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Coupled open innovation and innovation performance outcomes: Roles of absorptive capacity

耦合性開放式創新與創新績效：吸收能耐之調節角色

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Abstract: A recent paradigm for firms to solve problems is searching boundary-spanning solutions, a process known as open innovation. Among the different types of open innovation, the coupled approach is the most typical and challenging approach. Based on the organization search theory, this paper aims to provide a comprehensive understanding of coupled open innovation and its relationship with absorptive capacity and innovation outcomes. We ask whether coupled open innovation leads to innovation and how the two dimensions of absorptive capacity – potential and realized absorptive capacity – facilitate this process to increase performance. We employ survey data, annual reports and financial data for 216 Taiwanese high-tech firms to test the research hypotheses. The results show that coupled open innovation is positively associated with incremental performance outcomes but not with radical outcomes. Regarding the role of absorptive capacity, potential absorptive capacity strengthens the positive relationship between coupled open innovation and incremental performance, while realized absorptive capacity strengthens the coupled open innovation–radical performance relationship. This study contributes to organizational search theory by connecting the dynamic capability view of absorptive capacity with open innovation research. Practical implications are also provided.

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1. Introduction

Organizational search, the way in which firms search for knowledge to address their problems, is a central issue in innovation management theories (Cyert and March, 1963; Nelson and Winter, 1982). To respond to this issue, academic attention in recent years has shifted considerably from the concept of closed innovation (local search) to that of open innovation (non-local search), which allows innovative ideas and knowledge embodied in people and intellectual property to flow freely either inwardly or outwardly (Chen, Chen, and Vanhaverbeke, 2011; Chesbrough, 2003b; Enkel, Gassmann, and Chesbrough, 2009). Through a series of case studies, previous studies have suggested that open innovation generates positive organizational outcomes; however, they have also called for more systematic empirical evidence in this field (Chesbrough and Crowther, 2006; West and Bogers, 2014).

Chesbrough (2003b) defined open innovation as a firm's use of 'external ideas as well as internal ideas, and internal and external paths to market' (Page xxiv). This definition extends the notion of innovative search by which firms use the creation and recombination of technological ideas to solve their problems (Katila and Ahuja, 2002). By analyzing a firm's process, Enkel *et al*. (2009) classified open innovation into three primary approaches – inbound, outbound, and coupled open innovation. While these three approaches compose the entire process of open innovation, the coupled mode of open innovation best represents the definition of open innovation. Coupled innovation refers to 'co-creation with (mainly) complementary partners through alliances, cooperation, and joint ventures during which give and take are crucial for success' (Enkel *et al*., 2009: 313).

Coupled open innovation is a more complex search process than inbound or outbound innovation due to its interactive nature and longer time frame. Laursen and Salter (2014) coined the term 'paradox of openness,' meaning that the creation of innovations often requires openness, while the commercialization of innovations requires protection. This conflict can be found most representatively in the process of coupled open innovation because this occurs not just once but rather endures over a long period of time, so all players need to give and take. A major line of inquiry in this situation is whether, given these conflicts, coupled open innovation leads to favorable organizational outcomes and whether the performance outcome is facilitated by any organizational conditions.

A good illustrative example can be found in Intel Corp.'s Components Research Laboratory, which the company uses as a link to the outside research community. The firm acknowledged that it also needs internal work to be able to quickly transfer promising research results to the organization (Chesbrough, 2003b). We are inspired by this practice and the academic work on studying how internal resources affect firm performance (Han, Chao, and Chuang, 2012). We therefore bring the concept of absorptive capacity into our analytical framework because absorptive capacity is the key factor of whether a firm can effectively address knowledge from external sources (Cohen and Levinthal, 1990; Tsai and Wang, 2007). Absorptive capacity is regarded as a dynamic capability that specifically addresses the resources a firm possesses or uses to tackle an ever-changing environment (Winter, 2003). While open innovation brings in external knowledge or resources to organizations, absorptive capacity helps firms to better utilize these assets. Absorptive capacity reflects the ability of a firm to value and integrate external knowledge, and scholars have introduced both potential and realized absorptive capacity (Jansen, Van den bosch, and Volberda, 2005; Zahra and George, 2002). Absorptive capacity has been frequently studied for inbound open innovation (e.g., Tsai, Hsieh, and Hultink, 2011). With a large number of companies using the coupled approach (Schroll and Mild, 2011), there is an urgent need to further investigate the roles of different dimensions of absorptive capacity in this process.

Along these lines of theory and practice, this study makes several contributions. First, we contribute to the literature on open innovation by focusing on the coupled approach of open innovation. West and Bogers (2014) reviewed 70 papers concerning coupled open innovation in major journals, among which researchers did not consistently adopt 'coupled open innovation' as a common term. Under the conceptual umbrella of coupled open innovation, most studies have usually focused on one specific type of coupled open innovation over another, such as alliances (Faems, de Visser, Andries, and van

Looy, 2010; Lin, Wu, Chang, Wang, and Lee, 2012), co-patents (Belderbos, Cassiman, Faems, Leten, and Van Looy, 2014) or platforms (Meyer and Dalal, 2002; Sawhney, Verona, and Prandelli, 2005). However, these activities share common traits that can be integrated into one focal construct, which can be a useful foundation for further theorization (Gassmann and Enkel, 2004). This study, following the typology created by Gassmann and Enkel (2004) and Enkel *et al*. (2009), aims to incorporate these activities into a unified construct of coupled open innovation and to study its effects on both incremental and radical innovation performance outcomes. By doing so, this study constitutes the type of progress that Geletkanycz and Tepper (2012) refer to as a 'new beginning' that motivates future discussion.

Second, this research study enriches the understanding of organizational search theory. A successful search process in general requires that focal firms possess different organizational practices to work with a variety of non-local organizations (such as suppliers or rival firms) or individuals (such as scientists or communities) (Laursen and Salter, 2006). This condition therefore characterizes firms adopting coupled open innovation, given that the search process is complex and enduring. Due to these difficulties, firms predominately adopt local search to solve problems (Laursen, 2012). This paper endeavors to discover whether non-local search behavior brings advantageous performance outcomes, especially in the context of innovation management, where organizational search is the central theme.

