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A Brief Review of Systems Theories and Their Managerial Applications

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Introduction

Since Aristotle's claim that knowledge is derived from the understanding of the whole and not that of the single parts (Aristotle's Holism), researchers have been struggling with systems and parts in terms of their contents and their relative dynamics. This historic effort evolved during the last century into so-called "systems theory" (Bogdanov, 1922, 1980; von Bertalanffy, 1968, Lazlo, 1996; Meadows, 2008).

Systems theory is an interdisciplinary theory about every system in nature, in society and in many scientific domains as well as a framework with which we can investigate phenomena from a holistic approach (Capra, 1997). Systems thinking comes from the *shift in attention from the part to the whole* (Checkland, 1997; Weinberg, 2001; Jackson, 2003), considering the observed reality as an integrated and interacting *unicuum* of phenomena where the individual properties of the single parts become indistinct. In contrast, the relationships between the parts themselves and the events they produce through their interaction become much more important, with the result that "*system elements are rationally connected*" (Luhmann, 1990) towards a shared purpose (Golinelli, 2009). The systemic perspective argues that we are not able to fully comprehend a phenomenon simply by breaking it up into elementary parts and then reforming it; we instead need to apply a global vision to underline its functioning. Although we can start from the analysis of the elementary components of a phenomenon, in order to fully comprehend the phenomenon in its entirety we have to observe it also from a higher level: a holistic perspective (von Bertalanffy, 1968).

Systems theory encompasses a wide field of research with different conceptualizations and areas of focus (e.g. Boulding, 1956; Maturana and Varela, 1975; Senge, 1990). Specifically, within management and marketing, a number of authors and scholars have adopted – implicitly or explicitly – a vision of organizations as systems with the aim of analyzing the relationship between organizations and their environment (e.g. Burns and Stalker, 1961; Lawrence and Lorsch, 1967; Aldrich, 1979).

The aim of this paper is to provide an overview of systems theories. In particular, focus is given to those that make a specific reference to management. We shall focus on:

a) A brief review on multidisciplinary systems theories,
b) The introduction of basic systems concepts,
c) The managerial applications of systems thinking.

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This commentary closes the special issue of the Journal of Service Science. The hope is to raise questions, observations and dilemmas in order to foster dialogue about the opportunities and limitations of applying systems theory in management studies and practices.

1. Systems. A Multidisciplinary Point of View

A system can be defined as an entity, which is a coherent whole (Ng, Maull and Yip, 2009) such that a boundary is perceived around it in order to distinguish internal and external elements and to identify input and output relating to and emerging from the entity. A systems theory is hence a theoretical perspective that analyzes a phenomenon seen as a whole and not as simply the sum of elementary parts. The focus is on the interactions and on the relationships between parts in order to understand an entity's organization, functioning and outcomes. This perspective implies a dialogue between holism and reductionism.

Systems can be found in nature, in science, in society, in an economic context, and within information systems. A distinctive characteristic of systems theories is that it developed simultaneously across various disciplines and that scholars working from a systems theory perspective build on the knowledge and concepts developed within other disciplines. Examples include natural and ecological sciences (organic aspects, homeostasis and equifinality; Hannan and Freeman, 1977), chemical and biological disciplines (autopoietic aspects; Maturana and Varela, 1975), sociology and psychology (cognitive aspects; Clark, 1993), and information technology (cybernetic aspects; Beer, 1975).

As a result, today we have several kinds of systems perspectives. There are service systems (from Service Science, Management, Engineering and Design - SSMED), viable systems (from Viable Systems Approach - VSA), smart systems (from systems thinking), reticular systems (from network theories), living systems (from natural sciences), economic systems (from economics), social systems (from sociology), institutional systems (from law), technological systems (from cybernetics), conceptual systems (from psychology), and ecosystems (from ecology). This plurality yielded a rich research stream with interdisciplinary contributions. It is possible to outline an evolution pattern for these theories, with newer theories that tried to overcome the limits of the previous ones. However, we should consider that, currently, different theories co-exist. Researchers applying systems theories should be aware that some of these theories may have conflicting elements and should be seen as alternative perspectives. Moreover, on adopting a specific systems approach every researcher should be aware of its epistemological position. Next we review the key systems approaches.

