

# **Introduction to Agent-Based Modelling using NetLogo**

**C<sup>3</sup> Research Camp**

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**Robert E. Marks**

**Economics, UNSW Australia**

`www.agsm.edu.au/bobm`  
`robert.marks@gmail.com`

# **1. Modelling and Simulation – from March & Lave (1975)**

## **1.1 Overview**

**A. What is a model?**

**B. Why model and simulate?**

**C. What is a good model?**

**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.**

## **Why model and simulate?** (from Josh Epstein, *JASSS*, 2008))

**To:**

- 1. Explain (very distinct from predict)**
- 2. Guide data collection**
- 3. Illuminate core dynamics**
- 4. Suggest dynamical analogies**
- 5. Discover new questions**
- 6. Promote a scientific habit of mind**
- 7. Bound (i.e. bracket) outcomes to plausible ranges**
- 8. Illuminate core uncertainties.**
- 9. Offer crisis options in near-real time**
- 10. Demonstrate tradeoffs / suggest efficiencies**
- 11. Challenge the robustness of prevailing theory through perturbations**
- 12. Expose prevailing wisdom as incompatible with available data**
- 13. Train practitioners**
- 14. Discipline the policy dialogue**
- 15. Educate the general public**
- 16. Reveal the apparently simple (complex) to be complex (simple)**

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

- 1. Think “process”.**
- 2. Develop interesting implications.**
- 3. Look for generality/robustness.**

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

**That is, an interplay between the real world (truth), world of æsthetics (beauty), world of ethics (justice), and the model world.**

**(See the March & Lave extract at the SimSS web page.)**

<http://www.agsm.edu.au/bobm/teaching/Taiwan/marchlave.pdf>

## **Example: The firm —**

### ***Prices, Costs, and Values → Profits***

**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 (always) act, but nonetheless robust in aggregate.**

## 1.2 Modelling

**Speculations about human behaviour/social and organisation interactions.**

**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 aspects of the real world.**

**So ...**

**Need *skills* of:**

- *abstracting from reality*
- *squeezing implications out*
- *evaluating a model*

**We can easily produce more complex behaviour than we are capable of understanding:**

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



## **All Models Require Assumptions**

**Closed-form models often require assumptions for tractability (so that the modeller can solve the mathematical problem).**

**Simulation models also require assumptions (to simplify reality).**

**But the simulation model can be made much closer to reality than many closed-form models.**

**The trade-off: the exact answer to the wrong question (closed-form), or an approximate answer to the right question (simulation models)**

**— John Tukey (1915–2000)**

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

- 1. individual choice under uncertainty**
- 2. exchange/trade**
- 3. adaptation of ideas/technology**
- 4. diffusion of ideas/technology**
- 5. transition**
- 6. demography**

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

### **1.3 *A Model – Case 1): Contact and Friendship.***

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

**e.g. In a hall of residence,  
obtain lists of friends and their room numbers**

**Observe: friends live close together.**

**A process to generate this?**

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

## Two Speculations about Process:

1. **previous friends chose to live together at the beginning of the year**

⇒ **if had lists of friends from previous year, then fewer clusters of friends, why?**

**observe X: friendship patterns among first, second, and third years → no difference in clusters (against the speculation)**

2. **friendships develop through contact and common background, given a potential for friendship**

*What changes in these friendship clusters over time?*

⇒ **through the year a strengthening of clusters of friends**

**observe this? Yes. ✓**

## **Suggests a Model of the Model-Building Process:**

- 1. Observe some facts.**
- 2. Speculate about processes that might have produced such observations.**
- 3. Deduce other:**
  - results**
  - implications**
  - consequences**
  - predictions**

**— 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.**

## Generalisation

*We want to include earlier predictions but find a more general model that predicts new behaviours as well, more widely.*

**Can we generalise this?**

- **beyond the university?**
- **communication → friendship?**
- **enemies as well as friends?**

**e.g. Case 2): The professor forgets to bring the undergraduate homework to class. Why? Possible reasons? Different implications? Reality? ∴ which is better at explaining?**

## 1.4 Three Rules of Thumb

### 1. *Think “process”.*

**A good model is almost always a statement about a process. Many bad models fail because they have no sense of process. When you build a model, look at it for a moment and see whether it has some statement of process/dynamics/change/time.**

### 2. *Develop interesting implications.*

**Much of the *fun* in model building comes in finding interesting implications in your models. A good strategy for producing interesting predictions: look for natural experiments.**

### 3. *Look for generality.*

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

## **1.5 Evaluation of Speculative Models**

**I. Truth**

**II. Beauty**

**III. Justice**

**Justice:**

**be aware of a responsibility to society beyond the “search for truth”. Ethical model building.**

**Beauty:**

- **Simplicity, or parsimony**
- **Fertility (many predictions/assumptions)**
- **Surprise!**



*e.g. Parental preference for sons.*

**“Suppose that each couple agreed (knowing the relative value of things) to produce children (in the usual way) until each couple had more boys ♂ (the ones with penises) than girls ♀ (the ones without).**

**And further suppose that the probability of such coupling (technical term) resulting in a boy ♂ (the ones with) varies from couple to couple, but not from coupling to coupling for any one couple.**

**And suppose (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 suppose 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).”**

**Rule: “stop having kids when your sons outnumber your daughters”**

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

**A Surprise —**

→ **for *most couples*: more sons than daughters.**

**but —**

**for *society*: more girls ♀ than boys ♂,**

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

<http://www.agsm.edu.au/bobm/teaching/SimSS/NetLogo41-models/boysngirls2.html>

## Truth:

- **correct (or more correct) models**
- **requires clever, responsible detective work to find the truth**  
**(aim for objectivity, but face subjectivity if it exists)**
- **test implications, not assumptions**
- **predicting is not equivalent to understanding, necessarily**

## Need *Critical Experiments*:

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

## **Beware Circular Models:**

- a. “when the rain-dance ceremony is properly performed, and all the participants have pure hearts, then it will rain” – testable?**
- 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. Case 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”**
- D. Others?**

## How do the Implications Differ?

	<b>S p e c u l a t i o n</b>		
	<b><u>A</u></b>	<b><u>B</u></b>	<b><u>C</u></b>
<b>Q1: will surfers ask stupid questions out of season?</b>	<b>no</b>	<b>yes</b>	<b>yes</b>
<b>Q2: will surfers ask stupid questions in places that don't emphasise surfers?</b>	<b>yes</b>	<b>no</b>	<b>no</b>
<b>Q3: will surfers who don't look like surfers ask stupid questions?</b>	<b>yes</b>	<b>yes</b>	<b>no</b>

**(Note: we have already generalised: *surfers* plural.)**

## ***The Importance Of Being Wrong***

- **evaluate rather than defend (avoid “falling in love” with your model)**
- **delight in finding fault – be skeptical and playful**
- **always think of alternative models and explanations the academic ability of the surfer**