ABM Macro Lab: Agent-based Modelling Tools

Session 03

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Outline

Introduction

Where are we and where are we going?

Session I Basics of LSD and small models implementation

Session II Presentation of the Industry model and implementation

Session III (Today) Q&A, bug fixes, and analysis of results and Monte Carlo Experiment

Lost? I

In case you are lost, here are some few-liner to catch up (code may differ)?

```
EQUATION( "a" )
// Firm knowledge/productivity
RESULT( VL( "a", 1 ) * ( 1 + V( "eta" ) * beta( V( "beta1" ), V( "beta2" )
↪  ) ) )

EQUATION( "s" )
// Firm size/market share
RESULT( VL( "s", 1 ) * ( 1 + V( "A" ) * ( V( "a" ) - V( "aAvg" ) ) / V(
↪  "aAvg" ) ) )

EQUATION( "HHI" )
// Herfindahl-Hirschman concentration index
RESULT( WHTAVE( "s", "s" ) )
```

Lost? II

```
EQUATION( "exit_decision" )
if ( V( "s" ) < V( "sMin" ) ) {
    WRITE( "a", V( "aAvg" ) * ( 1 + V( "eta" ) * beta( V( "beta1" ), V(
    ↪  "beta2" ) ) ) );
    WRITE( "s", 1 / COUNT( "Firm" ) );
}
RESULT( 0 )

EQUATION( "aAvg" )
// Mean knowledge/productivity
v[0] = 0;         // accumulator
CYCLE( cur, "Firm" )
    v[0] += VLS( cur, "s", 1 ) * VS( cur, "a" );
RESULT( v[0] )
```

Lost? III

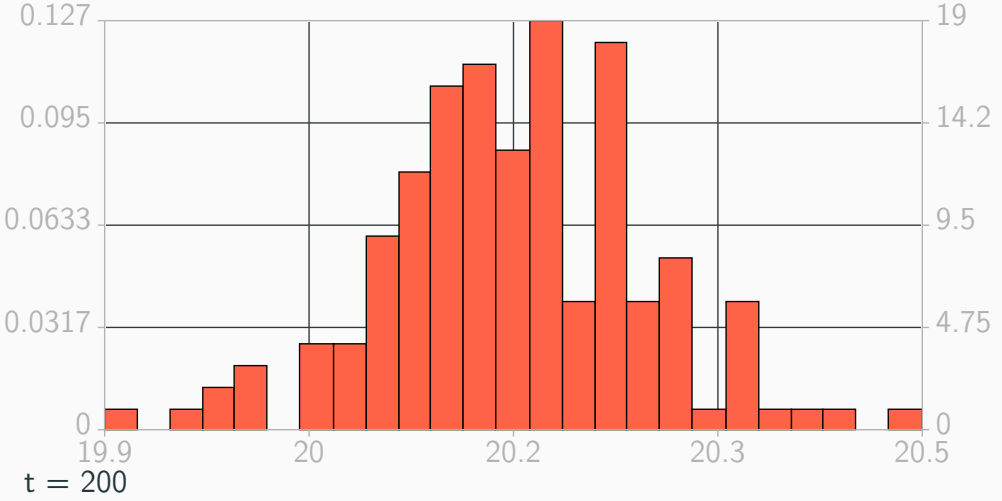
```
EQUATION( "exit_entry" )
// Trigger market-wise exit-entry dynamics and re-scale shares
V( "HHI" ); // first, compute HH index before exits
CYCLE( cur, "Firm" ) // second, ensure firms have decided on exit
    VS( cur, "exit_decision" );
v[0] = 1 / SUM( "s" );// factor to scale back to sum = 1
CYCLE( cur, "Firm" ) // third, rescale market shares after exits
    WRITES( cur, "s", v[0] * VS( cur, "s" ) );
RESULT(0)
```

Activities

Activity I

1. Show that average productivity (`aAvg`) is always between a maximum and minimum productivities
2. Check that the total market share of firms is constant and equal to 1
3. Increase (1) the number of firms to 150, (2) the exit threshold `sMin` to 0.001, and the number of simulation steps.
4. Run and analyze the results. What are the main differences?
5. Using this new configuration, produce a histogram of the firm log-size distribution at $t = 200$

