Technology acquisition and innovativeness and roles of R&D investment

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Abstract: As market competition intensifies, the importance of new product innovation for a firm to achieve competitive advantage is ever increasing. The pace of technological change is accelerating and the complexity of technological development is increasing. This paper use theoretical analyzes of the relationship between External technology acquisition and innovativeness and the moderating roles of R&D investment. This study, aims to fill this gap of knowledge by investigating the external technology acquisition-product innovativeness relationship and examining the moderating roles of R&D investment and configurational context on this link. External technology acquisition has a positive impact on innovativeness. R&D investment increases the effect of external technology acquisition on innovativeness.

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1. Introduction

The impact of technology as a source of competitive advantage for manufacturing industries is widely accepted by practitioners, governments and academics. In order to realise this competitive advantage, it is vital to understand both the specific technologies, and the ways in which organisations can best manage technology. These issues are of increasing importance as the pace of technology development and its complexity increase. Much of the effort since about 1980 in the area of technology management has been directed towards strategic issues (Drejer, 1997) - i.e. how to integrate technology strategy with marketing and other corporate strategies. For example, Mitchell (1985) has developed a simple matrix linking strategic technology areas to business areas. Effective implementation of a technology strategy requires management of the associated processes at the operational level; ``A strategy is only of value if mechanisms for its implementation and renewal are in place'' (Gregory, 1995). To this end, it is necessary to develop both an accepted framework for understanding technology management issues (see below), and a range of tools and techniques to support the implementation of strategy (for example, Tipping et al., 1995).

The valuation of and decisions about investments in research and development (R&D) are perhaps even more important for founders and potential investors in research-based start-up firms, than for large companies in research intensive industries. The relationship between market competition and incentives for innovation has been a controversial subject in economics since Schumpeter (1934, 1942) advanced the argument that competitive markets are not necessarily the most effective mechanism of exchange for promoting innovation. Arrow (1962) made the counterargument that competitive markets provide firms with a stronger incentive for R&D. Numerous theoretical and empirical studies have examined this subject, but as Gilbert (2006) pointed out, economists "remain far from a general theory of innovation competition, although the large body of theoretical and empirical studies is beginning to yield conclusions, however meager."

According to economic theory, there are several reasons why the private rate of R&D may diverge from the socially optimal rate of R&D. First, firms may under-invest in R&D because there are positive spillovers involved: when a firm makes a discovery, other firms can free ride on the invention and may even imitate the invention without having paid for the R&D efforts. Even with patent protection, these spillovers reduce the payoff to investing in R&D. A second reason why the private rate of R&D is lower than the optimal rate is the appropriability effect: in the absence of perfect price discrimination, the private surplus from innovation is lower than the social surplus (Tirole, 2001). A countervailing effect that leads firms to over-invest in R&D is the business-stealing effect: a firm that introduces a new product does not internalize the loss of profit suffered by its rivals on the product market (Tirole, 2001).

When firms cooperate in R&D but continue to compete in product markets, they internalize the negative externalities among their R&D projects by cutting R&D investments in all products and specializing more in their respective core products. If the degree of product substitutability is sufficiently high, firms will choose complete specialization in R&D by closing down their non-core products' R&D

labs. Although the possibility of R&D cooperation reducing R&D investments has been well analyzed in existing studies, its effect on the structure of R&D portfolios has not been adequately considered.

2. Technology acquisition

Technology is defined differently. Sociologists, Economists, Management Scientists, and other faculties, have their own definitions of technology. Apparently there are professional definitions for this word, but all have common aspects. Technology transfer in different countries and organizations with various' levels of technical knowledge covers limitations and problems for the less developed recipient. Technology transfer is a complex and challenging processes which needs deep and all out study. In case of overlooking of different aspects of the technology transfer; it may lead to weaknesses of the national technology. Technology transfer process includes some preventive scales, which should be addressed, before selecting the technology transfer method.

The first type of technology transfer determinants is "institutional determinants". They are classified as technology transfer office (TTO) determinants (Hauksson, 1998), universities licensing policies determinants (Hsu & Bernstein, 1997) and institutional prestige influence determinants (Sine, Shane, & Gregorio, 2003). In the aspect of TTO determinants, Tornatzky (2000) argued appropriate staffing, clearly articulated mission, customer-friendly orientation, clear policies and procedures, supportive university culture are vital for TTO practice.

