Will Systems Work?
A search for models for the 21st century

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ABSTRACT

Many people intuitively recognize large-scale problems as complex. Two recent problems in the US – terrorism and the resulting military response by the US, and the hurricanes that hit the Gulf Coast region – have highlighted such complexities. Even more, government responses have converged in unexpected ways. Systems, as a discipline, has sought to address complex problems, but has not been effective thus far in being accepted as the means for doing so by the public at-large, or by key decision-makers. The role that economics plays as a regulating force is proposed for comparison with roles that systems might play in the future.

Keywords: systems, systems theories, systems science, models, economics

1. SYSTEMS AND COMPLEXITY

The effort to develop the theory of a general system, at least as understood during the 20th century, is usually traced back to Ludwig von Bertalanffy and his work in biology. Many other theorists from diverse disciplines followed, with two basic (though not always obviously coherent) foci. One was the search for *isomorphies*, or principles that crossed and encompassed different disciplines. The other was a concern for the impact of science on humankind.

Today, at the beginning of the 21st century, progress towards a General System Theory has been sporadic at best. Most theorists and practitioners in fact, think and talk in terms of systems theories and applications (many of each,) which have experienced the same fate as other scientific, academic and professional disciplines: a persistent process of specialization of knowledge, and fragmentation of language and affiliation. There are myriad explanations, including the structure and funding of academic institutions which create competition rather than cooperation between disciplines. Whatever the reasons, though, the outcome has been the proliferation of the term *system* but with little or no clear meaning, at least in a sound, theoretical sense.

As a result, theorists in the more successful disciplines have not infrequently declared the systems movement to be either dead or irrelevant. And in their view, it should be so. The question, then, is why it continues to persist at all? Why has even the terminology remained in use, and not just disappeared due to its lack of fitness in the world?

The answer seems to have more to do with what people sense than what they can clearly define or explain. This often gets captured in terms of complexity (which tends to suffer much of the same lack of clarity as systems, despite what its proponents might contend.) People yearn for, and are drawn to, simple explanations, but also recognize that the world is not simple.

1.1 Complex Disasters

At the time of the writing of this paper, a number of events in the US have coincided, all of which may be considered complex systems problems – even by the popular media and the average citizen. Since September 11, 2001, a significant portion of the focus and resources of the US have been devoted to security, related to terrorism. One response chosen by the Bush administration was to attack al Qaeda members in Afghanistan, believed to have been responsible for the hijacking of passenger planes and destruction of the World Trade Center. Another response was the invasion of Iraq, and the overthrow of Saddam Hussein, resulting in a war that continues today. A third response was the consolidation of seven Federal agencies into one, creating the Department of Homeland Security – an agency reporting directly to the president, with a $37 billion budget and 170,000 employees. The new agency included all of the Federal employees responsible for enforcement of immigration, customs, and transportation security, as well as the Coast Guard, the Secret Service, and the Federal Emergency Management Agency (FEMA), which is the agency that responds to assist after disasters of any kind. The perceived problem had been lack of coordination between the agencies, and a need to bring them under one central authority.

In September 2005, Hurricane Katrina struck the Gulf Coast area of the US, with winds and rain that devastated a large portion of the region and caused flooding that broke through levies, submerging most of New Orleans under water.

Many of the agencies that had been moved into the Department of Homeland Security, to prepare for both prevention of, and response to, possible terrorist attacks in the US, were the same agencies that were supposed to respond to natural disasters: fires, earthquakes, floods, tornadoes, hurricanes, etc.

The Federal Government's lack of immediate response to the victims of Hurricane Katrina was chronicled by the news media – captured in images of people going without food or water for days, unable to escape to better conditions – and broadcast around the world. Criticism of political officials at every level of government was harsh, and investigations as to what went wrong, and who should be blamed, were called for almost immediately.

At the moment of this writing, a second hurricane is threatening the same region of the US. This time, government officials have reacted in the extreme, calling for mandatory evacuations of all areas that could be affected, and staging supplies to be ready to move to victims immediately. Even so, problems have arisen, leaving evacuees sitting in traffic jams that backed up for 100 miles and cars running out of gas while waiting.

