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The development and application of a process model for R&D project management in a high tech firm: A field study

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ABSTRACT

In R&D organizations of high tech firms, multiple R&D projects are executed concurrently and timeliness of project completion – i.e., developing the right products at the right times – is a matter of serious concern. Given that the priority of R&D projects and the interdependencies between the projects in a high tech firm change dynamically, high tech R&D project management is a complex and challenging endeavor. To improve the understanding and management of high tech R&D projects, this paper reports the findings of a field study where we, first, develop and empirically estimate a model that relates project priority over time with the generative mechanisms of market pull and technical challenge associated with R&D projects. Next, we develop and demonstrate the application of a process model within which the time-varying project priority model is embedded. The process model makes it possible to allocate fixed resources among competing projects with time-varying interdependencies, thereby improving the timeliness of project completion. This research was conducted in collaboration with a major U.S. high tech firm. The corporate R&D center of the firm served as the research setting for the field study. We present an application of the process model to delineate the evolution of the R&D organization with the merger of its (technology driven) parent firm with another (market driven) high tech manufacturing firm. The application of the process model generates theoretical insights that are used to develop testable propositions. Implications of the study findings and directions for future research are discussed.

1. Introduction

> "A substantial body of research [on project portfolio management]... has been focused on the question of which innovation projects to pursue.... The optimization paradigm so prominent... has been brought to bear on product planning problems over the decades. Surveys have shown that these models have found very little use in practice and only two of the articles published are empirical.... If 50 years of research in an area has generated very little managerial impact, perhaps it is time for *new approaches* (emphasis added)" (Shane and Ulrich, 2004, p. 136).

High tech firms compete in a dynamically changing market place where, to survive and thrive, firms need to introduce a continuous stream of successful new products. A conventional way of addressing this need would be to reduce the development time of products (Adler et al., 1995). But simply reducing product development time as an efficiency exercise alone – rather than basing it on strategic considerations – would lead to the development of products without customers (Stalk and Webber, 1993; Gerwin and Barrowman, 2002). Therefore, without belittling the importance of reducing product development time, the focus of this study is on timeliness – i.e., developing the right products at the right times.

The challenge of introducing new products in a timely manner is often complicated by the propensity of high tech firms to reduce market risks by concurrently executing multiple R&D projects that share human and capital resources (Adler et al., 1995; Krishnan and Ulrich, 2001; Nobeoka and Cusumano, 1997; Girotra et al., 2007). As a result, pooled interdependencies arise between such projects (Thompson, 1967; Verma and Sinha, 2002). Each project renders a discrete contribution to the entire pool of concurrent projects; each project is, in turn, supported by this entire pool, making every project interdependent (Loch and Kavadias, 2002). Therefore, if a product is developed when the market is not ready for it, it is conceivable that the resources committed toward development of the product could have been better utilized for other concurrent projects that had greater market potential (Meredith and Mantel, 2003).

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R&D projects in high tech firms are also characterized by changing goals and requirements during a project's lifetime, which can span several years. Due to the ongoing changes in the goals and requirements, interdependencies across projects vary over time. For example, the progress of an R&D project may be delayed due to external factors and require the unplanned carryover of their costs into the next fiscal year. While high tech firms are becoming increasingly agile in handling these contingencies, often, the presence of interdependencies across projects and limited availability of resources may lead to the postponement or cancellation of other projects because of in-budget transfers (Gurgur and Morley, 2008). Thus, the time-varying nature of interdependencies across projects necessitates dynamically monitoring and controlling the mutual compatibility of different project plans (Bardhan et al., 2004).

The task of managing such interdependencies across projects is made particularly challenging by the dynamic nature of project portfolio selection decisions (Kavadias and Chao, 2006). Generally speaking, R&D projects can be classified into two broad categories: (i) projects that operate within the realm of current technical capabilities or require a stretch of current technologies, and (ii) projects that require a radical innovation to deliver functions. The first category requires exploitation of old certainties and involves mutual learning between members of an organization and an organizational code. The code is buried in many features of organizational forms and customs, e.g., in organizational policies of reducing risk. The second category requires exploration of new possibilities leading to learning and competitive advantage (March, 1991). Since returns from exploration of new possibilities are systematically less certain, more remote in time, and organizationally more distant from the locus of action and adoption, it is easier to spend most of a firm's R&D resources on exploiting an existing knowledge base. The exploitation strategy is effective for short-term gains but can become self-destructive in the long run (Tushman and O'Reilly, 1996). Continuous growth in the long run requires some risky investments for the exploration of new ideas. However, firms that engage only in exploration without exploiting their existing knowledge base are likely to suffer from the cost of experimentation without gaining many benefits from it (March, 1991). It is therefore important for managers to utilize a dynamic project selection and review plan that balances between short-term profits and long-term sustainable growth when multiple R&D projects are executed concurrently (Benner and Tushman, 2003). As interdependencies across projects vary over time in such an environment, the ability to manage individual projects effectively along with the ability to manage interdependencies between projects is necessary for attaining superior R&D project performance. In this study, we address the following research question:

