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Service science,management, engineering, and design (SSMED): an emerging discipline -- outline and references

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Special Section Articles

Service Science, Management, Engineering, and Design (SSMED): An Emerging Discipline - Outline & References[1]

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ABSTRACT

The growth of the global service economy has led to a dramatic increase in our daily interactions with highly specialized service systems. Service (or value-cocreation) interactions are both frequent and diverse, and may include retail, financial, healthcare, education, on-line, communications, technical support, entertainment, transportation, legal, professional, government, or many other types of specialized interactions. And yet surprisingly few students graduating from universities have studied anything about service or service systems. Service Science, Management, Engineering, and Design (SSMED), or service science for short, is an emerging discipline aimed at understanding service and innovating service systems. This article sketches an outline and provides an extensive, yet preliminary, set of references to provoke discussions about the interdisciplinary nature of SSMED. One difficult challenge remaining is to integrate multiple disciplines to create a new and unique service science. [Article copies are available for purchase from InfoSci-on-Demand.com]

Keywords: *Literature Review; Service Economy; Service Science Management Engineering and Design; SSMED*

SSMED = Service Sc., Managem, Eng., Design = Service Science

THEORETICAL AND PRACTICAL FOUNDATIONS

The emerging discipline of Service Science, Management, Engineering, and Design (SSMED) or service science, for short, is outlined in this article (IBM Research 2004; Chesbrough, 2005; Horn, 2005; Chesbrough & Spohrer, 2006; Hidaka, 2006; Monahan, Pym, Taylor, Tofts, & Yearworth 2006; Spohrer, Maglio, Bailey, & Gruhl, 2007; IfM & IBM, 2008; Spohrer & Maglio, 2008). This section

provides some of the key theoretical and practical foundations of service science. What is truly new and unique about service science? Haven't people been doing service research for over thirty years? What's changed? The next section provides the primary connections to existing disciplines. How does service science relate to existing academic disciplines? Does every service scientist need to know about all these disciplines?

How is service science changing and being changed by these disciplines? The last section provides the primary connections to existing professions. How does service science relate to existing professions? Which professions are likely to benefit from the rise of service science?

Concepts and Questions

Why now? The International Labor Organization released a report[2] in January 2007 that stated there are, for the first time in human history, more service jobs (40%) than agricultural jobs (39.6%) and nearly doubles those of manufacturing jobs (20.4%). Nowadays most people survive (and some thrive) even though they do not create new physical things, such as food or tangible products, in their jobs. Over the past thirty years, a growing number of academics and practitioners have begun to study "service" as a distinct phenomenon, with its own body of knowledge and rules of practice. The growth of service value in society is undeniable.

However, aside from the statistics is there really anything new in this "growth of service" phenomenon, and is there anything worthy of a new science? And what is service? From von Mises (1998), we see that service relates to increasing value from more and more sophisticated forms of cooperation, or what we term *value-cocreation mechanisms*. Many have begun to observe that over time, service-for-service exchanges not only dominate in an economy, but become more specialized and knowledge-intensive, and further increase the value creation density of societies (Normann 2001). The growth of service also means interacting more with strangers (Seabright 2005); even though we know the role someone is playing in a service system, we do not always know the person. So what is going on? What is behind the growth of service? Ludwig von Mises (1998) wrote, near the middle of the last century, about the fundamental understanding of value and cooperation: "Within society, cooperation substitutes interpersonal or social exchange for autistic exchange. Man gives to other men in order to receive from them. Mutuality emerges. Man serves in order to be served. (Pg. 194)"

More recently, Vargo & Lusch (2004, 2006, and 2008) in their Service-Dominant Logic *define service as the application of competence (e.g., knowledge, resources, etc.) for the benefit of another entity*. They point out that most people today use a Product-Dominant Logic that has arisen from two centuries of measuring value as increases in physical output. For example, bushels of wheat or palettes of consumer goods are physical output. This focus on the physical products is quite understandable, in part, given that manufacturing production efficiencies have lead to enormous improvements in material wealth (Beinhocker, 2006). However, now with the rise of the internet and low-cost global communications, information and knowledge as a contributor in value-cocreation is becoming more quantifiable. Foray (2004) points out that information is easy to copy (known digital encoding in machines), while knowledge is hard to copy (unknown neural encoding in people). The growth of service is truly tied to the growth of information and knowledge.

What's new? While division-of-labor and cooperation are not new thoughts, the growth of service provides a new lens through which to see the world. The growth of service, seen as the evolution of value-cocreation mechanisms between service system entities, becomes a way to view human history and understand future change. Perhaps it is even true, as some writers suggest that people in modern societies are getting better at playing win-win games (Wright 2000). People are starting to understand that value-cocreation is the best game in town.

Service is in fact becoming the lens through which many disparate areas of study can be viewed within a common framework. For example, the increased focus on service in recent years is in large part due to the growing dominance of service activities in national economic accounts of jobs, GDP, exports, and productivity (Triplett & Bosworth 2004; Lewis 2004; Herzenberg, Alic, & Wial 2000). In everyday business and government, service is most strongly associated with the growth of high-value, knowledge-intensive types of customer-provider interactions, between entities such as people, organizations, agencies, machines, or infrastructure, in which taxes, advertising fees, subscription fees, usage fees, annual enrollment fees, or the scarce resource of human attention are typically exchanged for the actions, experiences, assurances, or access privileges of service providers. In computer science, service refers to computational resources (as in web service or grid service) that can be discovered, accessed, and applied using standard protocols (Spohrer, Anderson, Pass, Ager, & Gruhl, 2008). In the public sector and social sciences, service is often associated with intangible value from selfless acts of loyalty, courage, or ethical/religious convictions about what is right and good in human society. For example, the removal of *unfreedoms* (i.e., unhealthy, uneducated, unprotected, uninformed, etc.) from the billions of underserved people around the world is one view on the importance of service activities that connect economic, political, and social thinkers (Sen, 1998; Lewis, 2004). Also, one-time service encounters are very different from long-term or life-time service relationships (Gutek, 1995), and the application of knowledge-based assets is very different from the application of physical assets (Boisot, 2002). Manufacturing businesses are increasingly driven to understand service innovation, as they seek to transform themselves to higher levels of value-cocreation with their customers and other stakeholders (IfM & IBM, 2008). All these views contribute to an increasing need to understand the phenomenon of service as the evolution of and the design of value-cocreation mechanisms between entities – the business of society is becoming value-cocreation.

Basic Concepts. If we are to understand human history as the evolution and design of value-cocreation mechanisms between entities, then where should we begin? Let's start by understanding the following ten basic concepts: resources, service system entities, access rights, value-proposition-based interactions (a more traditional, business-oriented name for value-cocreation mechanism), governance mechanisms, service system networks, service system ecology, stakeholders, measures, and outcomes.

Resources: "Things come and go, and we name them in order to communicate about them." Every nameable physical and non-physical thing is a resource. For example, an instance of an apple is a physical resource, and the concept of a right triangle is a non-physical resource. As von Mises (1998) observed: "Thinking man sees the serviceableness of things, i.e., their ability to minister to his ends, and acting man makes them means." (Pg. 92); Legal man attributes rights to certain types of physical and non-physical resources. For example, adult people are physical resources with rights, and businesses, that have properly incorporated, paid their taxes on time, and fulfill other obligations, are non-physical resources with rights. Businesses may own physical resources or contract for physical resources, but as a type of resource they are themselves not physical, but instead a conceptual-legal construct. So in the end, all resources fall into one of four types: *physical-with-rights, not-physical-with-rights, physical-with-no-rights, and not-physical-with-rights*. In modern society, physicists are the professional authorities who tell us which resources are or are not physical. Judges are the professional authorities who tell us which resources have or do not have rights within their jurisdictions. Physicists and judges are types of authority stakeholders (a concept introduced below). As we will see later, communities of authority stakeholders establish and uphold the rules of the game. Thus, the concept

service dominates jobs and GDP (exports)

service = knowledge intensive interactions

Comp sci: → service = resources that can be discovered, accessed, used.

service → products

Toyota ←

→ services: value cocr. mechanisms ÷ entities

Concepts:
1. resources
2. entities (SS)
3. access rights
4. value proposit. interactions
5. governance mech
6. (SS) networks
7. (SS) ecology
8. stakeholders
9. Measures
10. outcomes

Knowledge of this = service science

Resources Types:
+ phys - rights
- phys + rights
+ phys - rights
- phys - rights

physicist judge

authority stakeholders

of resource and the four logical types is socially constructed (Berger & Luckmann, 1967).