General Systems Theory (GST)

Von Bertalaffy (1956) defines a system as *a complex of interacting elements*. Von Bertalanffy fosters systems thinking in all disciplines in order to find general principles valid to all systems. It introduces "system" as a new scientific paradigm contrasting the analytical, mechanical paradigm, characterizing classical science (von Bertalanffy, 1950).

A fundamental notion of general systems theory is its focus on interactions. The center in relationships lead to sustain that the behavior of a single autonomous element is different from its behavior when the element interacts with other elements. Another core tenet is the distinction between open, closed and isolated systems. In open systems there are exchanges of energy, matter, people, and information with the external environment. In closed systems there are no exchanges of information and matter, just exchanges of energy. In isolated system there is no exchange of elements. Building on general systems theory many approaches developed. Among others there are open system theory, viable system model and viable system approach. *Open system theory (OST)* looks at the relationships between the organizations and the environment in which they are involved. This focus reflects on organizations' ability to adapt to changes in environmental conditions (with or without the need for information processing) (Boulding, 1956; Katz and Kahn, 1978). This theory assumes that entities able of processing information about own specific environment show more adaptation skills to shifts in contextual conditions. Two orders of adaptive levels are identified, both referring to the informative deviation: i) *counteraction* – first level (to process information from an organism's environment), related to the ability of steering through a personal purposive behavior (Ashby, 1958); ii) *amplification* – second level, related to constructivism theory (as opposed to realism) leading to work on self-organization (von Foerster, 1981). Katz and Kahn (1978) apply the concept of open system to the organization. The organization is seen as a system built by energetic input-output where the energy coming from the output reactivates the system. Emery and Trist (1960) address organizations as socio-technical systems, underlining the two main components of the firm seen as a system: a social component (people), and a technical component (technology and machines). *Viable System Model (VSM*), on the other hand, outlines a system as an

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entity that is adaptable for the purpose of surviving in its changing environment (Beer, 1972). The viable system is an abstracted cybernetic description that is applicable to autonomous organizations. Since cybernetics represents an interdisciplinary study of the structure of regulatory systems, it refers to the study of how actions by a system cause changes in the environment that are understood by the system itself in terms of feedback, allowing the adaptation of the system to new conditions. In other words, the system can change its behavior. In cybernetics, the system and the environment present different levels of complexity, as the environment has degrees of complexity that are not perceptible to the system (Golinelli et al, 2002; Barile, 2005). When applied to organizations viable system model focuses on conceptual tools for understanding the organization of systems in order to redesign them through: i) change management; ii) understanding the organization as an integrated whole; iii) evaluating the essential functions of implementation, coordination, control, intelligence and policy (Beer, 1972; Espejo and Harnden, 1989; Espejo, 1999; Christopher, 2007). Finally *Viable system approach* (VSA) suggests a new interpretation of consolidated strategic organizational and managerial models: sub-systems and supra-systems. Sub-systems focuses on the analysis of relationships among enterprises' internal components while supra-systems focus on the connections between enterprises and other influencing systemic entities in their context (Golinelli, 2000; Golinelli, 2005; Barile, 2006; Barile, 2008).

Cybernetics

The work by Beer (1972) gave a strong impulse to systems theory. The "viable systems model" outlines a system as an entity that is adaptable for the purpose of surviving in its changing environment. The viable system is an abstracted cybernetic description that is applicable to autonomous organizations. Since cybernetics represents an interdisciplinary study of the structure of regulatory systems, it refers to the study of how actions by a system cause changes in the environment that are understood by the system itself in terms of feedback, allowing the adaptation of the system to new conditions. In other words, the system can change its behavior. In cybernetics, the system and the environment present different levels of complexity, as the environment has degrees of complexity that are not perceptible to the system (Golinelli et al., 2002; Golinelli, 2008; Barile, 2006).

Organization

Katz and Kahn (1966) apply the concept of open system to the organization. The organization is seen as a system built by energetic input-output where the energy coming from the output reactivates the system. Social organizations are then open systems due to their material exchanges with the environment. Emery and Trist (1960) instead address organizations as socio-technical systems, underlining the two main components of the firm seen as a system: a social component (people), and a technical component (technology and machines).

