

# **“Agent-Based Modelling in Socio-Economic Systems”**

**Summer School 2007  
Centre for Research in Complex Systems  
Charles Sturt University, Bathurst**

**Robert E. Marks  
School of Economics  
Australian School of Business  
UNSW**

**bobm@agsm.edu.au**

**<http://www.agsm.edu.au/~bobm/teaching/CSU.html>**

# Introduction to Modelling and Simulation

## 1. Modelling.

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**1. Modelling.**

**Simulation.**

**2.**

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**2. Agent-Based Modelling.**

**3.**

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**1. Modelling.**

**Simulation.**

**2. Agent-Based Modelling.**

**3. Learning and Simulation.**

# **1. Modelling — from March & Lave**

## **1.1 Overview**

**A. What is a model?**

**B.**

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**A. A model:**

- **a simplified picture of a part of the real world.**
- **has some of the real world's attributes, but not all.**
- **a picture simpler than reality.**

**We construct models in order to explain and understand.**

## ***Three Rules of Thumb for Model Building:***

-

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**Judge models using: truth, beauty, justice.**

**Interplay between the real world (truth),**



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**Interplay between the real world (truth), world of æsthetics (beauty), world of ethics (justice), and the model world.**

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**We assume rationality: that economic actors (consumers and firms) will not consistently behave in their own worst interests.**

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**We use verbal, graphical, and algebraic models of how consumers, firms, and markets work.**

**We assume rationality: that economic actors (consumers and firms) will not consistently behave in their own worst interests.**

**Not a predictive model of how individuals act, but robust in aggregate.**

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**Explore the arts of**

- **developing**
- **elaborating**
- **contemplating**
- **testing**
- **revising**

**models of behaviour.**

## **What is a model?**

- We can have several models of the same thing, depending on which aspects we want to emphasise, how we will use the model.**
- Models are constructs to explain and appreciate the real world.**

**So ...**

**Need *skills* of:**

—



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**Q: If we cannot understand individual behaviour, then how are we to understand systemic/social/bureaucratic behaviour?**

## **Six familiar models in the social sciences:**

- **individual choice under uncertainty**
- **exchange/trade**
- **adaptation of ideas/technology**
- **diffusion of ideas/technology**
- **transition**
- **demography**

**Each is treated by March & Lave (1975).**

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— from the model: “If the speculated process is correct, what else would it imply?”
4. **Are these *true*? If not, speculate on other models/processes.**

## ***Case: Contact and Friendship.***

**Why are some people friends and not others?**

**e.g. In a hall of residence,  
lists of friends**

**Observe: friends live close together.**

**Process?**

***What is a possible process that might produce the observed result?***

## Two Speculations about Process:

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$\Rightarrow$

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*What changes in these friendship clusters over time?*

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e.g. 2) The professor forgets to bring the undergraduate homework to class. Why?

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Ordinarily, the more situations a model applies to, the better it is and the greater the variety of possible implications.

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- Surprise!**

*e.g. Parental preference for sons.*

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**And (we still have a couple more) that no one divorces (an Irish folk tale) or sleeps around (a Scottish folk tale) without precautions (a Swedish folk tale).**

**And that the expected sex (technical term) of a birth if all couples are producing equally is half male ♂, half female ♀ (though mostly they are one or the other).”**

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**Question: “(Are you ready?) What will be the ratio of boys (with) to girls (without) in such a society?”**

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**Let’s simulate this using NetLogo:**

<http://www.agsm.edu.au/~bobm/teaching/SimSS/NetLogo-models/boysngirls.html>

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**Need *Critical Experiments*:**

compare alternative models  
with the same question → different answers:  
this is critical.

## **Beware Circular Models:**

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- b. “people pursue their own self-interest”  
— don’t predict values from behaviour and then predict the same behaviour from the values just derived.**
- c. Monty Python’s “the man who claims he can send bricks to sleep”**

***e.g. 3). The Case of the Stupid Question***

**e.g. “a surfer asked a stupid question in class”**

**Speculations:**

***e.g. 3). The Case of the Stupid Question***

**e.g. “a surfer asked a stupid question in class”**

**Speculations:**

- A. not enough time to study**
- B. success on the board is sufficient for her**
- C. jealous of her prowess at surfing, the rest of us look down on her classroom performance and interpret her questions as “stupid”**

## How do the Implications Differ?

	S p e c u l a t i o n		
	<u>A</u>	<u>B</u>	<u>C</u>
Q1: will athletes ask stupid questions out of season?	no	yes	yes

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Q2: will athletes ask stupid questions in places that don't emphasise athletics?	yes	no	no
Q3: will athletes who don't look like athletes ask stupid questions?	yes	yes	no

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- delight in finding fault — be skeptical and playful**
- always think of alternative models**

## **2. Simulation**

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**At the aggregate level, similar.**

**But at the micro level, the agents in social science models are people, with self-conscious motivations and actions.**

**Beware: Aggregate behaviour may be well described by differential equations, with little difference from models of inanimate agents at the micro level.**

## **The Five Functions of Simulations:**

**(from Hartmann 1996)**

**I.**

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1. As a **Technique** — to investigate the detailed dynamics of a system.
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4. As a **Tool for Experimentalists** — to support experiments.
5. As a **Pedagogic Tool** — to gain understanding of a process.