The second type of technology transfer determinants is "inventor-related determinants". They are classified as inventor involvement and cooperation as a team player (Thursby & Thursby, 2002), inventor being recognised as a technology leader (Allen, 1977), inventor credibility in the field (Berry & Broadbent, 1984), inventor has realistic expectations about his or her technology (Galbraith, 1990), incentives to inventor by the licensor (Jensen & Thursby, 2001).

The third type of technology transfer determinants is "technology-related determinants". The most important determinants are technology nature and sophistication, technology's significant benefits and advantages as identified and perceived by the user, technology's quantifiable benefits and advantages as perceived by the user when compared to current competing products, technology's sustainable competitive advantages and superiority as perceived by the user, the availability of a functioning prototype, the technology's degree of compatibility to other necessary technologies (Rogers, 1995), technology scope or future uses, technology uniqueness and superiority, the barriers to entry, the newness and the non-obviousness in the technology (Nerkar & Shane, 2007), the technology's degree of dependability on other necessary technologies, the technology's identifiable and quantifiable technological risks and weaknesses, the technology development time to market, the stage of development of technology, the technical feasibility (such as technical problems are solvable) (Rahal & Rabelo, 2006).

The fourth type of technology transfer determinants is "commercialization-related determinants". Based on literature review of (Rahal & Rabelo, 2006), they classified the determinants as follows: the technology's identifiable current and immediate market needs, the absence of a dominant competitor in the technological field, the technology has a large definable potential market, the technology's market growth anticipation, the technology's expected market trend the time for the technology to reach the target market penetration, market accessibility for the technology (no dominant technology), the technology's competitive pricing, the technology has a reasonable probability of market success, the technology being first to market (early mover advantage), the R&D necessary for the technology to reach the product development stage, the technology's expected payoff period, the technology's expected positive return on investment within a specified period, the technology's financial risk.

2.1. Technology management process framework

Gregory (1995) has proposed that management of technology is comprised of five generic processes (see Figure 1):

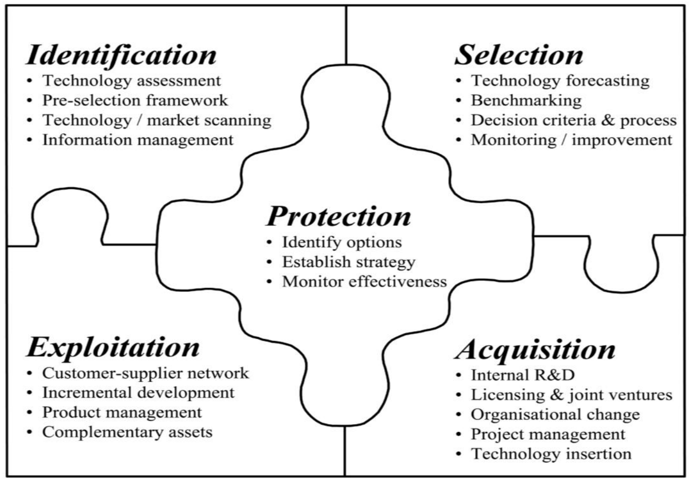
(1) Identification of technologies which are (or may be) of importance to the business.

(2) Selection of technologies that should be supported by the organisation.

(3) Acquisition and assimilation of selected technologies.

(4) Exploitation of technologies to generate profit, or other benefits.

(5) Protection of knowledge and expertise embedded in products and manufacturing systems.



Source: Gregory (1995)

As technology and innovation seem to be synergistic, a great deal of attention has been given to the importance of assessing the contribution of R&D investment to firm performance.

3. Innovation

Literature conceptualizes innovation in a variety of ways in the literature, as a process, and outcome of both (Damanpour and Gopalakrishnan, 1998; North et al., 2001; Wolfe, 1994). However, most of the definitions of innovation share the idea that innovation implies the adoption of a new idea or behavior. Literature also distinguishes different types of innovation. The classification most extended and accepted is the one Damanpour (1991) proposes. He distinguishes between technical and administrative innovations. Whereas technical innovations include a new process and new products or services, administrative innovations refer to new procedures, policies and organizational forms. Innovation helps the company to deal with the turbulence of external environment and, therefore, is one of the key drivers of longterm success in business, particularly in dynamic markets (Baker and Sinkula, 2002; Balkin et al., 2000; Darroch and McNaugton, 2002; Lyon and Ferrier, 2002).

