The European Proceedings of
Social & Behavioural Sciences
EpSBS

ISSN: 2357-1330

https://doi.org/10.15405/epsbs.2019.12.03.18

ICLTIBM 2017
7th International Conference on Leadership, Technology, Innovation and Business Management

FIRM INNOVATIVENESS FROM THE COMPLEX ADAPTIVE SYSTEMS THEORY PERSPECTIVE: A CONCEPTUAL FRAMEWORK

Halit Keskin (a), Ali Ekber Akgün (b), Tuba Etlioğlu (c)*
*Corresponding author

(a) Yildiz Technical University, Istanbul, Turkey
(b) Yildiz Technical University, Istanbul, Turkey
(c) Yildiz Technical University, Istanbul, Turkey, Email: tubae@yildiz.edu.tr

Abstract

Fierce competition and fast-growing technology in today's chaotic market environment, which result in fluctuating customer demands and expectations and shortening product and technology life cycles, force organizations to establish mechanisms providing them with the ability to adapt to the environment in which they operate. Complex Adaptive Systems (CAS), which explain the necessary conditions under which complex and dynamic behavior will occur in organizations organizations to develop their adaptive capabilities in general, and innovation and new product development capabilities in particular. Based on this, our conceptual paper aims to provide an insight into the organizational capabilities for sustainable innovation and new product development from the perspective of CAS theory. With this aim, we explain the mechanisms of CAS which are relevant with the new product development efforts in organizations, but rarely have been empirically proved to leverage adaptive capabilities of organizations by previous research in the innovation and new product development literature.

Keywords: Complexity theory, Complex Adaptive Systems (CAS), CAS dynamics, CAS mechanisms, innovation.

https://doi.org/10.15405/epsbs.2019.12.03.18
Corresponding Author: Tuba Etlioğlu
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

1. Introduction

Complexity theory, which has extensively found place in natural sciences as a research stream, also has attracted many researchers and practitioners in social sciences. There is a considerable number of research based on complexity theory in a wide range of areas in social sciences, from public administration to education and health care and service delivery (Bryne & Callaghan, 2013). Organizational research based on CAS theory has a relatively recent history. After 1960s, with the expansion of open system approach, organizational researchers brought a "complexity" lens into their studies and complexity has been viewed as a "structural variable that characterizes both organizations and their environments" by organizational theorists (Anderson, 1999).

Unpredictable market conditions, resulting from fast-developing technology and ever-changing customer demands and expectations, force firms to adapt themselves to their external environment. Adaptation to rapidly changing market conditions requires firms to improve their innovation and new product development capabilities. CAS theory helps us to understand the dynamic mechanisms (e.g. behaviors, processes, and practices) fostering organizational capabilities for innovation.

Organizational studies in the framework of CAS theory mostly concentrate on leadership context (Schneider & Somers, 2006; Uhl-Bien & Marion, 2009; Uhl-Bien et al., 2007, Marion & Uhl-Bien, 2001; Lichtenstein & Plowman, 2009). There are also studies in innovation literature (such as Van de Wetering, Mikalef, & Helms, 2017; Garud et al., 2011; Harkema, 2003), and particularly, in new product development context (McCarthy, et al., 2006; Iñigo & Albareda, 2016) but very few of them are empirical studies. In this conceptual paper, our aim is to provide an insight into innovativeness of firms which has been rarely addressed from the perspective of CAS theory in the organizational research. Based on this, we first define what a CAS is and explain what makes a system CAS. Then, we explain CAS dynamics which have been considered as relevant with new product development efforts in organizations by previous studies.

2. Literature Review and Theoretical Framework

2.1. What a Complex Adaptive System Is

Complex Adaptive Systems (CAS) theory is one of the most important research topics that has been studied under the framework of complexity theory. CAS include "heterogeneous agents which inter-relate with each other and with their surroundings and are unlimited in their capabilities to adapt their behaviour as a result of their experience". In other words, a complex system consists of a number of different agents, of which performance relies on the others, and the system as a whole (Chiva-Gomez, 2004).