Different types of resources are governed by different types of laws (Maglio, Kreulen, Srinivasan, & Spohrer, 2006). Physical resources are governed by the laws of nature. Conceptual or information resources are governed by the laws of logic-and-mathematics. Both physical and conceptual resources, in a modern human culture, are governed by human law (e.g., property rights). This notion of four types of resources is one of the first fundamental insights from service science, and is part of the service systems worldview.

Latour (2007) in "Reassembling the Social: An Introduction to Actor Network Theory" provides the term 'actant' to describe what we have termed 'resources' in this article. Vargo & Lusch (2004) make the distinction between operant (actor) and operand (object) resources, and note that all resources, depending on the context and event, may be of either category (e.g., when considering people, the surgeon may be operant and the patient on the table operand).

Service system entities. "Together we can change the world to our mutual benefit." Service system entities are *dynamic configurations of resources*, including at least one resource with rights (and responsibilities, as these come in pairs for legal man), including some type of access rights to all the resources in the configuration, either directly or indirectly through relationships with other service system entities. Recall, within a jurisdiction, an authority stakeholder is required to determine which resources have rights and the nature of the rights. Some dynamic configurations of resources are service system entities (a business or a city, including the people that make them up), and other configurations of resources are not service system entities (an automobile, without a resource with rights, such as the owner person or driver person included). The most common types of service system entities are people and organizations. New types of service system entities are constantly emerging and disappearing. Recently, open-source and on-line communities have emerged as service systems entities. The concept of service system entity is evolving rapidly (Spohrer, Maglio, Bailey, & Gruhl, 2007; Spohrer, Vargo, Maglio, & Caswell, 2008).

Access rights. "By what authority, do you use that resource?" Service system entities have four main types of access rights to the resources within their configuration: *owned outright, leased/contracted, shared access, and privileged access*. Shared access resources include resources such as air, roads, natural language, and internet web sites. Privileged access resources include resources such as thoughts, individual histories, and family relationships.

Value-proposition-based interactions. "I'll do this, if you'll do that." Service system entities interact (normatively) via value propositions. Normative behavior is behavior that "ought to happen according to an ideal model of one or more stakeholders," but in fact may not always occur. Interactions via value propositions are intended to cocreate-value for both interacting entities. Both interacting entities must agree, explicitly or tacitly, to the value proposition. A value proposition communicates a mutually agreeable plan to collaborate and cocreate-value, most often by reconfiguring resources or access rights to resources. A value proposition is a value-cocreation mechanism (Anderson, Narus, & Rossu, 2006; Lovelock& Gummesson 2004; Kim & Mauborgne, 2005; Slywotzky, Wise, & Weber, 2003; Afuah, 2004; Gummesson 2007; Normann 2001). For example, an installment payment plan can allow customers to pay over time for items they get to use in advance of completing payment, while increasing short-term sales for the provider. The value proposition creates a win-win relationship.

Governance mechanisms. "Here's what will happen if things go wrong." Service system entities may not realize the value expected from a previously (mutually) agreed to value proposition. If value is not realized as expected, this may result in a dispute between the entities. Governance mechanisms reduce the uncertainty in these situations by prescribing a mutually agreed to process for resolving the dispute. Gov-

ernance mechanisms are also known as dispute resolution or conflict resolution mechanisms (Williamson, 1999; Adams, 2000; March 1991; Omerod, 2005; Bernstein, 1998).

Service system networks. "Here's how we can all link up." Service systems entities interact with other service system entities (normatively) via value propositions. Over time, for a population of entities, the patterns of interaction can be viewed as networks with direct and indirect connectivity strengths. A service system network is an abstraction that only emerges when one assumes a particular analysis overlay on the history of interactions amongst service system entities.

Service system ecology. "Populations of entities, changing the ways they interact." Different types of service systems entities exist in populations, and the universe of all service system entities forms the service system ecology or service world (Bryson, Daniels, and Warf, 2004). The ecology is characterized both by the diversity of types of service system entities and their relative numbers, as well as the dynamics resulting from value-cocreation mechanisms and governance mechanisms.

Stakeholders. "When it comes to value, perspective really matters." The four primary types of stakeholders are *customer, provider, authority, and competitor*. Reasoning about multiple stakeholders and their perspectives on resource access is necessary to design new and improved value-cocreation mechanisms and governance mechanisms, as well as to design new and improved types of service system entities. In addition to the four fundamental stakeholder perspectives (customer, provider, authority, competition), other stakeholder perspectives include employee, partner, entrepreneur, criminal, victim, underserved, citizen, manager, children, aged, and many others. Designing business and societal systems that address more than the four fundamental stakeholder perspectives is sometimes considered to be the difference between having a society that is merely 'prosperous' and having a society that is truly 'great' (Collins, 2005).

Measures. "Without standardized measures, it is hard to agree and harder to trust." The four primary types of measures are *quality, productivity, compliance, and sustainable innovation*. Each of these corresponds to a stakeholder perspective: customers evaluate quality, providers evaluate productivity, authorities evaluate compliance, and, in a very real sense, competitors evaluate sustainable innovation. With regard to sustainable innovation, von Mises (1998) states: "Competitors aim at excellence and preeminence in accomplishments within a system of mutual cooperation" (Pp. 116-117). The ongoing challenge that service system entities (e.g., people) perceive is 'self competition' to sustain a balance between too much challenge (anxiety and risk of failure, if skills are lacking) and too little challenge (boredom and risk of meaningless success). A dynamic balance between anxiety and boredom helps to ensure a sense that change has meaning and value (Csikszentmihalyi, 1990).

Outcomes. "How did we do? Can this become a new routine or long-term relationship?" In a two player game, there are four possible outcomes: win-win, lose-lose, win-lose, and lose-win. Win-win corresponds to value-cocreation, and the other three are likely to lead to disputes. However, only four outcomes, relative to real world complexity, is too impoverished to be of much use. To create a more realistic model we developed ISPAR with ten possible outcomes (Spohrer, Vargo, Maglio, & Caswell, 2008). ISPAR (Interact-Service-Propose-Agree-Realize) includes outcomes in which: (1) value is realized, (2) the proposal (value proposition) is not understood, (3) the proposal is not agreed to, (4) value is not realized and disputes do not arise, (5) value-cocreation disputes are resolved in a manner that is OK for all stakeholders, (6) value-cocreation disputes are resolved in manner that is not OK for all stakeholder (7) an interaction is not a service interaction and is welcomed, (8) an unwelcomed non-service interaction is not criminal, (9) an unwelcomed non-service interaction is criminal and justice results, (10) an unwelcome non-service interaction is criminal and justice

does not result. Beyond a standard two player game, with a customer player and a provider player, ISPAR assumes there exists both an authority player as well as a competitor-criminal player. By admitting the notion of non-service interactions and competitor-criminal stakeholders, ISPAR goes beyond the normative view of service system entity interactions. Service system entities have the competence to make decisions about *relationships* over a life time of interaction, not only the history of past interactions but also reason about the possible future *customer life time value* of service interactions (Rust, 2000).

Service systems worldview. These ten basic concepts underlie the *service systems worldview*: The view that the world is made up of populations of service system entities that interact (normatively) via value propositions to cocreate-value, but often disputes arise and so governance mechanisms are invoked to resolve disputes. In the service systems worldview, people, businesses, government agencies, nations, cities, hospitals, universities, and many other entities are instances of formal service systems.

