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Foreign and Domestic Collaboration, Product Innovation Novelty, and Firm Growth

Wan-Lin Hsieh, Panagiotis Ganotakis, Mario Kafouros, and Chengqi Wang

Although prior research underscores the benefits of external collaboration for a firm's innovative output, little research has examined the role that collaboration plays across the different stages of the innovation process. Drawing from organizational learning theory, this article examines (1) how collaboration with domestic partners assists in the formation of collaborations with foreign partners, (2) how knowledge from these collaborations is associated with product innovation at different levels of novelty, and (3) how the relationship between the level of innovation novelty and firm growth is influenced by whether the focal firm engages in open or closed innovation and the origin of the collaborator (foreign or domestic). Three key findings emerge from the econometric analysis of a sample of 1684 Taiwanese firms. First, domestic collaborations assist in the formation of foreign collaborations when the partner type is the same. Second, the level of innovation novelty is associated with the type and geographic location of partners. This study differentiates among noninnovating firms, incremental innovators, and radical innovators and demonstrates that the role of partners changes as the number of countries in which a firm collaborates with each partner type increases. Third, only radical innovation is relevant to firm growth, regardless of whether it is developed internally or through collaboration with domestic or foreign partners.

Practitioner Points

- Managers will find it easier to form foreign collaborations with types of partners that a firm has engaged in collaboration with domestically.
- Managers that would like to develop radical products will benefit from collaborating with foreign customers and domestic competitors. However, they need to also be cautious about such collaborations because it is possible that they might lead to no innovation taking place at all.
- The development of incremental innovations is enhanced by collaborating with foreign consultants/private research institutes. Although collaboration with domestic suppliers can also lead to incremental innovation, this can occur at the expense of radical innovation.
- Managers that want to enhance sales should target the development of radical rather than incremental innovations. The choice of an open or a closed innovation approach should depend on internal knowledge availability.

Introduction

There is a consensus in the literature that the innovation process consists of three major stages (Un, Cuervo-Cazurra, and Asakawa, 2010; West and Bogers, 2014): (1) obtaining knowledge from external sources (e.g., by engaging in collaboration), (2) using internal and external knowledge to develop innovation outputs, and (3) commercializing innovations (including the relationship between innovation and firm performance). The three innovation stages find their theoretical foundation within the organizational learning theory (Huber, 1991). According to the theory, firms gain knowledge at different levels from both internal and external activities that may in turn lead to different learning outcomes (e.g., product innovation) (Dodgson, 1993) and to variations in firm performance (measured as sales growth in this study).

To capture the complexity and linkages between such stages, prior research has emphasized the significance of modeling the entire innovation process

Address correspondence to: Panagiotis Ganotakis, University of Liverpool Management School, University of Liverpool, Chatham Street, Liverpool L69 7ZH, United Kingdom. E-mail: p.ganotakis@liverpool.ac.uk. Tel: 0044 (0) 151 795 3000.

(Artz, Norman, Hatfield, and Cardinal, 2010; West and Bogers, 2014). Such an approach is important because success in sourcing knowledge might not guarantee success in developing innovations or superior firm performance (Hansen and Birkinshaw, 2007). This study seeks to advance organizational learning theory by contributing to the literature of each of the three innovation stages. Regarding the first stage, although the literature recognizes the value of international collaboration (van Beers and Zand, 2014) and the existence of complementarities among partner types (Roper and Arvanitis, 2012), it is unclear whether knowledge from domestic collaborations helps the formation of foreign collaborations. Although prior studies (Roper, Du, and Love, 2008) show that collaborating with one partner type (e.g., customer) increases the likelihood of collaborating with a different partner type (e.g., supplier), such complementarities might not exist among partners from the domestic to foreign markets due to cultural and institutional differences. Hence, the knowledge gained from domestic partners might be less useful for foreign collaborations (Eriksson, Johanson, Majkgård, and Sharma, 1997; Lavie and Miller, 2008).

BIOGRAPHICAL SKETCHES

Dr. Wan-Lin Hsieh is an assistant professor of creativity and innovation management at the department of Industrial Engineering and Enterprise Information, Tunghai University (Taiwan). Her research interests lie in the areas of open innovation, systematic innovation, and creativity management. She has published in a number of journals such as *Production Planning & Control*, *Total Quality Management & Business Excellence*, and *Journal of Testing and Evaluation*.

Dr. Panagiotis Ganotakis is an associate professor at University of Liverpool Management School and UOWD. His research interests center in the areas of open innovation, entrepreneurship, and international business. His work is published in a number of journals such as *Journal of Product Innovation Management*, *Journal of International Business Studies*, *Small Business Economics*, *International Business Review*, and *Oxford Economic Papers*.

Dr. Mario Kafouros is professor of international business and innovation at Leeds University Business School (UK). He has extensive industrial and academic experience in the field of innovation and international business. He has published in international journals such as *Journal of Management*, *Journal of International Business Studies*, *Journal of Management Studies, Research Policy*, and *Journal of World Business, Human Relations*, *and Organization Studies*.

Dr. Chengqi Wang is professor of strategy and international business at Nottingham University Business School, University of Nottingham (UK). His research is dominated by two themes—innovation and international business, particularly in the context of emerging markets. He has published extensively in international journals such as *Journal of International Business Studies* (four times), *Research Policy*, *British Journal of Management*, and *Journal of World Business*.

This study addresses Parkhe's (1991) unanswered question on whether collaboration with domestic partners assists in the formation of foreign collaborations, and it further considers under what conditions this occurs. Addressing this question is important because it extends the literature on the determinants of foreign collaborations and the complementarities that exist among different partner types, while increasing our understanding of whether the knowledge that firms gain from domestic collaborations can be transferred to foreign collaborations and for what types of foreign partnerships this knowledge is most useful. Furthermore, this work adds to organizational learning theory by changing our thinking regarding the way that lower (i.e., single-loop) and higher (i.e., double-loop) level learning are linked (Dodgson, 1993; Fiol and Lyles, 1985). Although the theory suggests that it is double-loop learning that can redefine single-loop learning (Parkhe, 1991), this study postulates and empirically verifies that under certain conditions, single-loop learning redefines double-loop learning.