How can a high tech firm allocate fixed resources between multiple, concurrent R&D projects with interdependencies that vary over time, to enhance the timeliness of project completion?

Addressing this question requires a "process theory" explanation of the temporal order and sequence in which a discrete set of events occur (Abbott, 1988). Following Tsoukas (1989) approach, we first investigate the generative mechanisms of *market pull* and *technical challenge* that cause events to happen in an R&D organization, and the particular circumstances or contingencies when these mechanisms operate. Next, the insights gained on generative mechanisms of project priority over time are used to develop a process model to understand and manage project timeliness.

We reviewed the extant literature to gain insights into the nature of generative mechanisms relevant to portfolios where R&D projects, with time-varying interdependencies, are executed concurrently. This literature review did not yield any useful insights. Hence, we conduct our inquiry as a field study. Specifically, we adopt an "inductive theory development" approach toward conducting this investigation (Edmondson and McManus, 2007, p. 1161). The *empirical setting* of this field study is the corporate R&D center of a major high tech firm head-quartered in the northeastern United States. The firm markets its products through multiple business units spread across the globe. R&D is a focal point throughout the firm with technology viewed as the key to its market place differentiation. Much of the firm's R&D activities are carried out at the corporate R&D center. The mission of the corporate R&D center is to provide world-class technologies, processes, and product concepts that fuel the global growth and profitability of the firm. The R&D center serves as an internal supplier to the business units, and the business units, therefore, are internal *customers* to the R&D center (Hauser et al., 1996). To continue fulfilling its mission, it is important for the R&D center to be evaluated favorably by the business units. This objective is generally reflective of internal R&D centers of most high tech firms today and is becoming critical to their survival in an increasingly competitive market that includes a growing number of specialized domestic and offshore technology vendor firms (Huston and Sakkab, 2006).

This study makes significant contributions toward advancing the extant literature. By characterizing the challenge of developing timely new products in a high tech firm as that of managing interdependencies across R&D projects that vary over time (especially resource interdependencies that arise from sharing scarce resource across different R&D projects), this study takes a much needed look inside the black box of a high tech firm's new product development process (Krishnan and Ulrich, 2001) and contributes to the growing literature on the dynamic management of project portfolios. Furthermore, the application of the process model to an R&D organization of a high tech firm demonstrates the importance of aligning resource allocation strategy of an R&D organization with the strategic orientation of the parent firm for improving the timeliness of project completion.

The uniqueness of the research methodology in this study also represents a key contribution to the extant literature. Using primary data collected from a focused sample of multi-year R&D projects, a combination of statistical and simulation analyses are used to develop a time-varying project priority model. Such a hybrid research design is appropriate for generating, inductively, theoretical insights and for developing a process theory explanation of how generative mechanisms within an R&D organization evolve and affect the timeliness of project completion within the organization (Edmondson and McManus, 2007; Harrison et al., 2007), especially when extant theoretical insights from prior analytical and empirical studies are limited (Fisher, 2007).

The remainder of the study is organized as follows. In Section 2, we present a review of the relevant literature, and discuss the theoretical foundation of the project priority model and its estimation with data from the research site. In Section 3, we discuss the development and application of the process model that incorporates the time-varying project priority model and also accounts for the interdependencies between multiple R&D projects being executed concurrently. In Section 4, we present an application of the model in the context of our research setting. The application of the process model generates theoretical insights that are used to develop testable propositions. Finally, in Section 5, we conclude by highlighting the theoretical and managerial contributions of this study, and outlining directions for future research.

2. The time-varying project priority model

2.1. Background

Initiating an R&D project does not necessarily mean that the project will come to fruition and a new product or technology will