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A configuration and contingency analysis of the development chain

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ABSTRACT

The area where product development (PD) and the supply chain (SC) intersect and interact to support new product introductions (NPI), the development chain (DC), is still under-researched territory. Based on a PD/SC interface with multiple sub-process connections, this study uses a configuration approach to classify project-level observations into DC groups with similar patterns of implementation. Further, the relationship between DC groups, contextual factors and NPI performance is investigated. In a sample of 124 NPI projects, four DC groups with distinct configurations are detected that interact with context in terms of industry clock-speed, annual firm revenue, product architecture complexity, agility of the product delivery strategy and newness. The results indicate that deliberate management of the PD/SC interface as a bundle of interrelated sub-process connections and careful alignment with the contextual terrain can benefit NPI performance. Overall, this article contributes to the body of knowledge concerned with NPI through vital insight into current practice at the interface of PD and SC. Further, it is envisaged that the detailed characterizations of the DC configurations and their interaction with context provided in this study serve to guide the purposeful management of the DC, as well as future research in this important area.

1. Introduction

In 1999, Srivastava, Shervaney and Fahey recognized that the important business domains of the Supply Chain (SC) and Product Development (PD) are not independent from each other and suggest that “exploiting their interdependencies is more likely to lead to marketplace success than focus on just one” (p.169). In a recent review of literature on concurrent PD and SC design, Gan and Grunow (2016) identify multiple design attributes as such interdependencies that require the joint work of PD and SC. Existing frameworks concerned with the characteristics of the PD/SC interface, as presented in Hult and Swan's (2003), Croxton et al.'s (2001) or Rogers et al.'s (2004) work, propose to examine and manage the interdependencies at the level of multiple sub-processes. More recently, Simchi-Levi, Kaminski and Simchi-Levi (2008) coined the term Development Chain (DC) to emphasize the pivotal role of the intersection between PD and SC in new product introductions (NPI). Accordingly, the Development Chain (DC) is referred to *as the union of PD and SC across multiple sub-process interfaces that supports new product introductions* (NPI). Making NPI's effective is evidently far from trivial: Recent studies report NPI mortality rates reaching as high as 95% (Hilletofth and Eriksson, 2011). As a consequence, research and practice should be increasingly concerned with the DC as a means to improve NPI performance. Interestingly, recent work still notes a remarkable deficit in research that addresses the link between PD and SC (Tan and Tracey, 2007; Hilletofth and Eriksson, 2011).

Existing frameworks that characterize the PD/SC interface imply that each sub-process represents a specific source of information and expertise, each pair of sub-processes corresponds to a specific set of interdependencies, and, finally, that active connections between PD and SC sub-processes need to be implemented to cope with their interdependencies. As it is PD and SC people who need to work jointly to detect, address and exploit the interdependencies, connections between PD/SC sub-processes retain a purely conceptual meaning (Wheelwright and Clark, 1992; Srivastava et al., 1999).

A number of prior studies have investigated the implementation of connections across the PD/SC interface (e.g. Wheelwright and Clark, 1992; Kahn and Mentzer, 1996, 1998; Tatikonda and Stock, 2003; Petersen et al., 2005; Koufteros et al., 2005; Zacharia and Mentzer, 2007; Tsinopoulos and Mena, 2015). However, the findings from this stream of research are limited, because they focus on one specific connection between selected PD/SC processes, or they investigate high-level constructs that collapse multiple connections across sub-processes into one internal or external dimension. Empirical work that studies the patterns, the multidimensional shapes that are created by the implementation of a full range of DC sub-process connections as an interrelated bundle, providing comprehensive scope and high-resolution, does not exist.

This paper contributes to the literature that is concerned with the nexus of PD and SC with a configuration and contingency analysis of a

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full range of multiple sub-process connections. For that purpose, I cluster project-level observations with similar implementation patterns of multiple sub-process connections into mutually exclusive groups and refer to them as DC configurations. In addition, this study examines the interaction and compatibility between DC configurations and context. Accordingly, this study extends a contingency view of the implementation of PD/SC connections from previous studies (O'Leary-Kelly and Flores, 2002; Tatikonda and Stock, 2003; Koufteros et al., 2005; Tsinopoulos and Mena, 2015) to a full range of DC sub-processes. Based on extant work, the contextual variables examined in this work include industry clock-speed, firm size, SC strategies and product related factors. An analysis of this kind promises an advanced understanding of how the multiple sub-process connections are configured under varying circumstances. Finally, an examination of the relationship between DC groups, contextual factors and NPI performance can guide the deliberate management of the DC.

The paper begins with a review of the literature that establishes the theoretical foundations of this study, identifies how this work advances the body of knowledge in this area and presents the conceptual model for the empirical part. The sections that follow introduce the main constructs, concepts and develop the hypotheses. The next sections present measures, describe the sample and show the results. The study concludes with a discussion of results, limitations of the work and the implications for research and practice that is concerned with the DC.

