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Complexity Theory and Its Evolution in Public Administration and Policy Studies

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This paper traces the evolution of the application of the complexity sciences in the literature of public administration and public policy. A four stage evolutionary model is used to track the development of this literature. The evolution of the literature has now reached a third evolutionary stage. This third stage is a proliferant stage in the development of the literature in which applications and knowledge production has increased dramatically.

Keywords: Complexity sciences, evolution, emergence, convergence, proliference, divergence, public administration and policy studies.

1. Introduction

We are fortunate to live in a historical period of both rapid and substantial change. This is a period in which human knowledge accumulates at rates that exacerbate efforts to accommodate and store this knowledge. Keeping up with the accumulated knowledge requires a singular focus that is rare in a world of continuous partial attention. The acceleration of knowledge as a global resource is also reflected in the acceleration of knowledge regarding complexity studies in public administration and public policy. The period of early research in this area has evolved, over the last quarter century, into a period of proliferation in which scholars have applied an increasing array of methods to examine the behaviors of complex governance, administrative, and policy systems.

In this paper I strive to explore the evolution of complexity studies in public administration and public policy. In particular, I view the knowledge accumulation in this area as an evolutionary process. Tracing the evolution of what and how we know does not reduce the uncertainties, errors, or omissions in knowledge production processes, but it does provide a means of exploring the field of complexity studies as an evolving enterprise.

This paper is comprised of four sections. First, I present Schumacher's (1986) evolutionary model as a means for appreciating the birth and maturation of complexity studies in public administration and policy. Next, the literature of the complexity sciences in public administration and public policy is placed within the evolutionary sequence of

Schumacher's model. This analysis provides means for assessing the relative maturity of this academic enterprise and for assessing its current evolutionary stage.

Any review of the current state of an academic field requires some sense of the evolution of that field. Complexity studies in public administration can be traced back approximately a quarter of century, to Kiel's early studies (e.g., Kiel, 1989, 1993, 1994). The sources cited in this paper are a small sample of the growing and evolving literature on the applications of complexity theory in public administration and policy. The realization of this very journal, *Complexity, Governance & Networks*, clearly represents the evolving maturity of the field.

How can we best understand the evolution of the applications of complexity theory in public administration and policy? The scholarly literature provides some frameworks for understanding the evolution of an academic field of study. Kuhn (1970) suggests that scientific paradigms are challenged from within themselves, through a Hegelian conflict of ideas, which first instigates incremental change, but at one point the entire paradigm shifts and a new paradigm achieves dominance. If complexity theorists in public administration and policy seek dominance, it is likely to be a mild dominance based on a few important insights, rather than an effort to alter the entire landscape of public administration and policy studies. Important insights such as the pervasive nature of nonlinear and dynamic phenomena in our field do not necessitate a revolution. These insights do suggest, however, that the simplifying requirements of the dominant linear model may fail to capture essential parts of the puzzle that constitute the reality of public administration and policy.

If complexity studies are seen as an extension of established open systems models then complexity is simply an enhancement to existing knowledge, rather than a seismic shift in world views. However, the recognition that the truly interesting elements of reality are nonlinear and non-Gaussian implies a more general critique of the value of using standard statistical techniques to understand complex dynamic phenomena.

Theories of innovation may also help to add insight into the evolution of complexity studies in public administration and policy. For example, Roger's (1983) oft-cited model of innovation reveals a standard sequence of behavior but also reflects a flattened normal distribution as a majority of followers allow early adopters to take on the risk of innovation. While such dynamics are likely to occur, Roger's model does not inform us of the continued process of the evolution of a scientific or technological innovation.

An evolutionary model of change may, however, provide insights into the change in an academic discipline. The model of evolutionary change offered by Schumacher (1986) may provide some insight into the evolution of complexity studies in public administration and policy. Schumacher's (1986) model of evolutionary change provides a means for assessing the relative maturity of the theory and methods used to study complex systems in public administration/policy. Schumacher's model includes a four-stage process that is intended to describe evolutionary processes in all living systems, including human sociotechnical systems. These four stages progress in a circular and sequential fashion. These four sequential stages are emergence, convergence, proliferance, and divergence.