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**“A simulation is no better than the assumptions built into it” — Herbert Simon**

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**Steve Durlauf: Is there an underlying optimisation by agents? (his “Complexity and Empirical Economics,” *EJ*, 2005)**

### **3. As a Substitute for Experiment**

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- *theoretically* impossible: counterfactuals; or
- *ethically* impossible: e.g. taxation, no minimum wage;

or to complement lab experiments

## **e.g. Agent-Based Models v. Economic Experiments**

**Hailu & Schilizzi (2004, p.155) compare and contrast ABMs with experiments using human subjects, under the headings:**

- **Approach to inference, or micro-macro relationship**
- **Specification of behavioural rules**
- **Informational problems**
- **Degree of control**
- **Explanation of agents' choices**
- **Temporal length of analysis**
- **Representativeness / realism**
- **Data**
- **Cost**

## 4. As a Tool for Experimentalists

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- **to analyse experiments  
(statistical adjustment of data)**

## 5. For Learning

**A pedagogic device through play ...**

**See Mitchell Resnick. *Turtles, termites, and traffic jams: Explorations in massively parallel microworlds*. MIT Press, 1994.**



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**Play with NetLogo models, and experience emergence: Life is famous, and others too.**

## Summary

**A simulation imitates one process by another process**

**With Social Sciences: few good descriptions of static aspects,  
and even fewer of dynamic aspects  
(Remember: existence, uniqueness, stability)**

## **Robust Predictions from Simple Theory**

**(from Latané, 1996)**

**Four conceptions of simulation as a tool for doing social science:**

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**Four conceptions of simulation as a tool for doing social science:**

- 1. As a scientific tool: theory + simulation + experimentation**
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**(from Latané, 1996)**

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- **Simulation: assumptions → data for inductive analysis**

**S differs from D & I in its implementation & goals.**

**S permits increased understanding of systems through controlled computer experiments**

## **Emergence of self-organisation**

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Adam Smith's Invisible Hand → prices

Schelling's residential tipping (segregation) model:

People move because of a weak preference for a neighbourhood that has at least 33% of those adjoining the same (colour, race, whatever) → segregation.

Need models with more than one level to explore emergent phenomena.

## Families of Simulation Models

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(from Simulated Evolution and from Psychology)**

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**So “agent-based models” excludes Systems Dynamics models, but can include the others.**

## **Simulation: The Big Questions**

from: [www.csse.monash.edu.au/~korb/subjects/cse467/questions.html](http://www.csse.monash.edu.au/~korb/subjects/cse467/questions.html)

- What is a simulation?
- What is a model?
- What is a theory?
- How do we test the validity of any of the above?
- When do we trust them, what sort of understanding do they afford us?
- What is an experiment? What does it mean to experiment with a simulation?
- What is the role of the computer in simulation?
- How does general systems dynamics influence simulations?
- How do we handle sensitivity to initial conditions?
- How precisely can a simulation approximate real life / a model?
- How do we decide whether to use a theory / model / simulation / lab experiment / intuition for a given problem?
- Does a simulation have to tell us something?
- How complex is too complex, how simple is too simple?
- How much information do we need to (a) build and (b) test a simulation?
- How/when can the transition from a quantitative to a qualitative claim be made?

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**To Verify: use a suite of tests, and run them every time you change the simulation code — to verify the changes have not introduced extra bugs.**

## Validation

**Ideally: compare the simulation output with the real world.**

**But:**

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**Use Sensitivity Analysis, to ask:**

- robustness of the model to assumptions made
- which are the crucial initial conditions/parameters?

**use: randomised Monte Carlo, with many runs.**

## **Judd's ideas (2006)**

**“Far better an approximate answer to the right question ... than an exact answer to the wrong question.”**

**— John Tukey, 1962.**

**That is, economists face a tradeoff between:**

**the numerical errors of computational work  
and  
the specification errors of analytically tractable models.**

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**Several suggestions:**

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5. **Synergies between Simulation and Conventional Theory.**

## **Axelrod on Model Replication and “Docking”**

***Docking:*** a simulation model written for one purpose is aligned or “docked” with a general purpose simulation system written for a different purpose.