Third, although previous literature usually links absorptive capacity with inbound open innovation, seldom does it examine the effect of absorptive capacity on coupled open innovation, nor does it separate the two dimensions of absorptive capacity. In this study, we integrate the dynamic capability view in general and absorptive capacity in particular to explicate the value-creation process associated with coupled open innovation. Borrowing the theoretical lens of the knowledge-based view and its extension to dynamic capabilities, this study brings fresh insights regarding what the process is and what facilitating mechanism is required.

The remainder of this study is organized as follows. The following section reviews the literature related to coupled open innovation and absorptive capacity, forming the basis of the hypotheses of this study. Next, the methodology section will describe the research methods and planned data collection, followed by a discussion and the conclusion.

2. Literature review and hypotheses

2.1 Open innovation: The coupled approach

Evolutionary economists have proposed that organizations and their managers make decisions based on their previous experiences and look only for ‘satisficing behavior’ (Nelson and Winter, 1982). This observation explains why many organizations have adopted local search, which uses existing knowledge or past experiences to solve problems (Laursen, 2012). However, open innovation emerged when researchers and practitioners found their problems or environment to be much more complicated such that a local search is sometimes not effective and that non-local or external search and boundary-spanning activities were desirable (Chesbrough, 2003a). This non-local search even extends to cross-border activities (Yang, Chu, and Wang, 2011). The adoption of open innovation makes innovative ideas and knowledge embodied in people and intellectual property flow freely either inwardly or outwardly across organizations (Chen *et al*., 2011; Chesbrough, 2003b; Enkel *et al*., 2009). Scholars provide empirical proof that this open business model leads to favorable financial performance (Chen, Chu, and Huang, 2012; Chu *et al*., 2005). Prior literature decomposes open innovation into three processes: inbound, outbound, and coupled open innovation (Chesbrough and Crowther, 2006; Enkel *et al*., 2009). Inbound open innovation refers to innovative ideas and technological knowledge that flow into the firm’s innovation system such that the firm can access external innovative knowledge and internal ideas to complement its business model. Outbound open innovation refers to ideas or technological knowledge that flow out of the firm’s innovation system, wherein focal firms purposively pursue commercialization or the outward transfer of their technological knowledge to outside firms to obtain monetary or non-monetary benefits. This pursuit includes selling intellectual property or multiplying technologies by channeling ideas or knowledge to the external environment (Chesbrough, 2003a).

Although the above two approaches reflect a certain extent of non-local search, the organizational practice required to implement them is straightforward and does not involve too many interactions with outside partners. For example, when a firm purchases a patent, the firm can continue to work on it within the organizational boundary without necessarily or constantly communicating with the original individual or firm. The same applies to selling intellectual property rights to other companies. Coupled innovation combines both the inside-out and outside-in processes with the goal of commercializing innovation, i.e., new products. This represents the academic quest to balance the local and non-local search, which may make the process not only more challenging but also more rewarding (Laursen, 2012). The coupled approach identified in previous studies includes alliances, cooperation, and joint ventures (Enkel *et al*., 2009). With the help of a 'market for technology' in which technology can be protected for exchange or trade, firms not only acquire market technological knowledge but also more efficiently commercialize their underutilized ideas or knowledge (Arora and Fosfuri, 2003; Arora, Fosfuri, and Gambardella, 2001; Gans, Hsu, and Stern, 2002). Technology markets, defined as 'transactions for the use, diffusion, and creation of technology' (Arora *et al*., 2001, p. 423), make coupled open innovation a more feasible option for firms.

Coupled open innovation is a type of co-innovation with complementary partners through structured cooperation, which often involves a set of inter-firm relationships and recombining external knowledge with existing knowledge (Mazzola, Bruccoleri, and Perrone, 2012; Schumpeter, 1934). Several representations of coupled open innovation are identified, including establishing a platform between firms, co-patents, and R&D alliances. A good example of the platform approach is the TSMC Open Innovation Platform® (http://www.tsmc.com.tw/chinese/dedicatedFoundry/services/oip.htm, accessed Jan 9, 2015). This platform aims to bring together the semiconductor design community and quicken the pace of innovation. The establishment of that platform is an attempt to link firms within the ecosystem, and its primary purpose is to collect and exchange ideas about the development of products or processes. If the platform is successful, time is shortened, with benefits for development, speed and profit.

Another common form adopted by firms is the technology alliance because, at the core of coupled open innovation, collaborations between firms are essential. Previous studies have noted that R&D interorganizational collaborations lead to innovation outcomes. Nieto and Santamaría (2007) used a longitudinal sample of Spanish manufacturing firms and found that different types of collaborative networks can achieve product innovation and increase the degree of novelty. They also found that collaboration with suppliers, clients and research organizations has a positive impact on the novelty of innovation, whereas collaboration with competitors has a negative impact. Other studies also show how R&D inter-firm collaboration affects innovation outcomes (Faems *et al.*, 2010; Faems, Van Looy, and Debackere, 2005).

Co-patents are also a possible choice between coupled open innovation partners. As Lin *et al.* (2012) indicated, co-patents are important indicators of coupled open innovation because they are a component of inter-firm collaborative relationships. This form of collaboration is an advanced form of coupled open innovation because partner firms already hold specific patents and they both understand the value of the cooperation. The process of co-patenting requires more intensive work and a longer time period until the new product is fully developed. The co-patent process can usually reduce costs and produce new products with high-quality and advanced technology, as well as increase the market adaptability of innovation outputs (Mazzola *et al.*, 2012).

Previous studies on open innovation in general show that open innovation affects innovation performance outcomes. For firms adopting coupled open innovation, one purpose is to acquire complementary or necessary technologies to manufacture their own products and to compete in markets for products and services. Whether by establishing a platform, an alliance, or co-patents, coupled open innovation allows firms to develop new knowledge that challenges their existing cause-effect relationships, and it enables firms to enrich their own knowledge base (Katila and Ahuja, 2002; Nelson and Winter, 1982). Based on their existing knowledge and markets, firms often acquire complementary knowledge or technologies to produce their existing products or services. Prior studies have used cases to show how companies use the external acquisition of technological knowledge to generate enhanced results when their efforts span both organizational and technological boundaries (e.g., Chesbrough and Crowther, 2006; Dodgson, Gann, and Salter, 2006). Incremental innovation outcomes involve the development and improvement of products and services, ranging from developing new products to minor improvements in existing products and services (Atuahene-Gima, 2005; Laursen and Salter, 2006). The goal of incremental innovation is to address the needs of and profit from existing products. Acquiring complementary or necessary technologies to manufacture products leads to incremental innovation.