Formal service system entities are types of legal entities with rights and responsibilities, that can own property, and with named identities that can create contracts with other legal entities. Formal service system entities are legal entities (Williamson, 1999; Roberts, 2004). Formal service systems exist within a legal and economic framework of contracts and expectations.

Informal service system entities include families (though households are formal from a tax law perspective), open source communities (that have not created a formal non-profit entity for governance or charitable giving purposes), and many other societal or social systems that are governed typically by unwritten cultural and behavioral norms (social systems with rudimentary political systems). A service scientist seeks to understand the fossilized value propositions that underlie these informal routines and norms. Informal service systems exist within a social and political framework of promises and expectations.

Natural history of service system entities. Service science seeks to create an understanding of the formal and informal nature of service in terms of entities, interactions, and outcomes, and how these evolve (or are designed) over time. An initial premise is that the entities, which are sophisticated enough to engage in rationally designed service interactions that can consistently lead to win-win value cocreation outcomes, must be able to build models of the past (reputation, trust), present, and future (options, risk-reward, opportunities, hopes and aspirations) possible worlds, including models of themselves and others, and reason about knowledge value (Fagin et al, 2003). The foundations for a natural history of service systems can be found in the anthropology literature, and the foundations for a natural history of value propositions and governance mechanisms can be found in the economics and law literature. The challenge of service science, as we see even more below, is the integration of these and other disciplines, centered on the service research literature.

Basic questions. A general theory of service system entities and networks formed through value-proposition-based interactions has four parts, which directly lead to the four basic types of questions that SSMED seeks to answer:

Science (improve understanding, map natural history, validate mechanisms, make predictions). What are service system entities, how have they naturally evolved to present, and how might they evolve in the future? What can we know about their interactions, how the interactions are shaped (value propositions, governance mechanisms), and the possible outcomes of those interactions both short-term and long-term?

Management (improve capabilities, define progress measures, optimize investment strategy). How should one invest to create, improve, and scale service system networks? How do the four measures of quality, productivity, compliance, and sustainable innovation

relate to numerous key performance indicators (KPIs) of business and societal systems? Is there a "Moore's Law" of service system investment? Can doubling information lead to a doubling of capabilities (performance) on a predictable basis?

Engineering (improve control, optimize resources). How can the performance of service system entities and scaling of service system networks be improved by the invention of new technologies (and environmental infrastructures) or the reconfiguration of existing ones? What is required to develop a CAD (Computer-Aided Design) tool for service system entity and service system network design?

Design (improve experience, explore possibilities). How can one best improve the experience of people in service system entities and networks? How can the experience of service system creation, improvement, and scaling be enhanced by better design? Can the space of possible value propositions and governance mechanisms be explored systematically?

Sciences of the artificial. Sciences of the artificial are different from natural sciences, and so it becomes especially important to consider these four parts – science, management, engineering, and design – as important knowledge components. In "The Sciences of the Artificial" (Simon 1996), Simon reflects "The world we live in today is much more man-made, or artificial, world than it is a natural world… … we must be careful about equating 'biological' with 'natural.' A forest may be a phenomenon of nature; a farm certainly is not. …A plowed field is no more part of nature than an asphalted street – and no less. These examples set the terms of our problem, for those things we call artifacts are not apart from nature. They have no dispensation to ignore or violate natural law. At the same time they are adapted to human goals and purposes. …Natural science is knowledge about natural objects and phenomena. We ask whether there cannot also be 'artificial' science – knowledge about artificial objects and phenomena. Unfortunately the term 'artificial' has a pejorative air about it that we must dispel before we can proceed." (Pp. 2-3). We note that some say 'service' with a pejorative air.

Service Science, Management, Engineering, and Design (SSMED) is emerging as one of the sciences of the artificial. Service science is knowledge about service system entities, value-proposition-based interactions (or value-cocreation mechanisms), governance mechanisms, and the other seven basic concepts. Following Simon even further, one could argue that service system entities are physical symbol systems, dealing with symbols that are named resources, and grounded in physical routines for carrying out the symbolic manipulations related to named resources. "A physical symbol system is a machine that, as it moves through time, produces an evolving collection of symbol structures." (*ibid*, Pg. 22). In our parlance, service system entities move through time and produce an evolving configuration of resources that are shaped by interactions with other service system entities. In a well working society, the interactions are based primarily on mutually agreed to value propositions. Service science seeks to improve our understanding by mapping the natural history (growth of service), discovering the mechanisms of change, and predicting future types of service system entities, value-cocreation mechanisms, and governance mechanisms.

Tools and Methods

B2C service. "When the customer is a person." James Teboul (2006) provides an easily accessible introduction to a few of the basic tools and methods that researchers and practitioners have created to both understand service and design new service offerings. The design of business to consumer (B2C) service offerings has especially benefited from two basic tools, the *service intensity matrix and service blueprinting*.

The service intensity matrix can be used to show how different businesses create different value-cocreation mechanisms that populate all the design niches, ranging from highly customized and high interaction service offerings to

highly standardized and low interaction service offerings.

The service blueprint tool (see examples from (Fitzsimmons 2008) and Bitner et al (2007)) is used to describe and improve customer-provider interactions in service processes. The service blueprint is particularly useful in helping management test out concepts, identify potential failure points and/or opportunities for innovation. Many variations of service blueprinting tools and methods exist, including one recently developed by Womack & Jones (2005) in their book "Lean Solutions." Heskett, Sasser and Schlesinger (1997) (p. 40) provided a method of calculating value from the perspective of the customer. The simple formula provides a good basis for formulating the win-win value proposition between the customer and the service provider. Gutek and Welsh (2000) proposed a COP model of encounters and relationships. The model described the linkages among Customer, Organization and Provider in a "Service Triangle". The tightness/looseness of the linkage among the components represents the type of and sustainability of the service encounter and relationship. ServeLab at Germany's Fraunhofer Institute provides a disciplined approach to new service product designs (Ganz, 2006). More and more service offerings are designed to be accessed on the web, via mobile phones, or via self-service kiosks. The design of these service systems has benefited from an explosion of development tools and methods.

B2B service. "When the customer is a complex organization." The design of business to business (B2B) service offerings has a growing number of tools and methods such as IBM's Component Business Model (CBM) approach. The CBM approach provides a business architecture view of the customer's business components, the key performance indicators (KPIs) that underlie business performance in that industry, and approaches to outsourcing or otherwise transforming the performance of components. Glushko & McGrath (2005) in "Document Engineering" provide a disciplined approach to business process design. Alter (2006) has developed the work system method and customized it for the design of service systems. Alter (2008) also developed the Service Responsibility Table (SRT) as a tool to bring the customer into the preliminary stages of analyzing and transforming a work system/service system. The advantage of using SRT is that it is intuitive and could be used by a customer who is not trained in heavy-duty systems analysis and design.

DISCIPLINES AND EXPERT THINKING

In this section, the ten academic discipline pillars of service science are presented. Service scientists may specialize in one of these ten areas (expert thinking skills, also known as contributory expertise), but must also be, to some degree, well versed in all ten areas in order to work effectively on multidisciplinary teams of professionals (complex communication skills, also known as interactional expertise) (Collins, Evans, & Gorman, 2007; Collins & Kusch, 1999; Levy 2005). Service scientists should be *T-shaped professionals* (the vertical of the *T* - deep in their home discipline area and appropriately broad to work well in teams – the horizontal of the *T*). We also suggest that T-shaped professionals can learn and adapt more rapidly to the changing needs of business. For this reason, we also refer to T-shaped professionals as *adaptive innovators* (IfM and IBM, 2008). In what follows, the rationale for selecting these ten pillar disciplines will be presented as well as some of the key concepts from each of them. Because students start with a great deal of commonsense and prewired cultural knowledge about the service system worldview, even though they do not have the formal vocabulary, there is good reason to believe material outlined below is not too much knowledge for students to learn (Richardson & Boyd, 2005).

