LONG TITLE: SERVICE SCIENCE: REFRAMING PROGRESS WITH UNIVERSITIES

SHORT TITLE: Service Science

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SERVICE SCIENCE: REFRAMING PROGRESS WITH UNIVERSITIES

ABSTRACT

Service science offers fresh perspective to re-orient the debate on what is "progress" and whether or not it is slowing down, and if so what might be done to reframe progress "at the speed limit of what is possible" with universities. When it comes to the "rate of progress," universities can play a greater role in improving the deeply interconnected societal measures of innovativeness, competitive parity, sustainability and resiliency. During the current "great recession," much is now being written about progress slowing down. From education levels to scientific discoveries to technical innovations to economic and environmental collapse, rhetoric about progress slowing down or nearing collapse or becoming uncompetitive in developed economies is on the rise. Boulding suggested in "the skeleton of science" that over-specialization could create communication barriers between scientific specialists slowing down *profitable talk*. We propose that a service science reframing of progress with universities as essential institutional actors might positively re-orient the debate.

Keywords: Service science, systems theory, service systems, co-creation, value

INTRODUCTION

Service science is an emerging branch of systems sciences with a focus on service systems (entities) and value-cocreation (complex non-zero-sum interactions). Service science is based on service-dominant logic, in which service, or the application of knowledge for the benefit of others, directly or indirectly underlies all economic exchanges between entities, including exchange of products and money as proxies for service capabilities (Vargo & Lusch 2004; Spohrer & Maglio 2010). Service science is an emerging transdiscipline that integrates insights from existing disciplines (e.g., service marketing, service operations, service computing, service design, service economics, service engineering, and service information) into a new whole without replacing any of the parts. Each disciplinary part contributes to the understanding of the evolution of value-cocreation interactions between complex adaptive entities – service systems - within an ecology of nested, networked entities.

For our purposes, knowledge is not something which exists independent of entities; it is a function of human and social entities, and it grows as a result of these entities constructing or receiving meaningful information and then applying it or "testing it out" internally or externally. If knowledge is the root of all human-imaginable service capabilities in a service ecology, then progress for our species in somehow tied to access to human knowledge. In practice, the body of human knowledge grows and is distributed between different people, businesses, and nations with rights and responsibilities, including property rights (e.g., owning technology or other assets with embedded or associated knowledge). These responsible, sometimes limited-liability, bounded-rationality entities specialize in applying their unique knowledge assets to co-create

benefits with others. Of course, also in practice, knowledge can be withheld or used to punish or harm others. And in spite of best intentions, even when people try to cooperate, people die, businesses fail, national economies collapse, and actions can have unanticipated consequences over multiple time scales and generations of entities. Therefore, the real-world of people (entities) is one of both friendly/unfriendly competition and feigned/unfeigned cooperation with both planned/unplanned achievements and avoidable/unavoidable accidents. The nature of interactions and outcomes is diverse in part because of path-dependence of the world (dynamic context) and bounded-rationality of entities (not reliably knowing oneself, others, the world, nor the past, present, or future). Uncertainty abounds, and our Bayesian-brains bootstrap patterns of human knowledge that seem to matter most to "making progress" as well as diverse other human activities and concerns.

In the next two sections, we survey some of the recent popular and research narratives around slowing progress, and then review Boulding's "Skeleton of Science" essay and his concerns that over-specialization could slow scientific progress.

After developing some of the common sense and empirical data on slowing progress, we present a service science definition of progress and suggest that universities could be redesigned to play an even more significant role than they do in today's progress-oriented knowledge economy. By reframing progress with universities from a service science perspective, we present a thought experiment about progress "approaching the speed limit of what is possible" with universities as essential institutional actors.

IS PROGRESS SLOWING?