Based on the above arguments, this study proposes the following hypothesis.

Hypothesis 1a. Coupled open innovation is positively related to incremental innovation performance.

Firms adopting coupled open innovation are also looking for new opportunities to obtain ideas or knowledge that are not used by the focal firm but still have economic value in technology markets. This approach allows a firm to co-create or co-develop this knowledge with another independent organization, such as through R&D alliances (Chesbrough and Garman, 2009; Nieto and Santamaría, 2007). Chesbrough (2003b) argued that overly protective firms forego their intellectual property opportunities, and therefore, co-patents become a feasible approach for them. Protective myopia may also hinder opportunities to trade knowledge with suppliers, users, and competitors. When a firm lacks sufficient market knowledge or other complementary resources to fully exploit its technologies, exploiting technology with other partners allows the firm to maximize unused intellectual property assets. By adopting this practice, firms can exploit their existing technological knowledge with other partners (Chesbrough and Garman, 2009). This approach may provide them with access to external technology (Grindley and Teece, 1997) and may also generate new business possibilities and growth options by putting technologies to work (Chesbrough and Garman, 2009). This approach often leads to radical innovations, which are defined as fundamental changes through new products that represent revolutionary changes in technology (Dewar and Dutton, 1986; Ettlie, Bridges, and O'Keefe, 1984; Song and Thieme, 2009). A radical innovation disrupts an existing technological trajectory and advances the price/performance frontier by much more than the existing rate of progress (Dosi, 1982; Gatignon *et al*., 2002). Co-creating and co-developing an idea or knowledge that is not used by the focal firm with other partners serve as an approach to radical innovations.

Based on the above arguments, this study proposes the following hypothesis.

Hypothesis 1b. Coupled open innovation is positively related to radical innovation performance.

2.2 Absorptive capacity

Cohen and Levinthal (1989, 1990) defined the term ‘absorptive capacity’ as ‘the ability of a firm to recognize new external information, assimilate it, and apply it to the commercial ends’ (Cohen and Levinthal, 1989:128). Absorptive capacity has received broad attention in the literature because innovative capabilities have become increasingly important for sustaining a competitive advantage (Bower and Christensen, 1995; Eisenhardt and Martin, 2000). Zahra and George (2002) further defined absorptive capacity as a ‘dynamic capability pertaining to knowledge creation and utilization’ (p. 185) and further proposed two dimensions of it – potential and realized absorptive capacity.

In fact, studies on absorptive capacity have to some extent come to a consensus about the definition of the term, but they differ in the consequences they examine. In previous studies, we observe an interesting construct development. The key point of the original seminal work by Cohen and Levinthal (1989, 1990) is whether and how R&D spending may affect absorptive capacity. Subsequent studies then examined the potential consequences of utilizing absorptive capacity (e.g., Szulanski, 1996; Tsai, 2001). In recent studies, the focus has switched to the identification of various dimensions of absorptive capacity (e.g., Zahra and George, 2002). The most adopted study analyzes the process of acquisition, assimilation, transformation, and exploitation (Brettel, 2011). Moreover, Zahra and George (2002) further divided absorptive capacity into two dimensions. One is potential absorptive capacity, comprising the acquisition and assimilation of knowledge; the other is realized absorptive capacity, including the transformation and exploitation of knowledge. Although Zahra and George (2002) indicated that both potential and realized absorptive capacity coexist and fulfill a necessary but insufficient condition to improve firm performance, in reality, firms might not have both at the same time. How these two dimensions of absorptive capacity facilitate innovation performance outcomes from coupled open innovation needs to be further discussed.

This study asserts that the two dimensions of absorptive capacity have different functions and should be applied in different types or stages of the innovation process (Jansen *et al.*, 2005). Specifically, potential absorptive capacity can be very valuable when firms use coupled open innovation to search for new solutions to their problems because firms tend to be constrained by their own existing knowledge and past routines (Nelson and Winter, 1982). Firms that combine existing knowledge with the ability to acquire and assimilate unfamiliar knowledge in areas that are still closely related to their existing activities have a more complete knowledge base in a novel way (Dosi, 1988). We thus expect that the relationship between coupled open innovation and incremental innovation performance can be enhanced accordingly. However, without transforming or exploiting external knowledge, radical innovation performance cannot be anticipated. We further propose that realized absorptive capacity helps firms to level up the knowledge they acquired from external sources via coupled open innovation. Through the transformation and further exploitation of the newly obtained knowledge, state-of-the-art innovation can be expected because companies can then span larger technological distances (Vanhaverbeke and Cloodt, 2014). That is, realized absorptive capacity strengthens the relationship between coupled open innovation and radical innovation performance. We provide a detailed rationale below.

As mentioned above, potential absorptive capacity refers to the ability to acquire and assimilate external knowledge and may enable a firm to generate a new and enlarged knowledge base (Zahra and George, 2002). In the coupled open innovation process, firms often need to search for and acquire new information or knowledge and then incorporate it with their existing knowledge to produce new products or services. In this situation, potential absorptive capacity helps a firm to quickly learn and assimilate new knowledge into the organization. One of the reasons for adopting coupled open innovation is that firms need to partner with other companies to monitor and understand the latest technological developments (Vanhaverbeke, 2006). Potential absorptive capacity relates to the know-how of a company and is associated with the firm’s ability to recognize and value new external knowledge (Cohen and Levinthal, 1990).