Innovation can occur in three broad domains; products, processes, and organizations, and is ‘‘an idea, product or process, system or device that is perceived to be new to an individual, a group of people or firms, an industrial sector, or a society as a whole’’ (Rogers, 1995). According to Damanpour (1991), organizational innovation combines the development and implementation of new ideas, systems, products, or technologies. In competitive markets, enterprises must increase their knowledge to adapt to new products and technology, and continuously distribute this knowledge to all employees. Based on an organization’s internal factors, the nature of innovation can involve technical, product, and process innovation. These internal factors include knowledge and skill resources, physical and management systems, and values and norms. The external factors include customers, competitors, statutes, and technology. A considerable debate exists regarding how to best measure innovation performance (Kanji, 1996; Tang, 1998).

Innovation also needs the transformation and exploitation of existing knowledge. That requires that employees share information and knowledge. As Nonaka (1994) suggests, innovation occurs when employees share their knowledge with the organization and when this shared knowledge generates new and common insights. In short, organizational learning allows the development, acquisition, transformation and exploitation of new knowledge that enhances organizational innovation.

4. R&D investment

The literature focusing on R&D performance measurement explains that a critical choice in the design of a Performance Measurement System (PMS) for R&D is the identification of the objectives (or purposes) of the measurement system (e.g. Kerssen-van Drongelen and Bilderbeek, 1999) and identifies the following as the most relevant objectives of R&D performance measurement: Diagnosing activity for supporting decision making (i.e. resource allocation and investment selection decisions); accordingly, performance measurement is introduced here with the purpose to monitor the projects’ progress along their critical dimensions (i.e. time and costs) and for evaluating their profitability (Kerssen-van Drongelen and Bilderbeek, 1999; Bremser and Barsky, 2004).
-Motivating personnel (Kim and Oh, 2002); performance measurement aims here at tailoring

people behaviours to the firm's overall objectives. Consistently with the theories of action, design and expectation (e.g. Moizer, 1991), this motivational goal requires a particular attention to the fact that the researcher or engineer' accountability is defined on the basis of those factors that deal with the influential aspects of their work and that they can completely control.

-Enhancing communication and coordination (Driva et al., 2000); according to this standpoint, performance measurement aims at providing useful information in order to facilitate people interaction and enhance knowledge sharing.

. Learning (Driva et al., 2000; Loch and Tapper, 2002), that is meant as an improvement in the knowledge of the company's R&D activities and of the external technological and market context. Performance measurement is conceived here as an instrument for gathering systematic information and therefore as a means to stimulate learning.

-Reducing R&D risks and uncertainty (Chiesa and Masella, 1996). Uncertainty is defined, consistently with Galbraith (1973), as the difference between the amount of information needed to successfully perform a specific activity and the information actually available. Since performance measurement provides for useful and systematic information, it has the potential to reduce both technical and commercial uncertainty.

-Improving R&D performance (Szakonyi, 1995); according to this viewpoint, the purpose of R&D performance measurement is very similar to the motivational one, although it is more specifically focused on the efficiency with which individuals or organisational units perform specific tasks or accomplish specific goals, e.g. the acquisition or development of new competencies.

5. Technology acquisition, innovativeness and of R&D investment

Technological innovation has been a powerful force for industrial development, productivity growth and indeed our rising standard of living throughout history (Abernathy and Clark, 1985). The advancement in the field of technology is phenomenal in the last century and more so in the last quarter of the century. Similarly, the rate of development in the field of manufacturing technology has been extraordinary in the last decade and many new, advanced and user friendly programmes and tools have become available to manufacturing managers. The availability of these supporting programmes and tools has made a modern manufacturing manager more effective, efficient and agile. But on the other hand, the modern manager is facing the dilemma of making the right choice between the available technologies as various manufacturing variables are closely linked with each other and have a complex interrelationship (Burbidge, 1984). There is hardly an industrial manager who is not touched by technological change and by the persistent challenge of technology planning and choice (Kleindorfer and Partovi, 1990). While research on the effectiveness of R&D investment is evident, little attention has been given to the differences in R&D expenditures between manufacturing firms and service firms, or differences in the subsequent impact on firm performance for each type of firm.