Biology and Sociology

In the 1970s, an important contribution to systems theory came from a different set of new principles, i.e., auto-learning, auto-organization, and autopoiesis (Maturana and Varela, 1975). From this perspective, the system assumes an identity through differences between itself and the environment. It is able not only to organize the relationships between its parts but also to generate its own reproduction. The term *autopoiesis* explains the nature of living systems and shows the process of a system that produces "itself from itself". An autopoietic system is closed with reference to its organization, but it is not isolated, as it exchanges energy with the environment. It does not adapt itself to its environment, but the system and its environment co-evolve and co-determine themselves in a structural coupling (Beer, 1972). The concept of autopoiesis has also been applied to sociology (Luhmann, 1990), where a system is defined by a boundary between itself and its environment, dividing it from an infinitely complex exterior (Morin, 2001). The internal side of this system is represented by a zone of reduced complexity; communication within a system operates by selecting only a limited amount of all information available from the outside. This process is also called "reduction of complexity" and enables the concept of an auto-referential system, which encompasses studies about self-regulation, self-organization and autopoiesis. The *auto-referential* system tries to manage the complexity, and the opposition between open and closed systems is overcome. In this view, the system's closeness refers to the system's organization, to its identity and to the auto-referential as a mechanism of reproduction; on the other hand, the system's openness is linked to the system's capability to draw energy from the environment, expanding the concept of complexity and of the systems' interpretation and solving. Similarly, the *auto-learning* principle focuses on systems' retroactive effects, where the output becomes the input, thus producing forms of learning. Self-regulating systems are capable of learning. In this case the system performs a reflective knowledge function, interpreting the environment based on its own knowledge. Auto-organizing systems finalize their energies to organize themselves; they reduce internal entropy to increase external entropy (von Foerster, 1981).

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System Dynamics and Smart Systems

On the basis of the principles of self-regulation and self-organization, Stermann's studies (1994; 2000) focus on how people learn in and about complex dynamic systems, stressing learning as a feedback process.

> "Learning is a feedback process in which our decisions alter the real world, and receive information feedback about the work and revise the decisions we make and mental models that motivate those decisions, Unfortunately in the world of social action various impediments slow or prevent these learning feedbacks from functioning, allowing erroneous and harmful behaviors and beliefs to persist. The barriers to learning include the dynamic complexity of the systems themselves" (Stermann, 1994, p.291).

The concept of learning is central to smart systems, which may be intended to be entities designed for the wise and interactive management of assets and goals, capable of self-reconfiguration (or at least of easily induced re-configuration) in order to perform enduring behavior capable of satisfying all of the involved participants in time. The "smart" characteristics of systems affect both stages, as the front stage is the input ground that the systems need to monitor in order to detect key elements for self-adjustment and reconfiguration, whereas the back stage ought to be based upon models and tools capable of enabling operational changes and time efficiency. Systems are smart because they react through technology and seek the wise and intelligent use of involved resources; according to VSA proposals, smart systems' search for reactive, dynamic and intelligent IT-based service systems may well be considered a viable behavior capable of promoting long-lasting competitiveness and performance of the system itself (Barile, Polese, 2010b). A system's being smart is a fundamental concept of organism adaptation that includes the use of self-increasing knowledge (Rullani, 2009), trying to "hear" one's own contextual pattern, and continuously learning and gaining experiences from external events.

2. Some Systems' Basic Concepts

A system can be defined as an assemblage of objects united by some form of regular interaction or interdependence.

> "A system can be natural (e.g., lake) or built (e.g., government), physical (e.g., space shuttle) or conceptual (e.g., plan), closed (e.g., chemicals in a stationary, closed bottle) or open (e.g., tree), static (e.g., bridge) or dynamic (e.g., human). In regard to its elements, a system can be detailed in terms of its components, composed of people, processes and products; its attributes, composed of the input, process and output characteristics of each component; and its relationships, composed of interactions between components and characteristics" (Tien and Berg, 2003, pp.23-24).

The fundamental unit of analysis is 'a system' made up of many parts or structures (Parsons, 1965). From a systemic perspective, every system, at a certain level, is in relation with supra-systems and sub-systems. The former are hierarchically ordered as a function of their influence on the system; the latter ought to be directed and managed by the system in order to contribute to its finality (Barile, 2006, 2008). The introduction of these concepts challenges the question of system boundaries which, from this perspective, make little sense. As contact creates participation; a given system tends to absorb supra-systems and sub-systems (components) in order to develop as a whole system (Barile 2006, 2008).