For example, when firms conduct co-patents, the focal firms tend to search predominantly for the knowledge that best fits their existing knowledge (Nelson and Winter, 1982). If firms increase their internal knowledge by bringing in knowledge from outside sources, they can use this knowledge to generate new products and process innovations (Cohen and Levinthal, 1989). In return, the expansion of the internal knowledge base also increases the firms' ability to recognize the value of the external knowledge and to further assimilate this knowledge (Vanhaverbeke, Vareska, and Cloodt, 2008). Moreover, coupled open innovation is positively associated with the incremental innovation outcome described above. Potential absorptive capacity helps firms to analyze, interpret, and comprehend new external knowledge, especially when the acquired knowledge is beyond a firm's usual scope (Brettel, 2011). With the help of potential absorptive capacity, the process of detecting and assimilating external and internal knowledge runs more smoothly. A firm's ability to acquire and assimilate knowledge can help it to combine the best available knowledge and produce improved or brand new products or services (Yang, Wang, and Ruan, 2013). Although a radical innovation outcome cannot be guaranteed, an incremental innovation outcome is anticipated.

However, when firms have only a lower level of potential absorptive capacity, they have less ability to smoothly apply the knowledge from coupled open innovation. For instance, when firms set up a platform to work with outside partners, if the focal firm does not have the ability to understand which knowledge to acquire, or how to comprehend this knowledge, the result of the collaboration might be seized by the other partners. A firm may then be trapped in a paradox of openness (Laursen and Salter, 2014) and cannot appropriate its economic returns. Based on the above arguments, this study proposes the following hypothesis.

Hypothesis 2. Potential absorptive capacity strengthens the positive relationship between coupled open innovation and incremental innovation performance.

The other dimension of absorptive capacity is realized absorptive capacity, which is a function of transformation and exploitation. Although potential absorptive capacity is important, realized absorptive capacity is the primary source of performance improvements (Zahra and George, 2002). Realized absorptive capacity aims to utilize a new knowledge base in the market, so its impact on performance outcomes is more obvious and influential (Brettel, 2011). That is, realized absorptive capacity can help a firm exploit the new knowledge well so that the result of a distant search can be fully utilized within the organization. Lin *et al*. (2012) noted that when a firm establishes an R&D alliance, the focal firm needs the ability to transform this knowledge into something it can comprehend and then to develop or exploit it further. When a platform is established, a firm is able to discuss the next generation of products with suppliers or customers, and some brand new ideas may occur in the process. The spillover of knowledge usually happens when firms have higher realized absorptive capacity to transform the non-local technology knowledge into something novel (K. Han *et al*., 2012). This function is beneficial when firms adopt coupled open innovation to achieve their radical innovation goals. That is, firms with high levels of transformation capability reach a high level of efficiency in converting acquired and assimilated knowledge into transformed and exploited knowledge; thus, they achieve innovative results (Brettel, 2011; Zahra and George, 2002).

However, when firms do not possess realized absorptive capacity, even though they may acquire new knowledge through the coupled approach of open innovation, these firms simply do not have the ability to transform non-local knowledge into their knowledge stock to then advance it to create the next generation of products or services. In this situation, while the firm can work with other partners to develop new patents, for example, the focal firm will be unable to use it to develop radical innovation, which is the main source of major innovation performance. We therefore predict that realized absorptive capacity strengthens the coupled open innovation-radical innovation outcome link. Based on the above arguments, this study proposes the following hypotheses.

Hypothesis 3. Realized absorptive capacity strengthens the positive relationship between coupled open innovation and radical innovation performance.

The analytical framework of this study is shown in Figure 1.

3. Methodology

3.1 Sampling and data collection

This study regarded all 784 listed firms in Taiwanese high-technology industries in 2012 as our population, including the semiconductor,

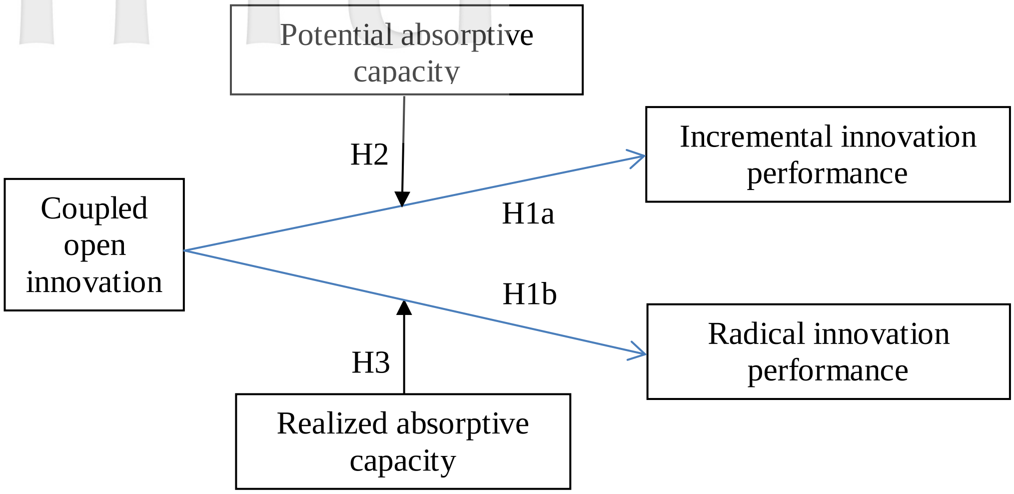

Figure 1
Analytical framework of this research

communication, and information service sectors, among others. These companies are most representative with regard to their innovation activities. Five hundred firms were randomly selected using a systematic sampling procedure. All targeted respondents in this study were senior- or top-level executives who were assured of anonymity in both respondent and firm identities. Finally, 216 completed forms were returned, producing a response rate of 43.2%. The respondents included 38 general managers (including chief executive officers, chief operations officers, and chief financial officers), which accounted for 17.6% of the total respondents; 82 vice general managers (38%); 67 middle managers (including managers, directors, and assistant vice presidents) (31%); and 29 others (including special assistants, factory chiefs, and supervisors) (13.4%).

After completing the above procedure, this study then collected data from various sources. We additionally collected the annual reports of these companies for the survey year as the basis for checking the company's open innovation activities. This study also uses financial data drawn from the *Taiwan Economic Journal* (TEJ), which provides the most comprehensive information on listed companies in Taiwan. The combination and triangulation of different data sources not only alleviate common method variance (CMV) problems but also increase the validity of the empirical evidence (Podsakoff, MacKenzie, Lee, and Podsakoff, 2003).

