Internal R&D, external R&D, and firm innovation: evidence from the pharmaceutical industry

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VALORIZATION

“We increasingly recognize that valorization is an excellent tool for promoting economic growth. This is especially important at a time of economic decline. We are thinking, working and collaborating on all fronts to raise the utilization of our scientific knowledge to the same high level as the knowledge itself.” (Aad Veenman, 2013)

The addendum as follows mainly addresses the valorization opportunities for the three empirical studies presented in this dissertation, including the social and economic relevance of the research topics covered by the dissertation, the innovativeness of the respective research findings, and their value for firm innovation and practices in management.

As stated in the introduction chapter, the principal purpose of this dissertation is to develop a better understanding of the impact of internal and external R&D strategies of firms on their innovative output. On the one hand, internal R&D is an important, and perhaps even the most important, contributor to firm innovativeness (Griliches, 1979; Scherer, 1982). On the other hand, the openness of firms to external R&D sources is another key element for firm innovation. In view of the increasing complexity and multidisciplinarity of research, even the largest and most self-contained organizations cannot keep abreast of all the relevant technological advances solely through their internal R&D (Teece, 1988; Vedelers, 1997). In recent years, more and more firms have actually been pursuing an ‘open innovation’ (Chesbrough, 2003) approach by leveraging internal and external knowledge development in parallel so as to build and hone their innovative capabilities.

Specifically, three research questions have been empirically examined in the dissertation. Firstly, in the attempt to learn about gestation lags in knowledge production of internal R&D by firms, researchers have repeatedly examined the relationship between R&D expenditures and patents. In line with a cumulative knowledge production or innovation process of firms, the current patenting output is expected to be dependent not only on recent R&D (i.e., a short-run effect of R&D) but also on R&D investments in the distant past (i.e., a long-run effect of R&D). However, the previous studies suggest that there was very little direct evidence of anything but simultaneity in the year-to-year movement of patents and R&D expenditures, or that the lag effects on patents were identified only for more recent R&D (Blundell et al., 2002; Gurmu and Pérez-Sebastián, 2008; Hall et al., 1986; Hausman et al., 1984; Montalvo, 1997; Pakes and Griliches, 1984a). To ex-
plore the potential long-run impact of internal R&D on firm patenting, the first empirical study in this dissertation revisits the classic research question regarding the lag structure of the patents–R&D relationship in the context of the global pharmaceutical industry.

The results from the first empirical study illustrate a cumulative knowledge production or innovation process of incumbent pharmaceutical firms, with current patent production being historically dependent on past investments in internal R&D. Our results are consistent with prior research which suggests that not only recent knowledge is important for new knowledge creation, but that older knowledge in knowledge stock accruing from long past R&D investments may also be valuable for firm innovativeness (Katila, 2002; Nerkar, 2003). This finding echoes the real options logic for managing R&D investment strategies of firms (McGrath, 1997; McGrath and Nerkar, 2004), according to which early R&D investments by firms in a new area with technical uncertainty may be influential in their knowledge production or innovation process over a long-term horizon. Subsequent R&D investments in the same area can further reduce technical uncertainty and reinforce the value of options opened earlier. Alternatively, firms may choose to wait or even exit the area they invested before. In this way, the earlier investments in R&D can still serve as part of the firms’ stock of knowledge, which may contribute substantially to their later innovations when conditions favor its use. From a managerial perspective, our study offers important insights into the cumulative knowledge production or innovation process of firms. In addition to emphasizing recent investments in internal R&D to stay abreast of the latest, cutting edge technologies, decision-makers in firms should also adopt a long-term perspective for organizing R&D investment strategies. Through periodically reviewing and recombining older, useful but under-utilized knowledge, firms can increase their creation of new knowledge (Garud and Nayyar, 1994; Nerkar, 2003). However, it is noteworthy that older knowledge tends to be lost over time due to lack of adequate organizational memory, inaccurate recording, and turnover in R&D personnel (Argote, 1999). As a consequence, for firms to effectively transfer knowledge across time, they need to build up the ‘transformative capacity’ which pertains to the choice of knowledge for future use, its maintenance over time, and the reactivation and synthesis of such knowledge when required (Garud and Nayyar, 1994; Nerkar, 2003). In this way, by making better use of older knowledge and actively maintaining stock of knowledge for future use, firms can enhance their returns from internal R&D investments.