Knowledge about the second innovation stage is limited in two important ways. First, although extant research suggests that the knowledge and motives of each partner type differ (Tether, 2002; van Beers and Zand, 2014) and that radical and incremental product innovations require different knowledge inputs, it is not currently clear what type of knowledge is required to achieve radical and incremental innovation (Slater, Mohr, and Sengupta, 2014; Un et al., 2010). To overcome this limitation, research should involve the explicit comparison of how certain determinants work differently for radical innovation vis-à-vis incremental innovation (Slater et al., 2014). This article contributes to this research stream by identifying what types of partners help firms to evolve from a state where no product innovation occurs to a state where they develop incremental product innovations and to evolve from incremental to radical innovators (Pittaway, Robertson, Munir, and Denyer, 2004; Un et al., 2010).

This analysis helps us to clarify the linkage between a certain type of partner and product innovation (both radical and incremental) and contributes to the organizational learning theory. According to the theory, firms can learn through vicarious learning (by observing the strategies and technologies of other organizations) and focused search (interorganizational learning) (Dodgson, 1993; Huber, 1991). Interorganizational learning can lead to a higher level of learning (in relation to vicarious learning; Bapuji and Crossan, 2004; Dodgson, 1993), change a firm's frame of

reference and help the firm identify novel solutions that can lead to radical innovations (Fiol and Lyles, 1985; Levitt and March, 1988). Vicarious learning allows a firm to enter an existing market (i.e., achieve incremental innovation). This study contributes to this line of thinking by suggesting and empirically verifying that not all interorganizational linkages lead to a higher level of learning (Bapuji and Crossan, 2004; Dodgson, 1993). Rather, some are more important for vicarious learning whereas others matter more for a higher level learning. Furthermore, the study shows that although some types of linkages (partners) can change a firm's frame of reference, the same types can also constrain learning and that it is not only double-loop learning (foreign collaborations—which provide access to diverse forms of knowledge from different innovation systems) that can change a firm's frame of reference but that this can also occur via single-loop learning (domestic collaborations—knowledge derived from the same national system of innovation).

A second limitation in our knowledge is that although organizational learning theory postulates that firms often fall in a "competency trap" of repeatedly using the same activities (e.g., collaborating with the same types of partner [Jean, Sinkovics, and Hiebaum, 2014]), which may lead to knowledge inertia (Levitt and March, 1988; March, 1991), the theory does not specify how firms can escape this trap. To this end, this study enriches the theory by showing that the detrimental effect of inertia related to using similar types of interorganizational linkages can be reversed when the routines that are the result of repetitive action are applied to a similar interorganizational setting but across borders. This applies when learning changes the firm's frame of reference (radical product innovation) but also in vicarious learning (incremental innovation). Our analysis therefore advances the literature by explaining the relationship between different types of domestic/foreign partners and the level of product innovation novelty; by specifying their role in differentiating among noninnovating firms, incremental and radical innovators; and by showing how this relationship changes as the number of countries in which a firm collaborates with each partner type increases.

Regarding the third innovation stage (the relationship between innovation and firm performance [sales growth]), it is not currently clear in the literature how the relationship between the level of innovation novelty and firm growth changes depending on (1) whether the focal firm engages in external collaborations (Almirall and Casadesus-Masanell, 2010; West and Bogers, 2014) and (2) where the collaborator originates (foreign or domestic).

Regarding the first point, although some studies report a positive relationship between collaboration and firm performance (Belderbos, Carree, and Lokshin, 2004; Harhoff, Mueller, and Van Reenen, 2014), others show that collaboration reduces performance (Faems, De Visser, Andries, and Van Looy, 2010) or that internal innovation projects lead to greater levels of performance than projects with external partners (Rosenbusch, Brinckmann, and Bausch, 2011). Furthermore, other studies show that the firms performing best in sales from new products are no more likely to engage in collaboration than poorer performers are (Barczak, Griffin, and Kahn, 2009). Regarding the second point, although foreign linkages provide access to diverse knowledge (Kafouros and Forsans, 2012) that may increase the commercial value of new products, coordination challenges and the risk of misappropriation are higher for cross-country collaborations (Barge-Gil, 2013; Lavie and Miller, 2008). To enhance understanding of this phenomenon, this study examines how the contribution of radical innovation to a firm's sales growth is influenced by whether innovative products have been developed through (1) collaborations with foreign partners, (2) collaborations with domestic partners, or (3) without external collaboration. These questions are important because ultimately the value of external linkages depends on how they affect firm performance (Barge-Gil, 2013; West and Bogers, 2014).

Addressing the above questions also contributes to organizational learning theory. Specifically, the theory postulates that only higher-level learning changes a firm's frame of reference and improves performance (Argyris and Schon, 1978; Huber, 1991). This can occur either through internal effort (e.g., R&D) and/or by engaging in external learning especially through focused search (interorganizational activities) (Dodgson, 1993). This article extends the theory by arguing that within the context of interorganizational learning, the performance of an organization can improve at the same extent when a firm is able to access not only double-loop external learning (collaboration with foreign partners) but also single-loop learning (collaboration with domestic partners).

Theory and Hypotheses

According to organizational learning theory (Huber, 1991), firms accumulate knowledge from internal and

external activities. Knowledge can be collected from internal organizational experiments, such as R&D, whereas external activities include vicarious and interorganizational learning (or focused search). Vicarious learning refers to a firm's attempt to mimic or learn about the technologies and practices of other organizations, mainly by observing their behavior in the external environment. It results in replicating part of the knowledge that rivals possess and assists in entering an already occupied market niche (and therefore incremental innovation). On the other hand, firms engage in focused search in order to identify and respond to novel opportunities or when there is a need for a novel solution to a problem that rests outside their knowledge boundaries (Dodgson, 1993; Huber, 1991). Focused search is expected according to the organizational learning theory to lead to more relevant but also higher levels (double-loop) of learning (Bapuji and Crossan 2004; Dodgson, 1993; Huber, 1991).

This is because (1) the main motivation for engaging in external focused search is the novelty of the solutions required to be generated (Huber, 1991), (2) the interaction that exists in such relationships increases the potential for novel knowledge combinations (Bapuji and Crossan 2004), and (3) the interactive process involved in interorganizational networks increases the ability of firms to be adaptive and introduce highly innovative products that other companies then try to mimic (Dodgson, 1993). In this study, focused search refers to a firm's collaborations with different types of external partners (customers, suppliers, competitors, and universities).

