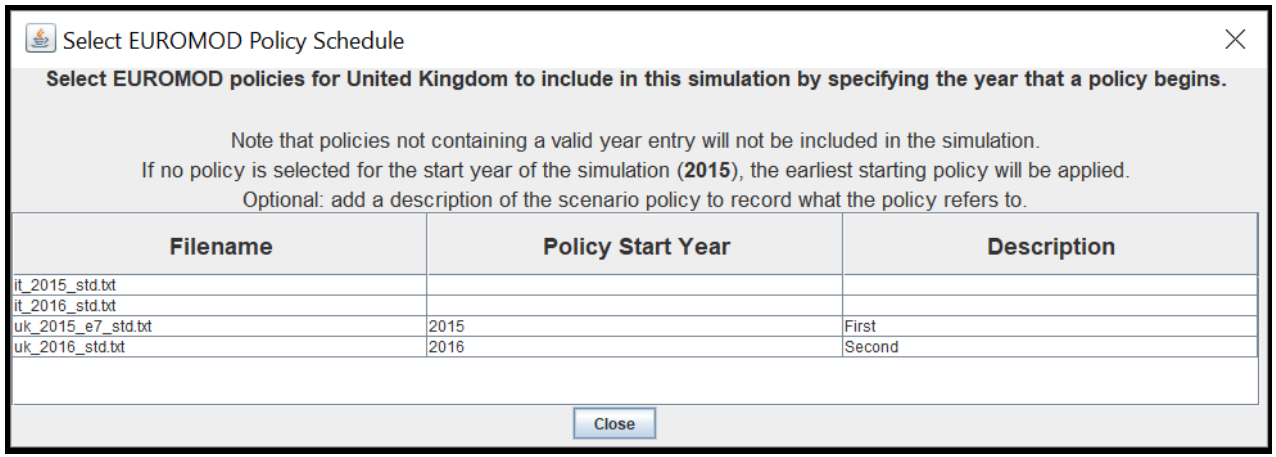
Static-dynamic linkage /2

Missing variables approach (cont'd)

Matching:

- Most of the matching variables are discrete, allowing for a perfect match. The number of hours worked in EUROMOD needs to be discretised to make it homogeneous with the labour supply module.
- Minimum distance matching can be implemented for continuous variables (unit wages).
- Disposable hh income and labour cost for the firm observed in EUROMOD need to be corrected to take into consideration the fact that matching in unit wages is not exact.
- Exact matching is relaxed if no households with the relevant characteristics are present in the EUROMOD sample.

"As many as you like"



Microsimulation feature #4: Labour supply

- Default: simple RUM (estimation in progress)

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- Under development: intertemporal work-leisure consumption-savings choices

Microsimulation feature #5: Education

- Process E1a: Prob. of being a student — always a student

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- **Additional controls**: education, lagged employment status

Simulation platform

+

Next steps

- Performances, validation and results to come

Thanks

matteo.richiardi@essex.ac.uk