3.2 Measures

Most of the survey items were adapted from preexisting scales in the literature, and most have been empirically validated by previous studies.

Dependent variables

Incremental innovation performance. Two items were adapted to measure firms' incremental innovation performance (Atuahene-Gima, 2005). One item is defined as the ratio of the sales from incremental innovation to the total sales of the firm for the past year. This item was measured on a five-point Likert scale, which included 5% or below, 5%~10%, 11%~15%, 16%~20% and 20% or above. The other item was measured using the total number of incremental new products for the past year, which included 1~10 as the fewest class, 11~15, 16~30, 31-75 and 75 or above. The average of the two items was used to score for this variable. The *Cronbach's alpha* coefficient for this construct is .73.

Radical innovation performance. Radical innovation performance was measured similarly to incremental innovation performance (Atuahene-Gima, 2005). Two items were measured: the ratio for the sales of radical innovations to the total sales of the firm for the past year and the total number of radical new products for the past year. Both items showed a satisfactory reliability (α=.72) and were combined and averaged to yield a single scale score.

Independent variables

Coupled open innovation. This study collected the annual reports of the sample firms to investigate whether each focal company has ever conducted the following activities: co-patents, spin-offs (including joint ventures), alliances with other partners and establishment of a platform to exchange ideas with other partners. Although previous studies used either partner numbers (Laursen and Salter, 2006) or subjective evaluation (Hung and Chou, 2013) to measure the extent of a firm's openness, classical studies (Chesbrough, 2003b; Enkel *et al*., 2009) used a practice-based approach, i.e., innovation activities, to measure open innovation. We thus followed this method and collected all possible open innovation practices as the foundation for further scrutiny. After checking whether a specific technology-related activity involved the coupled process, we identified the above four innovation activities, which can simultaneously reflect the inflows and outflows of knowledge and technology across firm boundaries (Enkel *et al*., 2009; Mazzola *et al*., 2012). One thing that needs to be clarified is that we coded these activities only for the technology patents and spin-offs with a technology or technology alliance; therefore, they are highly related to open innovation. Coupled open innovation was then measured using an ordinal variable with the value of zero representing firms that have never conducted these innovation activities, one for those only conducting unilateral (non-coupled) innovation activities, and two for those ever conducting one of the four coupled open innovation.

Potential absorptive capacity. We adapted the measurement of this construct used by Jansen *et al*. (2005). Eight items were designed to reflect two dimensions of the absorptive process: acquisition and assimilation. For the acquisition dimension, we used the following items: (1) Our company has frequent interactions with corporate headquarters to acquire new knowledge; (2) Employees of our company regularly visit other branches; (3) We collect industry information through informal means (e.g., lunch with industry friends, talks with trade partners); (4) Other divisions of our company are rarely visited (reverse-coded); and (5) Our company periodically organizes special meetings with customers or third parties to acquire new knowledge, e.g., employees regularly approach third parties such as accountants, consultants, or tax consultants. For the assimilation dimension, we used the following items: (1) We are slow to recognize shifts in our market (e.g., competition, regulation, demography) (reverse-coded); (2) New opportunities to serve our clients are quickly understood; and (3) We quickly analyze and interpret changing market demands. These items were measured on a six-point Likert scale, ranging from one (strongly disagree) to six (strongly agree). The principal component method was used to form a composite factor score as the proxy for the eight items combined (α=.80).

Realized absorptive capacity. Based on Jansen *et al*. (2005), twelve items on a six-point Likert scale were designed to measure two dimensions of realized absorptive capacity: transformation and exploitation. For the transformation dimension, we used the following items: (1) Our company regularly considers the consequences of changing market demand in terms of new products and services; (2) Employees record and store newly acquired knowledge for future reference; (3) Our company quickly recognizes the usefulness of new external knowledge to expand existing knowledge; (4) Employees rarely share practical experiences; (5) We laboriously grasp the opportunities for our company from new external knowledge; and (6) Our company periodically meets to discuss the consequences of market trends and new product development. For the exploitation dimension, we used the following items: (1) It is clearly known how activities within our company should be performed; (2) Client complaints fall on deaf ears in our company; (3) Our company has a clear division of roles and responsibilities; (4) We constantly consider how to better exploit knowledge; (5) Our company has difficulty implementing new products and services; and (6) Employees have a common language regarding our products and services. The principal component method was used to form a composite factor score as the proxy for realized absorptive capacity. A high *Cronbach's alpha* value of .90 indicates satisfactory reliability for this construct.

Control Variables

Firm size has commonly been found to have important effects on variables such as the degree of innovativeness (McGrath, 2001). This study thus included firm size – measured by the logarithm of total assets and number of employees (Haveman, 1992) – as control variables. In addition, resources have an impact on innovation performance (Akgün, Lynn, and Byrne, 2006). This study controlled the effect of organizational ***slack resources*** using a six-point Likert scale, and we measured the level of slack resources within each firm by asking managers whether the resources in their firms are sufficient to sustain various projects and whether they could be utilized in a timely manner, could be freely deployed, and could serve several purposes (De Luca and Atuahene-Gima, 2007). The four items were combined to yield a single factor score (α=0.89). We also controlled for ***firm age*** (Pérez-Luño, Cabello Medina, Carmona Lavado, and Cuevas Rodríguez, 2011). ***Prior performance*** was also included as a control variable because of its effect on innovation performance. Following Artz, Norman, Hatfield, and Cardinal (2010), prior performance was represented by return on assets (ROA) for the prior year (*t-1*). The high-tech ***industry*** was classified into four subcategories: semiconductors, communications, information services, and others. We used three industrial dummy variables (setting other sectors as the reference) to represent the first three sectors and included them in the regression models as control variables to account for their possible interference.

3.3 Validity assessment

To enhance the reliability of the constructs, this study used the item parceling technique suggested by Landis, Beal, and Tesluk (2000) to make the constructs parsimonious. The resulting factor loadings were examined, and the items with the highest and lowest loadings were paired as a first composite based on a single-factor method; the pairing continued until the items were exhausted. Following this procedure, the eight potential absorptive capacity items were reduced to four item parcels, the twelve realized absorptive capacity items were reduced to six item parcels, and the four slack resource items were reduced to two item parcels. As shown in Table 1, all the coefficients of Cronbach's α for the multi-item constructs are greater than the suggested threshold of 0.7 (Hair, Black, Babin, and Anderson, 2009). In addition, the values of composite reliability for the multi-item constructs are also greater than 0.7. Overall, the reliability indicators confirm that the constructs of this study possess high degrees of internal consistency.

