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October 28, 2014

UWP 104E

Reviewing the Commons Using Case-Study Agent-Based Models

Introduction:

In studies on common-pool resource management, solely taking an empirical approach to study the regulations of sustainable use of limited resources does not engage in assessing the actions and interactions of self-governing agents or their effects on the natural or human-made resource system as a whole (Ostrom 2010). Despite taking a rich qualitative study on common-pool resource management, challenges arise in understanding the interactions between the different components of the system. However, subsequent studies have created agent-based models for describing the decision processes of simulated actors on the micro-level and the structures that emerge at the macro-level from the action and interactions of agents with other agents within these resource systems (Bravo 2011). Using agent-based models can statistically test the different components of the resource system from which the empirical data is derived (Ostrom 2010; Bravo 2011).

Hardin’s seminal article *Tragedy of the Commons* (1968), describes the tragedy from self-interested individuals exploitation of a natural resources. In this article Hardin describes that without government or state intervention actors with individual self-interest will cause a resource to be overexploited leading to its demise (Hardin 1968). Subsequent scholars, who may be considered “anti-Hardin”, have focused on the sets of problems that cooperating groups must attempt in order to create institutions for collective-action to manage common resources for optimal sustainable use (Ostrom 1990). These problems in general terms, include: free-riding (i.e., someone who benefits from goods without paying the cost of the benefit), solving commitment problems, arranging for the supply of new institutions and monitoring individual compliance with sets of rules (Ostrom 1990). This is important because the issue of common-pool resource management is concerned with the provision of public goods, this relates to larger issues of group problem solving over limited resources and towards a theory of collective-action.

Earlier work focused primarily on communities that manage common-pool resources using empirical methods. The empirical approach emphasized the outcomes of collective-action rather than examining individual interest or input and the dynamics of group selection in the collective management of resources. The various ways empirical techniques are used, illustrate the main challenges of contemporary social sciences such as, how to develop models that are generalizable and still applicable in specific cases, and how to scale up the processes of interactions of a few agents to interactions among many agents (Janssen and Ostrom 2010). Increasingly, agent-based models are being used to simulate the actions and interactions among agents in natural or human-made resource systems (Janssen and Ostrom 2010). Agent-based modeling is considered to be an assured quantitative methodology for social science research because these models may illuminate and compliment the existing qualitative data (Janssen and Ostrom 2010).

Although empirical models reveals human actors being able to solve collective-action problems on their own without external rules and enforcement from outside agents, these empirical models do not statistically test the different components of the resource system from which the empirical data is derived. Though agent-based models begin to statistically simulate the different components of the resource system using empirical data, these models inadequately represent the behaviors of individual agents in natural and human-made resource systems. Despite developing a framework for representing the boundaries of behavior in agent-based models across various modeling contexts, these behavioral models do not convey the affects of situational and behavioral aspects of actors on simulated communities. Though one of the advantages of theoretical agent-based modeling is the ability to simulate the implications of decision-making processes in simulated communities, these models insufficiently represent real biological and social situations that contextualize the real world phenomena.

Empirical Models:

Although Ostrom’s study on common-pool resource management takes an empirical approach to study the regulations of sustainable use of limited resources, it does not engage in assessing the actions and interactions of self-governing agents or their effects on the natural or human-made resource system as a whole (2010). In this article, Ostrom reviews some of the structural variables that have been found to affect the probability of collective action, these include: the number of participants involved, whether benefits are subtractive or fully shared, the heterogeneity of participants, face-to-face communication, information from past actions, how individuals are linked, and whether individual can exit and enter voluntarily (2010). These structural variables affect the core relationships of reputation, trust, and reciprocity as these affect levels of cooperation in resource systems, though other variables, such as transaction costs and the development of shared norms also affect the probability of cooperation (Ostrom 2010). These variables simply generalize typologies of groups that engage in institutions for collective action but do not reflect individual self-governing agents interactions on a systems-level (Ostrom 2010). Furthermore, the empirical approach does not statistically test the different components of the resource system from which the empirical data is derived, with the lack of statistical data, it’s difficult to assess the resilience of resource management over time.

Agent-Based Models:

On the other hand, Bravo proposes both an analytical model and a more complex agent-based model designed to study common-pool resource management problems with a specific focus on the relation between agents’ beliefs and institutions, that moves beyond the empirical approach to a theory of collective action using computational statistics (2010). These models begin to statistically simulate the different components of the resource system using empirical data. Bravo models the relationship between the beliefs among actors involved in exploiting the common resource and the development of management institutions (2010). In this article, Bravo found that the conditions where agents are allowed to build management institutions, outcomes were much better than the ones where agents can only rely on individual beliefs in order to limit the resource consumption (2010). Though, in order to keep the model simple, many rules that are fundamental in real social and biological systems were only assumed in his research (Bravo 2010). Moreover, these models inadequately represent the behaviors of individual agents in natural and human-made resource systems.

Behavioral Agent-Based Models:

However, Smajgl et al. develops a framework for representing the boundaries of behavior in agent-based models across various modeling contexts (2011). Smajgl et al. classified and formalized various modeling contexts according to the size of the agent population, their behavioral diversity and the ability of researchers to acquire a representative sample of agent behaviors (2011). These classifications provide a structure that can be used to evaluate the suitability of various combinations of methods in different context using behavioral data (Smajgl et al. 2011). Though, Smajgl et al. does not provide a framework for examining the ways agents engage with their environment and how agents form social networks in solving common pool resource problems (2011). These behavioral models do not convey the affects of situational and behavioral aspects of actors on simulated communities.

Theoretical Agent-Based Models:

Instead, Vallino uses agent-based simulations to develop a theoretical model to simulate the implications of decision-making processes in simulated communities,

(2013). Vallino addresses a particular situation of natural resource management, that of a protected area (2013). By addressing a particular situation of natural resource management, agent-based models may better reflect the dynamics of natural and human-made resource systems. The presence of institutions and enforcement from an external entity such as the state, a donor, an NGO or some combination thereof, improves the management of the resource with respect to an open-access situation (Vallino 2013). The results from Vallino’s findings suggest that an exogenous institution imposed by external agents (i.e., the state, a donor, an NGO or some combination thereof) may crowd out agents’ intrinsic environmental motivations, and when an imposed exogenous institution is in place, the most effective rule is one allowing a sufficient degree of access to resources for the agents, provided that adequate rule enforcement is implemented (2013). Though theoretical agent-based models explore the consequences of different kinds of institutions for its users using simulated environments, it does not reflect the behavior of agents in real biological and social situations.

Case-Study Agent-Based Models:

Though, Wijermans et al. develops an agent-based model case study that real biological and social situations that contextualize the real world phenomena. The Wijermans case study is situated in the rice terraces of Bali and involves irrigation management. In this article, Wijermans et al. model explores cultural factors, such as regional temples that control water flow into these terraces and rice paddy farmer communities (2014). The model created is contextualized so as to relate previous theories/models from the literature to empirical data and later focusing it more for case-study specification (Wijermans et al. 2014). Wijermans et al. model provides real world social dilemmas to somewhat abstract theoretical models, making the model useful to explain the dynamics of common pool resource management and adaptation over time (2014). These case-study agent-based models entwine the empirical component, the qualitative method, with agent-based modeling, the quantitative method, using a framework or representing the behavioral aspects of real biological and social situations. Future work should focus on enriching generalized models with context sensitive social dilemma factors, as these provide a more realistic and useful insight into the dynamics of natural and human-made resource systems (Wijermans 2014).

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