



**University of
Leicester**

DEPARTMENT OF SOCIOLOGY

**Toughening the Methodology of
Agent Based Modelling by Working
Across Disciplines**

Edmund Chattoe-Brown

1. Plan

- Personal statement for context.
- The crucial role of methodology.
- A “sociological style” ABM for reference.
- Limitations arising from analysing the “Artificial Anasazi”: Methodology, research design, data, confusion, “working”.
- Two examples of challenges.
- Conclusions.

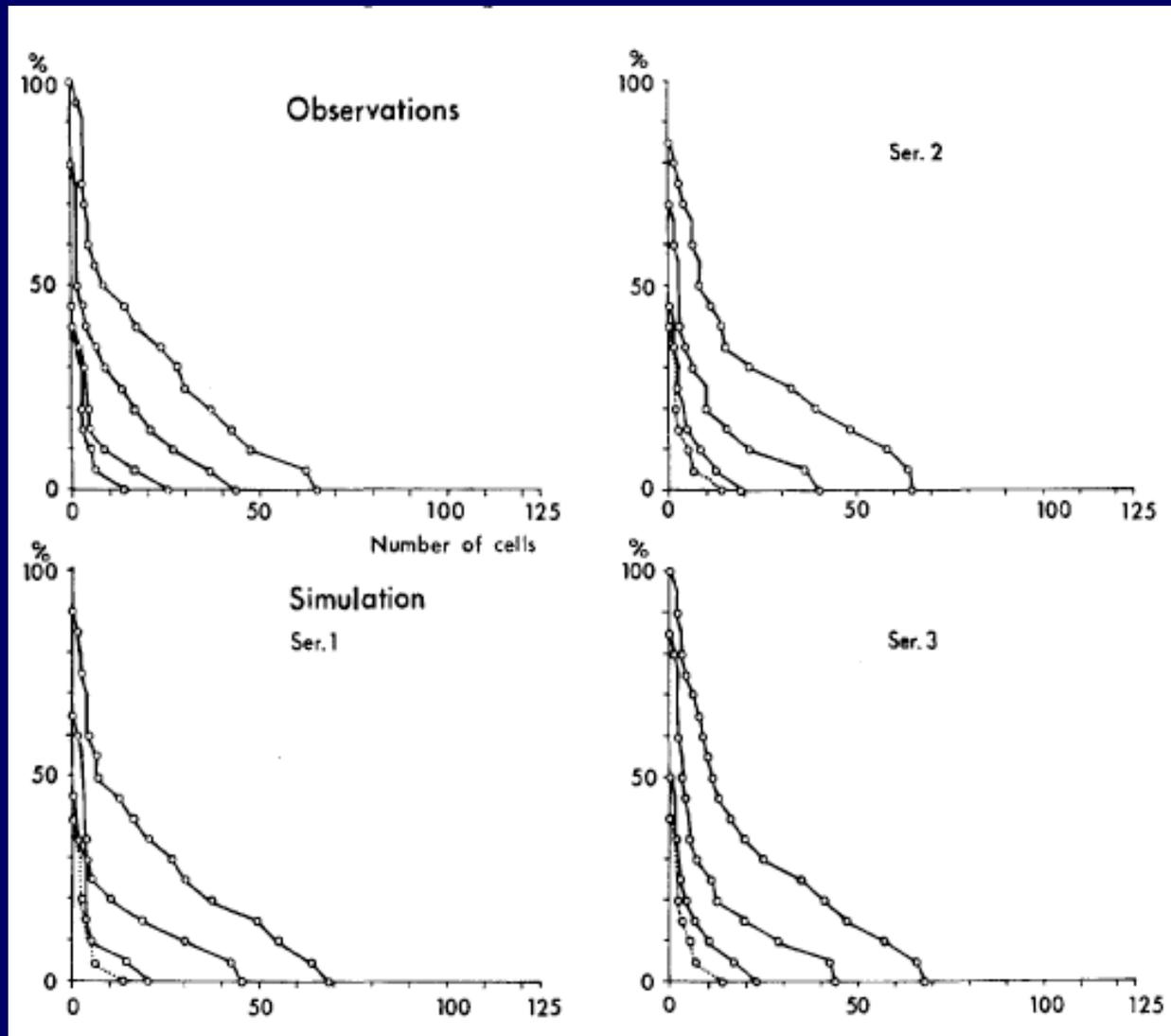
2. Personal statement

- “The assumptions you don’t realise you are making are the ones that will do you in”.
- Fortunate to move disciplines more than once.
- If, as I believe, ABM is a significant innovation in **research methods** across the social sciences then it should be able to meet their challenges on their own ground.
- Participating in debates (and ideally research) with other fields is a way to ensure this “tough testing” of the core ideas of ABM.
- More to be said: Just the highlights.

3. Enough gassing

- Running example: The “Artificial Anasazi”.
- Increasingly, the technology of ABM is being accepted but the implications of the methodology are still not properly understood even by practitioners.