Secondly, a substantial body of research literature has examined the interrelationship between internal and external R&D strategies in relation with firms’ innovative output, which has been accompanied by mixed empirical evidence. One set of studies demonstrate that internal and external R&D are complementary innova-
tion activities, suggesting their interrelatedness in improving a firm’s innovative performance (Cassiman and Veugelers, 2006; Lokshin et al., 2008; Rothaermel and Hess, 2007; Schmiedeberg, 2008). By contrast, a second set of studies indicates that there is substitutability (or, no complementarity) between internal and external R&D strategies (Hess and Rothaermel, 2011; Laursen and Salter, 2006; Vega-Jurado et al., 2009). The above studies are thus inconclusive about the relationship between different innovation mechanisms and focus merely on either complementarity or substitutability. However, as suggested by Cassiman and Veugelers (2006), understanding under what conditions different R&D strategies may in fact be complementary is more important than merely determining what activities are complementary per se. Given the scarcity of prior work on this line of research (exceptions are Cassiman and Veugelers, 2006; Hess and Rothaermel, 2011), our second study seeks to provide empirical evidence on the conditions under which there is complementarity or substitutability between internal and external R&D strategies within the context of the global pharmaceutical industry.

The results from the second study suggests that, instead of a clear-cut answer to the question whether internal and external R&D are complementary or substitutive innovation activities, there appears to be a contingent relationship between internal and external R&D strategies in shaping a firm’s innovative output. More specifically, internal R&D and external R&D, through either R&D alliances or R&D acquisitions, are complementary innovation activities at higher levels of in-house R&D investments, whereas at lower levels of in-house R&D efforts, internal and external R&D activities turn out to be substitutive strategic options. These findings highlight the complexity of understanding the relationship between internal and external R&D strategies and contribute to the extent literature by advancing and testing the contingency role of a firm’s in-house R&D efforts in determining the condition under which there is complementarity or substitutability between its various R&D strategies. From a managerial perspective, our empirical findings provide implications for firms in organizing their internal and external R&D strategies to match the rapidly changing technological environment. In order to continually update a firm’s technological know-how and capabilities, managers often choose to pursue internal and external R&D strategies in parallel, in hope of a potential complementarity between various innovation activities. Such complementarity, unfortunately, does not always exist. Our results show that it is contingent on the development of a firm’s absorptive capacity, which is mainly determined by how much the firm would invest in its in-house R&D. In other words, in-house R&D efforts play a key role in the interrelationship between internal and external R&D strategies to influence firms’ innovative output. Managers who can leverage external sources of innovation to adapt to the relentlessly changing technological environment.
environment and, at the same time, lay emphasis on in-house R&D endeavors will be most successful in building up sustainable innovative capabilities of firms.

Finally, the third empirical study moves from a dyad level to a network level to investigate the impact of alliance network structure on a firm’s innovative output. In spite of the growing consensus on the facilitative role of alliance networks, there has been an ongoing debate over the relative efficacy of different forms of network structure—network closure (Coleman, 1988) vs. structural holes (Burt, 1992)—as critical determinants of firm innovation. The empirical evidence has produced a rather mixed picture of how firms should be structurally embedded in interfirm alliance networks (e.g., Ahuja, 2000a; Baum et al., 2000; McEvily and Zaheer, 1999; Schilling and Phelps, 2007). To reconcile these conflicting arguments and results, researchers have proposed a contingency approach (Ahuja, 2000a; Burt, 2000). However, until recently there are relatively few studies (exceptions are Koka and Prescott, 2008; Vanhaverbeke et al., 2012) that have employed such an approach to examine the effects of interfirm network structure on a focal firm’s innovative output. Relatively, apart from network closure vs. structural holes as aforementioned, the role of indirect ties is another important aspect of alliance network structure relating to a focal firm’s innovative output. As argued by Ahuja (2000a), indirect ties are essentially characterized by a dual role vis-a-vis the focal actor—both as sources of information and as competitors in terms of using similar information. Although scholars have long studied the relationship between indirect ties and innovation, most research in this tradition has largely focused on the benefits from indirect ties as information sources but paid little attention to the role of indirect ties as potential competitors. To fill such research gaps, the goal of the third empirical study is to examine the impact of two aspects of interfirm network structure, i.e., structural holes and indirect ties, on a focal firm’s innovative output. A contingency approach is utilized in the study by considering the various dimensions of a focal firm’s innovative output—new technology and new products—and identifying their divergent requirements on the focal firm’s network structure of interfirm R&D alliances. In particular, the analytic focus is on incumbent pharmaceutical firms as the focal actors in the pharmaceutical industry network of interfirm R&D alliances.