To ensure good discriminant validity, Fornell and Larcker (1981) suggested that the values of average variance extracted (AVE) should be greater than both 0.5 and the squares of the correlation coefficients of other variables. The square roots of AVEs (ranging from 0.62 to 0.90 for each construct) are shown in Table 1, meeting the criteria suggested by Fornell and Larcker (1981) and thus indicating good discriminant validity. We also calculated the standardized factor loadings. All the factor loadings exhibited statistical significance (p<0.01), which, together with good values of composite reliability (CR; ranging from 0.86 to 0.96), indicated good convergent validity (Fornell and Larcker, 1981). Finally, this study conducted a confirmatory factor analysis (CFA) on the measurement model that simultaneously incorporates the constructs of potential absorptive capacity, realized absorptive capacity and slack resources. The results consistently show the goodness of the measurement model (χ^2=203.75 df =51; CFI=0.906; IFI=0.907; SRMR= 0.059; RMSEA=0.118).

Table 1
Descriptive statistics and correlations

Variables	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Incremental innovation performance	2.406	0.942	1												
2. Radical innovation performance	1.800	0.798	0.554**	1											
3. Semiconductor	0.190	0.397	-0.025	0.052	1										
4. Communication	0.100	0.297	0.054	0.123	-0.161*	1									
5. Information service	0.060	0.230	-0.035	-0.071	-0.119	-0.080	1								
6. Number of employees	6.620	1.666	0.124	0.081	-0.092	-0.084	-0.092	1							
7. Total assets	16.516	17.089	-0.024	-0.060	-0.036	-0.033	-0.031	-0.199**	1						
8. Firm age	22.898	9.037	-0.108	-0.123	-0.203**	-0.019	0.018	0.108	0.145*	1					
9. Slack resources	4.238	0.759	0.086	0.148*	-0.048	-0.075	-0.050	0.196**	0.011	0.054	1				
10. Prior performance	1.91	10.71	0.037	0.112	-0.070	0.078	0.094	0.038	0.044	-0.005	0.178**	1			
11.Coupled open innovation	0.400	0.562	0.205**	0.052	0.064	-0.013	-0.066	0.086	-0.025	-0.064	-0.023	-0.037	1		
12. Potential absorptive capacity	4.353	0.557	0.008	-0.021	0.169*	0.015	-0.063	-0.063	0.021	-0.073	0.387**	-0.038	-0.009	1	
13. Realized absorptive capacity	4.559	0.524	0.103	0.151*	0.110	-0.002	-0.003	0.050	0.024	-0.085	0.484**	0.055	0.100	0.740**	1
Cronbach's α											0.888			0.800	0.904
Composite reliability											0.949			0.862	0.958
Square root of AVE											0.903			0.624	0.793

* $p<0.05$, ** $p<0.01$ (two-tailed); n=216

3.4 Results

Table 1 presents the means, standard deviations, and correlation coefficients of all variables. The matrix of correlation coefficients demonstrates a satisfying correlation structure for the variables, with an exception that the highest correlation (.74) exists between the two dimensions of absorptive capability. This high correlation is reasonable and anticipated. When modeling the interaction effect, we also followed the procedures suggested by Aiken and West (1991) to standardize each original independent variable to produce the corresponding interaction terms. Because all values for the variance inflation factor (VIF) were smaller than the suggested ceiling of 10 (Stevens, 2002), there was no evidence of multicollinearity.

To test the hypotheses, this study used a hierarchical regression model design in which the control variables were first entered as the baseline model and the independent variables and interaction terms were then alternately entered into the models. The regression results are shown in Table 2 and Table 3. To test Hypothesis 1a, the variable for coupled open innovation was entered into Model 2 through Model 5. The results consistently show that coupled open innovation is positively related to incremental innovation performance (βs ranging from 0.179 to 0.217, $p<0.01$). Thus, Hypothesis 1a is supported. Model 7 through Model 10 in Table 3 test whether coupled open innovation is positively related to radical innovation performance. Unlike the results in Table 2, the results in Table 3 show that coupled open innovation is consistently insignificant at $\alpha=0.05$ level across all models, indicating no significant relationship between coupled open innovation and radical innovation performance. Therefore, Hypothesis 1b is not supported.

As predicted by Hypothesis 2, potential absorptive capacity strengthens the positive relationship between coupled open innovation and incremental innovation performance. Model 3 tests for the interaction effect between coupled open innovation and potential absorptive capacity and demonstrates a significantly positive relationship ($\beta=0.121$, $p<0.05$). Therefore, Hypothesis 2 is supported. Model 9 shows that the interaction between coupled open innovation and realized absorptive capacity has a positive and significant effect on radical innovation performance ($\beta=0.113$; $p<0.05$). Thus, Hypothesis 3 is supported.