Moreover, collaboration with foreign partners is linked with double-loop effort and learning while domestic with single-loop.[1] This is because firms have to exert a higher level of effort (double-loop) in order to engage in foreign collaboration because of the differences in organizational structures that exist among firms from different cultures (Parkhe, 1991). Nevertheless, through foreign collaborations firms are able to access more diverse and specialized forms of knowledge that are based on different national innovation systems (Arranz and de Arroyabe, 2008; van Beers and Zand, 2014). On the other hand, domestic collaborations are easier to be formed given the similarity in partners' organizational structures and management practices, but at the same type firms access less diverse and specialized forms of knowledge because these are derived from the same knowledge base and system of innovation that a firm is part of (Arranz and de Arroyabe, 2008; van Beers and Zand, 2014). This in turn leads to less valuable knowledge combinations.

Regarding the process of product development, exposure to a higher level of learning may change a firm's frame of reference. Frame of reference refers to the cognitive maps or cognitive frameworks (that can be partially defined by a firm's underlying technology) that shape a firm's ability to interpret and combine different forms of knowledge (Fiol and Lyles, 1985; Huber, 1991). It includes a firm's existing knowledge base, technological competences, but also organizational routines and processes (Dodgson, 1993; Parkhe, 1991). The introduction of a new frame of reference can then facilitate the development of radical (but also incremental) product innovations (Huber, 1991; Yeoh, 2004). Finally, prior studies suggest that organizational learning (i.e., innovation) leads to superior firm performance (Argyris and Schon, 1978).

Types of Collaborators: First Innovation Stage

Collaboration in this article is defined as active participation in innovation activities/projects with different types of external partners, and it therefore excludes pure contracting out work (Laursen and Salter, 2006; Tether and Tajar, 2008). Firms may collaborate with different types of partners, including customers (Bohlmann, Spanjol, Qualls, and Rosa, 2013), suppliers (Lawson, Krause, and Potter, 2015), competitors (Xu, Wu, and Cavusgil, 2013), consultants, and R&D institutes (Tether and Tajar, 2008) and universities (Bstieler, Hemmert, and Barczak, 2015). Prior studies suggest a complementary relationship (as explained in the introduction) exists among those partner types (Roper and Arvanitis, 2012).

This section contributes to the first innovation stage and to organizational learning theory by proposing that collaboration with domestic partners assists in the formation of international collaborative agreements and more specifically that this relationship holds only for the *same* types of partners (e.g., domestic and international customers). Building on organizational learning theory, the current study postulates that when a firm collaborates with a certain type of external partner, it learns from this activity. This results in the establishment of mechanisms and routines designed to support the collaboration. These routines include the development of a platform

[1]Double-loop learning requires more effort and involves redefining and changing the norms, values, and governing processes within a firm (Argyris and Schon, 1978; Huber, 1991). Single-loop learning requires little effort and does not involve a change in underlying firm processes, routines, and structures.

for communicating and coordinating effectively as well as processes used to create a shared context that facilitates knowledge transfer (Rothaermel and Deeds, 2006, Sampson, 2005; Un et al., 2010). These common knowledge-sharing systems increase the alignment in organizational structures[2] between the firm and the partner and therefore enhance the firm's ability to assimilate knowledge from that partner (Lane and Lubatkin, 1998; Schmidt, 2010).

Nevertheless, the mechanisms to aid collaboration with a given type of partner are context specific and cannot always be used for other partner types (Lhuillery and Pfister, 2009; Rothaermel and Deeds, 2006). Different partner types have different needs and demands and vary substantially in structures and practices, risk profiles, management styles, and the nature and breadth of knowledge being transferred (Belderbos, Gilsing, and Lokshin, 2012; Un et al., 2010). Hence, firms that collaborate with various partner types face coordination and communication complications that increase operating difficulties and hamper knowledge transfer and learning (Park and Ungson, 1997; Sampson, 2005). In such situations, further changes in a firm's organizational structure should occur in order to effectively assimilate knowledge from a new partner type (Schmidt, 2010). Although the creation of new routines to accommodate a different type of partner is possible, it increases complexity and requires additional investment and effort (Park and Ungson, 1997).

The difficulties associated with collaborating with a different partner type further increase because a firm's collaborative abilities are constrained by prior investments (Belderbos et al., 2012; Sampson, 2005). Hence, although complementarities among different types of partners can arise, firms are more likely to engage in types of collaboration for which the required organizational routines already exist.

Furthermore, firms that need complementary knowledge are more motivated to engage in international collaborations because they serve as a vehicle to access specialized technologies that are not available domestically (Kafouros and Forsans, 2012). International collaborations are however characterized with difficulties that arise because of cross-country differences in language and culture that increase friction and coordination costs (Barkema, Shenkar, Vermeulen, and Bell, 1997) and constrain knowledge transfer (Park and Ungson, 1997). Differences in national cultures between partners are also partly responsible for differences in management styles and organizational structures that constrain learning (Park and Ungson, 1997; Parkhe, 1991).

Nevertheless, it is possible that firms can overcome some of the challenges associated with diverse cultures in international collaborations when they have already collaborated domestically with the same type of partner with which they are attempting to collaborate internationally. Research on joint ventures (JVs) suggests that firms can learn some of the skills required to function within international JVs by first forming domestic JVs. Firms that form domestic JVs can develop partnering skills that can be subsequently used in international JVs, thus leading to their formation (Barkema et al., 1997). This argument may also apply to the case of collaborations. Hence, the routines that a firm implements to collaborate with a specific type of domestic partner can also be used when collaborating with similar types of foreign partners, thus lowering the barriers to international collaboration.

Reinforcing this view, Rallet and Torre (1999) and Park and Ungson (1997) found that the problems that emerge when transferring specialized knowledge over large distances and cultures decrease when the organizational proximity between partner firms increases and when precise information-sharing tasks and procedures are in place, thus effectively reducing the cultural gap between partners of different nationalities (Pittaway et al., 2004). As organizational proximity increases through the adoption of partner-specific routines and structures, domestic firms to a certain degree can overcome the differences in organizational structures and practices arising from differences in national cultures (Park and Ungson, 1997; Parkhe, 1991).