- Calibration: (Maybe) empirical assignment of “parameter values” often at the “micro” level. More shortly. Problem that not everyone (Axtell) agrees!
- Validation: **Measures** of match between simulated “aggregated” data and corresponding real data.

4. It works! So why don't we cite it?



Hägerstrand,
Torsten (1965) 'A
Monte Carlo
Approach to
Diffusion',
*European Journal
of Sociology*,
6(1), May, pp. 43-
67.



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5. Why does this matter?

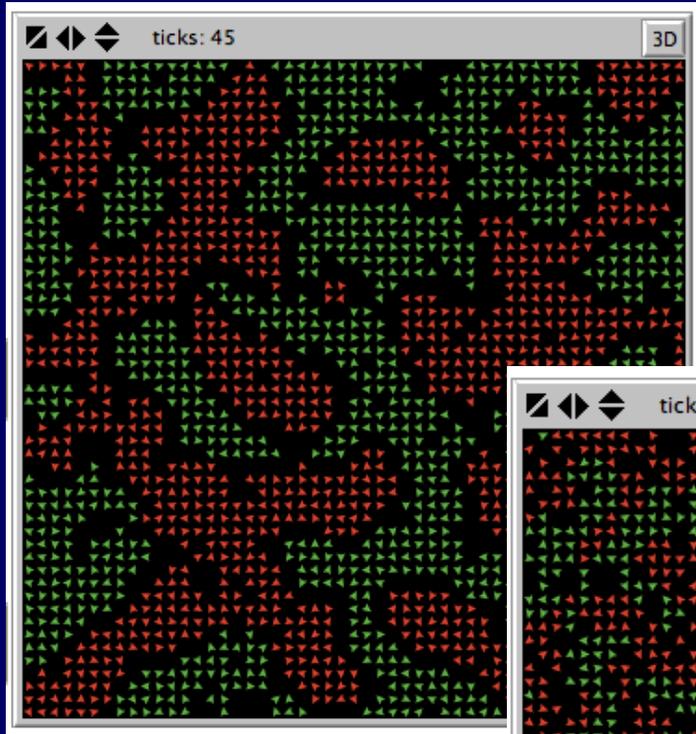
- “Toy” models (no calibration or validation): Who knows if they even **apply** let alone if we can safely “use” their results? How can they “progress?”
- “Rubber” models (validation but no calibration): How many different models can fit the same data about as well? (Equifinality.) Are typical ABM too lacking in parsimony for non-calibrated fit to be much of a result?
- Statisticians know about this already and can prove formal results. ABM probably need to develop “experimental” analysis.
- There are also “fudges” (IMO) about how using ABM in different ways obviates the need for data. Too convenient!