Table 2
Results of OLS analysis predicting incremental innovation performance

Variables	DV: Incremental innovation performance				
	Model 1	Model 2	Model 3	Model 4	Model 5
Control variable					
Semiconductor	-0.030 (0.171)	-0.037 (0.171)	-0.030 (0.171)	-0.036 (0.172)	-0.027 (0.170)
Communication	-0.018 (0.288)	-0.015 (0.285)	-0.020 (0.284)	-0.015 (0.286)	-0.029 (0.284)
Information service	0.059 (0.224)	0.060 (0.221)	0.059 (0.220)	0.061 (0.223)	0.045 (0.222)
Number of employees	0.128* (0.042)	0.100 (0.042)	0.098 (0.042)	0.101 (0.042)	0.093 (0.042)
Total assets	-0.006 (0.004)	-0.005 (0.004)	-0.002 (0.004)	-0.004 (0.004)	-0.003 (0.004)
Firm age	-0.133* (0.007)	-0.117* (0.007)	-0.124* (0.007)	-0.117* (0.007)	-0.128* (0.007)
Slack resources	0.067 (0.088)	0.058 (0.101)	0.037 (0.102)	0.058 (0.101)	0.018 (0.103)
Prior performance	0.015 (0.006)	0.014 (0.006)	0.025 (0.006)	0.016 (0.006)	0.021 (0.006)
Predictor variables					
Coupled open innovation		0.179** (0.116)	0.198** (0.116)	0.179** (0.116)	0.217** (0.118)
Potential absorptive capacity		-0.094 (0.176)	-0.081 (0.176)	-0.092 (0.177)	-0.084 (0.175)
Realized absorptive capacity		0.112 (0.195)	0.111 (0.194)	0.110 (0.196)	0.126 (0.194)
Interaction					
Coupled open innovation × Potential absorptive capacity			0.121* (0.064)		0.229** (0.093)
Coupled open innovation × Realized absorptive capacity				0.019 (0.068)	-0.145 (0.099)
VIF Min	1.028	1.030	1.031	1.031	1.031
VIF Max	1.110	2.603	2.604	2.616	2.626
F	1.108	3.017**	3.017*	0.075	2.587*
Adjust R^2	0.004	0.032	0.042	0.028	0.047
ΔR^2	0.041	0.041	0.014	0.000	0.023

*$p<0.05$, ** $p<0.01$ (one-tailed); n=216; Standardized coefficients are reported. Numbers in parentheses are standard errors.

Table 3
Results of OLS analysis predicting radical innovation performance

Variables	DV: Radical innovation performance				
	Model 6	Model 7	Model 8	Model 9	Model 10
Control variable					
Semiconductor	0.062	0.077	0.088	0.080	0.089
	(0.142)	(0.142)	(0.140)	(0.141)	(0.140)
Communication	-0.047	-0.065	-0.073	-0.062	-0.075
	(0.240)	(0.237)	(0.233)	(0.235)	(0.234)
Information service	0.136*	0.140**	0.139**	0.150**	0.135**
	(0.186)	(0.184)	(0.181)	(0.183)	(0.183)
Number of employees	0.069	0.034	0.031	0.037	0.030
	(0.035)	(0.035)	(0.034)	(0.035)	(0.034)
Total assets	-0.043	-0.044	-0.041	-0.043	-0.041
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Firm age	-0.117*	-0.105	-0.116*	-0.106	-0.117*
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Slack resources	0.137*	0.122*	0.091	0.122*	0.086
	(0.073)	(0.084)	(0.083)	(0.083)	(0.085)
Prior performance	0.085	0.063	0.080	0.074	0.079
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Predictor variables					
Coupled open innovation		0.007	0.035	0.004	0.040
		(0.096)	(0.095)	(0.095)	(0.097)
Potential absorptive capacity		-0.313**	-0.294**	-0.302**	-0.295**
		(0.146)	(0.144)	(0.146)	(0.145)
Realized absorptive capacity		0.301**	0.299**	0.289**	0.303**
		(0.162)	(0.159)	(0.161)	(0.160)
Interaction					
Coupled open innovation × Potential absorptive capacity			0.182**		0.210**
			(0.052)		(0.077)
Coupled open innovation × Realized absorptive capacity				0.113*	-0.037
				(0.056)	(0.081)
VIF min	1.028	1.030	1.031	1.031	1.031
VIF max	1.110	2.603	2.604	2.616	2.626
F	2.084**	3.593**	7.373**	2.912	3.744**
Adjust R^2	0.039	0.074	0.102	0.083	0.098
ΔR^2	0.075	0.047	0.031	0.012	0.032

* $p<0.05$, ** $p<0.01$ (one-tailed); n=216; Standardized coefficients are reported. Numbers in parentheses are standard errors.

As a further reconfirmation of our results, Figure 2 and Figure 3 exhibit the moderating effects of the two categories of absorptive capability on the relationship between coupled open innovation and innovation performance. Both diagrams show that, as the two categories of absorptive capability increase, there is a strong positive relationship between coupled open innovation and innovation performance.

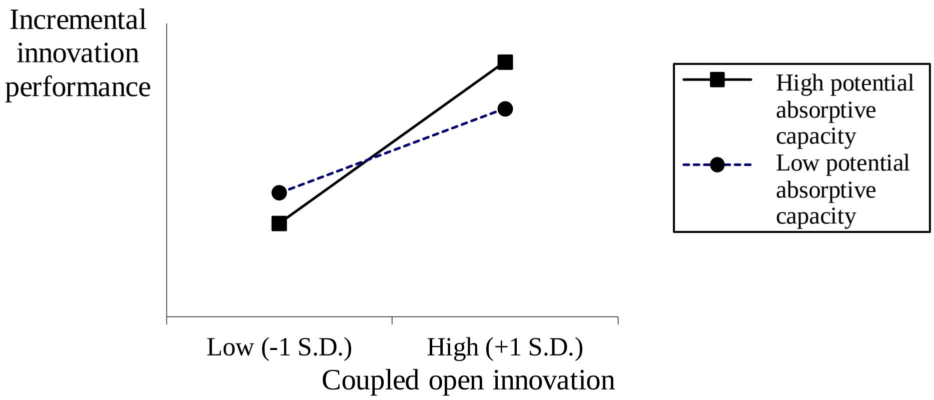

Figure 2
The moderating effect of potential absorptive capacity on the relationship between coupled open innovation and incremental innovation performance

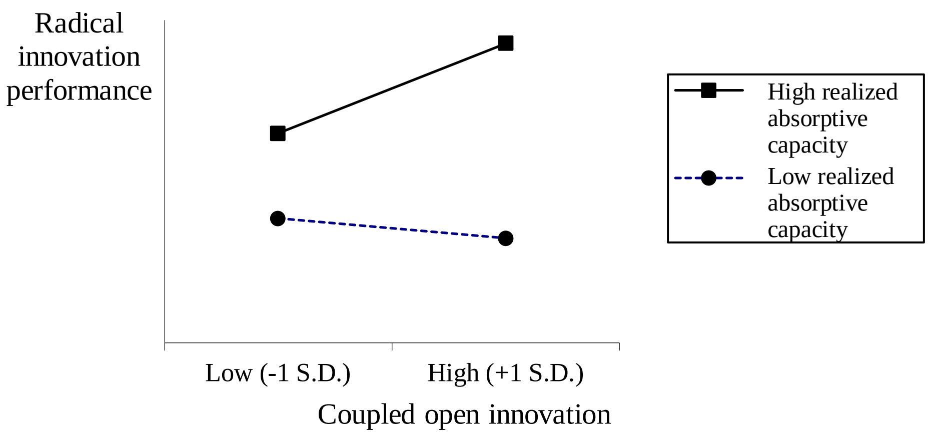

Figure 3
The moderating effect of realized absorptive capacity on the relationship between coupled open innovation and radical innovation performance