In the following subsections, we briefly introduce the ten disciplines that can provide an understanding of the past (***a***), present (***b-i***),

and future (***j***) of service systems, while highlighting the key types of resources/stakeholders (***b-e***) and measures/access rights (***f-i***) needed to understand service systems, value-cocreation mechanisms, and governance mechanisms. The reader should note that the knowledge in each of the discipline areas (clusters really) are expansive and growing rapidly. Our aim is to show how all ten might integrate into a service science framework.

a. History: Economics and Law Evolving

Evolution of trust. Service science, like biology, must ultimately explain the origins and evolutionary paths that lead to today's service system ecology. Wright (2001) in "Non-Zero" provides an accessible version of the history of the evolution of human cooperation and win-win relationship formation. More recently, Beinhocker (2006) in "Origin of Wealth" provides an introduction to evolutionary economics, including a summary of the works of many scholars on the evolution of cooperation. Seabright (2005) in "The Company of Strangers" provides an exposition of the evolution of trust in early human groups (informal service systems), and explores the physical and cultural change in humans that bridge from nomadic hunter-gatherers to the rise of agriculture and early cities. In cities, division of labor reached new heights as population density increased, and communication and transportation costs dropped in what Hawley (1986) called the human ecology.

Division of labor. Adam Smith wrote about the wealth of nations as created by division-of-labor that can lead to an increase in productive capacity (Smith 1776/1904). Smith also wrote about the importance of markets ('markets' as the 'the invisible hand') for coordinating prices based on supply and demand. Ricardo, another early political economist, addressed the issue of optimal import-export strategies for nations to maximize individual and collective productive capacities by appropriately dividing production tasks between nations (Ricardo 1817/2004). Paradoxically, even when one nation can do everything 'better' (i.e., more productively, profitably) than another nation, as long as 'comparative advantages' exist (i.e., relative differences in productivity), then there is often a mathematical, and therefore economic and social, advantage to interactions and exchange. The implications of Ricardo's insight are profound and go well beyond the notion of division of labor.

Learning curves. The evolution of service system interactions in a population of service systems can be seen, in part, as each service system entity 'doing a little bit more of what they do best, a little bit less of what they do worse, and a little bit more interacting with not just complementary service systems ('specialization', 'division of labor,' 'opposites attract'). Diversity creates the conditions for coevolution and complementary improvements of service system entities. Learning or experience curves (Argote 2005) provide further and on-going mathematical advantage to interactions ('practice makes perfect').

Value-cocreation mechanisms. Barnard provides one of the early attempts by a business practitioner to outline a theory of "cooperative systems," including a discussion of formal and informal cooperative systems (Barnard 1938/1968). Richard Normann's (2001) "Reframing Business" is a more modern treatment of many of the same issues, more from a service networks and value propositions rather than an internal organization perspective, and outlines a framework for 'value creating systems' that are very close to our notion of service system entities and networks. Normann identifies three fundamental sources of value: new technological innovation, legal and regulatory changes, and reconfigurations of resources and value propositions from existing value creating systems. Alfred Chandler (1977) provides the historical account of the rise of industrial age business organizations ('managers' as the 'visible hand'). The creation of new roles in existing or new types of service systems often means that individual service systems (people) must step up to new levels of multitasking in their

measure service quality → productivity gains

lives. Milgrom & Robert (1992) in "Economics, Organization, and Management" provide a quite comprehensive view of the value (economic advantage) of alternative organizational and management forms.

Governance mechanisms. Williamson (1999) in "The Mechanisms of Governance" refines views on transaction costs and the new institutional economics that provide the foundations for empirical comparisons in context of alternative governance mechanisms. Williamson's notion of "incomplete contracting in its entirety" speaks to rational design attempts to safeguard against both opportunism and bounded rationality when creating value propositions (contracts) with others. In many ways, contract diversity is to service providers as product diversity is to manufacturers. North (2005) in "Understanding the Process of Economic Change" writes about the success of human attempts to gain some measure of control over the physical world with science and engineering, and the limited success of human attempts to control or even guide the evolution of economic growth through the creation of institutions (combined social, political, economic, legal, linguistic systems).

science = human control of world BUT Limited control in econ. growth (services, population, expertise)

Evolving perspectives on service. Bastiat (1848; 1850), a French political economist in the early 19th century, provided one of the first and most prescient analyses of value as service instead of value in things. With the exception of Bastiat, it is worth noting that most of the accounts above have focused on the growth of productive capacity through manufacturing activities (i.e., the production of things). Colin Clark (1957) in his seminal work "Conditions of Economic Growth" was the first to systematically document the dramatic growth of service activities in national value creation. William Baumol (2007) also drew attention to the growth of the service sector in the latter half of the 20th century, as a drag on the productivity gains of nations. Gadrey and Gallouj (2002) have drawn attention to the difficulty in measuring productivity and quality for service activities compared to manufacturing activities that lead to tangible output. Triplett & Bosworth (2004) provide a modern account of attempts to measure productivity gains in service industries, showing recent periods of time in the US economy where service productivity gains have actually outpaced gains in productivity in extractive and manufacturing sectors. Baumol (2002) has also written about the importance of R&D services ("the leader of the services") to counteract the so called *Baumol's Disease* (asymptotically static service productivity), and provide continuous improvement and even discontinuous jumps in service productivity.

b. Marketing: Customers and the Quality Measure

Marketing and the customer stakeholder. Marketing, as a function within a business firm, has the responsibility to understand the existing and (potential) future customers of that business. Analyzing the relationships and interactions with existing customers, understanding the quality of the customer experience, and working to communicate the appropriate image of the provider firm to attract new customers and improve the customer experience is part of the marketing function of the firm.

Service is different. Service marketing is different from product marketing according to a leading textbook on this subject (Zeithaml, Bitner, & Gremler, 2006). Traditional product marketing deals with the four P's of product, place, promotion, and price. However, service marketing adds three additional P's: people, physical evidence, and process, because in many service provisioning situations, the service employees and customers interact directly. The service experience in these cases of simultaneous production and consumption is determined by the people, the physical evidence where the interactions happen, and process that guides the customer-provider interactions. Of eleven challenges and questions for service marketers highlighted in this textbook (Pp. 24-25), three mention quality: How can service quality be defined and improved? How does the firm communicate the quality and value to the consumer?

How can the organization ensure the delivery of consistent quality service?

Case studies are a common tool in textbooks and business books in the service marketing, relationship marketing, and customer lifetime value areas (Lovelock & Gummesson 2004, Rust et al 2000). These books provide methods for pricing services, communicating service value propositions (including by word of mouth from satisfied customers), recovering from service failure, estimating customer lifetime value, demand forecasting, segmenting markets, using CRM (customer relationships management) technology and systems effectively in organizations, and many other topics related to demand innovation and revenue growth from customers.

Measuring quality. Zeithaml, Bitner, & Gremler (2006) advance the Customer Quality Gaps Model as a way to understand the factors that contribute to service quality. Ben Schneider (Schneider and Bowen 1995, Schneider, & White 2003) has performed a number of empirical studies that show service quality levels inside the firm (as rated by employees) are reflected outside the firm in the experience of quality (as rated by customers). This finding is often used to emphasize the importance of business culture and cultural factors when implementing quality improvement initiatives (Moulton Reger 2006). Pine & Gilmore (1999) and Chase (Chase, Jacobs, & Aquilano, 2004) provide simple formula that help reason about improving quality measures. For example, Pine & Gilmore suggest two rules of thumb for estimating customer satisfaction (what customer expect to get – what customer perceives he gets) and customer sacrifice (what customer wants exactly - what customer settles for).