**Four lessons:**

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- 4. Minor procedural differences (e.g. sampling with or without replacement) can block replication, even at (b).**

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- 4. Software and/or hardware subtleties.  
e.g. different floating-point number representation.**

**(See Axelrod 2006.)**

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- **what should be? (i.e. prescription, normative)**

## Consider historical market data:

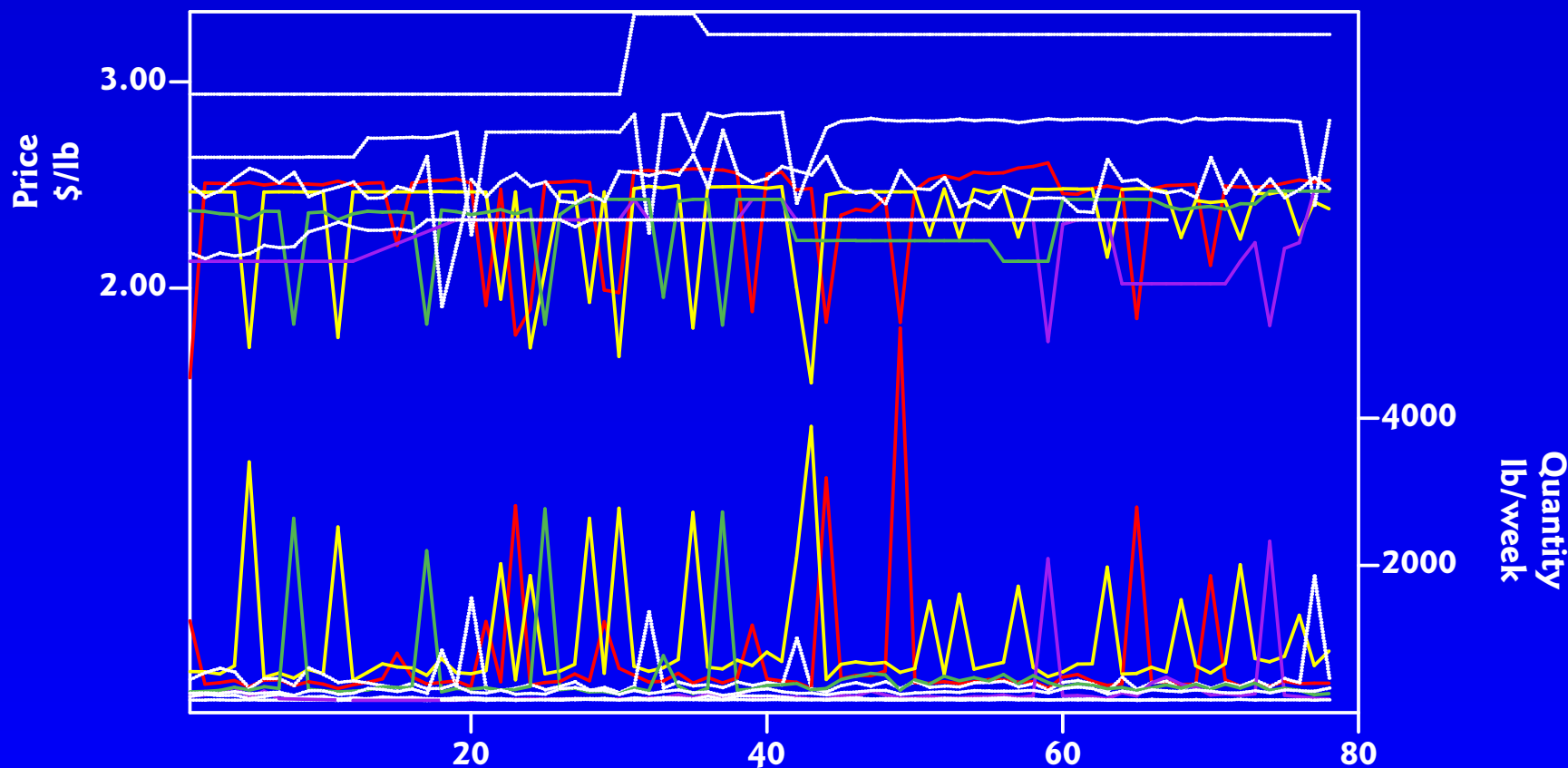


Figure 1: Weekly Prices and Sales (Source: Midgley et al. 1997)  
(Coloured lines: Folgers, Maxwell House, Hills Bros, CFON)

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- **unobserved marketing actions?**

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**Note: assuming profit-maximising (or purposeful) agents means that we are not simply curve-fitting or description using D.E.s. Going beyond the rivalrous dance.**

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**Examine:**

- **limits of behaviour  
(Miller’s Automated Non-linear Testing System)**
- **regime-switching**
- **range of behaviour generated**
- **sensitivity of the aggregate (or emergent behaviour) to a single agent’s behaviour.**

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