6. Developing ABM methodology

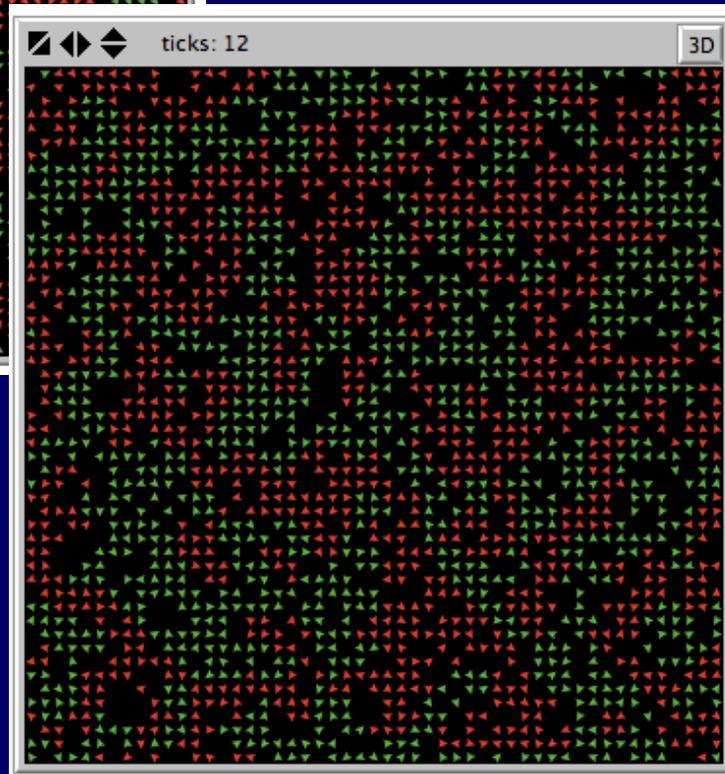
- A lot of progress is about asking the right questions. In this case how *can* we make ABM more empirical?
- The traditional idea of calibration (assigning parameter values) obscures the question of how we decide “what goes in” the model broadly. (I call this “element selection” for want of a better name.)
- Anasazi: Why the water table and not kiva or (much) kinship?
- Without some principled “empirical” approach, the danger is that ABM just reproduce arbitrary boundaries between disciplines (economic ABM have lots of rationality, psychological ABM have lots of “head content” and so on.) Real life is not obliged to respect disciplinary boundaries and ABM doesn’t need to “technically”.
- Synthesis of existing evidence based theorising?