Quality in B2C and B2B interactions. In B2C service interactions, quality of service is often both a major focus of employee selection and training, as well as an 'unconditional guarantee' made to customers as part of the value proposition used to attract and retain customers. Customer lifetime value is part of the calculation of how "generous" failure recovery offers can be, and still remain profitable over the expected lifetime of the relationship. In B2B and IT-enabled service provisioning, contracts may explicitly call out Service Level Agreements (SLAs) with specific objective measures and penalty clauses in case the SLAs are violated.

c. Operations: Providers and the Productivity Measure

Operations and the provider stakeholder. A leading Operations Management textbook (Chase, Jacobs, & Aquilano, 2004, Pp 6-7) states: *"Operations Management (OM) is defined as the design, operation, and improvement of the systems that create and deliver the firm's primary products and services … while operations managers use decision-making tools of OR/MS (such as critical path scheduling) and are concerned with many of the same issues as IE (such as factory automation), OM's distinct management role distinguishes it from these other disciplines."*

Service is different. Scott Sampson's (2001) "Unified Theory of Services" extends Chase's customer-interaction model of service production processes as distinct from traditional manufacturing production processes. Sampson is advancing a view of service operations as a distinct scientific field (Sampson & Frohle, 2006). The vocabulary of operations and operations management centers on the concept of *process*. The history of operations is primarily associated with the industrial revolution (processes with standard parts and economics of scale) and the rise of scientific management (processes with routine and repetitive human performance). More recently operations has sought an appropriate balancing between investments aimed at optimizing a process (queuing theory to eliminate waiting and inventory bottlenecks) and those aimed at maintaining an increasing flexibility of a process (capacity and demand matching, agility for rapid change). A good overview of these perspectives on operations, including some basics of the human element in processes, is provided in the book "Factory Physics" by Hopp & Spearman (1996).

Fitzsimmons & Fitzsimmons (2007) is the author of one of top selling service operations textbooks, "Service Management: Operations, Strategy, and Information Technology." While originally primarily focused on B2C service activities, recent editions have expanded the B2B and IT-delivered service sections.

Measuring productivity. Productivity, broadly defined, is a ratio of output to input from the provider stakeholder perspective. Productivity is a relative measure, typically used to compare a previous time period to a current time period to get a sense of either efficiency gains (reducing costs of inputs) or revenue gains (increasing demand for and hence value of outputs). Partial productivity measures, measure output to labor or output to capital or output to energy. Multifactor productivity measures, measure output in relation to the sum of a set of input factors. Total productivity measures combine all outputs and all inputs. In operations the emphasis is on efficiency while doing things at the lowest possible cost. The tradeoff most commonly perceived is not to lower the quality of the output of a process as the cost of performing the process is reduced – in fact, ideally the quality should increase as the cost is reduced. The standardization of processes by removing waste (Lean methods), removing variance (Six Sigma method), and then automating to achieve superior quality at the lowest cost is a typical operations worldview approach. Increasingly, operations add a final step of global sourcing (see subsection ***i***) to obtain the lowest cost labor resources required to operate the process. Pigou's Paradox demonstrates that the productive capacity of a system can be increased by adding a simple law to a service system with appropriate governance mechanisms (see subsection ***d***), while adding an advanced technology (i.e., zero cost network linkages) to the same service system could decrease the productivity capacity (Roughgarden 2005).

Back stage and front stage processes. Operations as a function of the firm seeks to understand provider processes and productivity, both those that do not directly involve the customer (back stage processes) and those that directly involve the customer (front stage processes). By understanding the value providers derive from a process as well as the value that customers derive from a process, appropriate operations techniques can be used to reconfigure activities, information, risk, etc. between people and technology, between organizations, and between employees and customers to improve productivity and quality of experience (Womack & Jones 2005). By segmenting types of processes into *front-stage* and *back-stage* processes, appropriate techniques can be used to optimize productivity as well as improve flexible responsiveness (Levitt 1976; Teboul 2006). By decomposing processes into reconfigurable components, service activities can be industrialized as technological capabilities advance to improve quality and economies of scale (Levitt 1976, Quinn & Paquette, 1990).

Industrial engineering compared to service science. The easiest way to appreciate the difference is to compare Hopp & Spearman's "Factory Physics" to Fitzsimmons' "Service Management." The key difference is the focus shift from factory systems, products, and processes to service systems, value, and interactions. That is, from systems governed by physical laws to systems governed by human-made laws.

d. Governance: Authorities and the Compliance Measure

Governance and the authority stakeholder. Political science, legal theory, contract law, all relate to governance. Principal-agent theory in economics also relates to governance (Roberts, 2004). Management mechanisms and administrative science are associated with top down control of resources in a hierarchy, while governance mechanisms are associated with agents or organizations (service system entities in our vocabulary) interacting in the context of markets, organizations, and institutions, and preferring the efficiency and freedoms associated with self governance wherever possible. Williams (1999) in "The Mechanisms of Governance" provides theoretical and empirical investigations of al-

ternative governance mechanisms. Computer scientists, mathematicians, game theorists, and economist have also worked to create the area known as mechanism design. Mechanism design provides a formalization of the properties of different types of auction mechanisms as well as algorithms to repeatedly exchange resources among agents in a system.

Service is different. Violating the laws of physics is impossible; violating the laws of logic is folly; violating the laws of man is either criminal or an innovation (e.g. "Declaration of Independence"). While service system interactions (normatively) are proposals to cocreate-value via win-win value propositions, many things can go wrong. For example, even if the value proposition succeeds, third-party stakeholders (victims) can step forward with grievances and claims against the primary stakeholders (providers-customers). Also, stakeholders known as criminals may act in the role of customer or provider with the intention to deceive and act opportunistically, thus they seek a win-lose outcome. Stakeholders known as authorities may act to bring criminals to justice, and legitimately use coercive capabilities to realize value propositions between authorities and citizens. The ISPAR model of service system interactions provides a description of the ten most common outcomes of service system interactions (Spohrer, Vargo, Maglio, & Caswell, 2008).

Measuring compliance. The overall level of regulatory compliance and the cost of maintaining or improving those levels vary considerably among the many nations around the world. Regulatory compliance is a factor in the transaction costs associated with doing business in different regions of the world (or even districts in a single city). For example, see the Rule of Law Index described in (Kaufmann, Kraay, & Mastruzzi, 2003). The Federalist Papers provide an example of a famous historical effort to design and advocate for a particular form of self governance – which led to the United States.

One measure of the success of a governance structure is its ability to align incentives and overcome opportunism. Langlois & Robertson (1995) in "Firms, Markets, and Economic Change" provide a dynamic theory of the boundaries of the firm that complements much of the work by Coase, North, and Williamson on transaction costs, new institutional economics, and governance structures.

100% compliance may not be optimal. The service systems worldview does not make the assumption that 100% win-win interactions are optimal. An ecology of interacting service systems with 100% win-win interactions could be achieved with 100% compliant service systems. For example, if people were as predictable as technological components in their performance, then success rates approaching 100% might be possible. However, in the case of 100% compliance, the ecology of service systems might not be very innovative.

Risk, rewards, and learning rates. Noncompliance may be risky. John Adams (2000), the UK scholar, in his recent book "Risk" describes the way in which people self-govern risk levels to balance risk and reward. By accepting some amount of risk, service system entities (people, businesses, nations) are able to take actions in a much wider range of situations and learn more rapidly than otherwise might be possible. Adams also describes four models of rationality that describe alternative worldviews about risk taking behavior in society. Systems that tolerate risk taking can also (under certain assumptions) be demonstrated to convert *unknown unknowns* to *known unknowns* and sometimes to *known knowns* to improve future performance. Governance, compliance, risk, trust, privacy, fairness, and learning are all interrelated. Governance mechanisms can also be designed to adjust the learning rates of service system entities in service system ecologies with many unknowns and dynamic properties. For example, the prime interest rate acts as a single parameter related to the cost of capital and is used by the chairman of U.S. Federal Reserve Bank to curb inflationary tendencies (raise interest rate) or curb recessionary tendencies (lower interest rate). Investing in R&D and innovation (risk taking) in an economy tends

to diminish when the prime rate is high, and increase when the prime rate is lower.

e. *Design: Competitors and the Sustainable Innovation Measure*

Design and the competitor stakeholder. Alternative designs compete. Unlike evolutionary change, design relates to conscious exploration of possibilities (changing resource configurations), while remaining sensitive to subjective and objective human response (changing experiences). Hunt (2000) in "A General Theory of Competition" outlines resource advantage theory, and warns that reducing competition in national economic systems has resulted in decreased innovation capacity over time. The design of new products, interfaces, processes, spaces, and systems are all related, but different. For example, the boundaries of a design task are often determined by considerations of who are the people involved: Are the people involved users of physical products? Are they users of information interfaces? Are they participants in a process? Are they participants in using a physical or virtual space? Or are they stakeholder/roleholders in a system with rights and responsibilities? What is the likely duration of the lifecycle of the product, interface, process, space, or system? Design is a conscious change that will compete with an alternative design, and may win or lose for reasons that are subjective, not objective.

