Diversification Fit between Country and Firm as a Driver of Research and Development Efficiency

Introduction

One of the strategic questions that managers must answer is related to research and development diversification. To which areas should the firms allocate their research and development budget? Target technological capacity determines the allocation of the research and development budget to the areas that enable firms to attain the technologies crucial for sustainable competitive advantage. Technological diversity provides managers many investment opportunities by various arrangements (Miller, 2006).

Selection of the areas for research and development projects is a complex decision. In other words, the success of research and development activities is related to many controllable and uncontrollable factors. Research and development process involves different elements. The process not only involves engineers but also other important components such as infrastructure, assets, governments, technological capabilities, networks, universities, and research institutions.

There is rich literature on both internal elements (i.e., firm age, top management, absorptive capacity) and external elements (i.e., customers, universities, research institutions) of research and development activities. As cited in Belderbos et al. (2013), firms increasingly rely on external knowledge sources (Casimon and Veugers, 2006; Chesbrough, 2003; Laursen and Salter, 2006; Marin and Bell; 2010). Despite the rich literature on elements of research and

development, researchers have recently been investigating their home country's effect on the process.

Edquist (1997), Lundvall (1992) and Nelson (1993) argue that national systems of innovation literature support the country specificity of technological path, and Nelson and Winter (1982) emphasize the tacit knowledge hidden in routines, expertise, and skills. Tacit knowledge leads to country specificity in the case of technological path (Cantwell and Vertova, 2004). Therefore, past technological successes in a country may lead to diversification in specific technological areas due to the tacit aspect of the technology, and the expertise level in those specific areas shows how the country is technologically diversified.

Companies allocate their resources by considering internal and external factors. Because of the differences in their resources and capabilities, companies cannot react to environmental changes in similar ways. For example, resource based view argues that firms are heterogeneous in aspect of their resources and capabilities (Wernerfelt, 1984), and the companies' resource endowments are sticky (Teece et al., 1997). Hence, the resource allocation decisions of a firm will not only affect its own future, but also will affect the other companies in the industry as well as other stakeholders such as workers, suppliers, and research institutions. Similarly, the externality created other firms and institutions will affect the firm. According to Dosi (1988), technological progress involves "free good" elements due to the free flow of information such as available publications and so on. Moreover, even when there is not a direct relation between the parties, arm-length relations between producers and users and industrial equipment (e.g., continuous chemical processing) might lead technological innovations in food processing due to the information flows and untraded interdependencies among sectors (Dosi,1988). Audretsch and Feldman (1996) argue that once the technological knowledge becomes publicly available, others

might use the information. Similarly, Griliches (1992) argues that the social rate of return for research and development activities is higher than the private rate of return, and that the social rate of return higher than private rate of return leads to underinvestment problems in research and development activities. In this big puzzle, it is inevitable that there will be a gap between technological diversification of the firm and technological diversification of the country. In other words, a firm may focus on technological areas that are not of interest to any other firm, university, or research institution of its home country. This may lead to a shift in the path of technological diversity in the home country for the firm. Moreover, the firm's current position and the paths ahead will determine the future direction (Teece et al., 1997). Therefore, the gap between technological diversification of the firm and the home country may last for a long time.

Although the technological breakthroughs make communication much easier today, the majority of corporate research and development facilities are still located in the firm's home country (Blomkvist et al., 2011; Di Minin and Bianchi, 2011). In the recent paper of Belderbos et al. (2013), home country bias is predominant in the location-selection process of multinational companies. The authors also emphasize the advantages of conducting research and development activities in the home country, path dependency, and embeddedness.

The goal of my study is to evaluate whether the fit between the technological diversification of the firm and its home country affects the efficiency of the R&D investment of the firm, measured as the ratio of the number of patents granted by the firm to research and development investment.

Theory and Hypotheses

According to internationalization theory, firms start doing business at home and then expand their activities to the other markets (Johanson and Vahlne, 1977). Therefore, the assumption behind this paper is that the first research and development activities of the firms start at home. In research and development literature, the centralization of the research and development activities is considered efficient for the three reasons: economies of scale, embeddedness in the home- country innovation system and coordination cost in international research and development operations (Belderbos et al., 2013).

