The agent-based modeling approach to MFM: A call to join forces

Macroeconomic Financial Modeling meeting

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J. Doyne Farmer
Mathematics Department and Institute for New Economic Thinking, Oxford University
External Professor, Santa Fe Institute
Mission: Recruit good economists to help construct an agent-based macroeconomic financial model.

- What is an agent-based model?
- Why agent-based modeling?
- Why now?
- Advantages and challenges of agent-based models.
- Ongoing projects for ABM for MFM
- How MFM group can contribute.
What is an agent-based model?

- A computer simulation of a system of interacting heterogeneous agents
  - e.g. households, firms, banks, mutual funds, government, central bank
- Agent decision rules can be:
  - behavioral or rational
  - hard-wired or evolving under learning as agents attempt to maximize utility
WHY AGENT-BASED MODELING?

- Diversifies toolkit of economics: Complements DSGE and econometric models.
- Time is ripe: increased computer power, Big Data, behavioral knowledge. Never let a crisis go to waste. Hasn’t really been tried yet -- crude estimates:
  - econometric models: 30,000 person-years
  - DSGE models: 20,000 person-years
  - agent-based models: 500 person-years
- Successes elsewhere: Traffic, epidemiology, defense
- Examples of successes in economics:
  - Endogenous explanations of clustered volatility and heavy tails; firm size; neighborhood choice
Advantages

- Can faithfully represent real institutions
- Easily captures instabilities, feedback, nonlinearities, heterogeneity, network structure
- Shocks can be modeled endogenously
- Easy to do policy testing
- Easy to incorporate behavioral knowledge
- Can calibrate modules independently using micro data -- much stronger test of models!
  - In some sense between theory and econometrics
- ABMs synthesize knowledge:
  - Possible to understand what is not understood
Challenges

• Little prior art
• Developing appropriate abstractions
  – What to include, what to omit?
  – How to keep model simple yet realistic?
• Finding micro-data to calibrate decision rules
• Realistic agent-based models are complicated
  – Big job: Cautionary tale of weather simulation

Note: Computation is not bottleneck
Projects

- INET: model of housing markets *(proof of principle)*
  - $375K from Institute of New Economic Thinking.
  - PIs: Rob Axtell, J. Geanakoplos, Peter Howitt, JDF
  - 2 year project starting Jan. 2011.

- CRISIS: macroeconomic financial model *(we want you!)*
  - 3.3M euro from ICT division of the EC
  - 11 groups in 7 countries, mostly physicists
  - Economists: Carvalho, Delli Gatti, Gallegati, Hommes
  - 3 year project starting Dec. 2011.

- Sloan: some funding for data and data analysis *(Rockmore)*
Agent-based model of housing market

Goal:

- Quantitative agent-based time series model
- Conditional forecasts and policy analysis
- Initializable in any given state of economy

10:1 simulation at level of individual households

- Exogenous variables: demographics, interest rates, lending policy, housing supply.

- Predicted variables: prices, inventory, foreclosure

16 micro-data sets: Census, mortgages, tax returns, real estate records, ...

Regional scale beginning with Washington DC
Module examples

- Household wealth dynamics (IRS, census)
  - consumption, income, savings, ...
- Buyers’ desired expenditure model (census)
  - target home price depending on income, wealth, ...
- Home quality (real estate records)
- Seller’s pricing model (real estate records)
  - seller’s offering price vs. quality, time on market, ...
- Buyer-seller matching algorithm (real estate agents)
  - links buyers and sellers to make transactions
- Loan approval (mortgage data)
  - mimics bank loan officer
- Default and foreclosure algorithm (mortgage data)
- Investors, rentals, ...

Calibration data does not include prices, inventory, foreclosures!
Housing model algorithm

At each time step:
- Input changes to exogenous variables
- Update state of households
  - income, consumption, wealth, foreclosures, ...
- Buyers:
  - Who? Price range? Loan approval, terms?
- Sellers:
  - Who? Offering price? Price updates?
- Match buyers and sellers
  - Compute transactions and prices
Tentative conclusion: Lending policy is dominant cause of housing bubble in Washington DC.

Results obtained by hand-fitting parameters

Still working on independent calibration
Purpose: Successfully use ABM for MFM
Households, firms, banks, financial markets.

Goals:
- tool for policy decision making
- working simulation of Mark II by end of year.
- series of models of increasing complexity
- create standard software library and baseline set of methods for simulating MFM.
Mark 2

Mark 2.1: firm shares owned by households instead of banks [similar to Adrian and Boyarchenko (2012)].
Future versions will allow:

- Central bank
- Mortgage markets
- Derivative markets
- Bond markets
- Shadow banking system
- Richer models of financial speculation
- Durable and nondurable goods
  - Possibility of realistic I/O structure
- ...

...
Design philosophy

- As simple as possible (but no more)
- Design model around available data
- Fit modules and agent behaviors independently from target data, using several different methods:
  - micro-data for calibration and testing
  - consult domain experts for behavioral hypotheses
  - adaptive optimization to cope with Lucas critique
  - economic experiments
- Systematically explore model sensitivities
- Plug and play
- Standardized interfaces
- Industrial code, software standards, open source
Summary

Agent-based models are intended to complement rather than supplant econometric and DSGE.

The time has come to give this a serious try.

Potential payoff in terms of practical understanding and realistic policy testing is huge.

Small contributions from members of MFM community could have a large impact.

We are looking for a few good men and women. Pay is low, hours are bad, but ...

Upcoming meeting:
April 8 - 12, Leiden
doynefarmer@gmail.com
Paul Krugman’s view of agent-based modeling

“Oh, and about Roger Doyne Farmer (sorry, Roger!) and Santa Fe and complexity and all that: I was one of the people who got all excited about the possibility of getting somewhere with very detailed agent-based models — but that was 20 years ago. And after all this time, it’s all still manifestos and promises of great things one of these days.”

Paul Krugman, Nov. 30, 2010, in response to an article about INET project in WSJ.