Service is different. Gustafsson & Johnson (2003) in "Competing in a Service Economy: How to Create Competitive Advantage Through Service Development and Innovation" state *"As an executive, your job is to set a service strategy and enable your people to both innovate and continuously improve your services."* They outline a progression from product value, to service value, to solution value, to experience value.

Measuring sustainable innovation. Innovation is a measure of value created for populations. Innovation in a service system ecology (multiple populations of interacting types of service system entities) is a relative measure of the value-cocreation increase both short-term and long-term (sustainability). Standard examples of service system innovation include: (1) a loyalty program for an airline, (2) a self-service system at a bank (ATMs), airport (tickets), or retail outlet (checkout scanning), (3) creating a financial services offering, (4) creating a new franchise model, (5) creating a new type of business or organizational structure, (6) specializing and streamlining a medical procedure to expand the number of patients that can afford and hence seek treatment, etc.

Experience design. Experience design is often seen as a balancing act. Csikszentmihalyi (1990) in "Flow" describes the design of optimal experience as balancing anxiety (too much challenge, and not enough skill) with boredom (not enough challenge, and too much unutilized skill). Csikszentmihalyi also describes the balancing act between differentiation (more unique individual experiences) and integration (more standardized collective experiences). Pine & Gilmore (1999) in "The Experience Economy" provide a perspective on economic evolution from commodities to goods to services to experience and then to transformations, as balancing more customization (customer satisfaction) with commoditization (customer sacrifice).

f. Anthropology: Privileged Access and People Resources

Anthropology and the people resource. Anthropology is the discipline that is concerned with the study of humanity – all people across all places, times, and dimensions of analysis. The "four fields" approach to anthropology encompasses physical anthropology (based on physical data of biological and human evolution), archeology (based on physical artifacts and environmental data), cultural anthropology or social anthropology (based on data of past and present organized groups of people who share learning contexts or culture), and linguistics (based on language data). It is worth noting the rough correspondence between the "four fields" and the four fundamental categories of

resources in service science (people, technology, organizations, and shared information).

Service is different. Dawson (2004) in "Developing Knowledge-based Client Relationships: Leadership in Professional Services" states that it is important to remember that ultimately knowledge and relationships are about people. He identifies seven drivers shaping the evolution of the professional services industries: client sophistication, governance, connectivity, transparency, modularization, globalization, and commoditization. One of four strategies for dealing with commoditization of knowledge proposed by Dawson is to automate ahead of the competition. This shifts the knowledge value from the people who deliver the professional service to the people who deliver the technology, and the people and systems that keep the necessary dynamic information and content up to date. One important knowledge value information flow in service systems is from frontline people who deliver service to customers to technology people who automate and operate/maintain technology systems to deliver the related service to customers. Ensuring the sustainability of this type of information flow over time is a requirement of sustainable innovation in most professional service firms.

Privileged access. People are special. They have unique and privileged access to their own thoughts. Also, kinship relations and historical facts are unique for individuals. Important properties of people as individual service systems include: they have finite lifecycles (e.g., time is a limited resource), identities (e.g., stakeholders and roleholders in many service systems with associated histories and future expectations), legal rights and responsibilities (e.g., ownership of property or assets, authority to perform certain acts, and this varies over the lifecycle from child to adult), perform multitasking as a way to increase individual productive output in a finite time, and engage in division-of-labor with others to increase collective productive output in finite time.

Life cycles. One view of service science is that it is the emerging theory of the lifecycles of resources (people, technology, shared information and organizations) as they are dynamically configured into service systems that interact via value propositions to cocreate-value (as mutually measured or judged by various stakeholders; "mutually" meaning they can reason about each other's reasoning processes – or step into each other's shoes temporarily). The value of knowledge, which is sometime thought of as embedded in resources, changes over their life cycles depending on the context of use (Boisot 1995).

g. Engineering: Owned Outright and Technological/Environmental Resources

Engineering and physical resources. Fundamentally, engineering is concerned with the translation of knowledge to value, by manifesting the knowledge in some physical and useful form. Engineering approaches have been broadly applied to areas relevant to service science, including industrial and systems engineering, industrialization of services, engineering economics (Woods & Degarmo, 1953/1959; Park 2004; Newman, Lavelle, & Eschenbach, 2003; Sepulveda, Souder, & Gottfried, 1984), activity-based costing (ABC), incentive engineering, human performance engineering (Gilbert 2007), financial engineering (Neftci 2004), process engineering and statistical process control, product engineering, document engineering (Glushko & McGrath 2005), and of course service engineering (Ganz 2006; Spath 2007; Mandelbaum and Zeltyn, 2008).

Service is different. Engineering problems are solved in order to create solutions that help realize a value proposition between service systems. Engineering of sustainable service systems seeks to economize on scarce resources (individual people's time, attention, and capital as well as environmental resources, societal and business resources, etc.). Engineering in close collaboration with their underlying science areas also seeks to create new abundant resources and infrastructures that can enable the translation of desired possibilities into reality.

Owned outright. Physical property can be owned outright. Since property does not have rights, it can be completely controlled at the whim of the owner. A good general introduction to the role of engineering in modern society is Beniger's (1986) "The Control Revolution: Technological and Economic Origins of the Information Society." North (2005) wrote about gaining control and predictability in economic systems by using knowledge to remove uncertainty first from physical systems and then social systems.

h. Computing: Shared Access and Information Resources

Computing and information resources. The area of services computing and web services (Zhang 2007) is one of the most fundamental of the emerging disciplines relevant to the design and engineering of scalable and sustainable service systems. Marks & Bell (2006) in "Service-Oriented Architecture: A Planning and Implementation Guide for Business and Technology" wrote that *"Many organizations wrestle with the semantic and linguistic barriers between the business community and the IT community... SOA offers the potential to create a unified language of business based on a unit of analysis known as a service."* As businesses embrace SOA, a service system worldview is catching on slowly, and both business practitioners and IT specialist have begun to converge on a common service-oriented language. Checkland & Howell (1998/2005) developed the notion that all information systems are in fact service systems: *"A consequence of the nature of the process, in which intentions are formed and purposeful action is undertaken by people who are supported by information, is that 'information system' has to be seen as a service system: one which serves those taking the action."*

Service is different. A key trend in service interactions is self-service. The provider that had empowered employees with a special information infrastructure opens up that infrastructure to sophisticated customers who engage in self-service interactions. Honebein & Cammarano (2005) in "Creating Do-It-Yourself Customers" examine this trend, starting with the rise of the sophisticated customer.

