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How does R&D intensity influence firm explorativeness? Evidence of R&D active firms in four advanced countries

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ABSTRACT

Despite R&D is seen as a starting point of innovation, firms usually confront a trade-off in allocating limited R&D resources to either exploratory or exploitative activities. Relative to the latter, the former produces a more distinctive variation from the prior knowledge base and helps the firm tap into new opportunity. Given the increasing importance of firm explorativeness in the fast changing environments, the influence of R&D investment on firm explorativeness is not yet conclusive in the literature, not to mention whether the increased R&D investment induces firms to become more explorative. This study aims to generate insight into how and when firm explorativeness is determined by their R&D intensity. As a notion of the use of knowledge new to the organization, firm explorativeness is treated as the degree of using knowledge new to the organization in the pursuit of innovation. Based on a panel data of 1267 firm-year observations in four advanced countries during 1999–2003, the results reveal that a higher level of R&D intensity makes firms more exploitative and less explorative. Nevertheless, the negative relationship between R&D intensity and firm explorativeness is found to be alleviated in the presence of technological opportunity or financial slack. The configurational model sheds further light on the combined and relative weight of two moderators.

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Incremental innovation is better than no innovation at all, but in an increasingly nonlinear world, only nonlinear ideas are likely to create new wealth.

~Gary Hamel (2002), "Leading the Revolution"

1. Introduction

Research and development (R&D) has long been considered essential for the survival and growth of modern industrial firms (Shefer and Frenkel, 2005; Kor, 2006). Almost all successful "built to last" companies rely on their commitment to R&D (Collins and Porras, 1994). However, the R&D-performance relationship has constantly been debated. For example, in a study of the top 1000 innovative companies by Booz & Company, Jaruzelski et al. (2011) pointed out that more spending on R&D does not guarantee more

economically or socially desirable outcomes. The fallen giant Eastman Kodak is also a well-known counterexample. Kodak maintained high R&D expenditures relative to its sales in 1990s in the range 5.7% to 7.9% but by the time the majority of R&D resources went to support chemical photography technology; whereas digital photography was not taken seriously into consideration even though Kodak pioneered the technology. A similar fate happens to Sony which has long been a big R&D spender but became less revolutionary and fell behind in the technology parade. In contrast, numerous studies show that the start-ups, which have limited R&D resources in comparison to their well established counterparts, are more active in generating disruptive or radical innovation (e.g., Cooper and Schendel, 1976; Foster, 1986; Christensen, 1997). The above evidence not only suggests that the logic of "big ones get bigger" for R&D investment may not hold universally, but leaves us a puzzle why R&D investment cannot effectively make firms more adaptable to the changing environments.

As is known, R&D is conducted to solve problems or generate new knowledge, but the way that R&D resources are allocated and spent may imperceptibly influence a firm's innovation posture and

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its consequent performance. Most R&D resources in general are used in pursuit of either explorativeness or exploitativeness (Garcia et al., 2003). The former refers to a conscious attempt to deviate away from current knowledge in order to seek new ways of problem solving (Gupta et al., 2006), while the latter aims to refine and extend existing knowledge for the benefit of efficiency (He and Wong, 2004). Based on the relative advantage of explorative and exploitative innovation, some believe that high-performing firms must be able to act ambidextrously by pursuing exploratory and exploitative innovation simultaneously (O'Reilly and Tushman, 2008). However, others question the administrative easiness of accomplishing organizational ambidexterity since the two types of innovation activities tap into different organizational routines, supportive infrastructures and managerial mindset (March, 1991; Mudambi and Swift, 2011). Hardly realizing ambidexterity without structurally dividing the two activities, most firms have to make trade-off decisions on R&D resource allocation which in turn determine their innovation posture in the marketplace.

In contrast to the incremental nature of exploitativeness, firm explorativeness, known for its discontinuity from the prior trajectory and the odds of its incidence, enriches a firm's breadth of knowledge by creating distinctive variation in its competence base and yields novel solutions to its problems. The literature has documented that explorative innovation helps firms to build new competencies and thus disrupt the markets (e.g., Benner and Tushman, 2002; Phelps, 2010). Such radical or high-impact innovations are mainly a result of explorative efforts, such as distal learning (Wong, 2004) or commitment to basic research (Rosenkopf and Nerkar, 2001), but these efforts may not proportionally lead to explorativeness because the ways that R&D resources are allocated and spent vary greatly across firms. Proposing a balance between exploration and exploitation, the organizational learning scholars admit that most firms intend to seek solutions within familiar domains of knowledge (March, 1991; He and Wong, 2004). Although productivity-enhancing opportunities are never exhausted, it is possible that all of the low-hanging fruit have been picked. The bias toward exploitativeness not only leads to diminishing returns on R&D investment (Katila and Ahuja, 2002), but is also a sign of a firm's short-term orientation (Andriopoulos and Lewis, 2010) or failure-intolerant culture (Lewin et al., 1999). As today's business environments become increasingly volatile and dynamic, an explorative orientation becomes vital for firms to maintain their adaptability and the odds of survival (Levinthal and March, 1993). Given the extent to which R&D investment determining the odds of explorativeness has been relatively sidelined in the literature, this study aims to revisit the black box of innovation dynamics behind firm explorativeness.

