COMPLEXITY SCIENCE AND KNOWLEDGE-CREATION IN INTERNATIONAL RELATIONS THEORY

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Summary

This article demonstrates how Lakatos built his systems of justificationism and falsificationism upon the foundation of Curry’s formalist mathematics. Its fundamental result establishes the logical status of complexity science, as distinct from and superseding those existing systems of proof and refutation commonly acknowledged in social science methodology in particular and scientific epistemology in general. It establishes that this result, concerning the logico-mathematical status of complexity-based scientific reasoning, is not restricted either to the field of international relations theory in particular or to the social sciences in general. The article begins by setting out the significance of complexity science for international relations theory by explaining its epistemological and ontological significance for the level of analysis, scope of analysis, and scale of analysis. It then explains how these points demolish Lakatos's methodology of research programs as an epistemology for scientific progress. In particular, it dissects his construct of the “problemshift” for developments not only within a single research program but also for shifts from one research program to another. For this purpose, it presents a detailed example of theoretical development drawn from applied international relations theory. The example analyzes the succession of Western theories of the domestic politics of Soviet foreign policy making during the first half of the Cold War. The article analyzes the epistemology of scientific progress inherent in complexity science, as illustrated in that example. It describes this as

"complex justificationism," sets it within a "complex scientific-realist" ontology, and sets out, in complexity science terms, several key issues with which international relations theory has begun to grapple at the beginning of the twenty-first century. It argues how complexity science provides a basis for understanding the interrelatedness of these issues and treating them comprehensively. It underlines that the epistemological undergirding of that argument is valid across fields, disciplines and universes of inquiry.

1. Introduction

Complexity science is the study of complex systems. A complex system is a system having multiple interacting components, of which the overall behavior cannot be inferred simply from the behavior of components. Complexity science spans scales from particle fields to information mechanics (physical analysis of the dynamics of information transmission) and adaptive systems (learning and consciousness, including neural systems), to human society, ecosystems and extraterrestrial space. These phenomena all share the qualities of a self-organizing network. From their study, new methodologies and concepts of the nature of reality have emerged. In international relations, the emergence of an interconnected global civilization manifests this sort of complexity. In knowledge-creation, so do the cross-fertilization and merging of academic specializations into ever newer and more numerous interdisciplinary subfields.

The next section below sets out import of complexity science in general and for international relations theory in particular. The epistemological and ontological significance is explained for the level of analysis, scope of analysis, and scale of analysis. Then it is explained how these points demolish Lakatos's methodology of research programs as an epistemology for scientific progress. In particular, it dissects the construct of the "problemshift" for developments not only within a single research program but also for shifts from one research program to another. For this a detailed case study is also given, drawn from applied international relations theory. The epistemology of scientific progress inherent in complexity science is then analyzed, and it is described as "complex justificationism" within a "complex scientific-realist" ontology. The conclusion sets out in complexity science terms, a few non-exhaustive issues with which international relations theory has recently begun to attempt to deal. It indicates how complexity science captures their interrelatedness and provides the foundation for their comprehensive treatment.

2. Complexity Science: Its Epistemological and Ontological Significance

"Complexity" is neither complicatedness, nor overdetermination, nor a multiplication of explanatory variables. It is not merely a new implement to be added to an existing theoretical tool-kit. Complexity science is a fundamentally new way of looking at physical, biological, and social phenomena. It is a cross-disciplinary field with its own approach to knowledge-creation that includes a set of methodological approaches to problematization. As such, it offers distinct and innovative perspectives on the evolution of international systems and on the behaviors of actors in them. Certain insights are valid universally across all complex phenomena. These insights are epistemological and ontological. They concern the level of analysis, the scale of analysis, and the scope of

analysis.

2.1. Issues of the Level of Analysis Focus on Emergence

Issues of the level of analysis draw attention principally to the category of emergence. Emergence is the evolution of new (qualitative) phenomena through a system's interaction with the environment. Ontological issues concerning the level of analysis include the dependence of the whole on parts, the interdependence of parts, and specialization of parts. Since studying parts in isolation does not work, a good place to start is to look at how changes in one part may affect the others and the behavior of the whole. The increased political-science interest in counterfactuals in the 1990s, after the end of the Cold War, reflects how unavoidable this aspect of complexity has become after the top-down international hierarchy of that era collapsed.

The reconstruction of the international system from the bottom up after the Cold War thus presents issues concerning the level of analysis of which complexity science offers distinctive treatment. The multiplication and incorporation of new issue areas in international politics and security manifests nothing less than an emergence in the quality of knowledge that reflects the complexity of the real world. This includes the whole growth of questions about deterritorialized aspects of international politics. Specifically, it adds problems of boundary-definition in issue-area space to those that are evident in geopolitical space. Concerning the latter, the reconfiguration of international regions in the early twenty-first century, and their increased relative autonomy of great power conflict, in comparison with the Cold War system, are exemplary. Although distinctions among superpowers, great powers, and regional powers have not disappeared, middle-range and lower-level phenomena have become the predominant motive forces in an international system that self-organizes from bottom up.

Epistemological issues concerning the level of analysis force the analyst to recognize that describing the behavior of a system in response to its environment is neither straightforward nor uncomplicated. Since the amount of information available and necessary for such description grows exponentially with the complexity of the environment, psychological behaviorism -- indeed any strict phenomenology at all -- is ill-founded. That is because, in such an information-rich environment, the use of inference to obtain description and analysis from small amounts of information becomes problematic. The significance of how we think (or fail to think) *about thinking* is thus enhanced.

2.2. Issues of the Scope of Analysis Focus on Stability and Change

Also there are issues of the scope of the analysis. These draw attention principally to the dual category of *stability-and-change*. This category subsumes adaptation, pattern formation, and evolution. As such, it forces the question of learning, including organizational learning. It also balances issues of emergence (such as transnational networks about nonterritorial issues) with equally important territorial aspects of world politics (such as the self-organization of regional international systems and the relations among them).

