A SPECTRUM OF PRODUCT DEVELOPMENT PROCESSES: A FRAMEWORK FOR MATCHING METHODS TO OUTCOMES

Robert J. Lahm, Jr., Ph.D.
Professor of Entrepreneurship
College of Business
Western Carolina University
Cullowhee, NC 28723
http://www.DoctorLahm.com
rjlahm@wcu.edu

Martin L. Tanaka, Ph.D.
Associate Professor of Mechanical Engineering
College of Engineering and Technology
Western Carolina University
Cullowhee, NC 28723
https://faculty.wcu.edu/mtanaka/
mtanaka@wcu.edu

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ABSTRACT

Selecting the best process for product development is highly correlated with the investment required to develop a product. When products that are complex, expensive, or require expensive tooling, it is usually best to develop them using a more structured approach in order to avoid financial loss resulting from design errors, system integration problems or unforeseen events. When the product is simple or it requires little investment in tooling, less structured methods are often beneficial because they avoid unnecessary bureaucracy, reports, and presentations, enabling developer(s) to focus effort on the product and quickly shift the design if needed. Most products that entail higher risks tend toward the more structured side of the spectrum. Such risks are not only embodied in direct development costs, they can also be associated with loss market opportunities and profits. In this paper, we will present a "Spectrum of Product Development Processes" illustrating where commonly used product development processes lie upon a continuum of approaches used for new product development. We will discuss different aspects of a company including the complexity of products that are developed, annual volume, risk of product failure, need for innovation, frequency of new product introduction, time to respond to market factors, and risk aversion of the company. Using these factors, we will develop general guidelines that can be used to customize the product development process for an individual company.

INTRODUCTION

As recounted by Archibugi (2017), according to Schumpeterian theories "economic expansions are associated with the introduction of successful new products, processes and services" (p. 535). At a firm (organizational) level, when facing highly competitive environments, organizations must be able to expeditiously develop and market new products (Ahmadi, Roemer, & Wang, 2001). In some cases, a firm's innovativeness may result in making its own existing product or product lines obsolete (Chandrashekaran, Mehta, Chandrashekaran, & Grewal, 1999). Calantone, et al (2010) conducted a meta-analysis of research on innovation in New Product Development (NPD, or sometimes in the discipline's literature, PD), which drew upon marketing, management, and new product literatures. Among their conclusions they found that "the greatest source of turbulence that managers must track is technological in nature" (p. 1077). In their systematic review and analysis of NPD research Kalluri and Kodali (2014), studied articles published during the period from 1998 to 2009 and reported that the literature reflected increased attention being paid to people, teams, and creativity.

For instance, among the 1127 referenced items cited by Kalluri and Kodali, one such article concluded that the "NPD process in most organizations is in essence a group activity that involves people throughout the organization" (Akgün, Lynn, & Yılmaz, 2006, p. 211). "Group cohesiveness and external communication were also important predictors of NPD outcomes indicating the importance of *esprit de corps* within the team and boundary spanning across teams and organizations" (Sivasubramaniam, Liebowitz, & Lackman, 2012, p. 816). Zhang and Thomson (2019) examined product development—especially as it relates to more complex products—from

a knowledge management perspective, whereby they viewed product functions, design activities, and designers themselves as a "network of interdependent agents" (p.203), with all of these being linked to knowledge.

LITERATURE SEARCH STRATEGY

For this present paper, a general search strategy has been to focus on often overlapping topics: 1) innovation and its primary typological variants (e.g., models, constraints, drivers, etc.), and 2) new product development processes. Once one delves into the innovation literature, connections arise, including robust discussion concerning large scale entities as compared to entrepreneurship—Small and Medium Enterprises (SMEs). The new product development literature is equally vast, often crossing paths with marketing, engineering, project management, and other literatures. Additional existing (local) databases and a prior research stream has been established on the part of one of the authors pertaining to small business generally. A database comprised of approximately 300 artifacts have been collected and reviewed for this present paper. The basis for the following discussion is informed by literature and findings from researchers' efforts to discern patterns. Several artifacts relate to previous systematic and meta-analyses (Calantone et al., 2010; De Goey et al., 2019; Díaz, Pérez, Alarcón, & Garbajosa, 2011; Hausberg & Korreck, 2020; Kalluri & Kodali, 2014; Page & Schirr, 2008; Sivasubramaniam et al., 2012; Tian, Deng, Zhang, & Salmador, 2018).

INNOVATION DRIVERS AND RELEVANCE

Hyland and Beckett (2005) summarized: "By definition, innovation involves something new. It changes the status quo and is disruptive" (p. 338). As observed by Bhaskaran and Krishnan (2009), firms are being forced to continually invest, and in greater amounts, due to: "the lifetimes of products shrinking, technical complexity increasing, and daunting odds of success [having become] a norm" (p. 1152). "It is estimated that more than 90% of all patents are developed by people working in the industry where their product is applicable or with a specific technology" (Sternberg, 2005, p. 43). "Another driver of innovation is good old marketing" (Sternberg, 2005, p. 43).