Equally important to the innovation effect of R&D investment in this study are the contingencies upon which the outcome of R&D investment may be altered. As firm behavior is not created in a vacuum but in specific contexts (Sharma, 2003), external opportunity or internal resourcefulness always facilitates or hinders a firm's decisions made, resources allocated and actions taken (Cestone and Fumagalli, 2005). The external contingency considered in the present study is the technological opportunity characterized as the extent to which firms are in fertile breeding grounds for technological progress (Hitt et al., 1997; Wu and Lee, 2007). While firms operating in mature industries face limited or no possibility of technological breakthroughs, those in emerging industries may have abundant space to advance the technological frontiers. As such, the presence of technological opportunity usually drives firms' R&D investment willingness and the way R&D resources are spent (Naranjo-Gil, 2009). In contrast, the internal contingency for a firm's R&D decision refers to the organizational slack which represents resources in excess of the minimum necessary to produce a given level of organizational output (Nohria and Gulati, 1996; Geiger and Makri, 2006). Slack

resources are not only used or leveraged at managerial discretion but buffer the firm from the threats of uncertainty (Tan, 2003). Accordingly, the present study argues that R&D investment may not lead universally to a certain pattern of innovation outcomes, and thus proposes a contingency view on its situational consequence. We likewise attempt to highlight the context-dependent nature of innovation dynamics and empirically test whether the innovation posture of R&D investment should reflect the contexts in which a firm operates.

In addition to the contingency view, the study intends to further explore the nuances of the interplay between a firm's behavior and the contexts from the configurational perspective. Miller (1987) argued that multivariate configurations may offer a more thorough explanation of complex organizational behaviors than do simple univariate or even bivariate analyses. In this vein, this study aims not only to clarify the situational influence of R&D investment on firm explorativeness, as suggested by Garcia et al. (2003), but also to heed the recent calls (Sidhu et al., 2004; Alexiev et al., 2010; Phelps, 2010) for more scholarly attention to innovation dynamics by investigating how a firm's innovation pattern is determined by its R&D intensity when subject to various levels of technological opportunity and slack.

To address the above research questions, this study chose a sample of R&D active firms in a number of industries subject to a great variance in resource endowment internally and technological opportunity externally, both of which either stimulate or lessen the necessity of a firm's explorativeness. The empirical setting includes 311 industrial firms in four developed economies (Japan, Germany, the UK, and the US) over a four-year time span (1999–2003). This spectrum, covering different regions and contrasting institutional environments, softens the problems caused by industry- and country-specific data, and results in more robust and generalizable findings.

The rest of this paper is organized as follows. The next section reviews the literature on R&D investment and the distinct types of innovation activities; this is followed by four hypotheses on the main relationship and the moderating and configurational effects of technological opportunity and financial slack. Section 3 describes the data, measures and methodology, while the following section presents the empirical results. The last section concludes and develops the theoretical and managerial implications.

2. Literature review and Hypothesis development

2.1. R&D intensity and explorativeness

With the increasing rapidity of technological change and the dispersion of knowledge in most industrial environments, R&D has become a critical investment for survival and prosperity (Chan et al., 1990). The literature documents a variety of positive influences of R&D investment which contribute to productivity gains (Verspagen, 1995), inventions (Rosenberg, 1990), patent production (Kondo, 1999), new product development (Stam and Wennberg, 2009), growth and profitability (Rogers, 2004), product diversification (Alonso-Borrego and Forcadell, 2010), or citation intensity (Geiger and Makri, 2006). However, the influences of R&D investment on either organizational behavior or firm performance may not be universally positive because of various ways of allocating R&D resources within the hierarchy (Hirshleifer, 1993; Jensen, 1993). The mixed blessing of increased R&D spending not only implies that more spending on R&D does not guarantee a better chance of achieving business success, but suggests that the dynamic nature of R&D effect merits more inquiry.

The ambiguous effect of R&D investment is also caused by the mixed uses of the term of R&D, which actually includes different

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