Therefore, the existence of practices that facilitate information sharing and decrease the cultural gap among similar types of domestic and international partners means that relatively little mutual adjustment of existing processes is required to sustain collaborative effectiveness. In this situation, a firm will find it easier to form international collaborations with a type of partner that the firm has collaborated with at the domestic level. On the other hand, organizational difficulties caused by dissimilar mechanisms and routines between different domestic and foreign partners require firms to exert greater (double-loop) efforts and investments to enhance collaboration effectiveness and coordination (Parkhe, 1991; Sampson, 2005). Thus, collaborating with a partner type abroad, without

[2]Organizational structure is considered to be an aspect of absorptive capacity (the ability to identify, assimilate, and exploit external information) alongside internal R&D expenditure, staff skills, and training (Schmidt, 2010).

collaborating with a similar one domestically, becomes more difficult and less likely. Hence, the following hypothesis is proposed:

H1: *Domestic collaborations assist in the formation of foreign collaborations but only when the types of domestic and foreign partners are the same*.

Knowledge Inputs and Innovation Outputs: Second Innovation Stage

The second innovation stage concerns the transformation of knowledge inputs, including those from external partners into product innovations. This study postulates that some partner types tend to be *on average*, more important for radical product innovations, while others are more important for incremental innovations (van Beers and Zand, 2014).

Collaboration with Customers, Suppliers, Competitors, and Universities

Collaborations with supply chain members (i.e., customers and suppliers) have been linked more with radical rather than with incremental product innovation (Mention, 2011; Nieto and Santamaria, 2007). For customers, such contributions may differ, however, depending on whether a firm collaborates with lead users or mainstream customers (Herstatt and Hippel, 1992). For instance, collaboration with mainstream customers might push a firm toward unattractive technological paths that focus on improving existing products while neglecting the development of competences that lead to radical product innovation (Chatterji and Fabrizio, 2014; Nijssen, Hillebrand, de Jong, and Kemp, 2012). In contrast, lead users experience needs ahead of the rest of the population, and are often involved in the development of technological solutions aimed at satisfying needs not met by existing products. Such collaboration is usually based on the combination of more diverse knowledge components that tend to be focused on exploration and new technology development (Bonner and Walker, 2004; Chatterji and Fabrizio, 2014; Enkel, Kausch, and Gassmann, 2005).

Nevertheless, strong support exists for the view that collaborations with customers (on average) enable firms to identify novel ideas that lead to the development of radical product innovations (Amara and Landry, 2005; Freel and Harrison, 2006; Ganotakis and Love, 2012). Collaborations with customers enable firms to refine the direction of their R&D efforts and to enhance internal competencies by assisting in new product design, technology, project management, and prototype assessment as well as by enhancing the creativity and problem-solving skills of the firm's new product development (NPD) team (Lawson et al., 2015; Menguc, Auh, and Yannopoulos, 2014; Tsai, 2009). Such collaboration allows firms to respond to simultaneous changes that occur in a product's underlying technological platform and in customers' expectations and needs; issues that frequently arise in the development of radical product innovations (Bohlmann et al., 2013).

Similarly, the relationship between supplier collaboration and the level of innovation novelty might depend on the stage of supplier involvement (predesign or commercialization stage) (Song and Thieme, 2009) and on the suppliers' level of innovativeness (Kibbeling, der Bij, and Weele, 2013). Although not all suppliers make a similarly strong contribution to the development of radical products, such contribution, on average, is likely to be more strongly linked with the introduction of radical innovation products than with incremental innovations (Amara and Landry, 2005; Freel and Harrison, 2006; Harhoff et al., 2014; Petersen, Handfield, and Ragatz, 2003).

First, firms are increasingly reliant on suppliers to generate creative solutions required for the development of radical innovations because each firm progressively tends to specialize in niche core competencies and to possess a particular set of skills and knowledge associated with specific technologies and NPD activities (Lawson et al., 2015). By collaborating with suppliers, firms extend their range of valuable knowledge regarding new technological specifications, especially in design and manufacturing. Examples offered in some studies indicate that this complementary knowledge is required and is more beneficial in situations where the technology involved is rather unique and complex and novel solutions are needed (Lawson et al., 2015; Menguc et al., 2014). Through supplier collaboration, a firm can also access knowledge regarding entirely new production technologies or codevelop with suppliers processes that are necessary for the creation of radical new products (Un and Asakawa, 2015).

Firms also collaborate with rivals and once again, the contribution of such collaborations to product innovation novelty might vary depending on a firm's absorptive capacity and ability to protect its innovations (Ritala and Hurmelinna-Laukkanen, 2013).

Nevertheless, collaboration with competitors is again, on average, more likely to lead to radical rather than incremental innovation. This is because the main motivations to engage in such collaborations are linked with creating a new market or with increasing existing market size, sharing risk and costs, improving competitive positions, and beating competition that comes from other rivals (Bouncken and Kraus, 2013; Ritala and Hurmelinna-Laukkanen, 2009). All these motives are related to or are achieved through radical product innovation.

Moreover, firms collaborate with competitors not only to gain access to complementary technological knowledge, but also to exploit their combined market presence that helps in promoting novel innovations in the market and in reassuring customers about the advantages of the innovation (Bouncken, Fredrich, Ritala, and Kraus, 2017; Tether, 2002). Finally, such collaborations allow access to a variety of complementary knowledge in different areas including new technology, product development, production, and new market entry, all of which increase the likelihood of developing radical product innovations (Quintana-Garcia and Benavides-Velasco, 2004).

Although some studies observed that collaboration with universities leads to the development of radical product innovation (Tether, 2002; Tsai, 2009; Un et al., 2010), other studies found no such link (Ganotakis and Love, 2012; Partanen, Chetty, and Rajala, 2014). The inconsistent results can be justified by the different work processes and agendas of universities relative to those of the industry (Bstieler et al., 2015; Un and Asakawa, 2015; Wirsich, Kock, Strumann, and Schultz, 2016). Overall, the association between university collaboration and product novelty is believed to depend on the level of intensity and diversity that characterizes the collaboration and the level of trust among partners (Bstieler et al., 2015; Wirsich et al., 2016).