Embeddedness in the home country innovation system and coordination cost in international research and development activities are related to Dunning's eclectic paradigm (1977). Embeddedness in the home country innovation system matches up with ownership advantages. Economies of scope and coordination cost in international research and development is related to location advantages of the eclectic paradigm. An embedded firm that follows the innovation path in its home country may exploit the advantages that stem from operating in its home country. If the firms follow different trends than its home countries' innovation path, they may not get benefit from the from the ownership advantages. For example, if there are not enough available human sources for specific research, the firm will pay higher salaries to the researcher as a result of lack of supply. Similarly, the firm can get benefit from collaboration with other companies, universities and research institutions that form the scientific base of country. These advantages are recognized in studies on centralization of the research and development; however, the link between diversification of research and ownership advantages is still a missing point.

If a firm internationalizes research and development activities without shifting its technological diversification, the firm gets benefit from internationalization of research and

development either by reaching the advanced sources of the new location or capturing the market information related to the new location. The latter is related to the product adaptation and customization benefit of overseas research and development argued by Kumar (2001). Therefore, such expansion is motivated by development, not research. Advanced sources of the new location in terms of technology can be appealing to the firm that is willing to improve its technological diversification.

Although the firm can reach the advanced resources in the new location, it may not exploit the opportunity in the new location as efficiently as local firms. Hence diversification through internationalization can be a more costly process than exploiting diversification opportunities at home. Accordingly to Dunning (1995), the enterprises home of the home countries have hierarchical related and alliance or network related ownership advantages of those of another. He argues that home country's enterprises have exclusive and favored access to inputs due to the size, product diversity and learning experiences such as specialization. Also, they have better access to the research and development, design engineering, and training facilities of their suppliers. This can enable local enterprises to capture new insights and monitor new developments in materials as well as evaluate their effects on existing products and production processes. Also, horizontal alliances enable companies to reach complementary technologies and innovatory capabilities. Besides vertical and horizontal capabilities, networks offer opportunities for developing niche research and development, joining shared learning, and exploiting training advantages (Dunning, 1995). Although other enterprises can use alliances and networks for research and development activities, Dunning (1995) argues that enterprises of home countries exploit these opportunities more efficiently than those of another country.

Dunning (1995) does not argue that vertical and horizontal alliances and as networks cannot provide opportunities for the non-local companies.

According to Dunning (1995), internalization of research and development activities can increase international transport and communication cost, and transaction cost associated with artificial barriers such as import controls. Also, he argues that a decentralized firm loses economies of centralization research and development production and marketing advantages. Additionally, the firm has to deal with social and infrastructure provisions such as legal commercial, and educational (Dunning, 1995). To summarize, home bias of the companies' in the case of research and development can be explained by his theory.

In order to evaluate the antecedents of the research and development process and the link between the antecedents and with ownership and location advantages, there are many factors that affect the success of research and development activities. These factors can be either internal or external. Firm characteristics, available human resources in the market, relations with host governments and home governments, market demand, universities, and research institutions some of the factors that may affect the success of research and development activities. Therefore, it is beneficial to examine the role of these factors in research and development process from ownership and location advantages perspective.

Firm characteristics are important factors in research and development diversification. Innovative capability of the firm has an idiosyncratic nature. R & D intensity, resources of the firm, size of the firm, patent history of the firm and organizational differences such as absorptive capacities can differentiate the firm's technological base platforms from other firms.

Eurostat, European Union's statistics institution, defines research and development intensity for an enterprise as "R & D intensity is the ratio of a firm's R & D investment to its revenue (the percentage of revenue that is reinvested in R & D)." Kamian and Schwartz (1982) argue that the managers of larger companies should be more optimistic in investing in research and development than managers of small companies. According to Dosi (1988), there is a log linear relation between firm size and research and development expenditures. In other words, the research and development intensity is strongly related to firm size. Also research and development intensity is affected by different aspects of organizations. For example, Kor (2006) argues that top management team composition and board composition directly affect research and development intensity. Moreover, firms choose a lower level of research and development intensity if their managers have higher tenure in the company, shared team experience or functional heterogeneity (Kor, 2006).

Higher levels of research and development intensity enable managers to invest in broader areas because searching innovation in different areas requires new resources and capabilities such as well-trained personnel, equipment and different laboratories. I do not claim that higher levels of research and development intensity always lead to diversification for every firm, but I do consider higher levels of research and development intensity to be an opportunity for managers to expand the firm's research areas.

A firm's historical path also affects the diversification of the firm. According to organizational learning theory, the knowledge generation of the firm reaches its maximum at the domains that are close to its existing knowledge (Autio et al., 2000). Hence, the managers of these firms may not find diversification efficient in the areas that are unrelated to the firm's existing knowledge.

