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Optimal R&D investment strategies under the threat of new technology entry

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Abstract

This paper studies the R&D investment decisions of a firm facing the threat of new technology entry. The R&D project is subject to technical uncertainty. The incumbent can successfully prevent entry by innovating. However, in an entry deterrence situation the resulting monopoly is different from a monopoly without an entry threat, because potential competition means that the monopolist completes the R&D project, which it otherwise would not have done.

Greater technical uncertainty stimulates initiating exploratory R&D and can result in implementation of more expensive research projects. This is a result of the limited downside risk of the project: it does not matter whether the outcome of an initial R&D stage is disappointing or very disappointing, since in both cases the firm will simply abandon the project. The welfare analysis shows that the threat of entry may reduce welfare in case of entry deterrence.

JEL classification: C72; D21; O31

Keywords: Investment under uncertainty; Real options; R&D; Competition

1. Introduction

The aim of this paper is to provide analytical results regarding incentives for R&D investments of firms dealing with an entrant that produces with a more modern technology. To do so we design the simplest possible framework that contains the specific aspects of strategic

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R&D: uncertainty, time to complete, competition, and entry threat. Next, we discuss these aspects in this order. The introduction ends with a presentation of the paper's contents and our main results.

Two important features of R&D investments are that an R&D project takes time to complete and that the outcome of R&D is uncertain. In the existing literature technical uncertainty is mainly represented by assuming a random date of new technology or innovation arrival (such as Poisson arrival in Kamien and Schwartz, 1971; Loury, 1979; Dasgupta and Stiglitz, 1980; Weeds, 2002; Doraszelski, 2003). In our paper technical uncertainty results in a random outcome of the costs of R&D. Following Dixit and Pindyck (1994, pp. 345–356), we assume that the firm does not know beforehand how much time, effort, and resources it will need to complete an R&D project (see also Kort, 1998; Schwartz and Moon, 2000). A typical characteristic of technical uncertainty is that it cannot be resolved by waiting. The firm can obtain information about the true cost of R&D only by starting the R&D project.

R&D cost uncertainty is modeled in a different way, compared to Kort (1998) or Schwartz and Moon (2000). Instead of employing a stochastic Wiener process, we introduce a simple two-stage R&D process with uncertain outcome of the first stage. This enables us to obtain analytical results for a framework containing both technical uncertainty and competition. As in Moscarini and Smith (2001), in our model first-stage R&D decreases uncertainty about future payoffs by revealing the true R&D cost. Unlike the one-decision-maker model of Moscarini and Smith, we study the effect of R&D cost uncertainty on the firm's decision to undertake R&D in a strategic setting, combining the effects of technological uncertainty and competition.

We require that completion of the next stage requires that the previous stage be carried out in full. In many cases the introduction of a new process is done by reequipping or reorganizing the production line (Rosenbloom and Christensen, 1998). To do so, the firm must first develop new tools and machinery with required specifications, followed by building and testing prototypes (with the outcomes of tests being uncertain), and later integrate them into the production process and test the upgraded production line as a whole (the cost of which depends on the outcome of the previous stages).

In our framework it is important that the firm has the possibility to abandon the R&D project midstream, which is a key characteristic of sequential investment (Dixit and Pindyck, 1994). This opportunity can be worthwhile in case completion of the R&D project is more difficult or costly than expected. The implication is that this abandonment possibility can make it optimal to start up the R&D project even if its NPV is negative.

We conclude that greater R&D cost uncertainty encourages the firm to start undertaking the R&D project in order to resolve the uncertainty. The fact that greater technical uncertainty stimulates R&D also holds in decision problems without strategic interactions as shown in Kort (1998) and Schwartz and Moon (2000). The point we want to make here is that this result can influence the market behavior of firms. As it is now, many papers are devoted to the topic of R&D without taking the effect of technical uncertainty into account. We will show that increased uncertainty raises the incentive to start the R&D project, which implies that the entry deterrence power of R&D is larger.

In the context of strategic interactions the model is related to Kulatilaka and Perotti (1998) but differs in three aspects. In Kulatilaka and Perotti the firm can carry out one investment expenditure in order to reduce unit production costs in the next period, while in our framework the firm needs to go through a two-stage investment procedure. In Kulatilaka and Perotti there is demand uncertainty while we have R&D cost uncertainty. We assume an explicit difference between the incumbent and the entrant by allowing the incumbent to have a one-period lead over