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The effect of R&D novelty and openness decision on firms' catch-up performance: Empirical evidence from China



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ABSTRACT

This paper explores the strategic dimensions of R&D decisions toward novelty and openness in explaining the performance of latecomer firms in a developing economy. A structural equation model of R&D decision-making is formulated using survey data from 279 Chinese firms. The dimension of R&D novelty is defined as the degree of technological newness found in firms' R&D projects, while R&D openness describes the degree to which technologies are acquired from external sources. Our results indicate that firms' R&D decisions regarding novelty and openness are associated with demand opportunities, market competition, technological capability, and external networks. Greater R&D novelty contributes positively to innovative output but does not affect sales growth. Greater R&D openness contributes positively to sales growth but negatively to innovative output.

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1. Introduction

Chinese leaders have long placed the development of science and technology at the center of China's modernization plan, regarding it as the key engine for catching up with advanced industrialized countries (Bin, 2008; Liu et al., 2011; Ning, 2009). Over the last two decades, China has been continuously making substantial investments in R&D. This spending reached a record high of 162 billion US dollars in 2012, accounting for 1.97 percent of China's GDP and making it the second most R&D-intensive country in the world since 2009 (ChinaDaily, 2013; OECD, 2012). Such a huge R&D effort was also made in the hope of transitioning the country's economy from being labor-intensive and export-led to a more sustainable innovation-driven growth model by 2020, as announced in China's 12th Five Year Plan for Science and Technology Development.

In this economic transitional period, Chinese firms, similar to their East Asian newly industrialized economy (NIE) counterparts in the peak of their catch-up period, face a "strategic dilemma". This dilemma is whether they should try to become innovation

leaders, relying on in-house R&D, or continue their low-cost, imitation-based competitive strategies (Hobday et al., 2004; Xiao et al., 2013). This is particularly relevant for some of China's largest firms (e.g., Huawei, Lenovo, and PetroChina) and is increasingly important for many others that are approaching multinational stages. Given China's substantial investment in technology and innovation, it is important to understand how firms are making their R&D decisions to catch up and reduce the technological gap with the industrial leaders.

Previous research has well documented the processes of technological capability building by NIE latecomers. One view rooted in the product life-cycle theory is that latecomers improve their technological capability following the technological trajectory of the developed country firms by assimilating and adapting relatively obsolete technology (Kim, 1997; Utterback and Abernathy, 1975; Vernon, 1966). Latecomers should initially focus on developing production capability through licensing or joint ventures and then move on to building up independent technological capability in stages (Kim, 1980, 1997). An alternative view derived from the Perez and Soete's (1988) leapfrogging thesis suggests, on the contrary, that the constraints on an innovation pattern are lifted by technological paradigm shifts. This type of 'window of opportunity' allows latecomers to catch up, as all industry players are new to the emerging paradigm. Latecomers can omit some parts of the trajectory or even forge novel pathways, bypassing older technology

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to catch up with advanced countries (Hobday et al., 2004; Lee and Lim, 2001; Mu and Lee, 2005; Park and Lee, 2006; Perez and Soete, 1988; Xiao et al., 2013).

Latecomer transition, however, is not a simple dichotomy between catch-up and leadership strategy, as technological development and innovation are not mutually exclusive options (Hobday et al., 2004). R&D investment is not a result of catching up but an important input to enable it (Hobday et al., 2004; Mu and Lee, 2005). Considerable R&D is required for firms to achieve radical innovation and alter the patterns of competition. All NIEs have spent a substantial amount on R&D during their catch-up process (Gill et al., 2007; OECD, 2012). However, relatively little is known about the strategic dimensions of latecomer firms' R&D decisions and the consequential innovation performance in their catch-up process.

To this end, this paper deconstructs R&D behaviors along two strategic dimensions to answer this question: R&D novelty, which is the extent to which firms employ technological newness in products or production processes through knowledge exploration and exploitation, and R&D openness, which is related to the degree to which firms' knowledge sourcing strategy is through internalization or externalization (see Section 2 for details). Because R&D behaviors are constrained by the specific conditions of the technological regime, a theoretical framework is built to link antecedents, R&D decisions, and consequent outputs to explain latecomers' technological catch-up performance. We use a structural equation model based on a survey of Chinese firms.

This study contributes to theory development and has practical implications for managers and policy-makers in China as well as providing a useful reference for other developing countries that are promoting their technological development. Regarding theory development, this paper reanalyzes several common R&D concepts and attempts to integrate R&D decisions into a comprehensive and consistent technological catch-up framework. Regarding practical implications, the results of the structural equation model provide guidance on how to implement R&D resource allocation to balance novelty and openness, which, in turn, helps to address the challenge of optimizing the balance between imitation and innovation. Moreover, this quantitative study of R&D decision-making complements the many qualitative studies in the field of catch-up research.