Holland (1992) explains the attributes which make a system complex and which make it adaptive exemplifying the immune system of human body. An immune system includes antibodies which continuously fight against a number of antigens (microorganisms such as bacteria) at "an almost infinite variety of forms". The immune system lack of time to identify each "invader" and store all information pertaining to each invader. Thus, "the immune system must change or adapt ("fit to") its antibodies as new invaders appear. It is this ability to adapt that has made these systems so hard to simulate." On the other hand, the immune system must identify itself not to use its antigens to fight against the cells of the body itself. Other complex adaptive systems, which include "a kaleidoscopic array of simultaneous interactions", like the immune system of a human body, pass through similar self- identification and adaptation process (Holland, 1992).

https://doi.org/10.15405/epsbs.2019.12.03.18
Corresponding Author: Tuba Etlioğlu
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

Holland (1992) proposes three common characteristics of complex adaptive systems, which are *evolution*, *aggregate behavior*, and *anticipation*. Primarily, based on the Darwin's evolution theory, a complex adaptive system has the ability to "adapt" or "learn" in order to survive, as the immune system adapts its antibodies every time it faces a new antigen. Secondly, complex adaptive systems do not display the mere sum of the individual behaviors of its components, but instead, they behave in an aggregate manner. The ability of self-identification, which enables the immune system to distinguish itself from the others, for example, is the aggregate behavior of the immune system. Lastly, the aggregate behavior of complex adaptive systems depends on their ability to anticipate the probable results of their particular reactions to their environment. This is similar to a circumstance in which oil prices increase in response to an expectation of oil shortage, which in turn results in a seek for a substitute source of energy, even if this anticipation does not come trues as expected. This final characteristic is the one that not fully understood and requires a deeper insight in complex adaptive systems literature (Holland, 1992).

2.2. Innovation and Complex Adaptive Systems

Although recently, organizational innovation from a CAS perspective has become a research stream gaining momentum since "NDP efforts are complex, iterative, non-linear, and co-evolutionary in today's turbulent and competitive environmental conditions" (Akgün et al., 2014b, p.22). However, the enabling conditions of CAS, which are defined as "the necessary settings in which complex behaviors and dynamics occur in product development efforts" have been rarely addressed in new product development researches to date.

Uhl-Bien et al. (2007) propose a conceptual model (Figure 1 below) to explain "network dynamics" – contexts and mechanisms - that leverage adaptive leadership in an organization. "*Context* is the interactive ambiance within which complex dynamics occur, and *mechanisms* are the dynamic patterns of behavior that produce complex outcomes"…"In complex networks, ideas emerge, combine, diverge, become extinct, conflict with one another, adapt and change, and increase in complexity. The primary outputs of this complex dynamic are adaptability, creativity, and learning" (Uhl-Bien et al., 2007, p. 307).

The conceptual complexity leadership model is shown below in Figure 01.

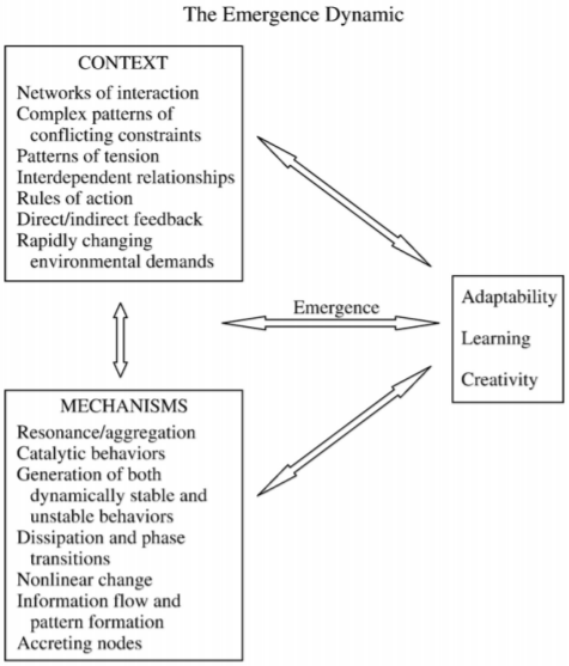

Figure 01. The conceptual Complexity Leadership Model proposed by Uhl-Bien et al., 2007

https://doi.org/10.15405/epsbs.2019.12.03.18
Corresponding Author: Tuba Etlioğlu
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