In "The Great Stagnation," economist Tyler Cowen (2011) equates national economic growth with progress, and described a GDP/capita as a good proxy for average individual progress to achieve needs, wants, and aspirations. According to Cowen, growth and progress come from good ideas in two ways: (1) knowledge application: applying an existing stock of good ideas to soak up un-skilled labour and under-utilized capital into more economically productive activities (such as what happened in the US two centuries ago, and what is happening in China and India today), or (2) knowledge creation and application: adding new ideas to the stock of good ideas and applying them (what happened in the US in the last century). Cowen suggests the large expansion of the US economy fuelled by under-utilized land and under-educated populous is reaching a point of diminishing returns in the US, and so, economically speaking, there are greater benefits/return on capital by investing capital outside the US (improving human capital outside the US). Several reports from the US National Academies take a different view suggesting that US policy needs to double-down on investments in STEM education pipeline and research universities in the US, or risk a drop in the level-of-education and quality-of-life of the next few (or more) generations of Americans (NAE 2010, 2012).

In "The Knowledge Burden, the Death of the Renaissance Man," economist Ben Jones (2005) describes a formal model of "the knowledge burden mechanism" and works to

measure the increasing educational hurtles faced by innovators as well as the average age at which they create their first productive patent. In his model, specialists become narrower and still take longer to be educated, with negative implications for long-run economic growth. However, maybe Jones' data reflect lack of innovation in the underlying education and research systems rather than a fundamental aspect of progress.

At this point we could present more of the news and research narratives around the slowing of progress, but instead we will make just a few notes before moving on to the challenge of re-defining progress from a service science perspective. The first note is that a large percentage of these narratives fall into familiar categories: (1) the category of narratives equating progress with economic growth at the national level, (2) the category of narratives that argue progress is slowing in the US and other developed nations, but accelerating in the developing nations, and (3) the category of narratives that argue progress is on the verge of collapse because of economic and environmental instability, or inevitable rare events, both natural and human-made disasters, that loom closer every day. The second note is that progress has a long history in the literature and several traditions including social progress, scientific progress, and even "the myth of progress" as three of the most prominent traditions. The third note is that as part of the American Dream, there is the notion of progress in terms geographic and social mobility, such as new frontiers and more opportunities for success through hard work, generation after generation.

BOULDING'S SKELETON OF SCIENCE

Boulding (1956) in a short essay entitled "General Systems Theory - The Skeleton of Science" motivated the importance of general systems theory for fools like us¹. Fools like us use highly specialized symbols and language to learn and communicate scientific findings between the Right People. He also indicates that "General Systems Theory' is a name which has come into use to describe a level of theoretical model-building which lies somewhere between the highly generalized constructions of pure mathematics and the specific theories of the specialized disciplines." As Boulding observes the need for general systems theory is accentuated by the present sociological situation in science... the crisis of science today arises because of the increasing difficulty of such profitable talk... The Republic of Learning is breaking up into isolated subcultures... the total growth of knowledge is being slowed down by the loss of relevant communications... General Systems Theory is the skeleton of science in the sense that it aims to provide a framework or structure of systems on which to hang the flesh and blood of particular disciplines...

Boulding suggests two possible approaches to organize general systems theory... at least two roads each of which is worth exploring. The first is to pick out certain general phenomena, such as population, individual, growth, and information and communications, which might be called an ecological approach (a general field theory of dynamics of action and interactions). The second is to arrange... a hierarchy of

¹ In this paper, all use of italics is to refer to phrases and sentences directly taken from Boulding (1956).

complexity of organization, such as statics, dynamics, control, self-maintenance, genetic-societal, teleological, symbolic-communication (with self-awareness, and the ability to know what one knows), social-value, transcendental systems, which might be called an evolutionary approach (system of systems... each level incorporates all of those below it).