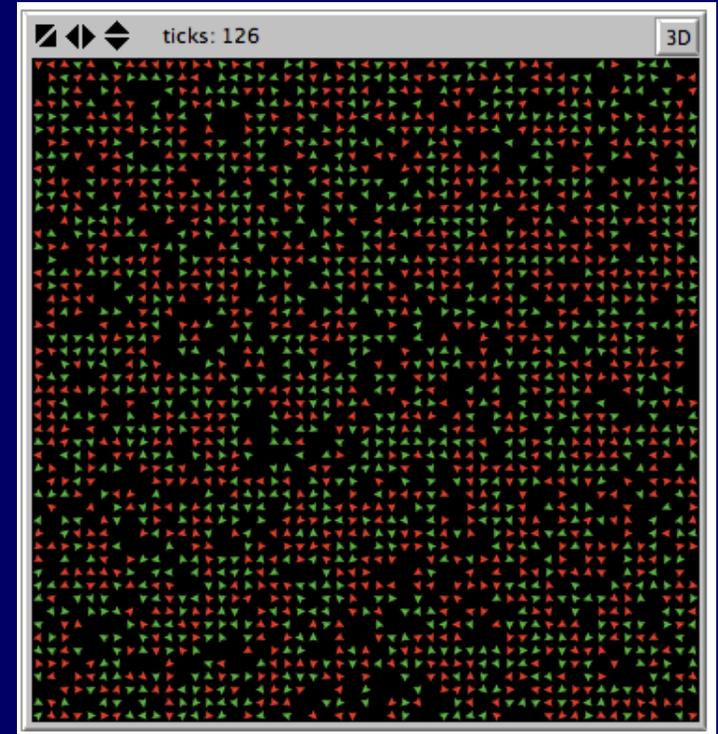
7. Schelling model behaviour



$PP=0.7$



$PP=0.3$



$PP=1$

8. Computational experiments

Individual Desires and Collective Outcomes



9. Important insights

- If a model so simple does this, why would real social systems *not* do it? (“Lower bound” argument?)
- We need “qualitative” data (how do agents decide whether and where to move), “quantitative data” (what does our real city look like) and, very important, “environment data” (how do we know “realtors” are involved and how discriminatory might they be?) Predators? Enemies?
- Sociologists have it easy: We can ask people directly and (broadly) what we want to study is in the state in which we want to study it. Archaeology has neither of those privileges.

10. Limitation 1: Doing it right

- Any method is only useful to the extent you follow its methodology.
- If you “fit” the model to the Anasazi population data then this will always “work” (in some sense) but it doesn’t really tell you what you have left out. (If disease fits the final collapse better, maybe it makes the rest of the history fit worse?) Destructive test: Could you fit the same model to the *inverse* of the data?
- Multiple models may be equi-final. Because of fitting, the model may be “correlative” rather than causal (and because we are dealing with an extinct society there is no “true out of sample” to check this: Sociology can look at segregation “next year” even before the data has been collected.)

11. Limitation 2: Asking a clear question

- A general point due to my colleague Patrick White.
- An ABM, like any other piece of research, should be *designed* to answer a clearly defined research question.
- I am becoming more interested in the precise “structure” of academic argument: How did Dean, Axtell and others *actually* argue? (And how was their argument culturally reproduced?)
- We have got “good” fit on population but we don’t predict the final collapse so *ex post*, we start discussing the logic of settlement agglomeration, disease and so on. But we don’t (to my knowledge) actually build those models. (This is a bit of an oversimplification.)
- So has this work actually answered the question it appears to claim that it set out to answer? Potentially not.

12. Limitation 3: Meeting data challenges

- Broadly, all data that archaeology is ever going to get already exists (though more *discovered* and perhaps new measuring technologies).
- Is this data sufficient (and how reliably can it be “treated”) to test an ABM according to its methodology? We can’t interview the Anasazi about how important “non farming matters” were to them. There are a lot of steps in the discussion by Dean *et al.* in estimating the maize yield of Anasazi “farms”. How much potential error is contained in these? Sensitivity testing?
- Example: What about the corpses?
- Can we design models to be “less far” from the data: Docking.
- But don’t forget, the baseline is *not* “Is this perfect?” but “Can anyone else do any better?”
- A different kind of argument for simpler models?
- Is getting more/different data an option? Design again.

13. Limitation 4: Self imposed confusion

- I have a principle that has never yet been falsified: “If you can explain it clearly, we can model it.”
- One of the strengths of ABM is that it doesn’t have to make “technical” (non empirical) assumptions in order to “work”. Compare “analytical tractability” in formal modelling. These assumptions divide disciplines unnecessarily.
- Sometimes, however, researchers can’t seem to fight their way out of their disciplinary or data strait jackets.
- How can all households have 5 members when new households arise from daughter departure and it takes time to have several children? There is a weedy *post hoc* rationalisation about in migration in just one article that is not anchored to anything else. What happens with widows and orphans? 3 sons?
- Doing this “properly” is “elegant” (brings more phenomena into the same conceptual framework) i. e. maize consumption is not another separate “parameter” but derives from household composition.



