Computational Models

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In political economy, computational models are used to simulate the behavior of institutions or individuals. Researchers use these models to explore emergent patterns in the behavior of individuals and institutions over time. Computational models are used as a complement to mathematical models –and as a form of independent theory construction in their own right. (This distinguishes computational models from statistical computation for data analysis: Although statistical models may involve simulation of mathematical functions, they use simulation in order to approximate known statistical models that are difficult or impossible to analyze analytically.)

While some scholars used computers to model political behavior in the early 1960's many of the fundamental ideas now used in computational political economy did not appear until much later. (For a surveys of early and more recent work see Johnson, 1999; and Taber and Timpone, 1996.), In particular, Schelling's (1978) pioneering work, *Micromotives and Macro Behavior*, which created micro-simulations of individual without computers, showed dramatically how complex and unexpected patterns of behavior could emerge from individuals acting with simple motives and simple rules of individual behavior. This directly influenced the first major work (and one of the most-cited) of computational political economy, Axelrod's (1981), The Evolution of Cooperation, in which he showed how cooperative behavior can emerge from self-interested agents that operate using simple heuristics.

Modern computational models that describe the behavior of individual actors are sometimes known as "agent based" simulations. In most modern agent-based simulations, local interactions are important -- individuals are modeled as acting upon locally available information, and as interacting with other local agents. Also, in typical agent-based simulations individuals are modeled as being boundedly rational: agents use heuristics to make decisions, rather than acting optimally (in the game-theoretic sense). Moreover, the institutional environment in which individuals act is characterized as both stochastic and dynamic -- evolving with, or co-evolving in reaction to, the behavior of individual agents. (For an enlightened discussion of these and other characteristics of computational models, see Page 1999).

Computational models are not required to use individuals as the modeling unit. For example, models of international conflict, in which nations are the fundamental actors, date back to the early 1950's. Although used less frequently in political economy, institutional-level models are common in macroeconomics and finance.

Although initially opposed by formal theorists as too imprecise, and by qualitative theorists as too impoverished, computational models have gained a share of acceptance in the last decade. As a complement to mathematical theory, computational models are most often advocated as a way to generate both examples/counterexamples with which to probe the robustness of the mathematical model to changes in assumptions. Computational models may also be used as an constructive form of theory building independent of a formal mathematical model: as the basis for making predictions, and for generating qualitative insights. As such, they are often justified as a middle ground between purely mathematical formal models and purely textual qualitative models. Since computational models are far easier to construct than formal mathematical models, the researcher can use them to obtain, in the happiest of circumstances, the precision of a formal model with the realism of a qualitative model

Proponents of computational models argue further that dynamic computational models, are better fitted models to studying dynamic patterns than standard mathematical equilibrium models. (Using equilibrium models to study dynamic behavior is sometimes likened to trying to understand Niagara falls by staring into a collection bucket.) Still even ardent proponents emphasize the need for caution in model building and interpretation. As in other forms of model building, seemingly innocuous assumptions may sometimes yield striking different patterns of outcomes. Thus, all models should be built with care, and researchers should actively seek cases in which competing models yield diverging predictions that may be directly compared.

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