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Decision Support

New product development flexibility in a competitive environment

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ABSTRACT

Managerial flexibility can have a significant impact on the value of new product development projects. We investigate how the market environment in which a firm operates influences the value and use of development flexibility. We characterize the market environment according to two dimensions, namely (i) its intensity, and (ii) its degree of innovation. We show that these two market characteristics can have a different effect on the value of flexibility. In particular, we show that more intense or innovative environments may increase or decrease the value of flexibility. For instance, we demonstrate that the option to defer a product launch is typically most valuable when there is little competition. We find, however, that under certain conditions defer options may be highly valuable in more competitive environments. We also consider the value associated with the flexibility to switch development strategies, from a focus on incremental innovations to more risky ground-breaking products. We find that such a switching option is most valuable when the market is characterized by incremental innovations and by relatively intense competition. Our insights can help firms understand how managerial flexibility should be explored, and how it might depend on the nature of the environment in which they operate.

1. Introduction

Any new product development (NPD) project is susceptible to uncertainty regarding the success of its development. This uncertainty relates to the quality of the resulting product and to its commercial success, which is influenced by market conditions. An NPD firm should consider the evolution of both these uncertainties, i.e., its development success as well as the state of the market, when deciding how much to invest in the development, when to launch the product, or whether to abandon the development completely. Consider, for instance, Microsoft's announcement of postponing the launch of its Vista operating system for consumers in late 2005 (Lohr & Flynn, 2006). It is likely that this decision, while being influenced by the success of its development effort, was also influenced by the fact that Microsoft did not face harsh competition in the operating system market. A delayed launch of Vista was less likely to have a negative impact on Microsoft's profitability. Similarly, consider Apple's decision to launch a compromised iPhone 4S rather than delaying the launch of the new iPhone until the iPhone 5 was fully functional, which was undoubtedly influenced by the highly intense smartphone market environment (Blodget, 2011). In patent protected NPD environments such as pharmaceuticals, firms explicitly consider a set of future scenarios associated not only with their own technical success, but also with the commercial success and market conditions when evaluating their projects and related launch dates.

It is well known that managerial flexibility, also referred to as real options, can have a major impact on the value of NPD projects (Dixit & Pindyck, 1994). Many have explored how this impact depends on the characteristics of the development process (Cui, Zhao, & Ravichandran, 2011; Huchzermeier & Loch, 2001; Santiago & Vakili, 2005; Wilhelm & Xu, 2002). What is not yet fully known, however, is how the value of flexibility in NPD is influenced by the competitive environment in which a firm operates. Some of the previous works (Canbolat, Golany, & Mund, 2012; Chronopoulos, De Reyck, & Siddiqui, 2014) have employed game theoretical approaches to account for the competitive market environment when valuing NPD flexibilities. While game theoretical approaches can be effective in dealing with duopoly markets with homogenous players, they may not be easily extendable for markets with several firms that are heterogeneous in their development capabilities, assets, and strategic development goals. In such markets, considering the competitive environment in aggregate, as a stochastically evolving process, can be useful. This is the approach that Clark (1985) proposes. There is limited research,

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however, that does so while focusing on investigating the valuation and optimal use of NPD flexibilities. Therefore, our main objectives for this study are to (i) develop modeling tools that allow accounting for, in aggregate, the stochastically evolving competitive market environment and (ii) derive insights about the value and optimal use of the development flexibilities under different competitive market environments. Thus, we aim to advance the practice and theory of successful NPD project management (Cooper & Kleinschmidt, 1987).

To achieve the objectives of the study, we develop a stochastic dynamic programming framework for a single firm. We do this by expanding the model of Huchzermeier and Loch (2001) to incorporate the stochastic evolution of the competitive market environment. We are not aware of a similar approach being developed before or used in the investigation of the value of NPD flexibilities under competitive market environments. Our model accounts for (i) uncertainty in a firm's development success and in the competitive market environment via their stochastic processes, (ii) different market types, such as a winner-takes-all market where only the best performing product earns revenues and a shared market where also inferior products can earn some revenue, and (iii) several types of managerial flexibilities. Specifically, we consider the following types of flexibility: (i) abandon the development, (ii) enhance the development, (iii) defer the product launch, and (iv) switch the development strategy to pursue more radical innovation. In next few paragraphs, we review related studies that investigate the use and value of some of these options. For a broader review of the NPD literature, see Krishnan and Ulrich (2001).