Nevertheless, cooperation with universities has been largely linked with the development of more advanced, new-to-the-market, product innovations, which are often intended for the opening of new segments (Belderbos, Carree, Diederen, Lokshin, and Veugelers, 2004; Mention, 2011). This link occurs because universities own specialized research laboratories that may not be available in industry, employ highly qualified scientists (Bstieler et al., 2015), and develop theoretical knowledge, whereas firms focus on developing applied knowledge. Nevertheless, the novel combination of those two heterogeneous types of knowledge becomes the foundation for radical innovation (Un and Asakawa, 2015; Wirsich et al., 2016). University collaboration should therefore be linked with the development of radical product innovations.[3]

Overall, despite some contradicting arguments about the level of innovativeness associated with collaboration with customers, suppliers, and competitors, on average it is expected that collaboration with those three partner types is more likely to be related to radical product innovation than to incremental. This prediction is consistent with the view that collaboration with those partner types is more likely to occur by innovation-intensive firms that focus on radical product innovations (Amara and Landry, 2005; Tether, 2002).

Collaboration with Consultants and Private Institutes

Conversely, collaborations with consultants and private research institutes are more likely to lead to the introduction of incremental innovations. Those partner types carry out similar activities and are hence categorized in the literature under the same group of companies: technological knowledge-intensive business services (t-KIBS) (Doloreux and Shearmur, 2012; Probert, Connell, and Mina, 2013).

Consultants help firms to innovate, but in general, they do so not by developing new technologies but by brokering ideas, technology, and knowledge that they have observed in numerous firms operating in various industries and locations. These interactions enable consultants to transfer existing tacit knowledge from one context to another and to adapt it to fit the specific requirements of each firm (Bessant and Rush, 1995; Nieto and Santamaría, 2010). By possessing experiential knowledge of similar innovation projects, consultants therefore assist in the development of incremental product innovations (Tether and Tajar, 2008). Private research institutes are also involved in knowledge intermediation and brokering of technologies the same way as consultants are, i.e., by gathering and combining knowledge from different clients and by collaborating with new customers in applying them to a new setting (Probert et al., 2013), leading to incremental product innovation.

Private research institutes differ from consultants in that such institutes are more active in IP registration. Such activity can occur through knowledge gathered

[3]Given that linkages with foreign universities were almost nonexistent (considerably less than 1% of firms used them) and a relevant variable could not be added to the econometric model, only domestic universities are included in the analysis.

from customer interaction and the combination of their own internal R&D effort but also by purchasing the IP associated with projects in which a previous customer has discontinued funding and then pursuing further development with new customers (Probert et al., 2013). Because of those activities, private research institutes can sometimes be responsible for the development of radical product innovation (Tether, 2002; Tether and Tajar, 2008). Nevertheless, this is not the result of direct collaborations, which is the focus of our study. It is rather the result of research institutes licensing the IP technology to other companies or spinning off new companies to commercially exploit the new technology (Probert et al., 2013).

Furthermore, as discussed in the previous section, collaboration with customers and suppliers enables firms to cope with situations in which the underlying product/process technologies and consumer preferences change simultaneously. Such change often occurs during the development of radical products (Bohlmann et al., 2013; Un and Asakawa, 2015). On the other hand, consultants and private research institutes might be less effective in supporting firms under such external dynamic conditions (Heirati, O'Cass, Schoefer, and Siahtiri, 2016). In such situations, the knowledge that consultants and private research institutes possess may become obsolete. Moreover, those organizations are not willing to spend the time required to develop the solutions needed. Consequently, they often use unproven processes and technologies that lead to inefficient results (Heirati et al., 2016).

Geographic Breadth of Collaborations

The above relationships should be reinforced when a firm engages in collaborations with foreign partners in different countries, something that provides access to country-specific knowledge reservoirs that are not available domestically. Therefore, it is not only the types of foreign partners but also the breadth of the collaborating countries that is important for product innovation. Having collaborative agreements in multiple countries exposes firms to diverse national knowledge bases and facilitates the absorption of complementary knowledge from locations that specialize in a variety of scientific and technological domains (Kafouros and Forsans, 2012). The exposure to a greater range of heterogeneous knowledge types promotes technological learning, increases the probability of creating valuable combinations of knowledge, enhances problem solving, and helps firms to introduce innovative products to the market (van Beers and Zand, 2014; Zahra, Ireland, and Hitt, 2000).

Increased country breadth should therefore enhance the probability of introducing radical product innovation (via collaboration with customers, suppliers, and competitors) and incremental product innovation (via collaborations with KIBS). For the latter case, this improved probability is expected because knowledge that can be used for the development of incremental product innovation is clustered around specific geographic areas in different countries and is part of certain local innovation systems in which KIBS participate (Doloreux and Shearmur, 2012). KIBS, after they absorb the knowledge they gain from their external network, transfer it into other foreign countries (He and Wong, 2009). Given that the development of an existing market product can require the combination of numerous types of knowledge that can nevertheless be geographically constrained, collaborating with KIBS in multiple countries can not only increase the probability of accessing the required set of knowledge, but also allow firms to tailor those technologies according to their requirements. Hence:

H2: (a) Radical product innovation is positively associated with collaborations with foreign customers, suppliers, and competitors, whereas (b) incremental product innovation is enhanced through collaborations with foreign consultants and private research institutes. (c) The strength of these associations increases as the number of collaborating countries increases.

Innovation and Growth: Third Innovation Stage

The third innovation stage investigates the relationship between product innovation (innovation outputs) and firm performance (sales growth). Prior research has linked radical product innovations with sales growth rates that are higher than those associated with commercialized incremental product innovations (Marsili and Slater, 2005; Sorescu and Spanjol, 2008). The launch of radical products has the potential to place firms in new global niches and expanding market segments. This positioning enables firms to capture greater market share and increases customer willingness to pay a premium for such products (Thornhill, 2006; Zhang, Ko, and Lee, 2013). Incremental

innovations, by contrast, usually yield modest returns because of their smaller market share and the need to be priced competitively (Sorescu, Chandy, and Prabhu, 2003; Sorescu and Spanjol, 2008). Finally, incremental innovations can turn obsolete in the short term, which can adversely influence sales. Conversely, companies that pursue products that depart from existing technological standards do not face such problems (He and Wong, 2009; Sørensen and Stuart, 2000).