These kinds of situations raise questions about complexity and systems at so many levels that it is hard even to identify all of them. Implicit in the criticisms, though, are beliefs and expectations that someone has, or should have, the capacity to anticipate and respond to – and hopefully avoid – even the worst disasters.

1.2 Systems responses

At a macro level are two distinct types of complex problems: human (social systems) and natural (ecological.) Neither is new, and both have proven to be catastrophic in different ways at different times. (At the highest level, of course, are questions about how the impact of human systems on the natural environment has affected weather patterns.)

Criticism of the Federal response include problems caused by putting FEMA under an agency whose sole focus seemed to be defense, and neglecting other types of disasters that could be equally devastating. In the end, it looked ineffectual in dealing with any type of disaster, and therefore undermined confidence in the government as a whole.

For purposes of the discussion, the most important question may be, can systems (e.g. systems thinking, systems science, or systems approaches) offer anything to these kinds of problems? If not, then the world of systems may remain esoteric and eventually just fade away. If so, then it might provide the framework for what is needed as a foundation for the systems sciences as we move into the 21st century.

Large-scale problems are certainly nothing new to systems theorists and systems scientists. Systems models and solutions have been developed for multi-national corporations, governmental bodies, and international organizations. There are still rather stark differences, though, in the assumptions and philosophical positions behind different systems ideas.

A long-standing distinction has been between hard and soft approaches to systems [1,2] Hard systems approaches are usually based, to some degree, on the principles of physics and laws of nature that pervade the natural sciences, which can be expressed in numerical terms. Soft systems approaches, very generally, conclude that many phenomena – most importantly in the realm of human social systems – cannot be adequately understood that way, and therefore cannot be measured and captured in such concrete terms.

The work of Jay Forrester, for instance, and his development of system dynamics, is based on principles of growth and equilibrium – the same foundation which spawned the field of cybernetics [3]. Forrester sees these principles pertaining to all levels of organization, from the cellular to the global. Well-known applications, just by Forrester himself, range from business organizations to urban planning to global ecology (the latter being the famous and infamous Club of Rome project that created *World Dynamics*, later edited into the book, *Limits to Growth*.)[4]

One of the advantages of Forrester's approach is the ability to create computer models of complex, dynamic situations. A disadvantage is the difficulty of understanding system dynamics in principle, which prohibits average decision-makers from fully comprehending why good solutions are so often counter-intuitive.

A soft systems approach might be typified by Peter Checkland's Soft Systems Methodology (SSM), which in application he also describes as an action research approach [1]. Rather than attempting to develop quantified, objective models of a given process, the goal is the cooperative development of a satisfactory model by a group of stakeholders, such that they can learn enough to make improvements. (Interestingly, many systems applications developed by many of Forrester's protégés, including Peter Senge, mirror this more general way of modeling.)

There are many ways of interpreting the contrasts between hard and soft approaches to systems, and many different methodologies and methods that might be used as examples of each – understanding, also, that this is only a very general and somewhat arbitrary distinction. But there remains a fairly strong, philosophical divide as to whether systems models are, or should be, considered models that reflect the actual properties of real elements and their interactions in the world, or whether they are only representations of human perceptions. In the case of the examples at the beginning of this paper, is the modeling of hurricanes and other natural disasters the same as the modeling of human organizations and actions?

There are divisions, as well, about the degree to which properties are universal or limited. Systems theorists have long searched for descriptors, such as Forrester's stocks and flows, which could account for general characteristics of systems at all levels. Many natural scientists hold the same hope, of course, but seemed to reach a threshold with the discovery of quantum mechanics, where different properties apparently apply to different levels of physical organization.

In systems, a similar threshold has been suggested by biologists, from von Bertalanffy to Maturana to Rashevsky and Rosen. Essentially, the argument is that the properties of physical matter cannot account for the self-organization of living organisms. Said another way, life cannot be reduced to physics, or the natural laws that seem to govern the stars and planets. There appear to be different qualities that begin at a biological level of organization – something more complex than the structure of particles.

