Proposition 39
Understanding Complexity

In a Word In development agencies, paradigms of linear causality condition need much thinking and practice. They encourage command-and-control hierarchies, centralize decision-making, and dampen creativity and innovation. Globalization demands that organizations see our turbulent world as a collection of evolving ecosystems. To survive and flourish they must then be adaptable and fleet-footed. Notions of complexity offer a wealth of insights and guidance to twenty-first century organizations that strive to do so.

Introduction

Lord Kelvin (1824–1907), a Scottish physicist, mathematician, engineer, and one-time President of the Royal Society—the national academy of science of the United Kingdom and the Commonwealth—is alleged to have remarked in an address to the British Association for the Advancement of Science that "There is nothing new to be discovered in physics now. All that remains is more and more precise measurement."

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Building on centuries of progress in human thought, sped by the Newtonian Revolution,[1] the early years of 1900s were characterized by such declarations in Europe and North America.[2] (In a word, with the birth of modern calculus in the seventeenth century owing to Newton and Gottfried Leibnitz,[3] the dominant philosophy had been one of integration: from reasoning one could sum up and draw global conclusions about a system.)

Soon enough, however—*pace* Lord Kelvin, Michelson, and others—multiple transformations in environment, economy, society, polity, and technology threw up fundamental challenges to linear conceptualizations (and mankind's desire to control the physical world). We do not stand outside the systems we study: rather, we are an increasingly essential part of the complex patterns in which we live: our perceptions, thoughts, beliefs, and ways impact the world profoundly.

The End of Certainty

As one would expect, development work is not immune to ordered and reductionist thinking. Karl Marx (1818–1883) and W.W. Rostow (1916–2003), among others, strove to force development into rigid, sequential patterns. Not to be outdone, from the Second World War, development economics fired silver bullets for food aid, free trade, foreign direct investment, import substitution, industrialization, human capital investment, basic human needs, poverty alleviation, structural adjustment, sustainable development, governance, gender and development, poverty reduction, debt relief, community-driven development, and partnerships—to name a few—in succession or volley according to the changing modernist ideological stances and foci of donors, all firmly based on conceptions of Western liberal democracy.

The reasons of a phenomenon defined at a high level might not explain that low-level properties can be several, ranging from mere ignorance of hidden relations to theoretical uncomputability. But whatever these causes may be, a consistent issue remains—that of emergence. Over the course of twentieth century, rapid

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[1]Isaac Newton (1642–1727), an English physicist, Mathematician, Astronomer, Natural Philosopher, Alchemist, and Theologian, is generally regarded as the most original and influential theorist in the history of science. In addition to his invention of infinitesimal calculus and a new theory of light and color, Newton transformed physics with his three laws of motion and the law of universal gravitation. He was recognized in his lifetime for having created a revolution.

[2]In 1894 Albert Michelson (1852–1931), a German-American physicist and soon-to-be Nobel Laureate, had also quipped: "The more important fundamental laws and facts of physical science have all been discovered, and these are so firmly established that the possibility of their ever being supplanted in consequence of new discoveries is exceedingly remote. Many instances might be cited, but these will suffice to justify the statement that 'our future discoveries must be looked for in the sixth place of decimals'."

[3]Gottfried Leibniz (1646–1716), a German mathematician and philosopher, invented infinitesimal calculus independently of Newton—his notation has been in use since then. He also invented the binary numeral system, used by all modern computers since 1950s.

advances in fields such as physics and biology that highlight holism, uncertainty, and nonlinearity[4] (and de-emphasize reductionism, predictability, and linearity) forged related, interdisciplinary intuitions and concepts that attempt to explain complex phenomena, e.g., catastrophe theory, chaos theory, coevolution, dissipative systems, nonlinear dynamics, self-organized criticality theory, and systems thinking. In loosely bound form, they are often referred to as complexity theory (or the sciences of complexity, to emphasize their plural nature). Even though reductionist and mechanistic thinking persists in the face of now major global concerns,[5] interest in applying concrete and practical complexity approaches to social systems, such as how organizations strategize and change, is growing.