The smallest system is a single unicellular organism; the largest one is represented by the universe. As discussed before, it is possible to consider a system to be "open" if it is able to exchange energy, matter and information with the environment. These exchanges lead to internal processes of transformation of elements such as homeostasis, self-regulation, equilibrium/balance, autopoiesis, equifinality/common finality:

- *Homeostasis* is based on information exchanges between the system and the external environment, and it allows the system to maintain a state of equilibrium over time (Hannan and Freeman, 1977);
- *Self-Regulation* is an adaptive mechanism that allows the system to keep itself under a balanced condition, within the limits of its structure and through information exchange with the outside world (Beer, 1975);
- *Equilibrium/Balance* represents the attitude and ability to provide an appropriate contribution to the needs of some or all supra-systems within the framework of reference systems (Beer, 1975);
- *Autopoiesis* is a self-organizing feature of systems that stimulate a selective mechanism to align the systems' internal complexity with the complex environment (Maturana and Varela, 1975);
- *Equifinality* is the principle that refers to open systems reaching the same end state, starting from conditions and/or taking different paths (Katz and Kahn, 1978);

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- *Common finality* is necessary for a system's survival and considers organizations as a set of parts interacting with each other, organized and managed to reach the same final goal (von Bertalanffy, 1962).

Within systems thinking, it is important to note the observer/observed relationship, highlighting how important the specific viewpoint is in interpreting organizational behavior. Behavioral aspects underline the importance of individuals in the performance of businesses (Polese, 2010), suggesting the need to look at social relationship dynamics, individual lifestyles, individual motivations, and individual conditions (Gatti, Biferali and Volpe, 2009). In short, the concept of a system is not connected with the notion of objectivity, but instead refers to a specific point of view and can vary from actor to actor; it strictly depends on the contextualized system's perception in time and space.

3. Systems Theory Applications in Management

In this section we provide some examples about how systems theory and systems thinking can be applied in management and marketing as well as to the concept of service systems engineering. We focus specifically on knowledge, value, quality, environment, relationships, adaptation, and complexity.

Knowledge
Under this vision, the firm is seen as a learning system and as having a set of skills and competences that enables it to produce its own knowledge. (Nonaka and Tacheucki, 1995) The firm is then a cognitive system establishing its existence, creating information and activating skills in order to produce knowledge through continuous leaning processes (Vicari, 1992). Knowledge is at the core of an autopoietic process of resource generation, creating resource-behavior-resource cycles where cognitive schemes allow the entire system to function. Senge (1990) analyzes how the systems method of thinking enables firms to become learning organizations. He looks at systems thinking, personal mastery, mental models, building shared vision, and team learning as the basis for the development of three core learning capabilities: fostering aspiration, developing reflective conversation, and understanding complexity to address value generation.

Value
From this approach the firm is seen as a holistic system, characterized by a high degree of integration between the factors intervening in the process of value creation (Grant, Shani and Krishnan, 1994). The firm's value can be expressed as the "potentiality of existence, development, evolution" (Vicari, 1992). Business value creation is related both to the sub-system (through quality management, R&D activities, internal auditing, feedback daily research, etc.) and to the supra-system (through cooperation logics and asset improvement in terms of technical, cognitive, relational and adaptive aspects) (Mele and Polese, 2010). For example, the systemic perspective allows one to move from the single firm to the entire supply chain (Mele, 2003) or network (Polese, 2004), involving many system actors (firms, individuals, districts, nations, customers, markets; Alter, 2008).

Quality
When discussing quality issues, it is necessary to focus on the link between TQM and *systems thinking* (Kim, 1990; Senge and Sterman, 1990; Kim and Burchill, 1992). In TQM, the systemic conception of the firm is strengthened by its emphasis on the importance of the relationships of the parts to the goal to be reached (Mele and Colurcio, 2006).

> "TQM is a learning system: Through TQM every size of unit, from individual to team to company to region and nation, can learn how to learn. TQM can be thought of a system for learning new skill for the benefit of society ….TQM as a system for developing individual, team, company and national skill" (Shiba, Graham and Walden, 1993, p. 534).