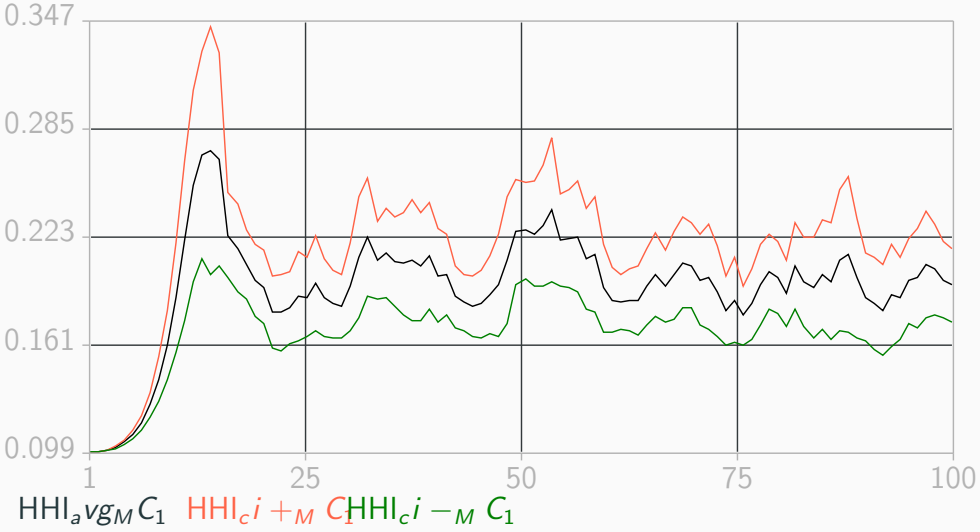
Histogram of firm log-size distribution ($t = 200$)



A simple Monte Carlo experiment I

1. Close Analysis of Results window
2. Re-open the baseline configuration
3. Set the simulation runs to 20 (Run > Simulation)
4. Save as a new configuration
5. Run the new configuration (Run > Run)
6. Choose Data > Analysis of MC Experiment, accept using last results, and mark to create Average and Maximum and minimum series, and to include confidence intervals
7. Analyze the Monte Carlo experiment results

A simple Monte Carlo experiment II



Activity II

1. Show the max-min intervals for the average log-productivity (aAvg) and the HHI in the MC experiment
2. Why the MC confidence width is not comparable for the two variables?
3. Show the distribution of the productivity (a) considering all MC runs (tip: select Keep original series in Monte Carlo options)
4. The Monte Carlo analysis uncovers a potential problem with this simplified version of the model, try to identify it, and to reason if it can invalidate the results obtained

Simple parameter sensitivity check

Introduction

In this part of the lecture, we will playaround with A and η parameters and check their impacts on the model output. Here, we will leverage the benefits of an OOP design associated with an isolated configuration setting.

In the same way we made copies of a specific firm, we can also make a copy of the whole structure of the model. By doing this, we can make different experiments on each copy and analyze it on LSD.

Good news!
LSD has some ways to automatize this task for us.

Setting the DoE I

1. Load `Sim1.lsd` and save it as `Sim1_DoE.lsd`
2. Right click on `A` and select Sensitivity
3. On the new window, specify the parameter range as follows:

`=MIN:MAX@NUM%L`

MIN	Minimal value
MAX	Maximum value
NUM	Number of samples
%L	Indicates to vary linearly

Next, repeat the same for `eta`

Example of the parametric space

	Desc	Baseline	Min	Max
η	Innovation opportunity support	0.3	0.1	0.7
A	replicator dynamics intensity	1	0.2	5