A question that naturally follows from the discussion thus far is whether the relationship between product innovation and a firm's sales growth depends on whether the innovation is developed internally or through collaborations with domestic and/or foreign partners. Given the discussion in the previous sections, one might be tempted to conclude that firms that engage in foreign collaboration develop products that enhance their performance to a greater extent than products developed in collaboration with domestic partners or those developed without collaboration. Although within the process of product development, the extant research generally argues in favor of external collaboration (Freel and Harrison, 2006; Ganotakis and Love, 2012), a number of competing arguments arise regarding the relationship between product commercialization and firm-level performance, especially in whether a closed or an open innovation strategy is more beneficial (Almirall and Casadesus-Masanell, 2010). Collaboration may facilitate the commercialization of innovative products with new or improved features that would otherwise be difficult to design and develop exclusively in-house. This commercialization is a result of the firm being exposed not only to complementary technological but also to commercial and market-related knowledge (Duysters and Lokshin, 2011; Laursen and Salter, 2006). This can result in a better fit between product features and consumer preferences, therefore improving the commercial value that the product creates (Almirall and Casadesus-Masanell, 2010). Furthermore, in situations where additional knowledge is required, collaboration can accelerate the introduction of an innovative product to the market, thereby increasing the likelihood of introducing a product more novel than rivals' products and capturing market share early on (Xu et al., 2013). Therefore, when a firm lacks the internal knowledge necessary to develop an innovative product, external collaboration may enhance firm performance by providing access to complementary knowledge located domestically and/or internationally.

Other studies, however, suggest that the importance of interorganizational collaboration and the view that firms are rarely capable of innovating independently tend to be exaggerated and that collaboration is neither a necessity nor a sufficient condition for innovation to occur at any level of novelty (Freel and Harrison, 2006; Rosenbusch et al., 2011). Open innovation appears to also be detrimental when a firm is inherently better at producing certain types of innovations in house and can therefore draw a competitive advantage from internally generated knowledge. This negative effect can arise because externalizing the innovation process in order to share costs/risks and collaborating with a certain partner that does not add value beyond what the firm can develop internally can erode that advantage (West and Bogers, 2014). In such a situation, the product developer loses some control or freedom in regard to the creation of the innovation, which results in the firm operating under decision-making and technological constraints that could have been avoided under a closed innovation approach (Almirall and Casadesus-Masanell, 2010; Rosenbusch et al., 2011). This situation can adversely affect innovation novelty and sales.

In regard to capturing value from innovation, external collaboration is not without its disadvantages (Rosenbusch et al., 2011; Rothaermel and Alexandre, 2009). First, the sales of innovative projects may need to be shared with external partners. Second, opening the innovation process can reduce the effectiveness of property rights, as features of the developed technology that are not entirely protected by IP can be exploited by external partners (David and Greenstein, 1990), thus impeding the returns from innovation. Hence, when a firm can develop an innovative product by using internal knowledge alone, closed innovation is expected to enhance firm-level performance and will therefore be the approach adopted. In summary, regardless of whether a firm follows an external or internal approach, performance outcomes are not expected to differ significantly because what matters is whether a firm is able to commercialize radical products (rather than how the firm commercializes such products). Hence:

H3: The association between radical product innovation and sales growth is the same regardless of whether the innovation was developed internally or through collaboration with domestic or foreign partners.

Data and Method

Data Set

The empirical analysis is based on data derived from the second Taiwanese Technological Innovation

Survey (TIS II). This nationwide government-run survey of both manufacturing and service companies was conducted by seven Taiwanese universities in 2007. The survey collected information on firm performance, innovation collaboration, and innovation outputs for the 2004–2006 period. The respondents were all members of a company's top management team or other highly ranked managerial staff. To make the survey comparable to those of other countries, the TIS questionnaire was based on the fourth Community Innovation Survey (CIS), and the definitions of variables related to innovation were created in accordance with the Oslo Manual (2005). The survey is based on a stratified random sample of 20,000 companies. The survey provided a final sample of 9845 companies (3965 manufacturing and 5880 service firms); 1,684 manufacturing companies provided complete answers to the relevant questions and are considered in this study.[4] The distribution of the sampled firms by industry sector can be found in Table 1.

The study focuses only on the manufacturing sector, given the consensus in the literature that the innovation process is quite different between manufacturing and service firms. Within services, the issue of inseparability arises because of the difficulty of distinguishing between the production and delivery/consumption of a service and distinguishing among product, process, and organizational innovation, which might create inconsistencies in the definition of innovation if both manufacturing and service firms are considered (Love, Roper, and Bryson, 2011).

Table 1. Distribution of Sample Firms by Industry

Industry Sectors	Sample Respondents (%)
Nonmetallic mineral and quarrying	2.26
Food, beverages, and tobacco	4.00
Textiles, wearing apparel, leather, paper, and printing	11.76
Natural resources (petroleum, coal, wood) manufacturing	5.30
Metal	13.7
Machinery repair and installation	1.00
Construction	8.10
Chemical and pharmaceutical products	7.43
Electronic parts and components manufacturing	13.42
Computers, electronic, and optic products	9.15
Electrical equipment manufacturing	5.76
Machinery and transportation equipment	15.44
Other manufacturing	2.68
Total	100% (1684 firms)

Variables

For the dependent variables in the first-stage analysis regarding internal and external sources of knowledge, our analysis considers six different sources: internal R&D; external R&D; and collaborations with customers, suppliers, competitors, and consultants (Roper et al., 2008, Un et al., 2010). The latter four were differentiated with respect to domestic and foreign-based sources. They were measured as 10 dummy variables depending on whether a firm had conducted internal or external R&D or had formed collaborative agreements with each of the domestic or foreign partner types.[5] Dummy variable specifications for those 10 sources of knowledge were also adopted in their capacity as independent variables in each of the 10 first-stage models because the study aims at comparing probabilities of the simultaneous use of different partner types.

For the second stage (regarding the level of product innovation novelty), incremental product innovations are considered to be those products that were new to a firm (Freel and Harrison, 2006; van Beers and Zand, 2014), whereas radical innovations were those products that were new to the market and/or significantly improved innovations (the latter as also defined in Laursen and Salter, 2006; Leiponen and Helfat, 2010). These innovations were measured by adopting dummy variables for each category and were used as dependent variables in probit and multinomial logit models (described in the following section).

To capture the relationship between the 10 knowledge sources and innovation outputs more accurately, our analysis employs more detailed measures of those variables in relation to the first stage. Internal and external R&D was measured as the expenditures on those activities over total sales. Collaboration with foreign partners was measured by taking into account the number of foreign countries where a firm had formed collaborative agreements with each partner type (i.e., with customers across a number of countries).