> *For my part I know nothing with any certainty, but the sight of the stars makes me dream.*
>
> —Vincent van Gogh

To date, however, the use of complexity thinking in aid and development, for instance, where it might collectively and in individual organizations help promote the Paris Declaration on Aid Effectiveness,[6] is still unusual and rarely older than about 10 years. Even so, complexity approaches may one day counterbalance the path dependence and "lock-in" management practices embodied in the near-universal (and all too often restrictive) use of the logical framework (and the evaluations based on these). When facing volatile, uncertain, complex, and ambiguous environments such as those that characterize development work, monocausal explanations founded on "rational choice," best specified top—down, are ever more recognized as inadequate or at least insufficient (Figs. 39.1 and 39.2).[7]

[4]A nonlinear system displays no simple proportional relation between cause-and-effect. The weather is famously nonlinear and, therefore, diverse and unpredictable: simple changes in one part of the system produce myriads of effects throughout.

[5]A non-exhaustive list of world problems includes (i) population growth; (ii) natural resource depletion or degradation; (iii) pollution; (iv) climate change; (v) unequal distribution of financial resources; (vi) rising expectations in developing countries; (vii) military approaches to resolving quarrels; (viii) nuclear weapons; (ix) genocides; (x) bigotry, racism, and sexism; (xi) terrorism; and (xii) the power of multinational corporations over elected governments.

[6]The Paris Declaration on Aid Effectiveness is an international agreement to intensify efforts for harmonization, alignment, and managing for development results.

[7]A typical logic model might progress thus (i) certain resources are needed to operate a program; (ii) if one has access to them, one can use the resources to accomplish planned activities; (iii) if one accomplishes the planned activities, one will hopefully deliver the products or services intended; (iv) if one accomplishes the planned activities to the extent intended, participants to the program will benefit in certain ways; and (v) if the benefits to participants are achieved, certain desired changes in organizations, communities, or systems might be expected to take place. More simply: (i) identify the problem, (ii) commission studies and investigations, (iii) analyze the results, (iv) select the best option, (v) agree on the change, (vi) implement the change, and (vii) monitor and evaluate the development intervention.