New Product Development (NPD) Basics

Ultimately, the development of new products and services are both aimed at creating value (Schleimer & Shulman, 2011; Witell et al., 2014). Such value creation can impact one or more levels: "the individual, the organizational and the society level" (Aho & Uden, 2013, p. 682). New Product Development has been characterized as a "dynamic and nonlinear process that has great interdependency and uncertainty" (Zhang & Thomson, 2019, p. 204). Thus, in short, NPD is a *process*. Moreover, Hyland and Becket (2005) have argued, "innovation needs to be managed as a *business process* [emphasis added]" (p. 338). More formalized approaches to this process entail "activities, tasks, stages and decisions that involve the project of developing a new product/service or improvement on an existing one" (Salgado, Valério Antonio Pamplona, Carlos Henrique Pereira, & Carlos Eduardo Sanches da, 2018, p. 2). "Different labels have been used to characterize the differing stages of the PD process; however, the ideation stage is commonly

referred to as the 'fuzzy front end,' and the final stage is commonly referred to as commercialization or postlaunch" (Holahan, Sullivan, & Markham, 2014, p. 330).

NPD in Small and Medium Enterprises (SMEs)

While there may be similarities in terms of motivations and strategies for NPD, larger organizations differ from Small and Medium Enterprises (SMEs). Terziovski (2010) concluded that "SMEs are likely to improve their performance as they increasingly mirror large manufacturing firms with respect to strategy and formal structure" (p. 899). According to Breitzman & Hicks (2008), in their research entitled "*An Analysis of Small Business Patents by Industry and Firm Size*" (which referenced Schumpeter's theories including that of creative destruction[1]): "In some cases, small firms may be able to play the role of disruptive innovators" (p. 28). The only way for small technology-based firms to remain competitive (and thus survive) is to engage in both exploratory as well as exploitative innovation (Soetanto & Jack, 2018). These authors also observed that "small technology-based firms face uncertainty, tough competition and substantial obstacles due to the innovativeness of their products or services" (*Ibid*. p. 1215). Outsourcing can apply to both large firms and the smallest of firms, although either context assumes a budget to do so. By working with business partners (as an alternative to in-house NPD), firms may be able to react to, and seize upon market opportunities more quickly (Yam & Chan, 2015).

A SPECTRUM OF PRODUCT DEVELOPMENT PROCESSES

"'Eureka!' does not typically happen without any knowledge or experience with the problem that the invention is designed to solve" (Sternberg, 2005, p. 43). Therefore, it is common to create product development teams (Sivasubramaniam et al., 2012) containing members with the skills needed for product development. Even for small projects these teams can be large involving people from many areas of the company including design engineering, manufacturing engineering, purchasing, sales, marketing, quality assurance, and production. Coordinating the team activities is usually accomplished using a product development process. Well known processes include Stage-Gate and Agile, but there are many others. Below, we present a "Spectrum of Product Development Processes" as a conceptual rendering. It is not possible to state that one process within this Spectrum is better than another, they are simply different. Furthermore, when one considers the possible variations of each process, we believe that the options for new product development are better represented as a continuum than individual discrete process.

[1] Schumpeter, J. A. (1942). Capitalism, socialism, and democracy. New York: Harper and Brothers.

The best results are obtained when the process employed is matched to the type of product being developed. Determining the best product development process to use is highly correlated with the investment required to develop the product. Developing products that are complex, expensive, or require expensive tooling, often benefit from using a more structured approach in order to avoid financial loss resulting from design errors, system integration problems or unforeseen events. When the product is simple or requires little investment in tooling, less structured methods are often beneficial because they avoid unnecessary bureaucracy, reports, and presentations, enabling teams to focus effort on developing the product and quickly shift the design if needed.

CONCLUSION

As observed by Bargelis, Mankute, & Cikotiene (2009), "the need for a new design of products and processes with minimum cost has considerably increased" (p. 13). Product development can entail great uncertainty (Zhang & Thomson, 2019). This uncertainty can be exacerbated by many issues that are outside of the actual design effort. For instance, as observed by Ogawa and Piller, (2006) "forecasting the exact specifications and potential sales volumes of new products is becoming more difficult than ever" (p. 65). Large scale development may entail coordinating complex information interdependencies with individual design activities and couplings (Ahmadi et al., 2001). At the same time, successful new product development outcomes depend on additional conditions besides selecting the right NPD model (Salgado et al., 2018). Findings from Sivasubramaniam, et al (2012), led researchers to conclude that teams (and their effective functioning, or not) are an important factor as well. Such teams are responsible for effecting innovative outcomes while the environments in which the conduct their work involve collaboration among cross-functional discipliness, significant ambiguity, resource constraints, and are anything but routinized (*Ibid*. p. 803). Thus, as suggested by Kalluri and Kodali (2014), a key motivator for conducting research in new product development lies in the possibility of developing new practices that lead to improved new product success rates.

This paper has presented a "Spectrum of New Product Development Processes" as a conceptual rendering in light of the importance of products as a form of innovation, with innovation being regarded as being both necessary and driven by an ever-changing global economy. Within this Spectrum, one might find the most suitable approach for a given set of conditions and goals.

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