The results from the third study confirm, to a great extent, the above contingency framework. Research findings on the relative efficacy of network closure vs. structural holes suggest that an R&D alliance network rich in structural holes is more advantageous for incumbent pharmaceutical firms’ creation of new technology, whereas a dense, interconnected network of interfirm R&D alliances turns out to be more beneficial for their development of new products in the market. Concerning the dual role of indirect ties, our estimation results indicate that incumbent pharmaceutical firms with more indirect ties in an R&D alliance network are actu-
ally associated with reduced innovative output in terms of new products, while no significant effect is found in the case of new technology. These findings provide important implications for the literature on interfirm network structure and firm innovation. On the one hand, by showing that the optimal network structure for firms to embed themselves in is contingent on the various types of innovative output, our study contributes to a better understanding of under what conditions firms mandate the distinct benefits provided by the different forms of network structure. On the other hand, in contrast with prior research that has predominately demonstrated the benefits from indirect ties as sources of information (Karamanos, 2012; Salman and Saives, 2005; Vanhaverbeke et al., 2012), our results shed insights into the dual role of indirect ties (Ahuja, 2000a) as potential competitors as well as information sources for a focal firm. From a managerial perspective, our findings offer implications for the network configuration of interfirm R&D alliances towards the improvement of firm innovativeness. Our study suggests that whether a dense or a sparse network constitutes an optimal network structure for firms to embed themselves in is contingent on the various types of innovative output, i.e., new technology and new products. Managers need to assess the conditions under which firms require the distinct benefits provided by the different forms of network structure. When developing collaborative norms and reducing partner opportunism are important, a dense network is more valuable; conversely, when information diversity is crucial, a sparse network is more advantageous (Ahuja, 2000a). Moreover, managers should attend to the dual role of indirect ties as both information sources and potential competitors in interfirm alliance networks. Our study reveals that indirect ties maintained by firms, especially with their competitors, would cause risks and liabilities that may counteract or even outweigh the benefits from these indirect ties as sources of information. In this respect, a network of partners exclusively tied to a focal firm, relative to one in which the focal firm’s partners have other partners (i.e., indirect ties), provides more control advantage over alliance partners (Ahuja, 2000a; Brass and Burkhardt, 1992) so as to mitigate competition and information leakages and is thus considered to be more beneficial. Therefore, managers have to be fully aware of the dual role reflected by indirect ties and determine under what circumstances control advantage over alliance partners is more essential to success than the information benefits provided by indirect ties, and vice versa.

By and large, the studies presented in this dissertation can be found useful to anyone, especially researchers and decision-makers in firms, who are interested in improving the innovative output of firms by efficiently and effectively organizing the various R&D strategies. As aforementioned, in-house R&D investments are a crucial contributor to firm innovativeness, which not only give rise to a potential long-run impact in the innovation process, but also serve as a contingency variable.
that critically influences the association between internal and external R&D strategies in shaping firms’ innovative output. Moreover, a network analysis of interfirm R&D alliances—an important manifestation of external R&D strategy pursued by firms—suggests that the various dimensions of firms’ innovative output, i.e., new technology and new products, put divergent requirements on the network structure of interfirm R&D alliances. Yet, for any research or theory to be of any use and to create (societal and economic) value, it has to apply in practice and needs to be thoroughly tested. The knowledge valorization opportunities outlined in this addendum serve as an illustration of how to utilize the research of this dissertation not only for academic purposes but also for managerial practices in the business world. In so doing, I sincerely hope that the studies presented here can be applied to, and what’s more, enriched by real world practice, thereby opening up new avenues of research—a reciprocal process from theory to practice and from practice to theory.