2. Theoretical foundations, research deficits and conceptual model

A common theme amongst prior work that studies connections across the PD/SC interface is that the key implementation characteristic is the strength or intensity of the connection, because it determines a connection's capacity to cope with interdependencies (Wheelwright and Clark, 1992; Kahn and Mentzer, 1996, 1998; Tatikonda and Stock, 2003; Koufteros et al., 2005; Zacharia and Mentzer, 2007; Le Dain and Merminod, 2014). In the case of the DC, mutual and performance critical dependencies between PD and SC sub-processes arise, when outputs from one domain become inputs for the other (Wheelwright and Clark, 1992) and when decisions in one domain potentially constrain or enable processes in the other (Fixson, 2005). Broadly put, connections with higher intensity will provide more capacity to cope with such interdependencies to affect performance. On the empirical front, Koufteros et al. (2005) investigate PD/SC connections using an information processing perspective and find that stronger internal and external connections improve product innovation, product quality and profitability. Zacharia and Mentzer (2007) employ a resource dependency theory (RDT) perspective to examine the PD/logistics interface and find that greater involvement improves PD performance. This study is the first that examines the relationship between the intensity of connections and performance with a PD/SC interface that is grounded in multiple sub-processes. Zacharia and Mentzer's (2007) study provides an important conjecture for the implementation of multiple sub-process connections at the PD/SC interface. Specifically, they suggest that when the PD process is broken up into multiple sub-processes, as is the case with the DC, some connections with the logistics process might be more beneficial than others. Correspondingly, teams in different types of PD projects may place differing degrees of emphasis on the individual sub-process connections of the DC.

A second common theme amongst existing work that investigates the implementation of connections across the PD/SC interface is a contingency view. The contingency argument applied to a multidimensional PD/SC interface is three-fold: Firstly, existing research with a contingency view suggests that contextual factors are a determinant of the implementation of individual connections (Koufteros et al., 2005; Zacharia and Mentzer, 2007; Tsinopoulos and Mena, 2015). Zacharia and Mentzer's (2007) study confirms that greater salience of the logistics process determines its degree of involvement with the PD process. Tsinopoulos and Mena (2015) empirically confirm that contextual factors product newness and the position of the decoupling point affect the timing and scope of customer and supplier connections with the PD process. Secondly, a contingency view considers that individual connections interact and need to be consistent among each other, such that their intensities create a match, to affect performance (Koufteros et al., 2005; Flynn et al., 2010). For example, Flynn et al. (2010) found a significant interaction effect between customer and supplier connections on operational performance, suggesting that there is an optimum in the product of their connection intensities. A third approach argues that consistency (fit) between the intensity of connections and contextual factors will improve performance. The argument for fit follows the logic of structural contingency theory, which states that the closer an organizational structure meets the task demands created by context, the better the performance (Lawrence and Lorsch, 1967; Drazin and Van de Ven, 1985; Bresman and Zellmer-Bruhn, 2013). More specific to the PD/SC interface, Tatikonda and Stock (2003) argue that product related factors, such as complexity or novelty determine the degree of task interdependence and therefore the required connection intensity. Similarly, Koufteros et al. (2005) suggest that the relationship between connection intensity and performance is contingent on characteristics of the external environment, such as the pace and magnitude of technology changes. Other recent work in this area also considers contextual factors that relate to the product (Lau, 2011) or to strategic orientation (O'Leary-Kelly and Flores, 2002; Hong et al., 2011). This investigation is the first that applies all three facets of the contingency argument to a multi sub-process PD/SC interface.

To capture that the individual intensities of sub-process connections are contingent on one another (Koufteros et al., 2005) and that different emphasis may be placed on different sub-process connections under different conditions (Zacharia and Mentzer, 2007) in a holistic manner, this examination employs a configuration approach. Configuration models analyze multidimensional profiles and are therefore well suited to study complex, multivariate organizational phenomena, like the DC (Boyer et al., 2000). Configuration research is widely accepted in strategic management and has been used in a PD context (Bissola et al., 2014) as well as in a SC context (McKone-Sweet and Lee, 2009; Flynn et al., 2010). In addition to providing a holistic analysis of multiple dimensions as an interrelated bundle, rather than a series of isolated variables, a configuration approach is advantageous because it effectively deals with issues of multicollinearity (Flynn et al., 2010). In a study that closely relates to the DC, Flynn et al. (2010, p.61) identify five configurations of SC integration (SCI), which differ in terms of overall strength, "the extent to which SCI activities are carried out", and balance, "the extent to which a company pays equal attention to all […] dimensions of SCI". They hypothesize and confirm that strength and balance determine the relationship between SC integration and performance. Correspondingly, this analysis examines the *aggregate intensity*, defined as the total intensity of all DC sub-process connections, and *pattern variance*, defined as the degree of variability in intensities across all DC sub-process connections, as the key parameters that link DC configurations with context and performance. This is the first empirical examination that studies contingencies of multiple sub-process connections between PD and SC with a configuration perspective.

The conceptual model, shown in Fig. 1, illustrates the analytical approach and summarizes the contribution of this study. Firstly, it is expected that DC configurations can be distinguished by the pattern of intensities of their sub-process connections. Similar to Flynn et al. (2010), the model postulates that the aggregate intensity and the pattern variance determine the relationship between DC configurations, contextual factors and performance. Specifically, in accordance with prior work that investigates the interaction between the PD/SC interface and contextual factors, it is expected that context influences the implementation of DC sub-process connections (e.g. Tsinopoulos and Mena, 2015) and, based on the logic of structural contingency theory,