The first stage in Schumacher's model is emergence. Emergence refers to the creation or production of a "new state of matter" (p. 10). Such new matter, representing novelty, evolves as attractive forces "experiment" with environmental conditions to determine adaptive fit. Emergent phenomena may continue to evolve along uncertain pathways or may die out if the emergent "mutation" cannot survive in its environment. High levels of risk exist for emergent entities and survival is not ensured.

As an emergent entity evolves, forces of repulsion and attraction serve to determine whether the entity will die or converge into a coherent form capable of further reproduction. This second evolutionary stage is labeled convergence. At this stage of evolution, there is coherence with the mutation now being clearly distinct in its environment. A critical mass of the entity now exists providing the chance of further replication.

The converged entity, now with some solid grounding in its environment, may reach a stage of environmental fit in which it proliferates. The entity thus matures to a level that it fills multiple niches in its environment and may dominate its environment. This third evolutionary stage, a period of proliferance, allows the possibility for increased system complexity that may generate novelty and eventually new forms of the entity. Proliferance expedites complexity and further allows recombinations that may produce further complexity.

A fourth state in this evolutionary paradigm is divergence. The divergent stage evidences novel forms of the proliferant entity as it seeks new forms of adaptive fit. Divergent forms may die out with high frequency given the dominance of the previous form. Eventually, though, a divergent form creates adequate attraction so that the cycle continues and a new emergent form of matter is produced.

An example of this evolutionary model using technological innovation will serve to emphasize the relevance of this model. Consider the case of the evolution of modern computing technology in the developed world. The emergence of the mainframe (vacuum tube technology) in the late 1930's resulted in the convergence of the technology and its organizational applications in the 1950s–1970s. The rise of the microcomputer and networks engendered a proliferant era in which computers proliferated in the environment. A new divergent stage has emerged with wearable computing and sensors that may lead to new yet unknown emergent technologies.

As a further example of general applicability of this evolutionary model, let us examine its relevance to human cultural innovation. Consider the behavioral revolution in the social sciences as an evolving phenomenon. Many of the statistical tools supporting this "revolution" emerged in the early 1900's (Ziliak & McCloskey, 2008). The post-World War II era showed general convergence, as more social science disciplines relied on statistical analyses for scientific understanding. The proliferant period of the 1980s to the present shows an expanding array of statistical tools and techniques available to the social scientists. Predicting the forthcoming divergent stage may not be wise in a nonlinear world, but such a stage may include elements of capturing big data on social behavior combined with individual level means for assessing behavior and health (Pentland, 2008).

2. Emergence: 1989–1998

The emergent stage of the application of the complexity sciences to public administration and policy studies was in the decade of 1989–1998. These earliest efforts can be viewed as testing the relevance of the complexity sciences to the field of public administration and policy studies. These early publications were generally focused on applications of dissipative structures Kiel (1989) and notions of self-organization (Comfort, 1994) to public organizations. The majority of these early publications is quite general and definitional in nature and intended to acquaint the scholarly community with the terms and concepts of the complexity sciences. Thus these efforts tested whether the larger public administration and policy community would accept the relevance of the basic concepts of the complexity sciences. The challenge of identifying the proper language is evidenced in works that examined topics ranging from chaos theory to quantum mechanics (Overman, 1996). This body of literature was metaphorical in tone and content. In the literature public organizations were viewed as dissipative self-organizing structures.

In the emergent stage there were some early time-series analyses as well. Kiel and Elliott (1992) used phase diagrams to examine the nature of change in the U.S. federal budget. Kiel (1993) applied phase diagrams to spending and work activity dynamics in a State government agency. The most sophisticated time-series analysis during this period is Kiel and Seldon's (1998) discovery of nonlinearity and randomness in time series data from a police organization.