Maturana uses the concept of autopoiesis for the self-organization, reproduction and repair of biological systems [5]. Rashevsky proposed relational biology, in which qualities of living systems could be modeled using mathematical formalisms, but separate from the physical matter of their structures. Rosen used Rashevsky's foundation to propose anticipatory systems as the means through which living systems are formed and perpetuated [6]. Luhmann took Maturana's notion of autopoiesis into the human social realm, arguing that social systems are, in their own way, autopoietic [7]. Rashevsky, not entirely unlike Forrester, applied his relational model to everything from neurology through global economics. Rosen saw anticipatory systems as a model describing both cellular behavior and human cognition, including research, planning, and policy-making.

If biology cannot be reduced to physics, though, can human symbolism and cognition, and social systems more generally, be explained through the same models as biology? Luhmann described autopoietic processes, but based on different material structures. (For Luhmann, the biological, cognitive, and social realms were separate but interrelated and interdependent realms.) By contrast, Bohm's idea of an implicate order suggests that characteristics which we consider to be higher-level, such as intelligence, may in fact pervade matter throughout the universe [8].

Other strains of systems work fall exclusively into the realm of human social systems, often beginning with a concern about the human condition. Marxist philosophers, critical theorists, post-modern writers, and systems theorists who focused wholly or partially on ethics, all seemed to converge around an objection to the attempt to objectify humans and their interactions. Churchman pioneered much of the ethical work in systems ideas, and set the stage for work in systems design, including that of Ackoff, Banathy and Nelson. Ulrich, Jackson, and many others, largely in the UK, brought critical theory into systems, primarily in applications with management and organizations.

Systems designers such as Warfield and Christakis have emphasized a more technological approach to addressing complexity in the realm of human communication and decision-making. They, like Forrester, use computer software for model-building, in order to overcome some of the limitations of human cognition.

1.3 Systems critique

Recently, Warfield has outlined what he sees as the "bad practices" creating problems in systems work [9]. As he describes them, they include:

1. Underscoping in the systems domain (focusing too narrowly on specific methods or individual theorists)
2. Unimaginative workspace (workspaces which do not match the complexity of problem situations)
3. Mismatched media (use of small display devices, like computer screens or overhead

projectors, when physically large displays are needed to encompass descriptions)

4. Linguistic pollution (using ambiguous terms like "systems approach" instead of terms like "systems science," and the misuse of terms such as science)
5. Premature quantification (prematurely leaping into numerically-based methods, just because they are familiar to the user, and before a situation has been adequately defined)
6. Insensitivity to discovered behavioral pathologies (neglecting known human qualities that result in repeated errors)
7. Inadequacy of comparison alternatives (failure to compare alternative designs on the basis of relative complexity, etc.)
8. Blindness to history (the belief that systems thinking originated only in the last half-century)
9. Monotonous bifurcation (the focus of systems literature in one of two extremes, either theory with no empirical evidence, or empirical evidence with no supporting theory)

What Warfield proposes as a solution is the development of a true systems science, consisting of nested sub-sciences. In his schema, systems science would encompass a science of action (praxiology), which would encompass a science of complexity, which would encompass a science of design, which would encompass a science of description. If true to Warfield's own history, this would be founded on principles of logic (as espoused by Peirce, primarily.)

Assuming that Warfield is (with at least some margin for error) correct in both his critique and his recommendation, very practical issues still remain in the development of systems work that is both rigorous (in an academic sense) and truly practical, in terms of users in the real world.

One of these issues, which cannot be overlooked, is the *language* in which a systems science – if that is the goal – should be written. Forrester's models encompass great complexity around only two primary variables, and with aid of computer software to assist with mathematical calculations. Still, he has expressed great frustration about the limited ability of users to comprehend the problems being modeled. Banathy often conceded that it might take generations before humans developed design competence, in the ways that he envisioned. The basic concepts proposed by Rashevsky and Rosen are actually quite accessible, but are demonstrated in mathematical formalisms using category theory, and other advanced operations. The methods and processes used by Warfield and Christakis require specialized human and technological support, and still leave the true understanding of fundamentals outside the easy grasp of many users.

