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Flexibility planning for managing R&D projects under risk

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ABSTRACT

Incorporating managerial flexibility in an innovative R&D project is important, because managers face greater uncertainty in today's competitive and dynamic changing environment. It is essential to bring managerial flexibility into R&D project planning to decrease technical and market risks, while increasing potential market value. The objective of this paper is to develop a flexibility planning methodology based on real option analysis to improve managerial flexibility for R&D projects. The proposed methodology identifies potential risks that may occur during every R&D stage. It also recognizes a cascading option structure to resolve the identified risks, and evaluates and selects adequate options that maximize the potential value of the project. Instead of using a traditional option pricing method, a dynamic programming model that considers multidimensional product performance and market payoff is used to evaluate the R&D project value. Using the proposed methodology, managers can identify future scenarios as a function of their management actions. The proposed flexibility planning methodology can help managers improve managerial flexibility of R&D project and increase the success rate of product launch. A drug development project is used to illustrate the proposed methodology.

1. Introduction

In the increasingly competitive and globalized marketplace, enhancing innovation capability is a key strategy for high technology firms to increase profitability and growth. Therefore, innovative product development plays a key role in the successful performance for these firms. However, uncertainties in technology and market are the major inherent difficulties in developing innovative products. The presence of large uncertainty leads to high R&D risks, resulting in many failures in R&D projects. For example, in the pharmaceutical industry, where there are tremendous technology and market uncertainty, information on technology availability and feasibility and market requirements does not become available or stabilized until the late development phases. The success rate of a drug development project from the first study in humans to launch is less than 10% (CMR International, 2006). Therefore, how to effectively manage R&D risks to enhance successful product launch has become a very important issue for managers.

One solution approach, as seen in concurrent engineering (Prasad, 1996), front-loading problem solving (Thomke and Fujimoto, 2000), or quality function deployment (Hauser and Clausing, 1988), is to collect more information to minimize R&D uncertainty for making better decisions. However, it is hard to anticipate the life cycle impacts of R&D decisions at the early R&D phases. Furthermore, even if valuable time and cost are spent to perform early analysis and problem solving for life cycle impacts of R&D decisions in an early R&D phase, but the decisions made may later become inappropriate because of the highly dynamic nature of technologies and markets. Worst still, if the planned time-to-market goal cannot be achieved, the market opportunity may be lost due to sheer competition.

Another approach is to adopt managerial flexibility in the R&D project (Verganti, 1999). For example, we may postpone technology selection decisions to downstream phases, when the feasibilities of candidate technologies have become clear (Krishnan and Bhattacharya, 2002). R&D flexibility may be considered as the capability to bring new products to market with a minimum of disruption when markets and technologies changes rapidly (Thomke and Reinertsen, 1998). If a firm can introduce late corrective actions at low cost and time for developing a new product as new information emerge, then the firm have greater R&D flexibility. As technology and market has become more dynamic for hi-tech industries, building capabilities for R&D flexibility offers a fresh alternative. It recognizes that uncertainty is the essential core of innovation, and rather than trying to fight it or ignore it, managers should learn how to embrace change and enhance their flexibility. However, embedding flexibility in the R&D project may be useful for creating innovative products by more effectively reacting to high technology and market uncertainty, but it may increase R&D costs.

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Therefore, the management challenge is how to properly plan a flexible development process for the innovative R&D project and analyze its value of flexibility for exploring upside growth potentials and avoiding downside losses (Verganti, 1999; Buganza and Verganti, 2006).

Enterprise risk management (ERM) has emerged since the mid-1990s and it aims to provide a systematic and integrated approach to manage all risks and seize opportunities for achieving business objectives (Olson and Wu, 2008). Unlike traditional R&D risk management that considers the risk as adverse effects on R&D performance, ERM intends to shift risk management from a threat focus towards a greater concern with managing both upside (opportunity) and downside (threat) risks (Perminova et al., 2008). This new perspective would draw management attention to the need to understand variability in R&D projects and to incorporate managerial flexibility into the projects for exploring growth potentials of R&D investment, while avoiding downside losses.

This research defines the R&D risk as an uncertain event that, if it occurs, has a positive or negative effect on R&D project objectives. A methodology is proposed to analyze R&D risks and organize R&D flexibility based on real option analysis for innovative R&D projects. Since R&D flexibility is not inherent in an R&D project, the proposed methodology identifies potential risks, recognizes a set of R&D options to resolve the risks, and then applies a real option valuation model (Huchzermeier and Loch, 2001) to evaluate and select the options that maximize the value of R&D project. It can help R&D mangers improve managerial flexibility of an innovative R&D project to capture opportunities and avoid threats. A drug development project is used here to illustrate the proposed methodology.