As Boulding points out, these two approaches (general phenomena/ecological and ordered complexity/evolutionary) are *complementary rather than competitive* approaches. Simon (1996) further developed the notion of hierarchical complexity in his work on "sciences of the artificial." Arthur (2009) more recently developed a further theory of the nature of technology as ever more complex recombinations of prior technologies, and Auerswald (2012) talks about "production recipes" in economics as recombinations of prior recipes, including both technology and rule recombinations. However, perhaps the most profound elaboration of combined ecological and evolutionary approaches can be found in Deacon (2012), a work which carefully builds from thermodynamics to life to consciousness to societal systems, step by step with all the rigor of a philosopher's logical toolkit. Spohrer et al. (2011) provide a far less rigorous, but nevertheless useful broad brush perspective of the same territory, using a combined ecological and evolutionary view of physical systems, chemical systems, biological systems and service systems. In particular, this latter worked surveyed what scientists know about the origin of phenomena from the Big Bang some 14 billions years ago to the rise of cities some 10 thousand years ago to modern technologies such as the semiconductor transistor (~1947), integrated circuit (~1958), and microprocessor (~1971).

In sum, to overcome the problem of academic silos in universities and professional silos among practicing scientists in industry and government, Boulding suggested two approaches (general phenomena/ecological and ordered complexity/evolutionary) to work towards a General Systems Theory that all seekers of new knowledge would possess. General Systems Theory is the skeleton of science in the sense that it aims to provide a framework or structure of systems on which to hang the flesh and blood of particular disciplines and particular subject matters in an orderly and coherent corpus of knowledge. What is a service science perspective on an orderly and coherent corpus of knowledge?

REFRAMING PROGRESS

The ideas in this section are quite complex and still being worked out:

- 1. Without Trust, the whole system (human service ecology) falls apart, because entities lose the ability for sophisticated value-cocreation interactions (i.e., to successfully play complex non-zero-sum games generation over generation).
- 2. Progress is related to entities' knowledge of their rights and responsibility in value-co-creation interactions (i.e., complex non-zero-sum games). Sen (2000) empirically argues that development in the human societies is directly related to growth of freedoms and capabilities.

3. The Rate of Progress can be modelled as path-dependent, symbolic knowledge history embedded in entities and partially observable in their history of interactions.

In this section, we reframe progress from a service science perspective in terms of entities (service systems) and interactions (value-cocreation). We will borrow the concept of knowledge burden from Jones (2005) and the need for a General Systems Theory from Boulding (1956). Boulding and Jones emphasize the importance of notions such as discovery and innovation, which from a service science perspective relates to knowledge creation and the application of knowledge to create benefits broadly. Furthermore, these works also emphasize the importance of knowledge transfer, from one generation to the next.

From a service science perspective, progress can be thought of in terms of the rights and responsibilities of entities (individuals and institutions). Another way of saying this is that entities that can trust each other can more efficiently play complex non-zero sum games. In our human service ecology, value-cocreation depends on trust, and trust depends on rights and responsibilities. Rights are associated with societal benefits and freedoms, and responsibilities are associated with societal constraints (backed up by the threat of loss of rights or access to resources as well as reputation damage, fines, or coercion). Governance mechanisms are a special type of value proposition in the service ecology, and governance mechanisms are one of the twelve fundamental concepts in service science (Spohrer & Maglio 2010). In this service ecology, resources are people, technology, information, organizations; stakeholders are customers, providers, authorities, competitors; measures are quality, productivity, compliance, sustainable innovation; and access rights are own, lease, shared and privileged.

When we lose trust in "the system of others," society falls apart and progress slows. Therefore, progress can be seen in terms of rights and responsibility of entities to acquire and use competences (knowledge) for the benefit of themselves and others. This view has the potential to integrate the three major traditions associated with the concept of progress, namely, societal progress (responsibility to next generation's quality of life), scientific progress (rights to share, expand, and accumulate knowledge), and the myth of progress (not a linear scale).

First, consider competence without rights and responsibilities of entities to address the knowledge burden. Competence without comprehension can be seen in both organisms in the natural world (Darwin's theory of evolution) and machines in the technological world (Turing's theory of universal computation). Both organisms (evolved) and machines (designed) can do remarkable things, without comprehension of what or how they do what they do. Competence without comprehension is part of our daily human experience. We talk, but we do not know how. We value, but we do not know how. We learn, but we do not know how; though copying "how others with greater competence do things" is somehow essential.