Akgün et al. (2014a) adapted the model proposed by Uhl-Bien et al. (2007) to the innovation context. They define emergence, which is argued to have a mediator role in the relationship between context variables and firm product innovativeness, as "coordinated actions and interdependency". They propose that emergence fosters an organization innovativeness since it 1) facilitates knowledge (both "tacit" and "complex") sharing among people, 2) enables people to make better product development decisions, and 3) increases the new product success through numerous iterations on new product development process in both "self-redesign" and "incremental adjustments".

Context variables, which create "an interactive ambiance that generates a product development context's dynamic character" are proposed as 1) networks of interaction, 2) conflicting constraints, 3) patterns of tension, 4) dynamic rules of action, 5) dynamic feedback, and 6) rapidly changing environmental demands (Uhl-Bien, 2007; Akgün et al., 2014a).

Networks of interaction refers to the channels "connected by" organizational structures, such as work groups, personnel networks, architecturally open workplaces, through which new-product development related information spread out. Akgün et al. (2014a) argue that networks of interaction leverage emergence since they provide people (or departments) with a view of the activities of others in a "holistic" rather than a "fragmented" manner and build up "rich and meaningful connections" among people (or departments). Also, networks of interaction enable people (or departments) to reach a number of ideas and opportunities and prevent competitiveness among people (or departments) within the organization.

Conflicting constraints may arise in the form of conflicts on need preferences, information needs, resources etc. These constraints are argued to have a two-sided effect on emergence: First, such conflicts foster negotiation and coordination among people, allowing them to take the perspective of others. On the other hand, "an excessive level of conflicting constraints imposes barriers and challenges to organizations, restricting or preventing the occurrence of emergence" (Akgün et al., 2014b, p. 24).

An organizational culture supporting *dynamic feedback* system encourages coordination and interdependency since the individual actions are tied to the information received from "other internal and external people, groups, and organizations, and their environments". On the other hand, *dynamic rules of action*, encompassing the organizational routines that shape organizational behavior, foster coordination and interdependency "by providing a broad repertoire of options and action flexibility" (Akgün et al., 2014b, p. 25).

Patterns of tension emerges in two forms in CAS context – heterogeneity (referring to an environment in which diversity is gained acceptance) and injected pressure (referring to managerial pressures, such as diverting resources to creative tasks). These two forms of patterns of tension are also proposed to have a two-sided effect on coordination and interdependency in an organization: A broad array of practices results in "a synthesis of a variety of viewpoints and new ideas for emergence". On the other hand, too much heterogeneity may cause people to have a sense of losing control of their duties since they become exposed to a number of different viewpoints and high levels of injected pressure may cause people to focus on performing to meet managerial appeals rather than their task requirements. (Akgün et al., 2014b).

https://doi.org/10.15405/epsbs.2019.12.03.18
Corresponding Author: Tuba Etlioğlu
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

Lastly, *rapidly changing environmental demands,* including market turbulence ("the variability and unpredictability of customer preferences and expectations") and technological turbulence ("the rate of technological advances within an industry"), are argued to leverage coordination and interdependency in an organization in two ways: environmental turbulence 1) forces people to continuously adapt to their environment and 2) encourages to "reconcile their plans and actions informally".

Beyond the context variables, the mechanisms of CAS allow us to understand the "dynamic behaviors, processes and practices that occur within the product development efforts to leverage firm innovativeness" (Akgün et. al, 2014a, p.19). Akgün and his colleagues, in their empirical study based on Uhl-Bien et al. (2007), propose four dynamics of CAS, which are namely strategic resonance, accreting nodes, pattern formation, and catalytic behavior.