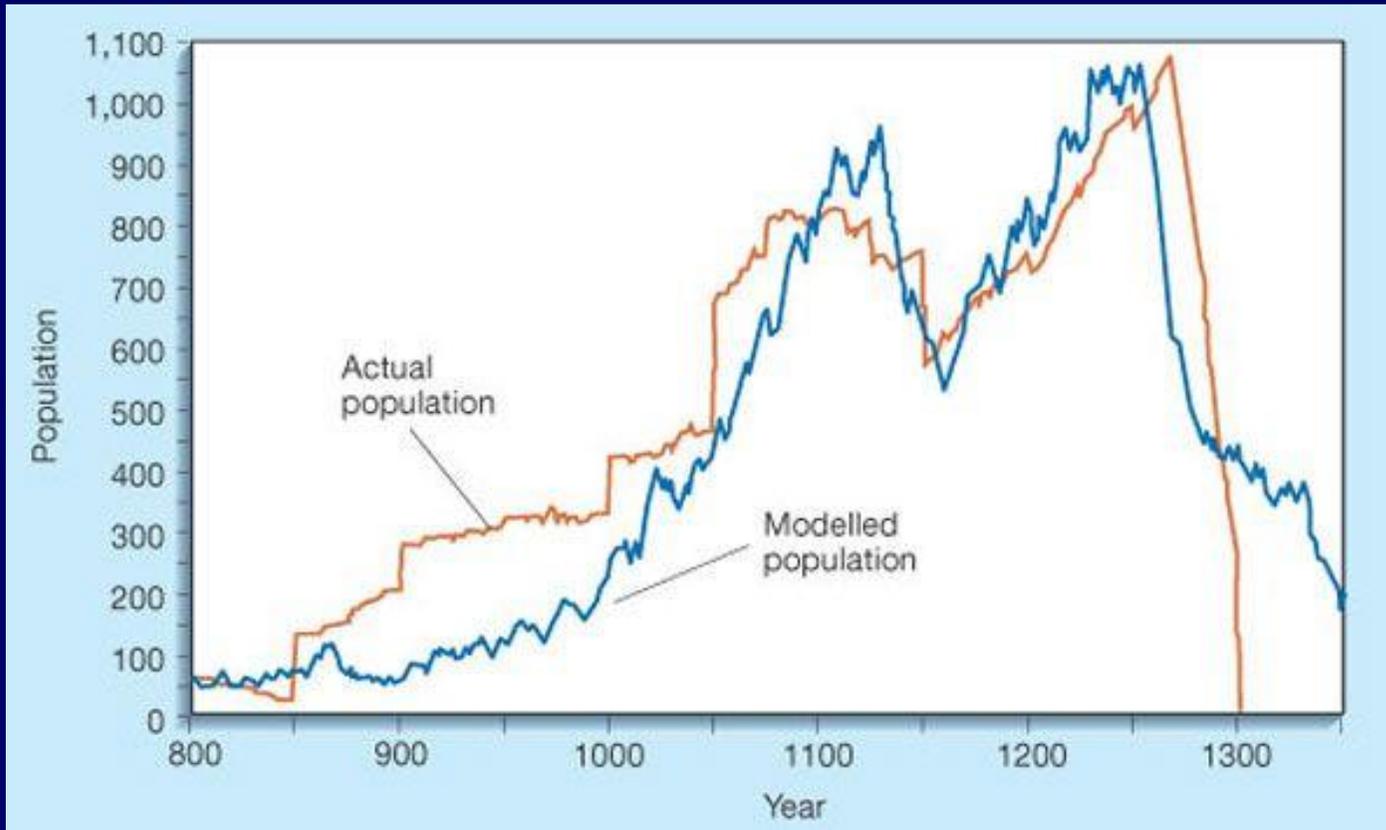
14. Limitation 5: Show your working

- Reading the relevant articles it is pretty hard to reconstruct what “really happened” in the evolving research.
- For example, can anybody find me text that clearly states whether validation on settlement size/location was “fitted” (problems already discussed) or “came free” with the fitting on population (which would be much more convincing). If the latter, why does the (problematic) population fit stay in later accounts and the settlement validation fade out?
- Plan not to document your project only in publications. Get this exactly right and then draw on it (like field notes?)
- Replication cannot be the whole solution.