4. Discussion and conclusion

4.1 Discussion

Open innovation has been regarded as a very important topic for theory and practice. This study uses the theoretical lens of organizational search to embed coupled open innovation within the literature. Moreover, we connect the dynamic capability view to this stream of knowledge. Representing the most complex search type of open innovation, this study focuses on coupled open innovation, including co-patents, spinoffs, alliances, and the establishment of platforms, as well as its relationship with innovation performance. Based on past literature, this study connects open innovation with absorptive capacity by discussing the moderating effects imposed by potential and realized absorptive capacity.

As the results show, coupled innovation is positively related to incremental innovation. Due to its complementary nature, coupled open innovation brings in new knowledge to improve existing products and services and, thus, incremental innovation. This performance link is further strengthened by potential absorptive capacity, which shows that firms' acquisition and assimilation abilities help in the process of adopting coupled open innovation to achieve incremental innovation performance. A firm usually has existing knowledge or products as a basis for further development of incremental innovation or new products. To look for complementary knowledge to improve products, technologies or markets, the abilities to detect knowledge and monitor the environment become necessary (Parida, Westerberg, and Frishammar, 2012). With the abilities to acquire and assimilate, the search is easier and more efficient.

The path from coupled open innovation to radical innovation performance appears to be more complicated. The result is contrary to our prediction that coupled open innovation can derive radical innovation outcomes directly. However, our analysis shows that only with the help of realized absorptive capacity can a radical innovation be achieved. Compared with incremental innovation, radical innovation is less frequent and, thus, needs more organizational conditions. This finding is interesting because radical innovations are ground-breaking developments that require significant resources to materialize and often have longer time lags to achieve profitability than incremental innovations (Chaney, Devinney, and Winer, 1991). The process needs more organizational factors. The results show realized absorptive capacity, with transformation and exploitation capabilities, can help focal firms transform technologies that are new to them. With these abilities, firms can achieve radical innovation from coupled open innovation.

4.2 Implications and future study

Through the theoretical lens of organizational search, this study asks whether coupled open innovation leads to favorable organizational outcomes and whether performance can be facilitated by absorptive capacity. With numerous companies adopting coupled open innovation, this study provides insights for theory and practice.

The research on open innovation originated from the observations of several large companies' practices, and many studies have followed this path to provide more empirical evidence. This is, of course, appropriate and inspiring to some extent due to its complex processes. However, following some previous exceptional work that aims to theorize these practices (Enkel *et al.*, 2009; Gassmann and Enkel, 2004), this study contributes to building a more coherent theoretical basis for further studies by specifically examining coupled open innovation and its organizational outcomes. Hopefully, future studies can build upon the results of this study to refine the open innovation model and continue the debate on this issue.

Organizational search theory notes that firms searching for solutions from external sources face the costs of building organizational practices to handle these processes (Laursen and Salter, 2006). Coupled open innovation is a more complicated and costly search behavior than solely inbound or outbound modes. Our results show that firms adopting coupled open innovation can experience incremental innovation outcomes but need the accumulation of realized absorptive capacity to jointly achieve positive radical innovation performance. This finding is encouraging because, given the costs associated with adopting this approach, the positive performance outcome can still be anticipated with the assistance of other organizational conditions. That said, while a local search is usually adopted due to firms' routines and past experiences, a non-local search can pay off with high absorptive capacity. This evidence opens the research agenda that connects the study of open innovation to organizational search theory.

Another academic dialog occurs when organizational search theory interacts with the dynamic capability view. Both theories aim to explore how firms use external resources to solve their problems. However, organizational search theory emphasizes the path or boundary of search behavior, while absorptive capacity focuses on how internal organizational mechanisms help to utilize the search results more efficiently. Connecting the two theories opens a debate and makes inroads for future studies. There are several worthwhile questions, such as whether these internal mechanisms to assist the transformation of external knowledge have limitations, as Cohen and Levinthal (1990) noted that absorptive capacity may also limit the resources that can be absorbed. Future studies can follow this line of research and investigate the possible optimal level of absorptive capacity.

The results of this study also benefit practitioners. Previous studies not only suggest that open innovation is almost imperative for all firms (Chesbrough, 2003b) but also warn of the potential paradox of openness (Laursen and Salter, 2006). Our empirical results generate the encouraging message that when firms aim to achieve incremental innovation outcomes, coupled open innovation is highly recommended, even with the costs of setting up new organizational practices to handle it. It is even more advisable if firms are equipped with a high level of ability to acquire and assimilate external knowledge. As for the radical innovation outcome, the process is more complicated. Firms need to accumulate adequate abilities to transform and exploit external knowledge so that they can benefit from coupled open innovation for a more radical innovation outcome. Managers might need more patience for the cultivation and accumulation of these abilities when their objective is to attain radical innovations.

Although these results are compelling, this study has several limitations that warrant additional research. This study uses annual reports to collect the practices that firms adopted for coupled open innovation. Some companies regard these practices as confidential data that should not be disclosed. Other measurements, in-depth interviews or experimental designs (Wang, Chen, Lin, Lin, and Lee, 2011) can be developed and used in future studies to complement the current research. In addition, this study uses a sample of high-technology firms that are typically characterized by high innovative capabilities and are thus suitable for observing coupled open innovation and its performance outcomes. To achieve generalizable findings, future studies should use other industries as samples. Furthermore, our study considers only the impact of coupled open innovation on innovation performance outcomes; future studies are advised to research the impact on financial outcomes or strategic outcomes, such as competitive situations or the creation of networks.

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