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Production experiences and market structure in R&D competition

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Abstract

In the R&D race the incumbent enjoys an advantage of learning from production experiences, but this important feature has not been incorporated into existing studies. Assuming that the technological knowledge is accumulated not only by R&D expenditures but also by production experiences, we study the properties of optimal investment strategies in a model with an incumbent and many identical challengers. After proving the existence of a unique Nash equilibrium in the R&D race, we demonstrate analytically that the likelihood of persistent leadership increases with production experiences of the incumbent but decreases with the number of challengers. Numerical analyses also establish that (i) the challengers always invest more than the incumbent and the difference increases with production experiences, the flow of monopoly profits and the number of challengers; and (ii) the likelihood of persistent leadership increases with the value of being the winner and the value of being a loser but decreases with expected waiting time of R&D innovation and the flow of monopoly profits. However, destructive innovations may still occur even when production experiences are allowed to play an important role in the R&D competition.

JEL classification: C61

Keywords: Production experiences; Market structure; Persistent leadership

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1. Introduction

In this paper we develop a framework to understand the impact of production experiences on the R&D race and study whether the incumbent can prevail in the face of possibly destructive innovations. Although the effects of production experiences on production costs[1] and the structure of an industry[2] are in the literature, their impact on the R&D race has not been fully analyzed.

Production experiences can play to the advantages of the incumbent in the R&D competition. For example, Intel's experience of producing 486 CPU provided the company with an opportunity to supersede its major rivals in the development of the products of the next four generations – namely, Pentium I, Pentium II, Pentium III, and Pentium IV CPUs (Yu, 1999; Chang and Park, 2004). Similarly, Gruber's (1994) empirical studies also show that production experiences helped the incumbent to prevail in the patent race for the next-generation EPROMs products. Production experiences, however, may not be sufficient for the incumbent to sustain its edge over its competitors as more challengers emerge. In the optical passive components (OPC) industry for example, an increase of new competitors from Taiwan and Korea caused most of the Japanese and American incumbents to switch to the optical active components (OAC) industry. It shows that destructive innovations may occur as the R&D race becomes more competitive.

In a seminal paper, Reinganum (1982) studies the strategies of a number of identical firms engaged in R&D race. An increase in the number of challengers is shown to lead to an increase in each firm's R&D investment.[3] Reinganum (1983) also points out that the incumbent's R&D investment is less than that of the challenger when there is only one challenger and one incumbent and when the innovation process is uncertain. Furthermore, when there is one incumbent and a number of identical challengers and when the new-generation products are introduced to replace the obsolete products as in Reinganum (1985), the incumbent always invests less than the challengers since the incumbent lacks an incentive for R&D investments. Hence, the Schumpeterian 'process of destructive innovations' can occur in a sequence of innovations as the incumbent is overthrown by a more innovative challenger.[4]

In this paper, we include not only the impact of market competition but also the effects of accumulated production experiences on the R&D competition for the next generation product. We assume that each firm's hazard function governing the

[1]See Dick (1994), Benkard (2000), Park (2002) and Cabral and Leiblein (2001).

[2]See Gilbert and Newbery (1982), Dasgupta and Stiglitz (1988) and Reinganum (1983, 1985).

[3]Loury (1979) and Lee and Wilde (1980) also discuss the variations of each participant's investment intensities as the number of competitors changes. In addition, Choi (1991) and Malueg and Tsutsui (1997) analyze a patent race for several identical firms with an uncertain hazard rate governing the innovation process.

[4]The persistence of monopoly in the R&D race for uncertain process innovations is possible when the monopolist incumbent has a first-mover advantage to commit to an entry-deterring level of investment (see Gilbert and Newbery, 1982, 1984; Reinganum, 1984).