Journal of Engineering and Technology Management xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Engineering and Technology Management

journal homepage: www.elsevier.com/locate/jengtecman

Effects of product lifecycle management systems on new product development performance

Yi-Ming Tai

Department of Information Management, National Pingtung University, No. 51, Minsheng East Road, Pingtung, Taiwan

ARTICLE INFO

Keywords:
New product development
Product lifecycle management systems
Process management capability
Coordination capability
Absorptive capability

ABSTRACT

To examine the effects of product life cycle management (PLM) systems on new product development (NPD) performance, the study developed a conceptual model linking firms' ability to diffuse and routinize PLM systems in NPD processes (called "PLM system capability") with process management, coordination, and absorptive capabilities. The study assumed that the selected management capabilities mediate the effects of PLM system capability on NPD performance. The empirical results supported the theorized relationships, indicating that PLM system capability shapes firms' capabilities for NPD process management, partner coordination, and knowledge absorption, which subsequently affect NPD performance. Therefore, in order to improve NPD performance, managers must create conditions conducive for implementing PLM systems to enhance NPD-required management capabilities.

1. Introduction

Challenges such as shrinking product life cycles and heterogeneous customer preferences have compelled manufacturing firms to recognize that outperforming their competitors requires improving the development of new products (Thomas, 2013; Kettunen et al., 2015). New product development (NPD) involves various complex and interdependent activities such as generating and assessing new product opportunities and ideas, incorporating product requirements into final design specifications, and launching products on the market (Hilletofth and Eriksson, 2011; Acur et al., 2012). Firms must effectively collaborate with external partners to achieve excellent NPD performance. Such collaboration involves intense interorganizational processes requiring coordination mechanisms to not only cultivate mutual understanding between firms and their NPD partners but also align partner activities with firm objectives (Mishra and Shah, 2009; Ma et al., 2012). Such intensive interorganizational interactions create an increased demand for information processing, the success of which depends heavily on a firm's ability to implement appropriate information technology (IT) solutions.

Product lifecycle management (PLM) is a strategic solution for the integrated management of product-related information throughout a product's life cycle (Ameri and Dutta, 2005; Schuh et al., 2008; Stark, 2015). PLM is possible because of recent advances in information and communication technologies. The information systems designed to support PLM, generally called "PLM systems" enable firms to integrate information and knowledge despite functional and organizational boundaries in NPD contexts (Ding et al., 2011; Cantamessa et al., 2012; Merminod and Rowe, 2012). The advent of PLM systems provides a dynamic, interorganizational, and integrative Internet-based information sharing platform to facilitate the creation, modification, and exchange of product information throughout a product's entire life cycle (Pol et al., 2008; Stark, 2015). PLM systems enable firms to manage product portfolios and product development project information by supporting the definition and standardization of the workflows and informational objects created during product development (Vezzetti et al., 2011; Merminod and Rowe, 2012). To improve NPD performance, numerous firms have developed PLM-related IT solutions to streamline NPD management processes, enhance NPD participant

E-mail address: ymtai@mail.nptu.edu.tw.

http://dx.doi.org/10.1016/j.jengtecman.2017.06.001
Received 27 June 2016; Received in revised form 9 June 2017; Accepted 12 June 2017

management, and improve NPD participant interactions. Companies such as Boeing, General Electric, and Honda have implemented PLM systems to facilitate collaboration with NPD partners (Fielding et al., 2014; Stark, 2015).

Previous studies on PLM have described various benefits of implementing PLM systems for product development. Ameri and Dutta (2005) stated that PLM systems enable firms to streamline the flow of information about products and effectively manage knowledge-intensive processes throughout their life cycle. Alemanni et al. (2008) proposed that the benefits of PLM systems can be divided into long-term benefits and short-term benefits. Schuh et al. (2008) suggested that the goal of PLM systems is to realize the benefits of reducing the time to market of products, improving product functionality, and enhancing customization. Cantamessa et al. (2012) suggested that the performance effects of PLM systems can be divided into individual operative effects such as the reduction of design mistakes, past design information reuse, and reduction of time invested for research; organizational process effects such as the reduction of data redundancy, higher design quality, and lower influence of product changes on the development process; and strategic effects such as higher levels of product innovation and product cost and process cost reductions. Hadaya and Marchildon (2012) suggested that firms can derive numerous benefits from adopting PLM systems, such as accelerating the delivery of innovative products, improving the success rate of newly introduced products, and establishing effective collaborative relationships with supply chain partners.