Because of the complexity of systems theories and applications, and the fact that as a discipline, systems is expansive rather than reductive, theorists and researchers in the field often find themselves outside the mainstream, to say the least. Certainly, there are luminaries who have achieved significant notoriety, and even some degree of wealth. As noted earlier, systems applications have been conducted with large and significant institutions and organizations. Promoting oneself as a systems theorist or systems practitioner, though, is not a recipe for success in many circles. There are very few university programs in the US or Europe that offer degrees in systems, per se (excluding information systems as a different discipline), and therefore few faculty positions or funding sources available. Students in these programs also quickly note the dearth of job postings for systems graduates.

Even for many luminaries in the systems field, their passion for the work diminished more than enhanced their own professional standing. Boulding was considered less of an economist by other economists due to his pursuits in other disciplines, which expanded his systems work. Maturana's work has set him outside the mainstream of biology for many biologists. Despite decades of work developing his Living Systems model, in conjunction with other notable figures, James Greer Miller probably achieved more professional success and recognition as a university president than for any connection with systems work, by the world at large.

A PROPOSED ANALOGY

In American politics, there has long been a way of expressing untouchable subjects – most notably, the almost sacrosanct entitlements of the Social Security System. Attempting to change that system became known as the "third rail" of politics, referring to the rail used in subway systems to transmit electricity. (Touching all three rails at the same time completed the electrical circuit, electrocuting a person foolish or unfortunate enough to do so.)

In traditional academic and professional realms, systems has been treated, at least in the US, almost as a third rail. Being identified as a systems professional, as a primary role, was almost an invitation to limitations, at best. This may well be changing, but if so, it is still a slow process at present.

From a professional standpoint, it might be helpful to identify an analogous system – another discipline that seems, at least, to have experienced similar issues and shown signs of hope. One candidate might be economics.

Like systems professional, economists seem to have something of an identity problem. Most of the public at-large seems to equate economics with money. Economics, though, is not concerned directly with money, per se, and it is not synonymous with accounting or finance. It is, rather, concerned with larger principles of supply and demand, and so forth.

At least one economist, in fact, has expressed the problems in terms that sound a great deal like a systems issue:

> Rather than being like physics, economics is more like biology, or better, ecology. Too often the economy is viewed as an engine or some other linear set of relationships, where it is presumed that by pushing lever A, I can move object B. I would argue that the economy is better understood as an ecosystem, a complex system of interactions where order emerges rather than being imposed from above [10].

Whatever the problems and misunderstandings, though, it would be hard to argue that economics has not established itself in positions of significant influence. As an example, it might be argued that Alan Greenspan has had at least an equal influence on the world, during his tenure as Chairman of the US Federal Reserve Board, as the US presidents who served concurrently.

With this example as a backdrop, how might systems thinking about progressing into the future, and on what kind of foundation should it be built? From this perspective, systems could remain a very high-level discipline, being used by experts to manage complexity in terms of policies and remedies. (As in economics, there would inherently be ethical questions about who might benefit most at any given point, and how that should be decided.) Different levels of understanding would still be required, though, in order to achieve some level of general support for policies – such as the very basic understanding by most business people of supply and demand, which they could only vaguely articulate, but believe is valid and important.

On a different scale, systems might actually see economics as a more formal model for its own development. In that light, economics has become the system through which the flow of goods and services is regulated around the world. Economic policy makers track a small number of measurements that feed into a larger picture of the health of an economy, and intervene primarily through just one mechanism – that of interest rates. This becomes, then, what Forrester termed a high-leverage solution, or what Warfield and Christakis might both see as a deep driver in their models – one variable with a great deal of influence over many others.

Given the current state of the economy for a large part of the earth's population – the billions of people who live on less than $2 USD per day – this analogy between economics and systems might not sound appealing. What is needed, then, is a regulating mechanism for addressing issues of most concern, the way that economics has addressed basic goods and services in the last couple of centuries.

It is also possible that using economics as an analogy for systems is far too limiting. It could be that, rather than systems supplanting economics as a regulating process per se, it remains a much larger theoretical base for the development of the discipline that does become the new economics – whatever that might be – into the next century.

To reflect back upon the examples at the beginning of this paper, the effects of war and recent natural disasters on the US economy are expected to be extreme. The solutions to terrorism and human suffering are not just economic, though, and will have to be addressed through more sophisticated means. This would seem to be an opportunity for systems theorists and practitioners to demonstrate the value of their work.

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