Similarly, Cohen and Levinthal (1990) emphasize the relationship between existing knowledge and future research and diversification decisions in their famous absorptive capacity framework. They define absorptive capacity as "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal, 1990, p. 128). According to Cohen and Levinthal (1989), research and development processes not only lead to new innovation, but also facilitate the learning process of the firm. The development of absorptive capacity is strongly related to history of path dependent processes, and the firms' area of expertise determines the prospective path of research and development investment (Cohen and Levinthal, 1990). For example, investing in research and development projects on chemicals may prohibit the firm from a prospective investment in semiconductors because the firm may receive more benefit from further investment in chemical research more efficiently than an investment in semiconductors.

Cohen and Levinthal (1990) argue that absorptive capacity of the firm is related to its research and development intensity. Their model shows that the research and development path of the company affects future research and development expenditures. Therefore, firms that want to diversify in different domains encounter higher costs than firms that have experience in the same field due to the differences in their absorptive capacities. Moreover, the cumulative knowledge and learning process of the firm not only facilitates learning in the same domain, but also decreases the efficiency of learning in different areas because the adoption of new knowledge may require unlearning of the old (Bettis and Prahalad, 1995; Nonaka, 1994 as cited in Autio et al., 2000). Therefore, cumulative knowledge and existing patents may determine the diversification decisions of the firms.

According to Buckley and Casson (1988), there must be resource indivisibility between two parties in order to get benefit from the cooperation, and the party who depends on the other's resources is likely to commit more to the owner of the resource (Luo, 2001). Hence, if the firm has to rely on the resources of the host country, it will likely act according to the host country's government expectations. Therefore, it can be expected that the firm should invest in the relationship between the governments of host countries in order to build close relations if there are complementary resources between the firm and government.

Universities and research institutions are important antecedents of research and development. Universities play an important role in the case of research and development activities. They are involved in the process of developing the human capital who work in research and development projects and also who innovate (Bartel and Lichtenberg, 1985). Malecki (1986) emphasizes the knowledge spillovers that stem from the universities. Proximity is an important factor that affects knowledge spillovers. In their empirical study, Botazzi and Perri (2003) find that spillovers are localized and they are a function of distance. Universities affect research and development activities in a direct way. Research and development cooperation between firms and universities is a common way of seeking innovation. Veugelers and Cassiman (2005) argue that cooperation between universities and the firms is related to the nature of the industry.

Considering the direct and indirect effects of universities and research institutions, universities may affect technological diversification decisions of the firms. Due to location advantages local companies and universities may create more synergies than the synergies that stem from the collaboration between a university and a foreign firm.

To summarize, a firm may get benefit from evaluating the home countries' technological capacity in order to get benefit from the ownership and location advantages of doing research at home. In other words, ownership and location advantages provide more opportunity to the firm that allocates its research and development expenditures to the areas that their home country specialize at. Therefore my aim is to see whether the fit between the home country's diversification at the macro level and firm's diversifications at the micro level affect the efficiency of research and development.

Hypothesis 1 : A gap between the home country's technological diversification and the firms' technological diversification decreases the research and development efficiency.

Although the gap between the home country's technological diversification and the firms' technological diversification decreases the research and development efficiency, firms can increase the research and development efficiency with the strategic alliances with the foreign companies.

Hypothesis 2: A gap between the home country's technological diversification and the firms' technological diversification increases the number of strategic alliances on research and development activities with the foreign companies.

Methodology

Data:

I will use US patent data for my research. More specifically, I will focus on the patents granted by the company and the total number of the patents granted by American firms, universities, and institutions in a given technological area. According to Griliches (1998),

technological performance can be measured by input and their R&D output (Hagedoorn and Cloodt, 2003). Hence, technological performances of the companies will be measured as the ratio of patent awarded to total R&D expenditures of the firm. I will examine the US patent data from 1992 to 2002

Dependent Variable:

For Hypothesis 1 our dependent variable is efficiency of the research and development activities (E) will be measured by research and development efficiency ratio which is:

Number of patents awarded by the company / Research and development expenditures

For Hypothesis 2, the dependent variable is the number of research and development alliances engaged by the company

Independent Variable:

Technological diversification gap will be measured by taking the absolute difference between revealed technological advantage (herein after RTA) of the firm in its core businesses and the RTA of the country. The degree of technological diversification of the firm is inversely proportional to the concentration of the firm's technological specialization in preferred sectors. RTA is used to measure the technological specialization of the firm (Cantwell and Piscitello, 2000). I will use the diversification fit (D) in order to see the degree of fit between the country and the firm. The previous four year's diversification fit values will be used as an independent value in the model 1 and model 2.

