# JASSS

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## Agent-Based Modelling: The Next 15 Years

## Abstract

This short note makes recommendations for the future direction of research in agent-based modelling (ABM). It is a personal view based on my experience as a policy adviser who has recently come to ABM. I suggest that to promote the use of ABM, the ABM community needs demonstrate the value of modelling to other social scientists by showing-by-doing and offering training projects; and to produce tools, guidance on good-practice and basic building blocks. Then the policy contexts most likely to benefit from ABM need to be identified along with any new data requirements, so that the usefulness of ABM can be demonstrated to policy analysts. This is, in my view, the challenge facing the ABM community for the next 15 years.

1.1    This note is based on my past experience as a policy adviser and as a modeller who has recently come to agent-based modelling (ABM). It was inspired by Squazzoni's (2010b) excellent article, "The Impact of Agent-Based Models in the Social Sciences After 15 Years of Incursions", published recently in the *History of Economic Ideas*. Squazzoni notes that ABM has made most progress among economists. This is hardly surprising. In economics, building models is a generally accepted method. In contrast, in sociology the value of modelling does not appear to be generally accepted and modellers are asked to justify their approach in a way that does not happen in economics. In economics the details of the modelling may be challenged but the value of modelling is not. Hedström & Bearman's (2009) *Oxford Handbook of Analytical Sociology* (recently reviewed in JASSS (Squazzoni 2010a)) suggests that sociology may be changing, but I expect it will be some time before there is in sociology the general acceptance of modelling that exists in economics. That is why it is important that the ABM community demonstrates the value of modelling by showing-by-doing and offering training projects such as Gilbert and Chattoe-Brown's (2009) SIMIAN project.

## Tools

2.1    Having instilled the desire to model, it is important to recognise that building agent-based models is difficult. Even using something as simple as *NetLogo* (Wilensky 1999) can be challenging for those with little programming skill (such as me). In contrast, packages have existed since the 1970s to facilitate macro-economic modelling. More needs to be done to make ABM simpler to use for those who are not programmers. Kahn's (2009) *Modelling4All* project is a leading example.

2.2    Putting on one side the technical problems of programming there are still many difficulties to be faced. There is a standardised method for describing models—the Overview, Design Concepts (ODD) protocol (Polhill et al. 2008 ; Grimm et al. 2010 )—but what about creating and assessing them?

2.3    As a newbie to ABM, I was faced with basic questions to which there appeared to be no obvious answers and no

guidance, such as;

- how many agents?
- how many runs?
- how to aggregate results?
- what statistics to use?

2.4    It is easy to assert that the results of a model cannot be valid because the model does not use enough agents or is not run enough times, or those runs are not aggregated in an appropriate way and the results are not assessed using proper statistical techniques. But what is "enough", "appropriate" and "proper"? For example, if we want a 95% confidence interval, should we use two standard deviations as for normal distributions or four as implied by Chebychev's formulation? Guidance and standard practices need to be developed. This is by no means straightforward because ABMs can be used for such a wide variety of purposes. Yet it needs to be addressed.

## Building blocks

3.1    I wanted to create an artificial society to assess the impact of new communications technologies. But I quickly discovered that basic building blocks did not exist. Some features were available from the NetLogo Library, such as methods of calculating Gini coefficients and path lengths through networks. But I spent much of my time creating the basic underlying features; in particular, creating a model of social networks, modelling household formation and generating income distributions. To illustrate my point, I will explain each in turn.

3.2    First, the social network problem is I think particularly acute as it underlies so many models. In my view, none of the basic network models, such as small-world or preferential attachment, are appropriate and so I had to devise my own. We need a better understanding of the implications of using different social network models. What is required is library of network models: so, for example, if you want, say, to create social networks of close family and friends, with certain network characteristics, use model A, but if you want the network to include acquaintances, and have a different set of characteristics, then use model B.

3.3    Second, I wanted to reproduce a sample of households in the UK from 1951 to 2001. It soon became clear that this was a major project in its own right. Yet such modules are essential if ABM is to be used for policy analysis. Of course demographic history will vary according to time and place, but basic work can be done, which can then be customised. (Furthermore, this revealed a conceptual issue that needs to be worked through. We may want agents to represent households but households comprise individuals and it is the individuals who act although their actions may be driven by household characteristics such as income.)

3.4    Third, I needed to create income distributions to produce given Gini coefficients. I devised two methods: a top down approach to be used for a period when there is little data available and a bottom up approach to use when data is plentiful. No doubt other, probably better, methods could be devised. Again, such modules are essential for policy analysis.

3.5    Because of this lack of building blocks, models are bespoke, "hand-crafted" as Squazzoni says. The ABM community needs to get away from this by providing building blocks.

## Policy use

4.1    Academics often refer to "policymakers". It is important to distinguish between the politicians who make the decisions (together with the senior civil servants who advise them) and the people who actually do the analysis. Politicians and senior civil servants are not interested in the details, just the output. They need statements such as "Option A will do this and cost £Xm while Option B will do that and cost £Ym"; and in just two pages, double-spaced.

4.2    The details are produced by the analysts and they will only adopt a new method if it provides something better than they already have. For example in the 1970s and mid-1980s, I was working on British tax and benefit policies. The impact of tax and benefit changes were then illustrated by sets of hypothetical examples, such as "a family with two children aged A and B and income of £Y per week would be £X per week better off, while a single person on state pension would be £Z per week better off". Microsimulation of tax and benefit changes allowed analysts to make statements such as "n thousand families will be better off by on average £Y per week but m thousand will be worse off by £Z per week". Thus microsimulation was adopted because it provided a

much superior output.

4.3    Furthermore, microsimulation of tax and benefit changes was possible because the data — *Family Spending* surveys — already existed. (The data was used to provide the weights for the retail prices index.) For some ABM policy-modelling, new data may need to be collected and this needs to be identified. For example, in macro economics the theory developed by Hicks and Keynes determined what macro economic data had to be collected (Akerlof & Shiller, 2009, pp.15-16).

4.4    To persuade policy advisers to adopt agent-based modelling there needs to be a clear benefit in terms of the output. The stakeholder games seem to be an example. I suspect, and this is just a hunch, that ABM might be particularly useful in policy areas involving minority groups. The policy areas and questions that would benefit from ABM need to be identified.

## Summary and conclusion

5.1    This view is highly personal, based on my experience of modelling over many years and most recently in ABM. I think ABM is a very powerful tool but we — and I include myself in this — have been trying to do sophisticated policy-orientated modelling when the basics are not yet in place. We are trying to run before we can walk. We need to focus on KISS rather than KIDS.

5.2    We must demonstrate the value of modelling to other social scientists by showing-by-doing and offering training projects. We should focus on producing tools, guidance on good-practice and basic building blocks. Then we need to identify the benefits of ABM over existing methods in particular policy contexts, identify what new data will be required, and demonstrate the usefulness of ABM to policy analysts. All this will require discussion and dissemination through both the traditional media of books and articles and new channels such as wiki websites. This is not a project for a single research centre. It is, in my view, the challenge facing the ABM community for the next 15 years.

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