The organization of this paper is described as follows. Section 2 provides the literature review on R&D risk management and real R&D options. The flexibility planning procedure and the real option model based on dynamic programming are developed in Section 3. A case study of a drug development project is illustrated in Section 4. Section 5 concludes the paper.

2. Literature review

2.1. Literature review in R&D risk management

Managing R&D uncertainty to enhance project success rates has been studies for many years (Doctor et al., 2001). Risk management is one of the approaches that has been widely applied in practice (Smith, 1999; Keizer et al., 2002; Raz et al., 2002; Cooper, 2003). Several studies have found that applying risk management techniques to R&D projects can improve their success rates, especially for radical innovative projects (Raz et al., 2002; Salomo et al., 2007; O'Connor et al., 2008).

Various R&D risk management frameworks, techniques, and tools have been developed in the literature for managing different types of risks to accomplish the goals of R&D investment. Lefley (1997) reviewed the state-of-the-art techniques used in the identification and assessment of new technology investment project risks. Browning et al. (2002) proposed a risk value methodology that quantifies technical performance risks to identify, assess, monitor, and control the identified risks throughout the project. Since R&D is people and knowledge intensive, Cooper (2003) suggested using knowledge management systems and collaboration tools that captured practitioner experience for reducing R&D risks. For ease of risk identification, Keizer et al. (2005) proposed a risk reference framework for diagnosing risks in technological breakthrough projects and concluded that the success of breakthrough innovation projects can be improved through formal risk assessment. From the perspective of time-to-market risk, Wang and Lin (2009) also presented an overlapping process model integrating with Monte-Carlo simulation to assess the schedule risk of an R&D project. Several process design strategies were proposed in their paper to reduce the risk of late product launch. To avoid the market risk, Ogawa and Piller (2006) suggested a new market research method called "collective customer commitment" that integrates customers into the innovation process to reduce the risk of unmet customer needs. In addition, Wang et al. (2010) proposed a performance-driven risk management framework that aligns the project risk management with the corporate performance measurement system for better accomplishment of corporate strategic goals.

It is worth noting that most literature in R&D risk management attempts to develop methodologies to reduce the risk having a negative impact on project outcomes. Few researches have been published on actively managing both upside and downside risks and integrating advanced financial tools (e.g., real option analysis) to evaluate the value gained from managerial flexibility. This research intends to fill this gap in the literature.

2.2. Literature review in real R&D options

The traditional net present value (NPV) and discounted cash flow (DCF)-based analyses usually underestimate the value of an R&D project, due to the assumption that once the decision is made to fund a project, expense and cash inflow occur without the possibility of being changed (Dixit and Pindyck, 1994). The concept of real option applies financial option theory to investment decisions that are characterized by irreversibility and uncertainty about their future rewards in many different application fields; for example, operation management (Bengtsson, 2001), supply chain management (Wallace and Choi, 2011), workforce planning (Qin and Nembhard, 2010), information technology projects (Benaroch, 2001), venture capital projects (Ko et al., 2011), research and development (Newton et al., 2004), and so on. Real option is defined as the right but not the obligation to acquire the present value of the expected cash flows by making an investment when the opportunity is available. This methodology is particularly applicable when there is a high degree of uncertainty, and some managerial flexibility, but not all the information is known at a particular time. Therefore, the concept of real option is quite suitable to improve R&D decisions that are generally characterized by uncertainty.

In the literature of real R&D option analysis, two common techniques are commonly used to value the R&D project. The first approach applies the famous Black and Scholes equations (Black and Scholes, 1973) for pricing R&D options. However, there are some inadequate assumptions needed when using the Black and Scholes model in an R&D project valuation, for example, neglect of multistage nature of R&D and inadequate underlying asset assumption of geometric Brownian motion. Several methods have been proposed to resolve its limitations (Pennings and Lint, 1997; Perlitz et al., 1999). The second approach is the binominal options method that uses a lattice to represent alternative possibilities over time (Cox et al., 1979). The binominal lattice model can be used to accurately approximate solutions from the Black and Scholes model with the advantage of allowing evaluation of the value of the early-exercise American option. Several studies have applied the binominal model to evaluate the R&D option values (Huchzermeier and Loch, 2001; Schneider et al., 2008).

Real option analysis has been applied in R&D project management (Huchzermeier and Loch, 2001; Santiago and Bifano, 2005; Santiago and Vakili, 2005), investment timing (Kauffman and Li, 2005; Lin and Huang, 2010), strategic planning (Smit and Trigeorgis, 2006), and R&D portfolio management (MacMillan