eta `=0.1:0.7@3%L`

A `=0.2:5@3%L`

Setting the DoE II

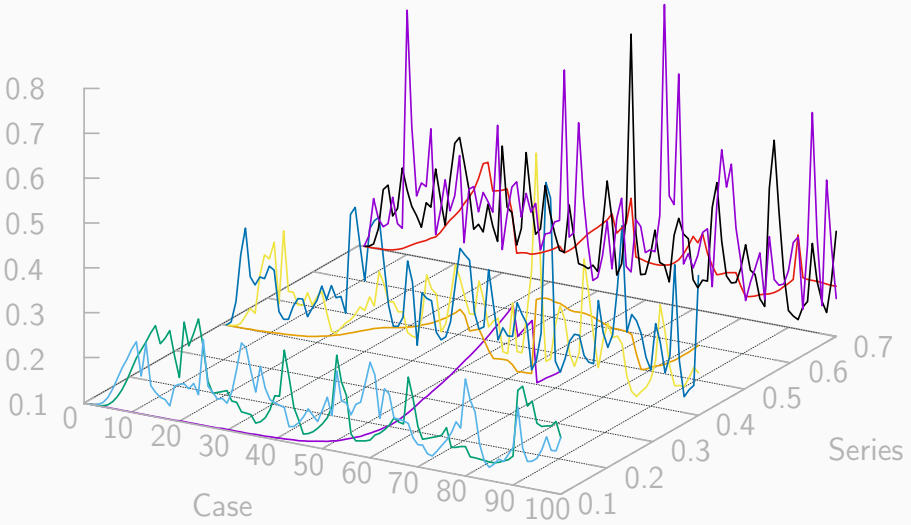
1. After, save the sensitivity analysis file (File>Save sensitivity)
2. Mark `A` and `eta` to be saved
3. Set the DoE (Data > Sensitivity Analysis > Full (Online))
4. Run the simulations (Run > Run) to produce the results files (accept the defaults)
5. Choose Data > Analysis of results and inspects the results
6. Whenever picking a variable to plot, right click on it and choose to select all

Activity III

Set your own parametric ranges (choose an small number for `NUM`).

- How can we evaluate the importance of a parameter?
- How each parameter affects the model's results?
- What is the economic intuition of this?
- How can we efficiently repeat this for all other parameters and initial conditions?

Visualizing this experiment



Primer on sensitivity analysis (Bonus)

Model sensitivity to parameters

How do parameters and initial conditions jointly affect variables?

- The most common approach is to perform a one-variable at a time change
  - In this small-scale model, we can play with different parameters and check
- However, even with this small parametric space, the number of combinations can get quickly large
- We will briefly check some Design of Experiments Techniques that helps with this situations

Sensitivity analysis

Sensitivity analysis requires many steps:

1. Screening: Filter down unimportant factors (elementary effects)
2. Select a Design of Experiments (DoE) strategy
3. Evaluate multiple runs per configuration
4. If required, fit a meta-model
5. Compute the sensitivity analysis statistics
6. Explore the response surfaces

Good news: LSD (+R) can handle this through a NNF approach

Note on screening
As the model is small, we will skip screening and jump directly to metamodels

Parametric space

	Desc	Baseline	Min	Max
η	Innovation opportunity support	0.3	0.0	0.7
β_1, β_2	beta distribution parameters	1.0; 5.0	1; 3	3;10
A	replicator dynamics intensity	1	0.2	5
s_{min}	minimum market share to not exit	0.01	0.0001	0.01
NF	number of firms	10	10	350

Monte Carlo vs Near Orthogonal Latin Hypercube

- All combinations possible (MC): 64 (x 5)
- NOLH: 43 (x 5)