Strategic resonance refers to the harmony between operational capabilities and the firm strategies, and also, the adaptability of its operational capabilities to the market within all functional units and organizational levels. Uhl-Bien et al. (2008), uses "acting in concert" metaphor to emphasize this harmonization (Akgün et al., 2014a). Resonance is considered as a valuable dynamic capability for firms in today's highly competitive markets. Since each individual functional units of a firm must be in harmonization with each sub-process of new product development process, the firm must be in harmony with its potential customer base in the market. IBM, starting as a computer manufacturer, is one of the biggest business solution consultant of the world. Pegasus airline's sustainable low-cost strategies is another example of resonance (İlhan, 2014). Strategic resonance forcing people to be continuously in harmonization with the internal and external environment of the organization, helps them to develop new ideas and concepts through "exposure to diverse and opposing views, ideas, and capabilities". Also, since resonance requires different functional units to be in collaboration in the adaptation process, people are able to take the perspective of different functional approaches, fostering new product development efforts (Akgün et al., 2014a).

Accreting nodes explain how "information/knowledge is developed and self-regulated through a procedural memory and transactive memory" (Akgün et al., 2014a, p. 20). Accreting nodes may occur in three ways in an organization: an idea or information/knowledge may 1) be developed through successive iterations, 2) progress through complementary beliefs and self-consistency, and 3) is fabricated through organizational stories, symbols, and rhymes. In order to sustain competitive advantage, firms must store and internally disseminate the information/knowledge within their functional units so that they are able to protect and use this information/knowledge that is difficult for their competitors to imitate (İlhan, 2014). By creating amplifying information/knowledge through dissemination within the entire organization, accreting nodes increase social interaction among people, which in turn, creates cohesion and collaboration among people and different functional units. Therefore, by way of this "cross-functional integration and collaboration" people are able to have a deeper understanding of the new product development process and to better handle the product-related problems, promoting new product development efforts (Akgün et al., 2014a).

Pattern of formation mechanism of CAS enables us to understand how people put events in order and make sense of the complicated situations in the external environment of an organization. Through pattern of formation, people or functional units are forced to adapt to steadily changing and turbulent environment and as firms continuously adapt in order to response environmental changes, this adaptation

https://doi.org/10.15405/epsbs.2019.12.03.18
Corresponding Author: Tuba Etlioğlu
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

process goes on (İlhan, 2014). From this perspective, firms must identify "what is important" for new product development efforts and know "how this is to be achieved". Pattern of formation improves the sense-making ability of people and help people better understand the new product development process by providing people with a more "holistic" view making product-related problems "more visible". Thus, pattern of formation is argued to improve the "problem-solving" abilities of people, leveraging the new product development efforts of firms (Akgün et al., 2014a).

Lastly, *catalytic behavior,* which is defined as "the ability of accelerating and enabling activities by the addition of catalysts in the organization", brings together the activities facilitating adaptation process, such as seeing the big picture, understanding the interrelationships, and eliminating the communication gap between functional units. Catalysts may be people, ideas, dreams, new technologies, symbols myths, or beliefs (Akgün et al., 2014a). Catalysts allow us to understand the dynamic adaptation process resulting from the interaction among people who are connected with each other. Catalysts help people or functional units transform implicit knowledge into explicit, discover new mental models, build up common opinion and views and a common language, and seek new patterns to gain insight for the adaptation process. Catalysts, in fact, display how people having restricted cognition, can achieve more effective results than what they can provide with their capabilities and efforts (İlhan, 2014). Based on these discussions, catalytic behavior is considered as a dynamic mechanism "creating an environment where feedback, creativity, and entrepreneurship are expected and approved" and also fostering collective learning, which are considered as leverages for successful product innovation (Akgün et al., 2014a).

3. Conclusion and Discussions

This study provides a theoretical framework for firm innovativeness from a complexity science perspective. The point of view from CAS theory enables us to understand the dynamic mechanisms fostering adaptive capabilities of firms, in general, and new product development efforts, in particular. Based on the study of Uhl-Bien et al. (2007) on Complexity Leadership Theory, which mostly adapted by many researchers in organization studies, we explain context elements and mechanisms of CAS to provide an insight into stimulus of product innovation. After explaining four mechanism of CAS, we present arguments of scholars (Akgün et al., 2014b) on how each CAS mechanism leverages new product development efforts of firms.