The emergent stage of applications of the complexity sciences to public administration and policy studies was sustained as top journals such as *Public Administration Review* and the *Journal of Public Administration Research and Theory* showed willingness to publish works incorporating the novelty of the complexity perspective. Kiel's work (1994) was the first book-length effort applying the complexity sciences, at that time generally labelled chaos theory, to public administration. The risk, inherent in all novelty, was reduced as the primary sources of knowledge dissemination accepted the value of the complexity sciences to our field.

3. Convergence: 1999–2002

In the convergent stage, once emergent phenomenon can now maintain a distinct and coherent niche in its environment. Such coherence is exemplified in two seminal works that evidenced the convergent stage of evolution. These two seminal works are Comfort's, *Shared Risk* (1999) and Morçöl's, *A New Mind for Policy Analysis* (2002).

Louise Comfort's book, *Shared Risk*, is an underappreciated work. This was the first book to apply the complexity sciences in a comprehensive and methodologically rigorous way to an important public administration and policy phenomenon. Comfort's highly detailed analysis used considerable data from actual seismic events to explore the dynamics of organizational responses to earthquakes. Comfort showed that statistical tools such as nonlinear logistical regression are useful in understanding responses to extreme events.

Comfort's study of organizational responses to extreme events is also important because it laid the groundwork for the larger recognition of the importance of networks when exploring complex governmental phenomena. Comfort's work (1999) remains required reading in the field today.

Göktuğ Morçöl's *A New Mind for Policy Analysis* further evidences the convergent stage of the evolution of complexity studies in public administration and policy studies. Morçöl's work reveals that the vast scope of the field of policy studies was also amenable to the epistemology and methods of the complexity sciences. *A New Mind for Policy Analysis* was the first work of philosophical depth to explore the relevance and need for applications of complexity to policy studies. His book also fit complexity studies into the larger socio-historical body of scientific explanation. He also examined a large scope of issues ranging from the relevance of governmental action in a complex economy to the relevance of cognitive science to studying complex policies.

I see these two seminal works as the archetypes of the convergent stage of an academic field. Morçöl (2002) places the complexity sciences within the larger evolution of scientific paradigms. This book provides the theoretical and philosophical foundations that provide future scholars the foundations for both applications and further theory development. Comfort's work (1999) confirmed that the complexity sciences could enhance our understanding of complex "real-world" phenomena. The theory and methodological foundations represented in these two works showed that the field was adequately stable to expedite a succeeding stage of proliferance.

4. Proliferance: 2003 to the present

The proliferating stage of an evolving phenomenon represents maturity and fecundity. The convergent stage resolves the risk of emergence, allowing more attraction and a proliferating body of knowledge and tools. The proliferant stage represents a stage of increasing production.

Applications of network theory and the methods of network analysis have proliferated in the current era (Kapucu, 2006; Kapucu, Arslan, & Collins, 2009; Kapucu & Garayev, 2011; Koliba, Meek, & Zia, 2011). The uncertainties, nonlinearities and instabilities often associated with networks coincide with the behavior of complex systems. Thus the complexity sciences provide a strong backdrop for further exploration of public sector networks. It is not possible here to provide a comprehensive picture of the scope and depth of the literature of network analysis applying complexity principles to public administration and policy studies. This proliferant literature though is likely to maintain its current upward trajectory as we learn more about the challenges and prospects of complex governance networks.

Another proliferating method that is associated with the complexity sciences is agent-based modeling (ABM). Numerous applications of agent-based modeling in public administration and policy now exist. These applications range from models of lottery

markets (Chen & Chie, 2008) to models of humanitarian interventions in war torn nations (McCaskill, 2012). The enormity of the potential applications of ABM to public administration and policy studies is clearly evident in this period of proliferation (See, Dennard, Richardson, & Morçöl, 2008; Kim & Lee, 2007). The fact that McCaskill's (2012) ABM-based dissertation received the best dissertation award of the National Association of Schools of Public Affairs and Administration is clear evidence that the public administration scholarly community is prepared to incorporate ABM into the body of accepted research methods.

