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Uncovering the reciprocal complementarity between product and process innovation

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ABSTRACT

The purpose of this paper is to provide a starting point in examining the relationship between product and process innovation beyond the industry and company level. This is the first study to integrate perspectives from contingency theory and the resource-based view of the firm to show how differences in resources and capabilities combined with the specific needs of the New Product and Process Development Projects, will influence the type of complementarity between product and process innovation. We develop a classification that defines seven unique complementarities between product and process innovation and illustrate them in a Product-Process Complementarity Map. This helps Product and Process Development Managers to visualize the variety of options companies have in their New Product and Process Development Projects. We advance our argument by identifying three contingency factors: technology trajectories, power of supply chain, potential and realized absorptive capacity. These three discrete, but interrelated resources and capabilities are widely referenced in the context of process industries that are likely to lead to different complementarity types. Finally, these two contributions are brought together in The Complementarity-Capability Matrix, where we propose seven complementarity strategies and resources and capabilities necessary to achieve them. The matrix was designed to contribute to our understanding of complementarities beyond the industry and company level and serve as a useful tool in decision making for managers that are facing New Product and Process Development Projects.

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1. Introduction

Product and process development are commonly interrelated. The introduction of a cost-reducing process is often accompanied by changes in product design and materials, while new products frequently require the development of new equipment (Lager, 2002; Reichstein and Salter, 2006; Tang, 2006). Companies that are able to develop a tighter relationship between product and process innovation will enhance the cost efficiency of production, effect the smoother launch of new products, and create new opportunities for product and process development (Pisano and Wheelwright, 1995; Pisano, 1997). Despite all of these benefits, over the past decades, the understanding of complementarity between these two types of innovative activities has been a rare theme in the innovation literature (e.g. Damanpour and Gopalakrishnan, 2001; Damanpour, 2010; Kotabe and Murray, 1990).

Models of the dynamics of product and process innovations were mainly developed at the industry level (Abernathy and Utterback, 1978; Barras, 1986). Given the limited number of models developed at the company level (Damanpour and Gopalakrishnan, 2001) the majority of studies have focused on studying these two phenomenon separately. Researchers have claimed, that product and process innovation are two different ways of contributing to the competitiveness of the company, which are influenced by environmental and organizational factors, such as intensity of competition (Kotabe, 1990; Weiss, 2003), company size (Cabagnols and Le Bas, 2002; Fritsch and Meschede, 2001) and the industrial context (Berchicci et al., 2013).

The stream of research investigating complementarities has followed two different perspectives. One group of researchers directly tested the economic value of combining different activities and practices on organizational performance, termed and defined by Ballot et al. (2015) as *complementarities-in-performance* (Pisano and Wheelwright, 1995; Pisano, 1997). The other group of researchers took the approach of *complementarities-in-use*, they linked between two sets of activities and argued that one practice often requires the other practice. These authors identified "mutual and beneficial

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integration between two sets of activities" (Ballot et al., 2015, p. 218). Three sub-categories emerged following the second approach, (i) product and process innovations are interrelated often implying expressions such as "brothers" (Reichstein and Salter, 2006) or "fuzzy set" (Lim et al., 2006), (ii) product innovation creates a need for process innovation (Damanpour and Gopalakrishnan, 2001; Kraft, 1990), (iii) process innovation creates a need for product innovation (Kurkkio et al., 2011; Novotny and Laestadius, 2014).

These studies frequently proclaimed that the synchronous adoption of product and process innovation is the "single best complementarity strategy" (Lager, 2002; Damanpour, 2010). It was also common for these studies to generalize their findings to a single industry sector, i.e. companies operating in the metal manufacturing industry should follow the product-process sequential pattern in their innovation strategies (Kraft, 1990). It may be that these two common features of prior studies have resulted in the "fallacy of the wrong level", as companies operating within a single industry sector could differ in their complementarity strategies. Moreover the literature does not account for the fact that companies are likely to be working on a portfolio of New Product and Process Development Projects that have different aims and require different set of resources and capabilities (Bruch and Bellgran, 2014; Cooper et al., 1997). A review of prior studies also reveals that they have adopted a wide variety approaches and methodologies, and explore different industries, sectors and structures. This reflects the immaturity of this research field, which has not progressed sufficiently to constitute a theory that would offer specific scenarios defining different types of complementarities or conditions for their emergence (Ennen and Richter, 2010). Our intent in this article is to provide a starting point in this research area. We position our article in the context of process industries. Within these industries this relationship is of particular pertinence as they are often characterized by tightness between product and process innovation in New Product and Process Development Projects (Kurkkio et al., 2011; Storm et al., 2013). We argue that New Product and Process Development Projects have different aims and require different resources and capabilities, in terms of technology trajectories, relationships among the supply chain members and companies' ability to absorb the knowledge from the external environment (Bunduchi and Smart, 2010; Lager and Storm, 2013; Huang and Rice, 2009). This will lead to different types of complementarities between product and process innovation. In our analysis of these empirical findings, we show a need for a contingency approach and argue that there is no 'winning strategy' in terms of development of complementarity between product and process innovation (Ballot et al., 2015; Storm et al., 2013). This leads to the following research questions: *What are the different types of complementarities that occur between product and process innovation within the portfolio of New Product and Process Development Projects of companies within process industries? What are the different contingencies, in terms of resources and capabilities that influence the adoption of different complementarities?*