This conceptual framework for the dynamics of innovation process from the perspective of CAS theory help us to gain insight into context elements and dynamic mechanisms of innovation process. However, new product development literature on CAS theory lack of empirical evidence. There is very limited number of empirical studies investigating the relationship between context variables and dynamic mechanisms of CAS and adaptive capabilities of firms in general, new product development efforts of firms in particular. Therefore, empirical studies on CAS mechanisms may be worthwhile for future researches.

https://doi.org/10.15405/epsbs.2019.12.03.18
Corresponding Author: Tuba Etlioğlu
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

References

Akgün, A. E., Keskin, H., Byrne, J. C., & İlhan, Ö. (2014a). Complex adaptive system mechanisms, adaptive managmenet practices, and firm product innovativeness. *R&D Management, 44*(1), 18-41.

Akgün, A. E., Keskin, H., & Byrne, J. C. (2014b). Complex adaptive systems theory and firm product innovativeness. *Journal of Engineering and Technology Management, 31*, 21-42.

Anderson, P. (1999). Complexity theory and organization science. *Organization Science, 10*(3), 216–232.

Bryne, D., & Callaghan, G. (2013). *Complexity Theory and the Social Sciences*: *The state of the art.* Abingdon: Routledge.

Chiva-Gomez, R. (2004). Repercussions of complex adaptive systems on product design management. *Technovation, 24,* 707–711.

Garud, R., Gehman, J., & Kumaraswamet, A. (2011). Complexity arrangements for sustained innovation: Lessons from 3M Corporation. *Organization Studies, 32*(6), 737-767.

Harkema, S. (2003). A Complex adaptive perspective on learning within innovation projects. *The Learning Organization, 10*(6), 340-347.

Holland, J. H. (1992). Complex adaptive systems. *Journal of the Academy of Marketing Science, 27*(4), 411-427.

Iñigo, E. A., & Albareda, L. (2016). Understanding sustainable innovation as a complex adaptive system: a systemic approach to the firm. *Journal of Cleaner Production* (accepted manuscript).

İlhan, Ö. (2014). *Dinamik adaptif mekanizmalar, adaptif yönetim süreci ve firma ürün yeniliği arasındaki ilişkiler* (unpublished PhD Dissertation). Gebze Tehnical University, Kocaeli, Turkey.

Lichtenstein, B. B., & Plowman, D. A. (2009). The leadership of emergence: a complex systems leadership theory of emergence at successive organizational levels. *The Leadership Quarterly, 20*(4), 617-630.

McCarthy, I. P., Tsinopoulos, C., Allen, P., & Rose-Anderssen, R. (2006). New product development as a complex adaptive system of decisions. *Journal of Product Innovation Management, 23*(5), 437-456.

Marion, R., & Uhl-Bien, M. (2001). Leadership in complex organizations. *The Leadership Quarterly, 12*(4), 389-418.

Schneider, M., & Somers, M. (2006). Organizations as complex adaptive systems: implications of Complexity Theory for leadership research. *The Leadership Quarterly, 17*, pp.351–365.

Uhl-Bien, M., & Marion, R. (2009). Complexity leadership in bureaucratic forms of organizing: a Meso Model. *The Leadership Quarterly, 20*(4), 631-650.

Uhl-Bien, M., Marion, R., & McKelvey, B. (2007). Complexity Leadership Theory: shifting leadership from the Industrial Age to the Knowledge Era. *The Leadership Quarterly, 18*(4), 298-318.

Uhl-Bien, M. (2006). Relational Leadership Theory: exploring the social processes of leadership and organizing. *The Leadership Quarterly, 17*(6), 654-676.

Van de Wetering, R., Mikalef, P., & Helms, R. (2017). Driving organizational sustainability-oriented innovation capabilities: a complex adaptive systems perspective. *Current Opinion in Envirınmental Sustainability, 28*, 71-79.