Next, consider competence with comprehension of what entities are doing, how they are doing it, and the associated rights and responsibilities of using the knowledge. For example, consider the work of a scientist trying to understand bird flu, or a pharmaceutical firm introducing a new drug. Individuals and institutions have rights and responsibilities associated with the use of knowledge.

So what is progress from a service science perspective? Progress can be seen as individual and collective, conscious and unconscious, rights and responsibilities that address the knowledge burden. Recall the knowledge burden arises because humans (individual service system entities) have limited life spans, limited ability to learn, and limited ability to predict the future, which is related to our limited ability to model entities, interactions, and outcomes ourselves. If people had infinite life spans, instantaneous ability to learn from others, and a perfect ability to predict the future, then there would be no knowledge burden. The hallmark of comprehension is science. Science accumulates shared, explicit codified (symbolic) knowledge that allows others to copy and use what has been learned.

To reframe progress from a service science perspective, we offer the following thought experiment. Perhaps this thought experiment is easier to imagine today than ever before, in this age of big data, social media and sensors proliferating in the world. Imagine four "parallel time streams" associated with (1) phenomena (sources of information), (2) research (knowledge creation), (3) education (knowledge transfer), and (4) practice (knowledge application). Practice could be further broken down into commercial practice (e.g., technology) and governance practice (e.g., rules). As a symbolic species, humans create new symbols at particular points in time, and these symbols are part of scientific theories that provide insights into the origins of abstract entities, interaction, and outcome universals (Spohrer and Demirkan 2012), such as when our star the Sun (about 8 billion years ago) and our planet Earth (about 4.5 billion years ago), or more recently when academic disciplines formed, when published papers first mentioned specific symbols and symbol sequences of significant scientific importance (e.g., division of labour, comparative advantage, bounded rationality, path dependence, knowledge burden).

The point being that we can image the following thought experiment, we have four streams of symbols with dates. The first stream is the <u>phenomena stream</u>, which begins with the symbol "Big Bang" and date of approximately 14 billion years ago. The second stream is the <u>research stream</u>, which includes the symbols referring to the names of scientists and their associated discoveries (such as the Hubble, 1924-1949, Big Bang) and the year (or range) in which an individual (or cohort) developed the conceptual framework and put names (that stuck or faded) to discoveries in published or public forums. The third stream is the <u>education stream</u>, which might include the symbols referring to the names of educators and their curriculum and the year in which they first began teaching about those topics. The fourth stream is the <u>practice stream</u>, which might include the symbols referring to the names of practitioners, their companies, and their market offerings and the year in which they began creating economic value embodying

certain knowledge in certain offerings. For example, the first advertisements for the Intel 4004 microprocessor appeared on November 15th, 1971 in Electronics News.

The fourth stream also includes symbols associated with new formal entities and rules. Formal service system entities have rights and responsibilities the can be described and debated in terms of formal symbol systems. As a symbolic species (Deacon 1997), we humans can be viewed as service systems entities (Spohrer & Maglio 2010) or in Simon's terminology physical-symbol-systems (Simon 1996, Newell 1982). Therefore, evolution of new types of service system entities is in part a legal process of naming and specifying rights and responsibilities, and in any nation or jurisdiction it is possible to determine when those formal entities were created. For example, the birth of the nation the United States of America in 1776, and it was 1886 (Santa Clara County v. Southern Pacific Railroad) that US corporations won many of the rights to be treated as legal citizens (Koliba et. al., 2011). Of course, our path-dependent service ecology was evolving new types of service system entities well before rule-of-law in the formal, symbolic sense, and the transition from primate to human, and early human to formal, written law is well documented in the literature, including the study of Friedman (2008). Simplifying all human knowledge to symbolic knowledge is a great oversimplification ignoring other forms of knowledge in tacit patterns and configurations, but doing so allows a systematic approach to the knowledge burden that can approach the speed limit of what is possible, regarding the rate of progress.