The increased awareness of PLM system support of NPD has encouraged firms to invest in PLM systems. However, industry-level studies have reported conflicting results regarding the effects of PLM systems on NPD performance (Cantamessa et al., 2012; Raap, 2013; Stark, 2015). This study suggests that this is because of a widespread belief that the relevance of PLM systems is not based a detailed understanding of the mechanisms through which they influence performance. The specific factors that mediate the effects of PLM systems on NPD performance have seldom been studied. Recent studies have questioned the direct effects of IT systems on firm performance by asserting that such effects are mediated by a firm's management capabilities (Mithas et al., 2011; DeGroote and Marx, 2013; Liu et al., 2013; Peng et al., 2016). Therefore, this study investigated the mechanisms underlying the influence of PLM system use. A firm's ability to diffuse and routinize PLM systems in NPD processes (called "PLM system capability") was conceptualized as the fundamental capability shaping the three critical management capabilities in NPD contexts (i.e., process management capability, coordination capability, and absorptive capability), which in turn affect NPD performance.

This study assumed that the ability to control and improve NPD processes (i.e., process management capability), coordinate NPD partners' resources (i.e., coordination capability), and identify and leverage valuable knowledge received from external sources (i.e., absorptive capability) are critical and direct sources of superior NPD performance. PLM systems provide firms with a platform to streamline NPD processes, align NPD activities, and govern knowledge production and dissemination in NPD contexts. PLM system capability represents a firm's ability to embed PLM system applications in NPD processes (Vezzetti et al., 2011; Merminod and Rowe, 2012; Fielding et al., 2014). Hence, this paper proposes that PLM system capability affects the development of process management, coordination, and absorptive capabilities, thereby influencing NPD performance.

The rest of the paper is organized as follows. First, the conceptual background of the study and hypothesis development are presented. Second, this paper describes the research methodology, including the data collection procedure, construct operationalization and measurement, and the results of hypothesis testing. Finally, the paper concludes with a discussion of the research findings, their theoretical and practical implications, and suggestions for future research.

2. Conceptual background and research model

2.1. PLM systems

PLM systems form the backbone of product information for firms and their NPD partners (Pol et al., 2008; Cantamessa et al., 2012; Stark, 2015), thereby assisting the firms in managing the creation, modification, and exchange of product information during the product development process. PLM systems comprise tightly integrated information systems that include numerous industrial application systems such as visualization, CAx integration, computer-integrated manufacturing, product data management, and configuration management systems (Gecevska et al., 2010; Segonds et al., 2015). PLM systems integrate product development information into a single logical database to support the definition and standardization of the workflows and informational objects created and used during product development (Merminod and Rowe, 2012; Bruun et al., 2015). Furthermore, PLM systems are designed to fulfill certain business requirements such as the efficient management of abundant information and knowledge, information and knowledge sharing, and standard database operations such as transaction management and concurrent control and recovery (Fielding et al., 2014; Segonds et al., 2015). PLM systems enable firms to effectively manage their product portfolios and product development project information, and collaborate with product development partners.

PLM systems support collaborative work in product development processes for the efficient integration of development participants and all associated information (Cantamessa et al., 2012; Hadaya and Marchildon, 2012; D'Amico et al., 2013). How PLM system capability is integrated into NPD processes determines whether the objective of PLM systems is ultimately achieved. This study conceptualized PLM system capability as a firm's ability to embed PLM system applications in NPD processes. This conceptualization paralleled that of "IT usage" and "IT assimilation," which are common in studies on information systems (Mithas et al., 2011; Liu et al., 2013). This study investigated how PLM system capability influences NPD performance. Although the advantages of using PLM systems in NPD contexts have previously been recognized, there is little evidence regarding the role of PLM system capability in fostering management capabilities that are crucial for achieving excellent NPD performance. Therefore, this study proposed and tested a model wherein the effects of PLM system capability on NPD performance are mediated by the three aforementioned critical management capabilities.