Economic compensation for R&D personnel is an important part of motivating R&D scientists and engineers to work more productively. Thus, it is important to design an effective compensation system: R&D managers must have a fair and effective mechanism to measure the R&D performance. An R&D performance measurement system perceived by the R&D personnel as fair and effective is essential for them to feel satisfied with their compensation: when satisfied with their compensation, they have commitment to their job, which in turn translates into high R&D performance. In effect, research on R&D performance measurement could shed light on designing an effective R&D compensation system.

The fact that technology is a source of competitive advantage is so widely accepted in the literature that it has become axiomatic (Morone, 1989). Technology is recognised as a major decision area within manufacturing strategy (Fine and Hax, 2000) and has received greater attention in the last few decades while formulating the manufacturing strategy. Hayes and Wheelwright (1984) mentioned that the availability of more than one kind of manufacturing technology gives rise to the following questions:

. What kind of manufacturing technology is appropriate for a given situation (what particular capabilities must it have and what weaknesses or constraint can it afford to have if tradeoffs are required? How frequently should changes be made in the technology and what circumstances or events are likely to trigger them?

. What procedures should be adopted to help identify, select and pursue the best opportunities for changing the firm's production technology? How should these changes be implemented and what organisational strengths are required to carry out the firm's strategy for technological improvement?

6. Conclusion

In general the evaluation of investments in R&D is complicated by features specific to these investments, many of them relating to the various uncertainties associated with the eventual profitability of the R&D project. Not only is the value of the output of the R&D project generally uncertain, but also there is often even greater uncertainty over the expected cost to completion of the R&D project. As R&D has been considered as a driving force for national competitive advantage, many countries have been raising R&D investments through various national R&D programs (Lee et al., 1996). Since R&D investment is one of the most decisive elements in promoting scientific and technological progress (Wang and Huang, 2007), the effective use of the limited R&D resources can be regarded as a prerequisite for benefiting from formulation and implementation of national R&D programs. Thus, performance evaluations of R&D programs need to be made so that the limited resources are allocated to promising R&D programs and poor R&D programs can be improved or terminated. The difficulty in making the connection between R&D investment and firm value continues to draw a great deal of interest. Osawa and Yamasaki (2005) outlined three factors that inhibit the linkage between R&D investment and firm value. These are having no definitive means to measure R&D results, time lag between initial R&D investment and the emergence of results, and lastly, appropriate indices not being adopted because of the absence of well-established concepts in respect to future project techniques, thereby undermining the pervasiveness of any measurement of R&D performance. There- fore, it becomes increasingly difficult to accurately quantify the total effects of cumulative investments in R&D as the time lag lengthens. As a general rule, firms that invest heavily in R&D are more likely to be profitable and successful.

Due to the important role SMEs play for economic and technological development, innovation in the context of smaller firms has received much interest in literature (Acs and Audretsch, 1988). Although SMEs typically face considerable resource constraints, they are often successful innovators. Smaller, nimbler structures and an entrepreneurial posture promoted by founders and managers can facilitate innovation activity in SMEs (Nooteboom, 1994; Vossen, 1998). SMEs pursuing an innovation strategy may benefit in several ways. Schumpeter (1934) argues that innovation is an opportunity for entrepreneurial firms to gain rents through the temporary establishment of a monopoly and considers continuous innovation activity as the key source of longterm entrepreneurial success. Since SMEs are nimbler than their larger counterparts, they can move faster and, hence, obtain these monopoly rents for a longer period of time. The introduction of innovative products, services, processes, or business models tailored to attractive niches is an additional opportunity for SMEs to stand out from competition (Porter, 1980). In so doing, SMEs can benefit from high brand loyalty of buyers and a reduced price sensitivity of demand as a consequence of customers valuing the uniqueness of the innovation (Lieberman and Montgomery, 1988).

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