Control Variables:

As I mentioned in the theory section, firm size, age, and industry affect the efficiency of research and development. Therefore, I will control the size, age and industry. Also, patent bases of the companies will be controlled in my analysis.

Model:

Because of the length of research and development projects, every period of five years will be examined. In other words four consecutive years diversification fit will be used as independent variable for the fifth years' research and development efficiency. Regression analysis will be used for examining the relationship between research and development efficiency and diversification fit.

Model 1

$$E_T=\alpha+\beta_0 D_{T-4}+ \beta_1 D_{T-3}+ \beta_2 D_{T-2}+ \beta_3 D_{T-1}$$

Figure 1

$$RTA_{Firm} = \frac{\frac{\text{Total number of firm's patents in activity j}}{\text{Total number of all patents granted by the firm}}}{\frac{\text{Total number of industry's patent in activity j}}{\text{Total number of all patents granted by the firms in the industry}}}$$

$$RTA_{country} = \frac{\frac{\text{Total number of the country's patents in activity j}}{\text{Total number of all patents granted by the country}}}{\frac{\text{Total number of patents inactivity j}}{\text{Total number of all patents}}}$$

$$D= \frac{\frac{\sum_{n=1}^{j} |RTAfirm - RTAcountry|}{j}}{\sigma\ |\text{RTA firm-RTA country}|}$$

Model will be used for testing Hypothesis 2:

$N = \alpha + \beta_5 D_{T-4} + \beta_6 D_{T-3} + \beta_7 D_{T-2} + \beta_8 D_{T-1}$ N: number of alliances with the foreign companies

Expected Results:

This paper is important for the strategic management field because, the role of home country technological base and research pattern will be examined in the research and development investments. I expect a negative relation between dependent and independent variables. If the relation between technological diversification gap and efficiency of research and development is negative, I can conclude that the firm is better off following the research trends of its home country. The study will enable us to examine the industries in which ownership and location advantages affect the efficiency of research and development activities.

References

Anselin, Luc, Attila Varga, and Zoltan Acs. "Local geographic spillovers between university research and high technology innovations." Journal of urban economics 42.3 (1997): 422-448.

Autio, Erkko, Harry J. Sapienza, and James G. Almeida. "Effects of age at entry, knowledge intensity, and imitability on international growth." Academy of management journal 43.5 (2000): 909-924.

Audretsch, David B., and Maryann P. Feldman. "R&D spillovers and the geography of innovation and production." The American Economic Review 86.3 (1996): 630-640.

Baysinger, Barry, and Robert E. Hoskisson. "Diversification strategy and R&D intensity in multiproduct firms." Academy of Management Journal 32.2 (1989): 310-332.

Bartel, Ann P., and Frank R. Lichtenberg. "The comparative advantage of educated workers in implementing new technology: some empirical evidence." (1985)

Belderbos, Rene, Bart Leten, and Shinya Suzuki. "How global is R&D? Firm-level determinants of home country bias in R&D." FEB Research Report-MSI_1308 (2013).

Bettis, Richard A., and Coimbatore K. Prahalad. "The dominant logic: Retrospective and extension." Strategic management journal 16.1 (1995): 5-14.

Blomkvist, Katarina, Philip Kappen, and Ivo Zander. "Quo vadis? The entry into new technologies in advanced foreign subsidiaries of the multinational enterprise." Journal of International Business Studies 41.9 (2010): 1525-1549.

Bottazzi, Laura, and Giovanni Peri. "Innovation and spillovers in regions: Evidence from European patent data." European Economic Review 47.4 (2003): 687-710.

Buckley, P., and M. Casson. "A theory of cooperation in international business'. Contractor, F. and Lorange, P.(Eds). Cooperative strategies in international business." (1988).

Cantwell, John, and Lucia Piscitello. "Accumulating technological competence: its changing impact on corporate diversification and internationalization." Industrial and Corporate Change 9.1 (2000): 21-51.

Cantwell, John,

and Giovanna Vertova. "Historical evolution of technological diversification." Research Policy 33.3 (2004): 511-529.