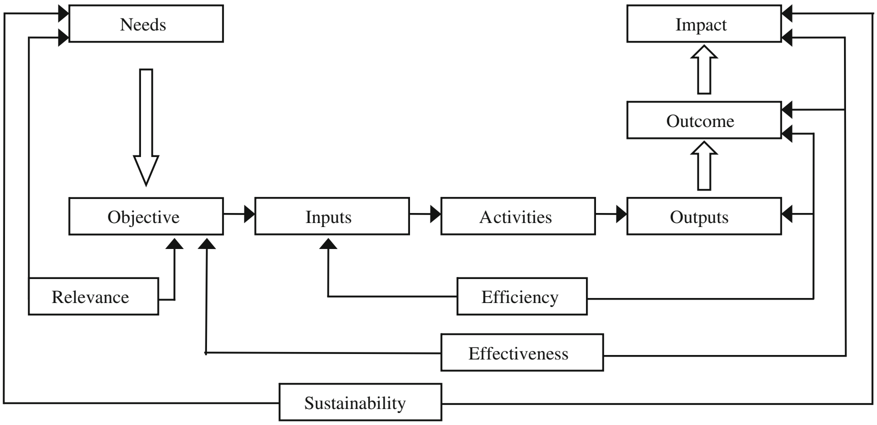

Fig. 39.1 The results chain explained. *Source* Author

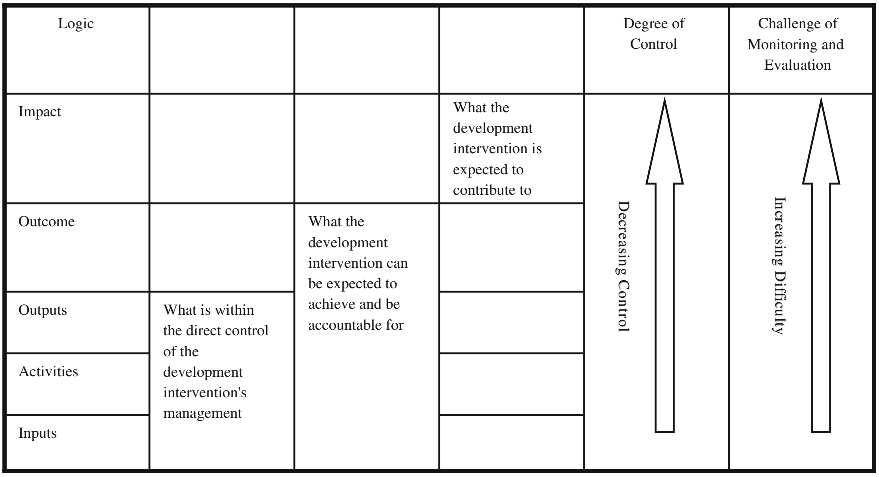

Fig. 39.2 Challenges and limits to management. *Source* Author

Defining Complexity

A complex system is one in which at least two parts interact dynamically to function as a whole. The parts are interconnected, and each is composed of subsystems nested within a larger one. (For instance, a person is a member of a family, which is part of a community, institution, village, province, region, country, group of countries, the earth, the solar system, our galaxy, the observable universe, and the universe.) Complex systems exhibit properties that are not obvious from the properties of their individual parts. Typically, they are characterized by (i) a number of interconnected and interdependent elements (or dimensions); (ii) local rules that apply to each element; (iii) constant movement and responses from these elements; (iv) adaptiveness so that the system adjusts to guarantee continued operation; (v) self-organization, by which new settings in the system take form spontaneously; and (vi) progression in complexity so that the system becomes larger and more sophisticated over time. Although a wide variety of systems are complex, some more or less than others depending on the range of characteristics they possess, all exhibit emergence and self-organization. Other features of complex systems are that their characteristics change over time, frequently in nonlinear ways, and that they seldom (yet sometimes) reach long-term equilibrium.

Key Concepts of Complexity Theory

> *The theory of evolution by cumulative natural selection is the only theory we know of that is in principle capable of explaining the existence of organized complexity.*
>
> —Richard Dawkins

Complexity theory is the science of complex systems.[8] Its origins lie in biology, ecology, and evolution as a development of chaos theory.[9] It is the theory that random events, if left to happen without interference, will settle into a complicated pattern rather than a simple one. In common parlance, complexity is often used to mean difficult or convoluted, that is, a problem where the answer is not obvious. However, when referring to complexity theory a more appropriate word to use might be complicated.[10]

Usefully, Ramalingam (2008) and colleagues at the Overseas Development Institute have circumscribed 10 concepts of complexity, organized into the three domains of (i) complexity and systems, (ii) complexity and change, and (iii) complexity and agency. The following excerpts their paper:

[8]Like many other scientific explanations, complexity theory does not present a unified perspective. But all its variations begin with the notion of complexity, be that taken literally or as a metaphor.

[9]The first discoverer of chaos was Henri Poincaré (1854–1912), a French mathematician, physicist, and philosopher of science. The problem of finding the general solution to the motion of more than two orbiting bodies in the solar system, originally known as the three-body problem, had eluded mathematicians since Newton's time.

[10]For example, an iPod is a complicated system but making Annette Poulard's famously perfect omelets is complex. A space rocket is also a complicated system but the stock exchange is complex. Harking back to Poincaré, three planets interacting altogether are a complex system.

- **Complexity and Systems** These first three concepts relate to the features of systems that can be described as complex
  1. Systems characterized by *interconnected and interdependent elements and dimensions* are a key starting point for understanding complexity theory.
  2. *Feedback processes* crucially shape how change happens within a complex system.
  3. *Emergence* describes how the behavior of systems emerges—often unpredictably—from the interaction of the parts, such that the whole is different to the sum of the parts.
- **Complexity and Change** The next four concepts relate to phenomena through which complexity manifests itself:
  1. Within complex systems, relationships between dimensions are frequently *nonlinear*, i.e., when change happens, it is frequently disproportionate and unpredictable.
  2. *Sensitivity to initial conditions* highlights how small differences in the initial state of a system can lead to massive differences later; butterfly effects and bifurcations are two ways in which complex systems can change drastically over time.
  3. *Phase space* helps to build a picture of the dimensions of a system, and how they change over time. This enables understanding of how systems move and evolve over time.
  4. *Chaos and edge of chaos* describe the order underlying the seemingly random behaviors exhibited by certain complex systems.
- **Complexity and Agency** The final three concepts relate to the notion of adaptive agents, and how their behaviors are manifested in complex systems:
  1. *Adaptive agents* react to the system and to each other, leading to a number of phenomena.
  2. *Self-organization* characterizes a particular form of emergent property that can occur in systems of adaptive agents.
  3. *Coevolution* describes how, within a system of adaptive agents, coevolution occurs, such that the overall system and the agents within it evolve together, or cosevolve, over time.

