

A Short Theoretical Essay on Causal Inference for Sociologists

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Manuscript submitted as a part of the application to the “Habilitation
à diriger des recherches” (HDR) at Sorbonne University.

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List of acronyms

ABM: an Agent-based Model or Agent-based Modeling

ABMs: Agent-based Models

DAG(s): Directed Acyclic Graph(s)

IV(s): Instrumental Variable(s)

KISS (principle): Keep It Simple, Stupid

KIDS (principle): Keep It Descriptive, Stupid

RCTs: Randomized Controls Trials (experiments)

List of tables and figures

Table 1: Observed combinations of “theoretical realism“, “empirical calibration” (input side), and “empirical validation” (output side) in 23 ABMs from economics, epidemiology, ethno-archeology, demography, marketing research, and sociology.

The structure of the answer

To develop the argument, my analysis goes through two main steps. These correspond to the two parts in which this essay is organized. Each part in turn contains three chapters.

In *Part I*, I make an effort of conceptual and methodological clarification that is needed to properly address my central question, i.e. *in what sense and under which conditions* ABMs can aid causal inference.

In particular, *Chapter 1* treats the notions of causality and mechanism, and stresses the diversity of accounts that both concepts have received. My goal is to establish that any argument about one favorite method's capacity to aid causal inference and model social mechanisms implicitly relies on one specific understanding of these two notions. As ABM is especially compatible with one specific understanding of the concept of mechanism, it follows that some are sympathetic towards using ABMs in causal research, while others are against it.

Chapter 2 moves from conceptual to methodological clarifications. It discusses generic features of ABMs, and clarifies the sources, on a technical level, of the special compatibility of this method with one specific understanding of the concept of causality and mechanism. Thus, what was only posed in *chapter 1* is now explained. This methodological discussion will also give the opportunity to address an important point, namely the role and the meaning of "variables" in ABMs, which still seems misunderstood by statistically-minded scholars.

Chapter 3 also focuses on ABMs on a methodological level, and adds an important clarification. In particular I stress that existing ABMs are various with respect to a/ the degree of realism of the assumptions that are used to design the model, b/ the type of information that is used to build it, and d/ the nature of the data that are performed to assess the model's validity. This is done empirically by analyzing typical models that contributed to establish the

research field as well as a selection of recent applications from a variety of disciplines. On the basis of this meta-analysis, I argue that, since all the three dimensions have a bearing on causal inference, a principled assessment of the usefulness of ABMs in causal research cannot neglect the variety of ABMs available on the market, which means that any conclusion drawn from studying this or that specific ABM will be ill-founded.

With such conceptual and methodological qualifications in place, *Part II* can address the central question of the essay, i.e. *in what sense* and *under which conditions* ABMs can aid causal inference.

In particular, *chapter 4* discusses the *in-principle* conditions for ABM to support causal inference, and relate them to the three dimensions, discussed in chapter 3, along which ABMs can be classified. I then highlight the *in-practice* obstacles to the realization of these conditions, and describe the research operations that, from within the method, are available to ABM modelers when these in-principle conditions cannot be satisfied.

Chapter 5 plays a crucial role within the structure of the argument. By focusing on a set of methods for which the causal capacity is usually regarded as indisputable, namely randomized control trials (hereafter RCTs), instrumental variables (hereafter IVs), and causal graphs (in particular, Directed Acyclic Graphs, hereafter DAGs), I show that, on close scrutiny, these methods, when they are used to establish proper causal claims, face challenges that are identical to the obstacles faced by ABMs. Similar to the latter, I argue, well-established methods for causal inference in fact also face issues of data availability, untestable assumptions, and uncertain reliability.

Chapter 6 concludes the argument by drawing all the implications from this important—but often under-estimated—fact that, similarly to ABM, traditional methods for causal inference generate evidence for causality only if specific, and highly demanding, conditions are fulfilled. In particular, I build

my plea for shifting the focus of the debate from proposing arguments that defend the superiority of particular methods, arguments based on an (often implicit) endorsement of particular notions of causality and mechanism, to discussing how different methods may coexist and ought to cooperate. This plea is motivated by explaining why different methods produce different kinds of evidence, and, since in practice every kind of evidence is likely to be imperfect, the defence of any causal claim can only be built at the intersection of these methods, the weaknesses of one method being compensated by the strength of another.

In conclusion, I first examine potential objections to my analysis (see *Discussion*) and, then, provide a detailed summary of it (see *Conclusion*).