Further evidence of the proliferation of the applications of the complexity studies to public administration and policy is the obvious increase in the number of scholars contributing to this literature. Edited volumes by Teisman and Klijn (2008) and Teisman, van Buuren, and Gerrits (2009) are evidence of this growing body of scholars capable of applying complexity concepts to issues of public concern and governance. Dennard, Richardson and Morçöl's (2008) edited volume also reveals the expanding body of methods and scholars capable of applying these methods to the many complex challenges of governance.

Three recent works also validate the view that the current period represents a period of proliferating knowledge production. Morçöl's (2012) recent book represents a new level of maturity in the field as knowledge of both theory and method proliferate to ask new questions and perhaps settle old questions concerning the potential for building theory of relevance to complex governance networks. Scholars have recognized for two decades that when contending with complexity practitioners and analysts may, at best, receive guidance only from heuristics (Kiel, 1994). The proliferant period of knowledge production reveals the production of such heuristics. Room (2011) now provides such a roster of heuristics applicable to policy guidance and implementation in our "turbulent world." Most recently, Ramalingam's (2014) application of the complexity sciences to the challenges of foreign aid reinforce the dynamics of a proliferating enterprise as the number of applicable phenomena of relevance expands. Finally, it is worthy of note that evidence of a proliferating academic enterprise is the reality of the increasing difficulty in keeping up with the growing body of literature.

5. Divergence: the future?

The divergent stage of an evolving phenomena represents a decoupling, a bifurcation perhaps, from the proliferant form (Schumacher, 1986). This decoupling may lead to novelty that creates new emergent forms that again initiate the process of emergence, convergence, proliferance, and divergence that constitute the cycle of evolving complexity.

The knowledge artifacts of the divergent stage are generally difficult to determine as to specifics since the proliferant period does not provide all of the information required to determine which mutations in the process of the knowledge "speciation" may diverge to create novel forms. Attempting to define the divergent stage of evolving nonlinear and dynamic phenomena, such as knowledge production, may prove fanciful. However, the

proliferation of knowledge in several academic fields may add insights into future developments in our field.

The vast majority of the literature of the complexity sciences applied to public administration and public policy is focused on the organizational or institutional level of analysis. Advances in the cognitive sciences and the neurosciences, however, may add to our knowledge of the challenges of complexity at the individual level. This new knowledge is salient, as it may enhance our knowledge of the individual level functions and dysfunctions of coping with rapidly evolving complexity. Improved understanding of the individual level cognitive challenges of evolving complexity, combined with our knowledge of organizations and institutions, may lead to new means for building human systems that are both resilient and appreciative of human capabilities and limitations.

The rise of "big data" and the ability to capture increased detail in related longitudinal data may also add to our understanding of the temporal dynamics of complex governance systems. Emerging mechanisms for tracking individual level behavior (Pentland, 2008) may also allow studies of human behavior within organizational and institutional contexts that provide greater levels of detail and complexity than have previously been available to scholars.

6. Conclusion

A distinct theoretical and methodological foundation for the study of complex governance systems now exists. The theory of the endeavor is now well established (Koliba, Meek, & Zia, 2011; Morçöl, 2012) and the methodological mechanics (Comfort, 1999; Dennard, Richardson, & Morçöl, 2008) are well defined. Scholars interested in expanding the body of knowledge now possess the means for moving the entire field beyond a stage of growth and expansion to a stage of great relevance and of greater support for understanding and managing complex human systems.

The success of any academic endeavor is subject to probability distributions of many interacting variables, such as timing, environmental circumstances, and validation. The trajectory of complexity studies in public administration and policy engenders confidence that the confluence of these probability distributions will result in achieving the goals of informing practice and in developing interdisciplinary social and administrative sciences that further knowledge production. In a historical period typified by increasing complexity, knowledge of the processes of complexity generation and the handling of that complexity are increasingly central to the democratic project, to the lives of individuals and to humanity's future.

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