15. Example: The devil is in the detail

- There are some arguments for sensitivity analysis: Tuning a parameter if you aren't certain of its true value (though *not* to fit the data better according to my argument).
- However, the logic of this is that there *is* a true value (or range of values) and it is potentially accessible to standard research methods: Compare “degree of cognitive dissonance” with “number of close friends you regularly discuss politics with”.
- The Anasazi model seems to “tune noise” which is doubly wrong: Done to fit the data and possibly not susceptible to calibration even in principle.

16. Example: Talkin' 'bout my distribution 1



Diamond:
“fairly well”

Axtell et al.:
“quite accurate”,
“closely
reproduces”

17. Example: Talkin' 'bout my distribution 2

- We need to devise better ways of having this conversation.
- The lines “match” under the description “initial slow but increasing rise, then plateau with dip – or “twin peaks” perhaps - and finally collapse”.
- Even narratively they don't match “total collapse” or “early slow stepped growth”.
- Quantitatively it might be argued that the simulation is “mostly wrong” (hardly ever close in the early phase, fairly wrong about the height and length of the first peak, too early in collapse).
- Should such a match be considered “good for archaeology”, “good as a first try” or some other thing?

18. Conclusions

- The burden of proof: Yes, there are limits but ABM is not creating them. In fact, it may be helping with them.
- What **can** we do with ABM just as formal objects to improve their effectiveness? (“Breaking” fitted models, sensitivity analysis of unavoidably error prone data).
- We really need to be sure of our methodology (and our terminology).
- We need not to reinvent the wheel over things like similarity measures, “over fitting” and so on.

19. Now read on 1

- <https://leicester.academia.edu/EdmundChattoeBrown>
- https://www.researchgate.net/profile/Edmund_Chattoe
- Chattoe-Brown, E. (2013) 'Why Sociology Should Use Agent Based Modelling', *Sociological Research Online*, **18**(3), <<http://www.socresonline.org.uk/18/3/3.html>>.
- Chattoe-Brown, E. (2018) 'Why Questions Like "Do Networks Matter?" Matter to Methodology: How Agent-Based Modelling Might Start To Answer Them', Draft Paper. [Available from me in draft.]
- Chattoe-Brown, E. (forthcoming 2020) 'Agent Based Modelling', in Atkinson, P., Cernat, A., Delamont, S., Sakshaug, J. and Williams, R. (eds.) *SAGE Research Methods Foundations* (Sage). [Available from me in draft.]

20. Now read on 2

- Axtell, Robert L., Epstein, Joshua M., Dean, Jeffrey S., Gumerman, George J., Swedlund, Alan C., Harburger, Jason, Chakravarty, Shubha, Hammond, Ross, Parker, Jon and Parker, Miles (2002) 'Population Growth and Collapse in a Multi-Agent Model of the Kayenta Anasazi in Long House Valley', *Proceedings of the National Academy of Sciences*, **99**(3), 14 May, pp. 7275-7279. doi:10.1073/pnas.092080799
- Dean, Jeffrey S., Gumerman, George J., Epstein, Joshua M., Axtell Robert L., Swedlund, Alan C., Parker Miles T. and McCarroll, Steven (2000) 'Understanding Anasazi Culture Change Through Agent Based Modeling', in T. Kohler and G. Gumerman (eds.) *Dynamics in Human and Primate Societies: Agent Based Modeling of Social and Spatial Processes* (New York, NY: Oxford University Press), pp. 179-205.
- Janssen, Marco A. (2009) 'Understanding Artificial Anasazi', *Journal of Artificial Societies and Social Simulation*, **12**(4), article 13, October, <<http://jasss.soc.surrey.ac.uk/12/4/13.html>>.