Cassiman, Bruno, and Reinhilde Veugelers. "In search of complementarity in innovation strategy: internal R&D and external knowledge acquisition." Management science 52.1 (2006): 68-82.

Chesbrough, Henry William. Open innovation: The new imperative for creating and profiting from technology. Harvard Business Press, 2003.

Cohen, Wesley M., and Daniel A. Levinthal. "Absorptive capacity: a new perspective on learning and innovation." Administrative science quarterly (1990): 128-152.

Cohen, Wesley M., and Daniel A. Levinthal. "Innovation and learning: the two faces of R & D." The economic journal 99.397 (1989): 569-596.

Di Minin, Alberto, and Mattia Bianchi. "Safe nests in global nets: Internationalization and appropriability of R&D in wireless telecom." Journal of International Business Studies 42.7 (2011): 910-934.

Dosi, Giovanni. "Sources, procedures, and microeconomic effects of innovation." Journal of economic literature (1988): 1120-1171.

Edquist, Charles, and Björn Johnson. Institutions and organizations in systems of innovation. Univ., 1997.

Elkins, Teri, and Robert T. Keller. "Leadership in research and development organizations: A literature review and conceptual framework." The Leadership Quarterly 14.4 (2003): 587-606.

Eurostad http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:R_%26_D_intensity

Griliches, Zvi. The search for R&D spillovers. No. w3768. National Bureau of Economic Research, 1992.

Kamien, M. I., and N. L. Schwartz. "Market Structure and InnovationCambridge University Press." New York (1982).

Kim, W. Chan. "The effects of competition and corporate political responsiveness on multinational bargaining power." Strategic Management Journal 9.3 (1988): 289-295.

Kogut, Bruce. "Country capabilities and the permeability of borders." Strategic Management Journal 12.S1 (1991): 33-47.

Kor, Yasemin Y. "Direct and interaction effects of top management team and board compositions on R&D investment strategy." Strategic Management Journal 27.11 (2006): 1081-1099.

Kumar, Nagesh. "Determinants of location of overseas R&D activity of multinational enterprises: the case of US and Japanese corporations." Research Policy 30.1 (2001): 159-174.

Laursen, Keld, and Ammon Salter. "Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms." Strategic management journal 27.2 (2006): 131-150.

Lundvall, Bengt-Ake. "User-producer relationships, national systems of innovation and internationalisation." National systems of innovation: Towards a theory of innovation and interactive learning (1992): 45-67.

Luo, Yadong. "Toward a cooperative view of MNC-host government relations: Building blocks and performance implications." Journal of International Business Studies 32.3 (2001): 401-419.

Malecki, Edward J. "Research and development and the geography of high-technology complexes." Technology, regions, and policy (1986): 51-74.

Marin, Anabel, and Martin Bell. "The local/global integration of MNC subsidiaries and their technological behaviour: Argentina in the late 1990s." Research Policy 39.7 (2010): 919-931.

Miller, Douglas J. "Technological diversity, related diversification, and firm performance." Strategic Management Journal 27.7 (2006): 601-619.

Murtha, Thomas P., and Stefanie Ann Lenway. "Country capabilities and the strategic state: How national political institutions affect multinational corporations' strategies." Strategic Management Journal 15.S2 (1994): 113-129.

Neffke, Frank, and Martin Henning. "Skill relatedness and firm diversification." Strategic Management Journal 34.3 (2013): 297-316.

Nonaka, Ikujiro. "A dynamic theory of organizational knowledge creation." Organization science 5.1 (1994): 14-37.

Nelson, Richard. "National innovation systems: a comparative analysis." University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship (1993).

Nelson Richard, R., and G. Winter Sidney. "An evolutionary theory of economic change." Harvard Business School Press, Cambridge (1982).

Rosenzweig, Philip M., and Jitendra V. Singh. "Organizational environments and the multinational enterprise." Academy of Management review 16.2 (1991): 340-361.

Teece, David J., Gary Pisano, and Amy Shuen. "Dynamic capabilities and strategic management." Strategic management journal 18.7 (1997): 509-533.

Veugelers, Reinhilde, and Bruno Cassiman. "R&D cooperation between firms and universities. Some empirical evidence from Belgian manufacturing." International Journal of Industrial Organization 23.5 (2005): 355-379.

Wernerfelt, Birger. "A resource-based view of the firm." Strategic management journal 5.2 (1984): 171-180.