We can summarize this section as follows:

- 1. When we lose trust in "the system of others," society falls apart and progress slows.
- 2. From a service science perspective, progress can be seen in terms of the rights and responsibilities of service systems that address the knowledge burden of entities with limited life spans, learning rates, and ability to predict the future.
- 3. The path-dependent history of symbolic knowledge (our knowledge burden) can he viewed in terms of four streams: phenomena, research, education, and practice (both commerce/entrepreneurship and governance/policymaker).

REFRAMING PROGRESS WITH UNIVERSITIES

Given that the path-dependent history of symbolic knowledge (our growing knowledge burden) can he viewed in terms of four interconnected streams: phenomena, research, education, and practice (both commerce/entrepreneurship and governance/policymaker), universities as home to diverse academic disciplines play a special role in human society. For example, Boulding notes that each discipline corresponds to a certain segment of the empirical world... the "real" world around us. Each discipline has further subspecialists who focus on knowledge creation (research), knowledge transfer (teaching), knowledge (commerce/ governance/ and application entrepreneurship and policymaking).

Universities today can be seen as "knowledge factories" with disciplines springing up to study phenomena associated with certain segments of the empirical world, as noted by Boulding. Universities have been described in terms of three knowledge-related activity streams or themes: create knowledge (research), transfer knowledge (education), and apply knowledge to create value (practice). Mollas-Gallart et. al. (2002) report that while most universities where founded principally on two activities, teaching and research, that they have always made wider contributions to civil society through their "third mission" activities, and now more than ever universities are the "dynamos of growth" for their regions in a knowledge-driven global economy. In fact, measuring the regional economic impact of universities and ranking universities in terms of start-up activities is becoming more and more important (UU 2011). Of course, knowledge can be applied in many other arenas beside commerce, for example policymakers creating new rules and rule systems to improve governance. For example, practice includes engineers developing new technologies (such as the microprocessor), and can also include leaders in management (total quality movement) or leaders in government (emancipation proclamation) or civic leaders (women's right to vote).

Observers of higher educational change expect more change in the next few decades than in the previous thousand years (Clark 2012). New technology and new business models are beginning to disrupt the lecture-mode of knowledge transfer that has characterized higher education for a thousand years (Christensen *et al.*, 2011). As a result, faculty labour in higher education is shifting more and more from the dominant first stream activities (transfer of knowledge - teaching) to rapidly growing third stream activities (applying knowledge to create value - entrepreneurship), which is, in turn, driven by accelerating second stream activities (create knowledge - research).

Through the institution of the university, most disciplines reward knowledge depth, not breadth. However, future universities, without sacrificing knowledge depth may be quite different. Reframed as test-bed living labs that embrace general systems theory, universities could better prepare students as "global citizens and adaptive innovators" with both depth and breadth, so-called T-shaped professionals (Barile et. al., 2012, Donofrio et al. 2009, Spohrer 2005). At least, a multi-disciplinary research perspective is required to develop the strategies, processes, training pedagogy and toolsets for lean engagement models that reduce integration overhead and that concomitantly prepare the next generation of service specialists (e.g., T-shaped professionals) who possess highly-evolved integration skills (Demirkan and Spohrer, 2010).

Furthermore, this reframing of universities might better balance the benefits and drawbacks of winner-take-all and improve-weakest-link policy logics, while continuously improving the recapitulations of recorded "phenomena, research, education, and practice" that advance quality-of-life levels (Spohrer and Giuiusa, 2012).

As spelled out by Boulding, general systems theory can provide a skeleton for disciplines, especially the empirical sciences that study the "real" world systems around us. Universities are both beacons and stewards of academic disciplines including all of the

sciences. The university in modern society is a type of essential institution that can be seen in terms of four intertwined and co-evolving threads, namely the threads of phenomena, research, education, and practice. Furthermore, we suggest that universities may already be leading a global societal transformation to balance the dominant zero-sum "winner-take-all" competitive logic with doses of non-zero-sum "improve-weakest-link" cooperative logic, resulting in an overall service-dominant or value-cocreation logic accelerating societal progress. In so doing, universities have the opportunity to improve important societal measures of innovativeness, equity, sustainability, and resiliency and become the leaders of regional economic development.