Environment
If the organization is the system at the micro level, then the environment is the system at the macro level. In the systems approach, the decision maker, by analyzing the structure of his own system and the structure of supra-systems, employs attenuating and amplifying actions of the kind needed for survival, thus modifying the borders between the system and the individual supra-systems (viability). Brownlie (1994) highlights two conceptualizations of the environment: the objective environment and the enacted environment. In the first case, "the construct 'environment' corresponds to some freestanding material entity that is independent of the observer, concrete, external and tangible" (p.144). On the other hand, scholars adopting the second approach reject the notion of an

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external objective reality; the environment is thought of as a "*mental representation embodied in a cognitive structure which is enacted in retrospect and fashioned out of the discrete experiences of managers*" (italics in original) (p.147). From this approach, organizations and environment are seen as labels for patterns of activities that are generated by human actions and their accompanying efforts to make sense out of these actions (Smircich and Stubbart, 1985). For scholars adopting this view, it is possible that different organizations within the 'same' environment will read different things into the same set of data about particular market conditions and circumstances. Within this second stream of literature, it is argued that the organization is embedded in a set of inter-organizational relationships (some stronger than others) with a set of stakeholders (Pfeffer and Salancik, 1978). In marketing, this view is adopted by the networks approach, which argues that companies are 'connected' and that they operate within a 'texture of interdependencies' (Hakansson and Snehota, 1995; Ford, 2002).

Relationships

According to the viable system model (Christopher, 2007), competitive firm behavior is strictly linked to the ability to identify and manage functions and relationships, thereby establishing communication channels, organizing information flow, and rationalizing and harmonizing a firm's development aligned with all external relationships. The governance of the viable organizations then has to address and direct the system towards a final goal by transforming static structural relationships into dynamic interactions with other viable systems. The ability to organize relationships delineates the efficiency of governmental action, which is a central characteristic of viable systems, contributing to the equilibrium of the system from one side and to the satisfaction of supra-systems' expectations from the other. For the organizations, it is fundamental to consider the compatibility between systemic actors *(consonance)* and to improve the effective harmonic interaction between them *(resonance)*. Consonance is linked to the concept of *relations*; it refers to a static vision and represents the potential harmonic relation. Resonance instead is related to dynamic aspect, the *interacting* between entities.

Adaptation

According to the viable systems approach (Barile and Polese, 2010a), any organization has to be able to preserve its viability and stability, creating its own internal environment that is able to respond effectively to external stimuli at all levels *(viability)*. Organizations are considered viable systems if they are able to survive in a particular context due to continual dynamic processes and several kinds of internal changes *(adaptation)*.

Complexity

Networked systems can be described based on three parameters: variety (possible variance that a phenomenon may present to the observer), variability (variety observed over time) and indeterminacy (the ability to fully understand a phenomenon) (Barile, 2009; Golinelli, 2010). Starting from these distinctions, it is possible to address the relative concept of *complexity*, which can be very useful in interpreting Service systems, since these are complex adaptive systems (Gell-Mann, 1994; Holland, 1999). They are *complex* in that they are diverse and made up of multiple interconnected network elements and *adaptive* in that they have the capacity to change and learn from experience.

4. Conclusions

This brief commentary was aimed at highlighting some elements of systems theories and their application in management and in marketing. Managers should become familiar with the concept of systems and the associated way of thinking. Managers have to plan structural adjustments to guarantee the survival of the whole system, constantly formulating new interpretations of the business scenarios in order to find an adequate positioning, implementing (when necessary) periods of adjustment, transformation and redefinition the organizational structure. This adaptive and proactive behavior should be based upon systems theory conceptual pillars in order to promote sustainable and long-lasting performance. Given real-world complexity, we strongly believe that systems theories and perspectives can effectively contribute to management, marketing and service research due to their dual approach: the global, holistic view of observed phenomena and the specific, reductionist view of their specific components and traits.

A good example of the suggested integration is found in service science. Service science aims to develop a theory of service based on systems. It is an integrative discipline of engineering, technology, management and other social sciences. Specifically, service science is the study of the creation of value within and among service systems, which are complex adaptive systems.

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