Exploring the industry model

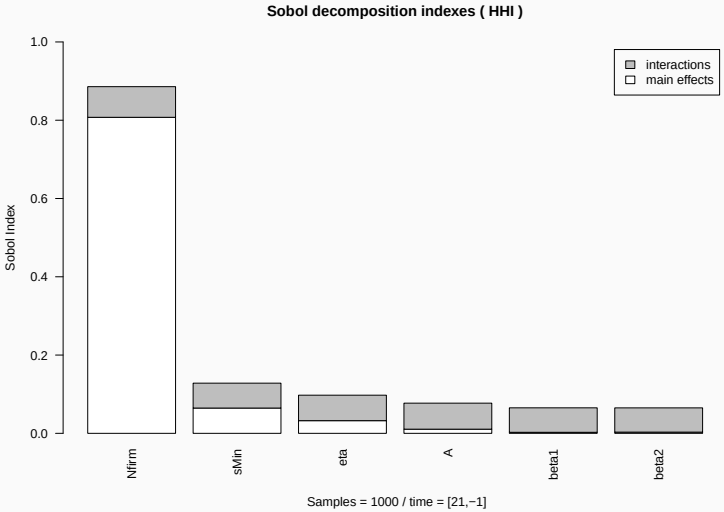
Load R/data/Sim-Sobol.lsd file in LSD

1. This is a copy of Sim1.lsd with 5 simulation runs

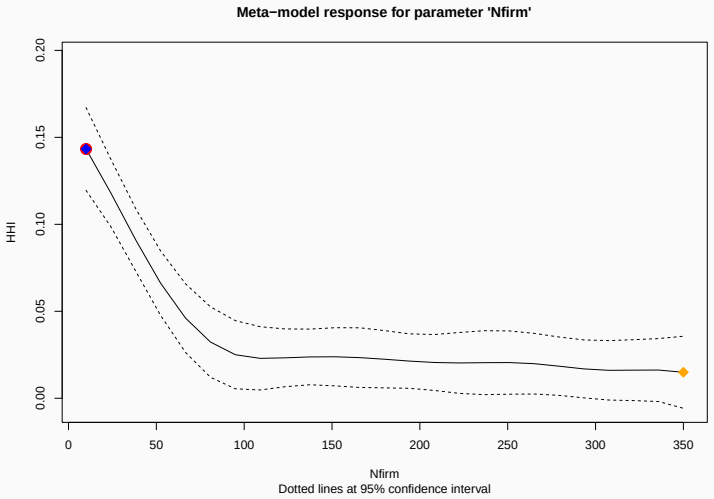
1. Load sensitivity analysis configuration (File > Load sensitivity...) and choose R/Sim-Sobol.sa
2. Set the DoE (Data > Sensitivity Analysis > NOHL sampling)
   2.1 Select Extended number of samples, hit OK and accepts the default
3. Run a parallel batch (Run > Parallel Batch) to produce the results files (accept the defaults)
4. Let's jump into R(studio) and create a project under the R folder
5. Select the sobol-SA.R and hit source

Before checking the results
Which parameters do you expect to most influence HHI? What about aAvg?

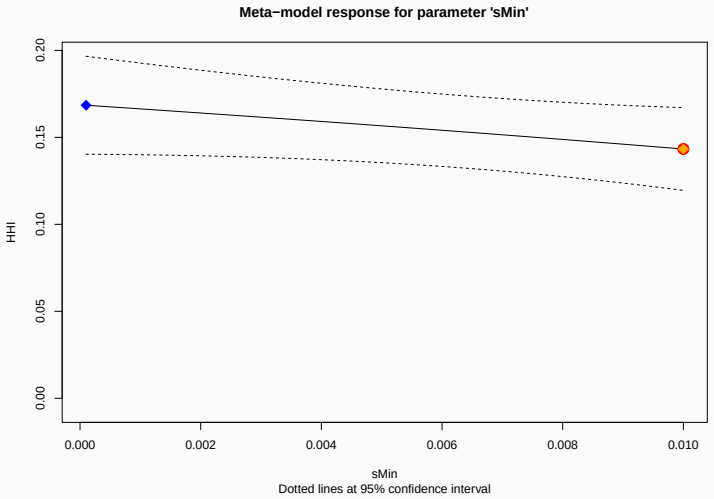
Sobol decomposition indexes (HHI)



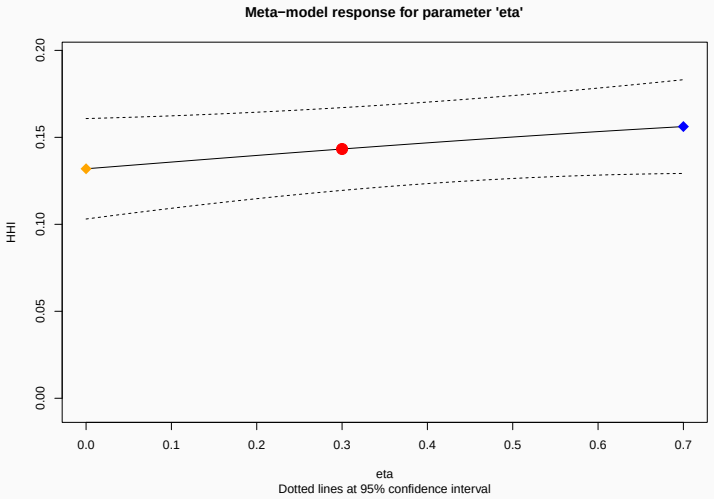
Meta-model response I



Meta-model response II



Meta-model response III



Bonus Activity

- In the Rscript, uncomment `varName <- "aAvg"` and source the file again
- Open the resulting PDF file
- Analyze the results and contrast with your expectations
- What are the economic intuition associated with these parameters?

Phew!

Our papers are available at:

http://www.lem.sssup.it/wplem.html

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Thank you!