CONCLUDING REMARKS: FUTURE DIRECTIONS

We propose a service science definition of progress that begins with an appreciation the knowledge burden of a service ecology. If the life-span of entities does not allow for the transfer of knowledge from one generation to the next, then problems and opportunities arise for progress. New ideas (knowledge) that can be applied to increase the life-span of entities, increase the efficiency of knowledge transfer between entities, decrease the amount of knowledge that needs to be transmitted by and to entities, etc. can impact the knowledge burden of a service ecology. New type of entities or re-inventing existing entities (institutions) with new capabilities can also impact the knowledge burden of a service ecology.

The proposed definition of progress is based on a simplification of history into four streams - phenomena, research, education, and practice. Allocating resources for universities to compete in re-doing history from scratch, builds the innovativeness, equity, sustainability, and resiliency of regions.

Future research questions include: How do we better determine the speed limit of progress? How can we better measure the knowledge burden of a service ecology? How do innovativeness, equity, sustainability, and resiliency interact? How can path-dependent history of symbolic knowledge guide the process? What if it has been possible to build the printing press earlier in history? Photography and wireless? What about controlling electricity and semiconductors? How early could these have been developed? Can students working from scratch redevelop society as the mental exercise of preparing them to solve problems in today's society? How do we get to a textbook and a tool to help students learn about rebuilding society more rapidly? How does infrastructure (nature and technology), individuals (skills and capabilities), institutions (rules and roles), and information (quality-of-life and culture) get rebuilt in the game to rapidly rebuild society at larger scales?

The key future research question from a service science perspective is to determine if there is a speed limit to progress. If one could rewind the tape of history, and replay it over and over, how fast could certain levels of progress be achieved?

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² For example, see the light-hearted design challenge at http://www.service-science.info/archives/2189

Of course, we are not the first to ask questions like these. And so we conclude this paper with several quotes from a New York Times Science section article (Angier 1998):

"The issue of convergence also plays into a recent philosophical debate between two prominent evolutionary biologists, Dr. Stephen Jay Gould of Harvard University and Dr. Simon Conway Morris of Cambridge University. In his best-selling book, "Wonderful Life" (Gould and Morris, 1989), about the discovery of the Burgess Shale, a trove of 70,000 fossils half a billion years old, Dr. Gould emphasizes the importance of what he calls contingency, the idea that many of the species we see today are here by dint of a series of accidents -- an asteroid that struck the earth, for example, thereby eliminating the dinosaurs and making way for the rise of mammals."

"If you could rewind the tape of life and run the whole program over again, Dr. Gould said, you would end up with a radically different set of organisms, one almost certainly devoid of anything as cortically over endowed as we Homo sapiens are. He has criticized many of his colleagues for engaging in what he considers to be excessive adaptationist thinking, a "Panglossian" faith that the fittest survive, that evolution invariably progresses from simple to complex and from stupid to clever, and that what is, is for the best."

"Earlier this year, however, Dr. Conway Morris, one of the discoverers of the Burgess Shale, took issue with many of Dr. Gould's ideas in a new book, "The Crucible of Creation" (Oxford University Press). Rewinding the tape of life may not result in such a drastic change, Dr. Conway Morris insisted, one reason being the principle of convergence."

"I would certainly not contest the reality of contingency and luck," Dr. Conway Morris said recently in a telephone interview. "We're all the product of one very, very lucky sperm. On the other hand, when you look at the broad structure of the history of life, you can't help but be impressed by the number of organisms that began at different starting points and have come together -- the whale that looks like a fish, an extinct marsupial, a sort of kangaroo, that looked like a sabre-toothed cat. The world is a rich and wonderful place, but it is not one of untrammelled possibilities."

The world is a rich and wonderful place, full of many possibilities for how history might have unfolded differently. Service science with its emphasis on service system entities and value-cocreation interaction can provide perspective for attempting a new definition of what progress is and if there is a speed limit to progress, what that speed limit is.

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