Shared access. The internet and world-wide-web have greatly expanded the shared information in the world. Effective customer-provider interactions are based on shared access to information. Value propositions (one type of shared information) can be communicated (a proposal), agreed to (a promise or contract), and realized (an event or assurance of a future event). The value of shared information is central to all service system entities. Information is used to update models of all stakeholders (customers, providers, authority, competitors) in the world (*world model fidelity*), which is essential to creating new value propositions, realizing value propositions that are part of existing relationships, as well as fairly and transparently resolving disputes. Customers 'own' the knowledge assets related to the problems they need solved. Providers 'own' the knowledge assets related to the capabilities that can be brought to bear to solve those problems. However, without somehow sharing the information, it is of little value. Castells (2004) in "The Network Society" describes *"A network society is a society whose social structure is made of networks powered by microelectronics-based information and communication technologies."*

Money as shared information. In the service system worldview, money and capital are primarily information (for example, see "The Shape of Actions: What Humans and Machines Can Do" by Collins & Kusch (1999)). The growth of on-line or virtual worlds with artificial currencies, makes the notion of "money as information" even more apparent. The connection between information accumulation and culture is a strong one (see the definition of culture and its relation to information in "Not By Genes Alone" by Richardson & Boyd (2005)).

i. Sourcing: Leasing/Contracts and Organization Resources

Sourcing and organizations as resources. Sourcing is also known as the discipline of procurement. Scott (1981/2003) in "Organizations: Rational, Natural, and Open Systems" observed that *"Today's organizations are vigorously pursuing a strategy of externalization, outsourcing functions and relying on alliances or contracts for essential goods and services..."* A single person can run a sole-proprietorship business, and so an organization can consist of a single individual. Clearly, a lot of functions would be outsourced in this situation. However, while most individual people are not considered organizations, all people are considered to be a service system. So 'service system' is a more general concept than 'organization,' as service system includes people, open source communities, and markets, as well as all organizations.

Moving beyond outsourcing, some authors and practitioners have begun talking about the notion of multisourcing (Cohen & Young, 2006): "*The disciplined provisioning and blending of business and IT services from the optimal set of internal and external providers in the pursuit of business goals."* Building a sourcing strategy requires a deep understanding of the short-term and long-term nature of the need for custom or standard, business outcome driven (value) or operational outcome driven (cost) service for every component of a business and service value network of partners.

Service is different. While oil and iron ore may only exist in specific geographies, people exist everywhere. Sourcing can redistributes jobs and expertise on a global scale. Friedman (2005) in "The World is Flat" fueled the growing concern that expertise, hence services, can be sourced from anywhere. These concerns have lead to the US report "Rising above the Gathering Storm" (COSEPUP, 2007) which provides recommendations for US policy aimed at ensuring a strong high-skill innovation economy in the US.

Leasing/Contracts. Access to resource via leasing and other types of contracts. The fundamental generalization of make-buy from early manufacturing is the concern in sourcing. Sourcing creates more interdependence and less independence.

Organizational intelligence. March (1999) in "The Pursuit of Organizational Intelligence" wrote *"Organizations pursue intelligence... In particular, organizations (like other adaptive systems) are plagued by the difficulty of balancing exploration and exploitation. By exploration is meant such things as search, discovery, novelty, and innovation. It involves variation, risk taking, and experimentation. It commonly leads to disasters but occasionally leads to important new directions and discoveries. By exploitation is meant refinement, routinization, production, and implementation of knowledge. It involves choice, efficiency, selection, and reliability. It usually leads to improvement but often is blind to major redirections."* This is a very fundamental observation. Organizations, and in general service system entities, are dynamic configurations of resources in a constant process of change. However, to continue to exist that organizational change must balance two types of activities – exploration and exploitation – in order to both exist in and adapt to a changing environment. This balance is not unlike the balance that individual people seek in optimal learning, in which too much challenge can lead to anxiety and too little challenge can lead to boredom. Balance is the key to sustainable change.

Open innovation and boundaries of the firm. Historically in large firms, common perceptions were that (1) internal sourcing (central R&D) is best to create innovations, and (2) external sourcing (partnership) is best for cost reductions and industry standardizations. However, open innovation models (Chesbrough 2006) may challenge the former perspective, and increasingly standardized approaches to leaning and automating processes may challenge the latter perspective. Moore (2005) in his book "Dealing with Darwin" states that *"The formula for tackling innovation and overcoming inertia in tandem is simple: Extract resources from context and repurpose them for core."* What is

context (can be outsourced) and what is core (should not be outsourced) changes over time, and must be constantly reassessed and is at the heart of business discipline.

j. Futures: Strategic Investment & Management

Strategy. Learning from the future is akin to what chess experts do when they 'look ahead' to possible worlds, and then invest their efforts in trying to realize the possible worlds that are more favorable to their ambitions. The challenge is to understand the likely responses of others. Nevertheless, strategy can be viewed as the art of learning from possible futures. Management then seeks to make wise investments to realize favorable possible futures.

Servitization strategy. Many enterprises which had successes in product development and manufacturing processes are facing growth pressures, and are seeking new revenue models through innovation and *servitization*. For example, this led to Toyota to declare itself a "service company". Servitization includes strategies of providing *customer solutions* combining products and service options with active customer and community participation in creating value. The impact of these actions is dramatic in some industries.

Investment. A key responsibility of management is to provide strategic direction to the firm, and allocate resources and investment wisely to ensure the future of the firm. Fitzsimmons & Fitzsimmons (2008) in "Service Management" provide an overview of the types of operational and strategic investment decisions typical of service firms, including mergers and acquisitions, divestitures, shifting to a franchise business model, etc. Mendelson & Ziegler (1999) in "Survival of the Smartest" identify the five characteristics (external information awareness, effective decision architecture, internal knowledge dissemination, organizational focus, and information age business network) of High-IQ versus Low-IQ companies, and show a correlation with superior growth rate for High-IQ companies..

Management. Management of information systems (MIS), project management (PM), innovation and management of technology (IMOT), operations management (OM), financial management (FM), supply chain management (SCM), enterprise resource management (ERP), customer relation management (CRM), human resource management (HRM), intellectual property management, contract management (CM), risk management, as well as strategy and organizational change management (S&OCM) are well developed fields of knowledge related to improving decision making and the performance of complex business and societal systems.

PROFESSIONS AND COMPLEX COMMUNICATIONS

Before students choose to study service science, they will surely ask about future jobs and professions. Is this a good career choice? Yes, from the perspective of flexibility. Service scientists must possess complex communication skills (interactional expertise) across multiple academic disciplines and areas of practice. Entrepreneurs and business consultants are in high demand, but it has been difficult to specify curriculum beyond exposure to technology change and management practice. SSMED offers a new opportunity to create curriculum relevant to those who aspire to entrepreneurship and business consulting. Scientists and engineers are also in high demand, but demand constantly shifts to new areas. We expect more students who aspire to be system scientists and system engineers will seek a solid understanding of service science for many different career paths in academics, government, and business.

Entrepreneurs, Business Consultants, and Mindset

Entrepreneurs. Entrepreneurial capitalism (Baumol, Litan, Schramm, 2007) is "a type of capitalism where entrepreneurs, who continue to provide radical ideas that meet the test of

the marketplace, play a central role in the system." The rise of entrepreneurial capitalism is a relatively recent phenomenon fueled in part by increasing global wealth. Simultaneously, more and more students aspire to have their own business. Student surveys at a number of universities indicate the growing importance of flexibility and personal growth, as well as open career paths, behind their interest in entrepreneurship.

Business Consultants. According to the US Bureau of Labor Statistics job growth will be strongest in business and professional services, even stronger than growth in healthcare, which is second strongest. Business consulting, which relates to global supply chains, organizational change, information technology-driven business transformation, mergers and acquisitions, as well as divestitures, are high demand areas. McKenna (2006) in "The World's Newest Profession: Management Consulting in the Twentieth Century." speaks to the cyclic focus on creating a more technical and advanced tool-based form of consulting. Service science seeks to provide the foundation for the growing technical and systematic approaches to consulting.

Mindset. A service mindset is based in part on empathy for customers, as well as a sense of empowerment that comes from understanding how things are likely to change in the future. Understanding the life time value of a customer is essential, and responding in ways that have the potential to scale beyond the customer to create whole new markets. A successful service mindset, like successful entrepreneurship, comes from creating new markets. Berry (1995) states, "Great service is a matter of mentality. The quest to improve is unrelenting; ideas are part of the job; the spirit of entrepreneurship is strong." (Pg. 16).