Ontological issues concerning the scope of analysis raise still deeper questions about the relationship between the whole and the parts. A complexity-based focus on stability and change establishes that multiple stable states exist (i.e., not just "Nash equilibria") as well as meta-stable states. If and when a single component of a system controls its collective behavior, then the collective behavior cannot be more complex than the individual behavior. The superpower nuclear bipolarity of the Cold War is an example showing how a dominant component of a system can restrain its collective behavior. In such an instance, there is no emergent complexity, and the question of stability and change hardly arises. Yet new complex systems may be formed from the recombination of parts or aspects of other complex systems. Indeed, such composites permit rapid evolution.

Epistemological issues concerning the scope of analysis under complexity, like those concerning the level of analysis, raise questions about the use of inference to obtain the description from a seemingly smaller amount of information. The use of inference in such a situation leads to the concept of "algorithmic complexity." This in turn raises such issues as the relationship between descriptions and systems, the connection between theory and simulations, and about the conceptual status of models used in simulations.

2.3. Issues of the Scale of Analysis Focus on Self-organization

Issues of the scale of analysis draw attention to the category of self-organization. Epistemological issues about the scale of analysis arise from the fact that under complexity, fine scales of influence affect large-scale behavior. To understand complex systems therefore requires multi-scale descriptions. Yet the degree of complexity that is apparent also depends on the scale at which the system is described. Ontological questions about the scale of analysis arise from the fact that the apparent complexity of a system depends on the scale at which the system is described. For example, a requirement of complexity on a large scale is to establish correlations on a small scale: these reduce the overall (though not necessarily everywhere local) smaller-scale complexity. A complexity-theory concept that we may call "mesolevel" structuration cuts through the "structure-vs.-agent" knot. The transformation and succession of international orders, for example, is triggered by properties emergent from (re)structuration on the mesolevel.

Self-organizing international regions, manifesting as emergent multilateral networks, are the categorical phenomenon characterizing the post-Cold War transition. These include not only continental regional international subsystems (e.g., Europe and Southeast Asia), but also littoral regional international subsystems (e.g., Pacific Rim, Baltic, and Caspian). Self-organization at the mesolevel is an emergent quality of the complex system. The new territorial aspects of contemporary world politics thereby lead to the concept of self-organized criticality. That in turn invites consideration of the global political system and its components as complex adaptive systems. From this it would follow that those systems are capable of learning and of pro-active behavior that shapes their own environment. The character of the post-Cold War transition is as the problematization of nontraditional issue areas of international public policy in security terms (e.g., environmental security, human security). The task of policy analysis in a

self-organizing complex system is to identify crucial intermediate points where cognitive and organizational intervention will instantiate large-scale restructuring of the system itself.

It follows from the ontological components of complexity science, that the definition of a research problem has no *a priori* referent in the world at large that is independent of the researcher's reflection. The application of complexity science to international relations theory therefore opens fundamental questions. Since the traditional analytical distinctions that once structured the "levels of analysis" problem are no longer valid, the standard solution to that problem is no longer reliable. For example, the emergence and incipient consolidation of regional international systems, as a distinctive characteristic of the global post-Cold War transition illustrates that the three standard levels of analysis -- the individual, the state, and the international -- are no longer collectively exhaustive. The new situation requires not only new theoretical categories but also new categories of theory and new concepts of knowledge creation.

3. How Complexity Science Overthrows Lakatos's Methodology of Research Programs

Complexity science recognizes that the world has a different nature than heretofore supposed. It thus challenges the criteria according to which theories are to be judged and the methods by which knowledge is to be cumulated. In particular, the models of reasoning that are required to deal with a complex world must go beyond the well-known Lakatosian formulae of the five types of justificationism and falsificationism. Complexity science opens a new way to create knowledge about the world, because it is founded upon the interdependence between that knowledge and this world. It does not require either the adoption of relativism or the introduction of anarchy into the market of ideas. It merely establishes that we have reached a stage in theory-construction where Lakatos's well-known and widely adopted model of scientific progress, called "the methodology of scientific research programs," no longer adequately describes the creation of scientific knowledge.

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Biographical Sketch

Robert M. Cutler was educated at the Massachusetts Institute of Technology and The University of Michigan, where he earned a Ph.D. in Political Science. He has held research and teaching positions at major universities in the United States, Canada, France, Switzerland, and Russia, including Columbia University, the University of Geneva, and Moscow University. Specializing in the interdisciplinary international affairs of Europe and Eurasia, he has published widely in the most highly regarded professional journals of his fields in Europe and North America. Writing in several languages, he also contributes to the mass media and policy reviews, as well as having a significant on-line presence. He has engaged in consulting in organizational design and analysis under complexity, including institutional learning and the management of information, especially in cross-cultural contexts. His interdisciplinary expertise covers several areas of geographical specialization. In particular, his geographic expertise includes Europe (various regional specialties under the EU/NATO area as well as institutional studies), Russia (spanning the Russian Empire, Soviet Union, and Russian Federation), and Central Eurasia (especially the South Caucasus and Central and Southwest Asia). He has extensive practical experience in Europe from the Atlantic to the Urals and the former Soviet area. His disciplinary expertise includes international relations theory and political economy, organizational and decision-making analysis, theoretical and empirical work on human information processing, and also international institutions and regimes. Topics of special interest include Caspian-region energy development and ethnic conflict, and

the design of institutions for cooperative security. Other special subjects include the political thought of nineteenth-century revolutionary Russia, with special attention to anarchism; and mathematical topics ranging through proof theory, combinatorics and number theory.