Complex Economic Systems

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In this chapter, the applicability of complex (adaptive) systems theory in economics is evaluated. Comparisons are made to standard approaches to economic theorizing that are based upon constrained optimization by individual units of analysis. It is explained why the standard approach is not a feasible theoretical basis for examining real economic phenomena except in some very special circumstances.

Acknowledgement that economic systems are both complex and adaptive, suggests that we begin by viewing them as network structures of elements and connections that are, at base, dissipative in nature. As such, they are subject to the laws of thermodynamics and survive and grow only if energy throughput can be maintained. However, with economic systems, we have to travel beyond Prigogine's representation of a complex physio-chemical system as a free energy processor and Brooks and Wiley's representation of a complex biological system as an information processor, relying on knowledge acquired from experience.

Sophisticated economic systems arise because new knowledge is actively sought, it is not just a product of experience. So, aside from fundamental energetic considerations, the acquisition and use of knowledge become central concerns in developing conceptualizations of complex economic system structure and behaviour.

Although many attempts have been made to represent the latter mathematically through the specification of dynamical equations, in both differential and discrete form, it is clear that mathematical deduction cannot be used to obtain realistic representations of structure and process in an evolving complex economic system. The nature and role of knowledge precludes the use of such analytical devices in any scientific sense, irrespective of whether they are specified in linear or nonlinear terms. This is well understood by many economic theorists and their response has been to make unrealistically strong assumptions concerning the universality of knowledge and the human capacity to process information.

Criticisms of such assumptions, even when made by Herbert Simon, a Nobel Laureate, have gone unheeded as economists have tried to create a discipline that has the form of a science, but not the content. Economics became mainly an application of decision theory in making choices along notional production and utility functions. However, when we depart from this illusory, but analytically convenient, context we are immediately confronted with very significant philosophical and methodological questions:

- *What should the fundamental unit of analysis be in economics – the individual or some collective entity or should this be variable depending on context?* The complex systems perspective leads us quickly to the conclusion that a sharp distinction between economics and sociology cannot be maintained, either philosophically or scientifically.

- *How do economic systems emerge?* The conventional economist's inability to deal with emergence means that an understanding of the actual process of economic evolution and the associated growth trajectory is not possible. From a complex systems perspective, emergence is predictable in the presence of appropriate energy sources and a cognitive capacity to acquire and apply knowledge in creative ways.
- *If we cannot use conventional mathematics how do we proceed analytically?* Economic evolution involves constantly changing network structures, sometimes this is slow and steady while, at other times, it is abrupt and destabilizing. So, economic science has to be done in a fundamentally different way. Theories have to be viewed as knowledge structures that have to be discovered. Discovery, typically, involves the simulation of the behaviour of interacting, interdependent agents and the examination of the trajectories of artificially generated economic variables to assess their generality. This is an *algorithmic* exercise and a range of methodological issues concerning calibration and other ways of verifying the validity of theories arise.
- *What are the boundary constraints on economic evolution and how can they be captured theoretically?* Brooks and Wiley stressed that, in biological evolution, the most important boundaries on self-organisational development are historical. This is also true in economic evolution. Functioning economic structures depend upon reliable internal networks that are durable in history. Much of economic development consists of expanding these networks in ever more complex ways. However, network structure can place severe limitations on the adaptiveness of economic entities, such as firms. The formation of external network connections are also important and, these too can eventually cause problems. So the internal (organisational) rules that determine network structure and the external (institutional) rules adhered to by the economic entity are crucial.
- *How can we capture historicalness in theory?* An essential component of theorizing is to place it in historical context. Without controlling for historical uniqueness, no general principles can be identified. So, if a theory developed by agent-based simulation is to be calibrated on historical data, it is essential that the key external and internal rules that prevail over the period of interest are identified and built into the artificial structure within which simulations are conducted. This can only be done through historical and statistical studies that can yield an understanding of the key rules (which may be found to be emergent or in the process of abandonment) in operation.
- *Can economic theory and economic history be separated?* Theory cannot be developed in a historical vacuum, as is the case with much of conventional economic theory. True theory is a general representation of historical reality, not something independent of that reality. And, because the latter involves interacting complex systems, the only theories that are admissable are those that do not breach energetic laws and cognitive

capabilities. In theorizing, we must understand fully both the physical and psychological science relevant to the economic decision-making that we are trying to understand. Philosophical and methodological conundrums arise when we explore this terrain. These will be identified, as will possible solutions, in this chapter.