This article makes three unique contributions to the literature. First, using a contingency theory (Burns and Stalker, 1961; Lawrence and Lorsch, 1967; Thompson, 1967) we provide a first attempt at the New Product and Process Development Project level to identify seven different complementarities between product and process innovation: *Reciprocal, Product* and *Process Sequential, Product* and *Process Amensalism* and *Product* and *Process Pooled*. Second, we illustrate this classification in the form of conceptual framework "The Product-Process Complementarity Map," providing Product and Process Managers with a tool to position a portfolio of their Projects. Third, we relate the perspectives from contingency theory with the resource based view (Barney, 2001; Barney and Clark, 2007; Helfat and Peteraf, 2003; El Shafeey and Trott, 2014) and build upon three discrete, but inter-related contingency factors that are widely referenced in process industries. In doing so, we provide new insights into development of complementarities that can be influenced by: *Technology trajectories, Supply chain rigidities and Absorptive capacity*. To orient our work, we include three empirically testable propositions; hence opening up new paths to future empirical research. Finally, we present a "Complementarity-Capability Matrix", where we relate the seven types of complementarities between product and process innovation with contingencies that are necessary to move toward achieving each complementarity type. This conceptual framework is the first conceptual attempt to provide guidance on complementarity strategies at the New Product and Process Development Project level. It is aimed to bring more insights for academics and help for Product and Process Innovation Managers by identifying different types of projects that they may choose from and what types of resources and capabilities this would require.

We structure the rest of the article as follows. We begin with a description of common characteristics, as well as differences among sectors of process industries to set the context for this paper. This is followed by a synthesis of four streams of research that have investigated *complementarities-in-use* between product and process innovation. Building on this synthesis we argue that there is limited conceptual work, which has contributed to a paucity of theory. Thus the section that follows proposes a classification of complementarities in product and process innovation followed by a positioning map. We identify three contingency factors that are likely to lead to these complementarities and bring both contributions into a single conceptual framework. Finally, we discuss implications for theory, future research and managerial implications.

2. Defining and characterizing process industries

Given the theory-building purposes of this research, we position our paper within the context of process industries in order to help us demonstrate the relationship between product and process innovation. Previous research has emphasized that within these industries product innovation is related to process innovation (Lager, 2002; Lim et al., 2006; Storm et al., 2013). A number of definitions of product and process innovation exist within the literature, for the purposes of our study we adopt the widely accepted definitions from The Organization for Economic Co-operation and Development (OECD). OECD defines product innovation as "*a good or service that is new or significantly improved. This includes significant improvements in technological specifications components and materials, software in the product, user friendliness or other functional characteristics.*" Process innovation is defined *as "a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software"* (OECD, 2015).

Surprisingly, little attention has been given to studying the complementarity between product and process innovation. A few studies have taken place in high-technology industries (e.g. pharmaceutical, biopharmaceutical industry), in which both product and process technology are rapidly evolving and therefore must be well synchronized (Feldman and Ronzio, 2001; Pisano and Wheelwright, 1995; Pisano, 1997). There is, however, a lack of academic attention to low-medium-technology (LMT) sectors of process industries (e.g. food and beverage, metal, mineral, pulp and paper). A systematic literature review conducted by Keupp et al. (2012) identifies the large gap in the academic literature on strategic management of innovation paid to low-and medium-low technology (LMT) industries in comparison to medium-high technology industries. This gap is particularly interesting because in most developed and developing countries, LMT industries account for more than 90% of the economic output and are more likely to contribute to economic growth (Robertson et al., 2009). Consistent

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