Complexity Theory, Aid, and Development

Development is a complex, adaptive process but—with exceptions—development work has not been conducted as such. It was suggested earlier that development assistance often follows a linear approach to achieving outputs and outcomes, underpinned by economic consensus among Western liberal democracies. That approach is guided by processes (and associated compliance standards) applied with limited and out-of-date insights on dynamic operational contexts. Any planning process is based on assumptions[11]—some will be predictable, others wishful. If the assumptions are based on invalid theories of change (including cause-and-effect relationships) and on inappropriate tools, methods, approaches, and procedures derived from those, development agencies jeopardize the impacts they seek to realize.[12]

> *I know that most men, including those at ease with problems of the greatest complexity, can seldom accept even the simplest and most obvious truth if it be such as would oblige them to admit the falsity of conclusions which they have delighted in explaining to colleagues, which they have proudly taught to others, and which they have woven, thread by thread, into the fabric of their lives.*
>
> —Leo Tolstoy

Yet, even culture theory draws insufficient conclusions about what complexity thinking could mean for development interventions. Some hard questions remain. How might emerging intuitions from complexity approaches, combined with field practice, systemically (rather than through a patchwork approach) reshape assumptions about the design of development assistance, improve reading of signals, and foster appropriate adapting of actions? What might be the implications of a shift from compliance with external standards to investing in capacities for navigating complexity?

Exploring the Science of Complexity gives lenses with which to distinguish, study, and see differently, the deeper realities that development agencies must grapple with. (Some hold that the rise of complexity theory, which questions the concepts and assumptions of Newtonian science, represents a paradigm shift in thinking.) Complexity approaches can potentially enhance insight and innovation among development leaders and practitioners and facilitate navigation of dense webs of connections and relationships. Specifically, *Exploring the Science of Complexity* calls for rethinking five key areas of development assistance: (i) the tools, methods, and approaches for planning, monitoring, learning from, and

[11]Kurtz and Snowden (2003) identified three basic, universal assumptions prevalent in organizational decision support and strategy: assumptions of order, of rational choice, and of intent.

[12]The rhetoric of local ownership, participation, empowerment, institutional reform, and aid effectiveness, for example, should not be at odds with actual development assistance practices.

evaluating;[13] (ii) the nature of the processes utilized; (iii) the dynamics of the changes triggered; (iv) the role of beneficiaries and partner organizations; and (v) the wider contexts and the real influence. To this intent, it invites development agencies to (i) cultivate collective intellectual openness to ask new, potentially rich but challenging questions about their mission and work; (ii) exercise collective intellectual and methodological restraint to accept the limitations of complexity thinking as a fresh, potentially valuable set of ideas; (iii) be humble and honest about the scope of what can be achieved through "outsider" interventions, about the types of mistakes that are repeatedly made, and about the reasons such mistakes are made so often; and (iv) develop the individual, organizational, and political courage to face up to the implications of complexity approaches.

The potential benefits of complexity theory in development work are that, by understanding what it means for a system to be complex in a complex environment, stakeholders including policy makers can work with those concepts and not block them unintentionally. One may then use the logic of complexity to understand the problem space (better, the space of possibilities) when addressing seemingly intractable problems and create coevolving enabling environments and more positive futures. Thus, complexity theory can be used as an explanatory framework, as a different way of seeing and thinking, and as a different language and set of concepts.

> *Human beings, viewed as behaving systems, are quite simple. The apparent complexity of our behavior over time is largely a reflection of the complexity of the environment in which we find ourselves.*
>
> —Herbert Simon

Still, where complexity meets development, a framework that helps decision makers determine the prevailing operating context comes in handy. Building on the Cynefin framework[14] reproduced above, Snowden and Boone (2007) have shown how effective leaders can learn to shift decision-making styles in simple, complicated, complex, and chaotic environments.

[13]The tools, methods, and approaches that are supportive of complexity thinking include culture theory; alignment- interest and influence matrixes; learning partnerships, outcome mapping; scenario planning; social network analysis; and storytelling. Training in their use should be promulgated. Collections of others should be built.

[14]Cynefin is a Welsh word, commonly translated into English as habitat, place, or haunt. (Related adjectives are acquainted, accustomed, or familiar.) The Cynefin framework was developed by David Snowden and his collaborators to explore the relationship between man, experience, and context and propose new approaches to communication, decision-making, policy making, and knowledge management in complex social environments.

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