In previous NPD literature, the use of abandonment option alone has been investigated by Hsu and Schwartz (2008). They examine the value created by an option to abandon a two-phased R&D project at the end of each development phase. Their model incorporates uncertainty in the duration of development, development cost, and quality of the R&D output. Brandão and Dyer (2011) expand this model by allowing the option to abandon to be exercised throughout the development phase. They show that opportunities to further expand the product once the development has been successful can significantly affect the project value and the optimal investment decisions. We add to this line of investigation by introducing an option to defer the launch of the product, which allows for additional product improvements during the delay. We explore how the viability of this option depends on the nature of the market in which the firm operates.

Miltersen and Schwartz (2004) show that competition in R&D shortens the development time and increases the probability of successful development. Their model highlights that for a monopolist, the value of the R&D investment is higher than the aggregate value of the R&D investment for both duopolists and that, on average, the time until the first project is completed is shorter. Souza, Bayus, and Wagner (2004) consider the impact of industry clockspeed, or the rate of declining prices of products, on the timing of the introduction of new products. Using an infinite-horizon Markov process, they show that it is optimal to introduce products more frequently under faster clockspeed conditions. Carillo (2005) defines the NPD clockspeed as the rate of introduction of new products, which is analogous to the competition's intensity we employ here. She analyzes optimal firm level NPD clockspeed and how it depends on whether the firm is the industry leader, operationally limited, or the industry optimizer. We add to the research on product introduction timing by showing how the timing depends also on the market's radicalness in innovation.

The performance and time-to-market tradeoff is also studied by several others. Cohen, Eliashberg, and Ho (1996) use a two-stage optimization model and show that if competition is either very strong or very weak, delaying product launch is suboptimal. Armstrong and Lévesque (2002), Lévesque and Shephard (2002) employ dynamic programming to characterize the optimal market entry time. The former study considers uncertainties in funding availability, product development success, and the growth in the competition and the latter study considers uncertainties in the environmental volatility and market competition. They both show that optimal quality and time targets can be derived for product launch. Langerak and Hultink (2006) investigate empirically the impact of product innovativeness on the link between development speed and new product profitability. They show that the profitability is an inverted U-shape function of the development speed and that the optimal development time depends on the innovativeness of the product (or the ease by which it is adapted in a new market). Several others have also considered the relationship between development speed and NPD success, as an extensive review of Cankurtaran, Langerak, and Griffin (2013) shows. Our work advances knowledge in this area by providing thresholds on the firm's performance advantage for launching or abandoning developed products.

Previous studies have analyzed more subtle development flexibilities. For example, Cui et al. (2011) focus on the use and value of flexibility in adjusting the scope of product launch using a system dynamic model. They show that such flexibility is highly valuable when the product is new and faces high uncertainty regarding the prelaunch forecasts. Similarly, Pennings and Lint (2000) analyze the value of a phased roll-out of a new product to learn about the market before abandoning the product or launching it globally. They conclude that a phased roll-out is an effective strategy when the uncertainty of the product success is high. Carillo and Franza (2004) assess the linkage between investing in product development and production capabilities and characterize optimal policies for them. McCardle (1985) investigates, using a dynamic programming model, the value gained from acquiring more information about the profitability of a new technology and whether it is optimal to adopt or reject the technology. He shows that even if the NPD project manager behaves optimally occasionally unprofitable technologies are adopted and profitable ones rejected. Yassine, Sreenivas, and Zhu (2008) analyze using a dynamic programming model the development flexibility in deciding when to incorporate new information in product development. In our study, we investigate also a managerial flexibility that has gained little attention in previous research, namely the flexibility to switch a development strategy trading-off some probability of successful development for pursuing a more innovative product.

2. The problem

2.1. The NPD project

We view an NPD project as composed of three phases: (i) initial development, (ii) additional development, and (iii) market phases. The initial development phase corresponds to the time required to develop a complete product that can be launched. During this phase, the product *performance*, reflecting the expected desirability of the product, can improve or deteriorate, due to uncertainty in the development process (Lévárdy & Browning, 2009). At each discrete time period, dictated by a phase-gate approach commonly used in NPD projects, the firm can decide whether to continue or abandon the development. A firm can also decide to enhance the development at a certain cost, to include new features or to integrate new innovative technologies, resulting in an increase in the expected product performance with the ultimate aim to maximize the expected net present value (eNPV) of the product. We assume that the duration of this phase is fixed, but that the resulting quality of the developed product is not.

Once the initial development is completed, the additional development phase begins. Within this phase, the firm can continue the development with or without enhancing the product, abandon the development, or launch the product. In this phase, however, the product's performance can no longer deteriorate, as it is always possible to disregard unsuccessful additional developments and launch the product as is. The duration of the additional development phase is not fixed, and terminates when a decision is made to launch the product, or to abandon the development altogether. Once the product is launched,