Finally, in the third stage, the percentage of relative (Gopal, Goyal, Netessine, and Reindorp, 2013) sales growth is used as a measure of performance, measured as the percentage of the difference in sales between 2004 and 2006 divided by sales at the beginning of 2004 (Love et al., 2011). The measure of growth was

[4]A brief discussion on the country context and an explanation of why common method bias is not a problem in our study can be found in the online supporting information.

[5]Four models are presented in this article. The remaining six are included in the online supporting information (Tables S2.1 and S2.2).

selected based on the theoretical rationale connecting innovation and growth (Weinzimmer, Nystrom, and Freeman, 1998). Sales rather than any other measure (i.e., employment) was chosen because innovation is theoretically associated with the ability to access different markets as well as expanding market share (Ganotakis and Love, 2012; Thornhill, 2006; Zhang et al., 2013). Moreover, researchers have argued that sales growth is an appropriate measure in situations where a firm can realize increased sales without achieving any significant change in employees or assets (Weinzimmer et al., 1998), such as when a firm is able to charge higher prices for products. Finally, a firm is unlikely to increase the number of employees without increasing sales at the same time or before this (Rauch and Rijsdijk, 2013).

In terms of the innovation variables used as independent variables in this stage, six mutually exclusive dummy variables were created through the interaction of the two mutually exclusive levels of product novelty ([1] radical and [2] incremental) with the three also mutually exclusive levels of openness ([1] internal effort only, [2] collaboration only with domestic partners, and [3] collaboration only with foreign partners or both foreign and domestic partners).[6] For completeness, our analysis also examined the relationship between sales growth and radical and incremental innovation, which was also measured as dummy variables. Table 2 describes the variables used in the analysis and reports the descriptive statistics.

Method

For the first innovation stage, 10[7] probit models are used. While the adoption of this method rather than a multivariate probit model sacrifices some statistical efficiency, it allows us to reflect more fully on the relationship among the partner types themselves and to identify readily interpretable marginal effects (see Ganotakis and Love, 2012; Roper et al., 2008, for a relevant discussion). The second innovation stage investigates the relationship between different types of domestic and foreign partner types and (1) the probability of introducing radical products as well as (2) the ability of a firm to transform from not innovating to being an incremental product innovator and, finally, to being a radical product innovator.[8] A probit model is adopted in order to investigate the factors that differentiate those companies that can introduce a radical product innovation (1) from those that either have not innovated or have introduced only a new-to-the-company innovation (0). As a robustness check, a probit model of whether a company has registered a patent[9] is also included in the study.

To investigate what allows companies to create incremental product innovations, a multinomial logit model is used. This model allows us to differentiate between those companies that have developed an incremental product innovation and those that have not innovated at all as well as between those that have developed a radical product and those that have developed only an incremental product innovation. Such a model is also more suitable because it accounts for the mutually exclusive product innovation categories, where the introduction of innovative products at different levels of novelty is not necessarily sequential or ordered. Furthermore, this model allows us to estimate the odd ratios[10] of the independent variables and provide more useful interpretations of the model's coefficients.

Finally, the last step of the analysis (third innovation stage) focuses on how the relationship between different types of product innovations and sales growth depends on the degree of product novelty and on whether a firm adopts a closed or an open (with domestic or foreign partners) approach to product development. At this final stage, an ordinary least squares (OLS) regression is adopted given that no evidence of endogeneity was found between the product innovation and growth variables.[11] Finally, the issue of heterogeneity in growth outcomes can arise because of

[6]Collaboration with foreign partners or with both foreign and domestic partners is grouped in one category, given that it is expected that it is foreign knowledge that matters more and is more valuable in relation to domestic because it allows firms to carry out more valuable knowledge combinations and offer a competitive advantage over firms with no access to such knowledge.

[7]In this article (Table 3), four models that are directly linked with H1 are presented, i.e., where foreign partner types are the dependent variables. The remaining six that assist in obtaining a complete picture of the complementarities between different domestic and foreign partner types as well as R&D effort can be found in the online supporting information (Tables S2.1 and S2.2) that accompanies this article.

[8]To provide a more complete picture, models for the relationship between domestic and foreign partners and innovative performance are also estimated (sales generated from either radical or incremental product innovations). The results are available in the online supporting information (Table S3.1).

[9]The results and relevant discussion are provided in the online supporting information (Table S3.2).

[10]The odds ratio of a variable in the case of a multinomial logit model can be used, for example, to estimate the change in the probability (chances) of introducing a radical product innovation over the probability of introducing an incremental product innovation for a one-unit increase in that variable.

[11]Six Durbin-Wu-Hausman tests were performed between each of the innovation variables and sales growth. Because this procedure is rather lengthy, we have omitted it to avoid overloading the reader. The entire calculation, including the potential instruments used and all relevant tests that were performed, is available upon request.

