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Complex adaptive systems theory and firm product innovativeness

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ABSTRACT

The enabling conditions of complex adaptive systems (CAS), such as context and emergence, for firm product innovativeness have rarely been addressed in the new product development (NPD) literature. In this study, we empirically investigated how emergence, which is a process involving coordinated actions and interdependency, influences firm product innovativeness. We also examined the role that the CAS context, involving networks of interaction, conflicting constraints, patterns of tension, dynamic rules of action, dynamic feedback, and changing environmental demands variables, plays in emergence and firm product innovativeness. By studying 235 firms, we found that (a) emergence variables positively influence firm product innovativeness, (b) different context variables have positive, negative, and nonlinear impacts on different emergence-related variables, and (c) emergence variables partially mediate the relationship between the CAS context and firm product innovativeness.

Introduction

Complex adaptive systems (CAS) theory, as an emerging research area in the new product development (NPD) literature, provides a framework for explaining the emergence of system-level (i.e., NPD process) order arising from the interactions of the system's interdependent agents (i.e.,

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people, departments, ideas, information, resources); thus, CAS focuses on the interplay between a system and its environment (McCarthy et al., 2006). In this sense, scholars have argued that examining product innovation through a CAS lens is particularly relevant as NPD efforts are complex, iterative, nonlinear, and co-evolutionary in today's turbulent and competitive environmental conditions (Garud et al., 2011; Buffington and McCubbrey, 2011). Accordingly, some studies in the NPD literature have examined the CAS perspective for new product design (Chiva-Gomez, 2004), radical product development (Rose-Anderssen et al., 2005), and decision-making process and levels (Garcia, 2005; McCarthy et al., 2006).

Nevertheless, previous studies specifically investigated how the CAS view is typically applied to, or works in, new product development processes or stages (Cunha and Comes, 2003; Chiva-Gomez, 2004; McCarthy et al., 2006) rather than the *enabling conditions* of CAS to adequately exploit its viewpoints, as McCarthy et al. (2006) suggested. Enabling conditions are the necessary settings in which complex behaviors and dynamics occur in product development efforts (Uhl-Bien et al., 2007). In addition to the lack of clarification regarding the enabling conditions of CAS in the NPD literature, little attention has been given to implications or empirical validation of the enabling conditions for the success of a firm's product innovation efforts, or *product innovativeness*.

To address the issues mentioned above, we adapted and used the CAS model developed by Uhl-Bien et al. (2007). Their model provides a theoretical framework for enabling conditions and compiles the components of enabling conditions under the umbrella of *context* and *emergence* factors. The model also implicitly proposes the mediator role of emergence factors between the CAS context and new outcomes, such as innovation.

On the other hand, note that the CAS model proposed by these authors is applied in the leadership context (i.e., at the individual level), is highly abstract, is implicit, and is not operationalized. In the current study, we leverage their views to an organizational level and apply the model in the product innovation context.

We contend that the CAS context provides an interactive ambiance that generates a product development context's dynamic character (Uhl-Bien et al., 2007). Based on the CAS theory, this context includes (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 variables, all occurring during product development efforts (Uhl-Bien et al., 2007).

Emergence, another enabling factor, is "a process whereby novel and coherent structures, patterns or properties arise on the global level out of the local interactions of the agents"[1] (Goldstein, 1999, p. 49) in product development efforts (McCarthy et al., 2006; Garud et al., 2011). Emergence involves coordinated actions, which represent the collective creativity, reflexivity, and synchrony of people or departments during product development processes and activities, and interdependency, which refers to the extent to which people interact collectively to accomplish shared goals or tasks (Goldstein, 1999; McCarthy, 2004; Kiel, 2005; Uhl-Bien et al., 2007; Uhl-Bien and Marion, 2009).

Therefore, the aim of this study was to operationalize and empirically test the impact of the CAS context and emergence on firm product innovativeness. Specifically, as shown in Fig. 1, this study investigated (1) the role of emergence variables on firm product innovativeness, (2) the simultaneous impact of the context variables on the emergence variables, and (3) the mediator role of emergence in the relationship between context variables and firm product innovativeness.

Hypothesis development

Emergence and firm product innovativeness

We argue that emergence (i.e., coordinated actions and interdependency) helps organizations to leverage their product innovativeness by improving their learning and new knowledge development

[1] Note that the "emergence" view differs from the concept of relational coordination (Gittell, 2001). For instance, relational coordination, which is a mutually reinforcing web of communication and relationships carried out for the purpose of task integration (Gittell, 2001), is imposed by external forces, implies the condition of already "being organized," and uses "communication" as the medium. On the other hand, in emergence, actions/behaviors are self-generative and are the products of interactive dynamics rather than external forces (such as an intervention) (Lichtenstein et al., 2007).