The remainder of this paper is organized as follows. We develop a conceptual model and our hypotheses in Section 2. Section 3 describes the research methodology and measurements, while Section 4 contains an analysis of the structural equation model. In Section 5, we present the results and discuss the empirical findings. Section 6 summarizes the key findings, outlines the managerial implications, and discusses the limitations of our research and directions for future research.

2. Theoretical background and hypothesis development

2.1. The novelty and openness dimensions of R&D decisions

The central concern of the literature on adaptive search behaviors is the relationship between the exploration of new vs. exploitation of existing technological capabilities in ensuring firms' competitiveness and the association of different types of learning and innovation (March, 1991). Exploitation is described as local searches that locally address 'problems' using knowledge that is closely related to the pre-existing knowledge base of a firm (Ahuja and Morris Lampert, 2001; Katila and Ahuja, 2002). Exploration is characterized as exploratory or distant searches that involve a deliberate effort to depart from present organizational routines and knowledge bases (Katila and Ahuja, 2002; March, 1991; Rosenkopf and Almeida, 2003; Stuart and

Podolny, 1996). Due to the path-dependent nature of technological innovation, firms need to combine these two search activities. Exploration without exploitation is likely to suffer from the high costs of experimentation and high rates of failure because of the inherent risks and uncertainties. Conversely, exploitation without exploration is likely to be trapped in suboptimal equilibriums due to core rigidities or competency traps (Gilsing and Duysters, 2008; Gupta et al., 2006; March, 1991; Nooteboom, 2000; Rosenkopf and Almeida, 2003; Yamakawa et al., 2011). Both activities are essential but compete for the same resources. As a result, achieving an optimum balance between the two to combine internal and external knowledge is a primary requirement for making R&D decisions on search behaviors (Bauer and Leker, 2013; Katila and Ahuja, 2002; Rivkin and Siggelkow, 2007). More importantly, the exploitation and exploration framework indicates that the key difference between the two is the degree to which search behaviors involve *the development of new knowledge and sources of such knowledge creation*.

Previous research has noted that catch-up firms' R&D behaviors are dependent on different technological regimes (Cho and Lee, 2003; Malerba and Orsenigo, 1993; Park and Lee, 2006). There is also considerably less clarity on how latecomer firms make use of R&D resources (Gupta et al., 2006; Kale and Wield, 2008). To arrive at an integrative view of latecomers' R&D decisions on search behaviors, we build on this exploitation and exploration framework and propose two strategic dimensions, R&D novelty and R&D openness. The first novelty dimension is related to the development of new knowledge, as firms often need to decide the extent of newness in their search behaviors, i.e., based on pre-existing knowledge (exploitation) or moving away from their current knowledge base (exploration). R&D novelty can therefore be defined as the extent of technological newness found in R&D projects, e.g., significantly new products or improved production processes (Bauer and Leker, 2013; Hult et al., 2004; Luecke and Katz, 2003; Rhee et al., 2010). Imitation can be a creative process, but it is not completely distinct from innovation (Dosi, 1988). In cases of high absorption costs, imitation may even be more economically expensive than the original innovation (Cohen and Levinthal, 1990). Furthermore, firms might need to acquire technology far from their existing knowledge base to avoid the familiarity trap and break existing technological paradigms (Ahuja and Morris Lampert, 2001; Gilsing and Duysters, 2008). The challenge for latecomers is more about increasing the novelty of innovation rather than whether the firms innovate. The choice over the extent to which search behaviors should be new is a trade-off in budget allocation between innovation and imitation (Nelson and Winter, 1982).

The other strategic dimension, R&D openness, is related to the sources of knowledge creation. Firms need to choose the extent of openness these exploitation and exploration search behaviors should incorporate, i.e., relying mainly on internal R&D efforts (internalization) or searching for external technology (externalization), to explore and exploit technology innovation. R&D openness can be seen as the extent to which technologies are acquired from external sources. These strategies cover a mixture of in-house R&D, strategic alliances, licensing of technologies, and other approaches. The transaction cost perspective has emphasized the costs related to these external sourcing options, such as organizational coordination, partner selection, risks of imitation, and knowledge leakage (Robertson and Gatignon, 1998; Steensma and Corley, 2001).

The knowledge-centered perspective in this paper is based on and focuses instead on boundary-spanning exploration choices (Rosenkopf and Nerkar, 2001). To escape from the negative effects of local searches and succeed in following sudden and unanticipated changes in the environment, exploratory search behaviors have to span some boundaries, be they organizational

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