Service System Design Lab Network: Beyond lectures and textbooks, to help ensure that students gain practical experience from realistic assignments, service science laboratories (also known as service systems design lab networks) are being envisioned by a number of academics (Kwan & Freund 2007). The goals of service system labs include: support of service science curriculum and research; engage industry and government partners; develop and disseminate service science curriculum materials; create collaborative opportunities among universities involved in the service science initiative; establish an entrepreneurial service mindset in students based on empathy for customers, and a sense of empowerment that can lead to establishing new markets. Service system design lab networks will connect academics, government, and business around challenge-based, project-based instruction aimed at real world, virtual world, and simulated world solutions to service system and value proposition design challenges.

Scientists, Engineers, and Leadership

System scientists. John Sterman (2000) in "Business Dynamics: Systems Thinking for a Complex World" wrote: *"The dizzying effects of accelerating change are not new. Henry Adams, a perceptive observer of the great changes wrought by the industrial revolution, formulated the Law of Acceleration to describe the exponential growth of technology, production, and population... A steady stream of philosophers, scientists, and management gurus have since echoed Adams, lamenting the acceleration and calling for similar leaps to fundamental new ways of thinking and acting. Many advocate the development of systems thinking – the ability to see the world as a complex system, in which we understand that 'you can't just do one thing' and that 'everything is connected to everything else.'"* Sterman then goes on to develop vocabulary, tools, and examples to enable systems thinking. Fortunately for our efforts, many of his examples are examples of complex service systems. Sterman contrasts the event-oriented view of the world and its vocabulary (goals + situation, problem, decision, results) with the feedback (double loop learning) view of the world and its vocabulary (real world, information feedback, decisions, mental models, strategy, structure, decision

rules). He goes on to identify the impediments to learning that make even the feedback view of the world problematic for dealing with the dynamic complexity of the real world. He concludes, and we agree, that simulations are an essential tool for professionals who want to approach systems thinking rigorously and seriously. Sawyer (2005) in "Social Emergence: Societies as Complex Systems" describes third wave systems theory and ever growing importance of simulations tools for thinking about emergence in complex societal systems.

Weinberg (1975/2001) in his classic "An Introduction to General Systems Theory" provides a distillation of many concepts from system theorists such as von Bertalanffy (1976) and many others. While general systems theorists seek to understand the general principles that underlie all systems (physical, chemical, biological, computational, social, etc.), service science aims to be descriptive, explanatory, and predictive of business and societal evolution. Within this more limited context of complex service systems, Wright (2001) in "Non-Zero: History, Evolution, Human Cooperation" provides insights into systems that establish and evolve win-win value propositions. Buchanan (2001) in "Ubiquity: The Science of History" and more recently in his (2007) "The Social Atom" provides insights into the path-dependent evolution of complex systems where, to understand the evolution, the properties of the parts are less important than organization of those parts.

System engineers. Bell Laboratories provided the foundational work for both systems engineering and stochastic service system analysis almost a half century ago. Hall (1962) in "A Methodology for Systems Engineers" laid the foundation for the field of system engineering. Riordin (1962) in "Stochastic Service Systems" drew on and then extended queuing theory for what he argued where more general types of service systems.

Science challenge: Confidential data. The best science depends on improved measurement and access to data. Businesses are service system entities, so much of the data that would inform service science are considered proprietary and hence not easily shared. For example, details of successful and unsuccessful contract negotiations and executions would be of enormous value in understanding learning curves for service interactions. However, most business would be reluctant to share the details of successful, much less, unsuccessful contracting attempts. One implication is that developments in service science will likely be much more dependent on simulated data as a result. The properties of simulated worlds will be more transparent and repeatable, and allow cumulative progress that might not otherwise be possible. As techniques for modeling and measuring simulated ecologies of service systems advance, these efforts may someday lead to the equivalent of a CAD (computer-aided design) tool for service system design and engineering. Ultimately, service scientists will have deep competence in using service system simulations tools.

Engineering challenge: Patent incentives. The best engineers create a lot of patents. This is personally motivating to the engineers, and highly beneficial to their employers. Just as many business method and software patents are challenged on the grounds of "technicity" (technical contribution - this area is already a major difference between US and EU patent law), the invention of new types of service systems entities, value-cocreation mechanisms, and governance mechanisms may be difficult or impossible to patent. Without the ability to patent inventions, a major incentive for innovation is removed. Nevertheless, the continuous innovation in this area may confer significant advantages to providers of service over their competitors, or even their own previous business approaches, and hence be a significant driver of investment. As the ability to design new service systems entities and networks (CAD for service) increases, along with the ability to drop them into simulation of existing ecologies, the technicity requirement may become easier to achieve, allowing innovative designs to become patentable.

National economic leadership. History provides evidence that emerging sciences and their associated engineering and management disciplines can provide the basis for national economic leadership. For example, Murmann (2006) describes the rise of chemistry in Germany in the 19th century, Bush (1945) foresaw the rise of computing in the US in the mid 20th century, and finally, the product quality and innovation management movements in Japan provides a more recent example. In these cases, the key to success was government, industry, and academic collaboration. Today, nanotechnology, biochemistry, computational biology, and service science offer the possibilities for such collaborations around emerging areas of science. However, of these four, only service science seeks to understand in general the complex sociotechnical dimensions of using new knowledge to enable new value creating systems. The full benefits of technological inventions cannot be realized without the development of new service system networks that carry the invention into the market. Understanding the science of service systems holds the potential to rapidly realize the value potential inherent in technological inventions, as well as to help prioritize which technological inventions might be poised to provide the most benefit to business and society.

SUMMARY

In sum, this article has attempted to provide an outline and set of preliminary references to better understand the emergence of Service Science, Management, Engineering, and Design (SSMED). Service science is at the beginning of the beginning, and a great deal of work remains to integrate across the disciplines. As a next step, we invite others to use the ten basic concepts to create a more integrated view of existing disciplines. Finally, we invite academics around the world to establish service system design lab networks in conjunction with practitioner partners from business, government, and non-profit agencies, and seek answers to the foundational questions in the context of specific service systems in which they live and work.

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Categorization of the References

Each of the references below has been given a primary mapping key number (1-14) as well as a list of secondary mapping key numbers (1-14) into each section of this article. The 15th category number indicates a "must read reference." We hope to encourage this *interdisciplinary service science reference categorization* to stimulate important connections in the emerging service science community.

1. service science researchers and students of service
2. service science practitioners and other practitioners
3. economists, historians, mathematicians
4. marketing professionals
5. operations professionals
6. political scientist, legal professionals
7. designers, artists, innovators
8. social scientists, anthropologists, cognitive scientists
9. engineers, technologists
10. computer scientists, linguists
11. organization theorists, procurement specialists
12. managers, investors, strategists, mathematicians
13. entrepreneurs, professors, lab instructors
14. systems theorists, leaders, general scientists

For example, consider the reference to the book that is of primary interest to economists (3), as well as organization theorists (11) and managers (12):

Milgrom, P. & Roberts, J. (1992) *Economics, Organization, and Management*. Upper Saddle River, NJ: Prentice Hall. [3 (11 12)]

An online version of all references (with quotations) is maintained at: http://www.cob.sjsu.edu/ssme/refmenu.asp

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ENDNOTES

1 An earlier version of this paper containing quotations accompanying the extensive set of references will appear in (Spohrer & Kwan 2008).

2 See URL http://www.ilo.org/public/english/region/asro/bangkok/public/releases/yr2007/pr07_02sa.htm.

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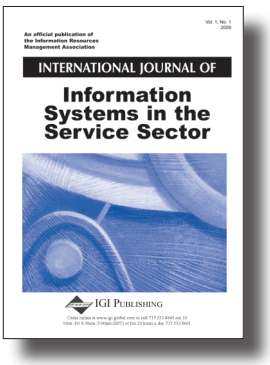

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