Table 2. Summary Statistics and Variable Description

Variable Description	Mean	S.D.
R&D activities		
Internal R&D—R&D undertaken within the firm (0/1)	0.82	0.383
Percentage internal R&D—R&D expenditure undertaken within the firm over total sales (%)	3.31	6.855
External R&D—R&D undertaken outside the firm in the form of totally outsourced contracts (0/1)	0.298	0.457
Percentage external R&D—R&D expenditure undertaken outside the firm in the form of totally outsourced contracts over total sales (%)	0.91	2.881
Domestic knowledge sourcing for innovative activities (in the last 3 years—2004 to 2006)		
Domestic customers—Whether a company has formed collaborative agreements with domestic customers (0/1)	0.211	0.408
Domestic suppliers—Whether a company has formed collaborative agreements with domestic suppliers (0/1)	0.196	0.397
Domestic competitors (0/1)—Whether a company has formed collaborative with domestic competitors	0.092	0.289
Domestic consultants—Whether a company has formed collaborative with domestic consultants or private R&D institutes (0/1)	0.147	0.355
Domestic Universities—Whether a company has formed collaborative agreements with domestic universities (0/1)	0.133	0.34
International knowledge sourcing for innovative activities (in the last 3 years—2004–2006)		
International customers—Number of foreign countries a company has collaborative agreements with customers	0.351	0.94
International suppliers—Number of foreign countries a company has collaborative agreements with suppliers	0.166	0.543
International competitors—Number of foreign countries a company has collaborative agreements with competitors	0.113	0.57
International consultants—Number of foreign countries a company has collaborative agreements with consultants	0.073	0.348
Innovation outputs (in the last 3 years—2004–2006)		
Radical product innovation—Whether a company introduced a new to the market or significantly improved product in the last 3 years (0/1)	0.606	0.488
Sales from radically new products—Amount of sales from new to the market or significantly improved product innovation (in thousands)	12186.54	134489.4
Incremental product innovation—Whether a company introduced a new to the company product innovation in the last 3 years (0/1)	0.0897	0.285
Sales from incremental product innovation—Amount of sales from new to the company product innovation (in thousands)	6179.63	56348.47
Patent—Whether a company applied for a patent (0/1)	0.453	0.497
Process innovation—Whether a company implemented a new process innovation in the last 3 years (0/1)	0.686	0.464
Innovation outputs by level of geographic openness (in the last 3 years—2004–2006)		
Radical product innovation with international partners—Whether a new to market or significantly improved product was created while the firm had collaborative agreements with just international partners or with international and domestic partners (0/1)	0.186	0.389
Radical product innovation with domestic partners—Whether a new to market or significantly improved product was created while the firm had collaborative agreements with domestic partners (0/1)	0.16	0.367
Radical product innovation created internally—Whether a company created a new to market or significantly improved product with the knowledge available just within the company (closed innovation)	0.259	0.438
Incremental product innovation with international partners—Whether a new to company product was created while the firm had collaborative agreements with just international partners or with international and domestic partners (0/1)	0.0216	0.145
Incremental product innovation with domestic partners—Whether a new to company product was created while the firm had collaborative agreements with domestic partners (0/1)	0.0282	0.165
Incremental product innovation created internally—Whether a company created a new to the company product with the knowledge available just within the company (0/1)	0.0398	0.195
Growth measures (2004–2006)		
Sales growth—Relative percentage sales growth (2004–2006)	21.67	75.31
Firm Resources		
Size—Number of employees (2004)	213.1	527.1
Firm age—Whether a company is less than four years old (0/1)	0.06	0.238
Domestic group—Whether a company is part of a domestic group (0/1)	0.077	0.266
International group—Whether a company is part of an international group (0/1)	0.11	0.313
Percentage of workforce with degree (%)	47.34	28.9
Product training—Whether a company used training for the development of an innovative product (0/1)	0.746	0.435
Market training—Whether a company used training for the introduction of an innovative product to the market (0/1)	0.442	0.496
Market strategy		
Exporter—Number of foreign countries that a firm exports to	1.485	1.463
Niche market—Whether products are made to serve a specialist niche market (0/1)	0.164	0.37
Cost reduction—Whether a company has adopted a cost reduction strategy (0/1)	0.138	0.345

Table 3. Knowledge Collaboration Estimations

Variables	Model 1 International Customers	Model 2 International Suppliers	Model 3 International Competitors	Model 4 International Consultants
R&D activities				
Internal R&D (0/1)	0.0367* (0.022)	0.00578 (0.0174)	0.0135* (0.0071)	−0.0021 (0.0128)
External R&D (0/1)	0.00414 (0.02)	0.0277* (0.0154)	−0.0176*** (0.0056)	0.0141 (0.0107)
Domestic knowledge sources				
Domestic customers	0.235*** (0.03)	0.00247 (0.0152)	−0.0059 (0.0066)	0.00582 (0.011)
Domestic suppliers	−0.0339 (0.0226)	0.159*** (0.026)	0.00351 (0.0077)	−0.0083 (0.01)
Domestic competitors	−0.0872*** (0.025)	−0.0325** (0.015)	0.233*** (0.042)	0.00292 (0.0161)
Domestic consultants	0.0664** (0.0324)	0.0412* (0.0221)	0.0066 (0.0102)	0.0666*** (0.0223)
Domestic universities	0.0797 (0.0287)	0.0178 (0.022)	0.00206 (0.00846)	0.0245 (0.0173)
International knowledge sources				
International customers	–	0.147*** (0.0264)	0.0614*** (0.0168)	0.0111 (0.012)
International suppliers	0.239*** (0.041)	–	0.0477*** (0.016)	0.0338* (0.0182)
International competitors	0.26*** (0.059)	0.13*** (0.0427)	–	0.0105 (0.02)
International consultants	0.036* (0.04)	0.07** (0.0338)	0.0111 (0.0145)	–
Resources				
Size	0.000028 (0.00003)	0.0000015 (0.00002)	0.000029 (0.00002)	−0.0000158 (0.00002)
Size squared	−0.0000000025 (0)	0.0000000022 (0)	−0.000000015 (0)	0.000000004 (0)
Domestic group	−0.039 (0.0298)	0.0152 (0.0235)	0.0064 (0.0114)	−0.00428 (0.0148)
International group	0.1*** (0.0358)	0.054*** (0.0235)	0.0438** (0.0174)	0.0362** (0.0185)
Firm age	−0.07** (0.0317)	−0.0094 (0.0253)	−0.0095 (0.0095)	0.0168 (0.0212)
Percentage of workforce with degrees	0.000282 (0.00032)	−0.00046** (0.00023)	−0.0000143 (0.00012)	0.00017 (0.00014)
Training	0.0507** (0.0226)	0.0207 (0.0155)	−0.00485 (0.01)	0.0085 (0.0117)
Market strategy	0.0187*** (0.0063)	−0.00116 (0.00422)	0.00563*** (0.00216)	−0.0023 (0.00328)
Exporter				
Observations	1683	1683	1683	1683
Log-likelihood	−648.8	−467.77	−260.405	−321.35
Pseudo R^2	20.18%	23.77%	35.5%	14.02%

Notes: Standard errors in parentheses; ***$p < 0.001$, **$p < 0.05$, *$p < 0.1$. Coefficients are marginal effects. All models include industry dummies.

otential large variations between the sales growth of sampled firms. To address this issue, a small proportion of observations with extreme values were excluded by estimating z scores and box blots prior to estimation and by deriving standardized residuals post regression estimations (Ganotakis and Love, 2012; Roper and Arvanitis, 2012).

Results

Knowledge Sourcing: First Innovation Stage

Table 3 reports the results of probit models that investigate the association between domestic and foreign partner types. The models included in the table show a significant relationship between the same type of domestic and foreign partners and that no other domestic partner type is linked with the formation of foreign collaborations with the only exception being domestic consultants/private research institutes (KIBS), for the case of foreign customers and suppliers. H1 is therefore largely supported. Having collaborative agreements in place with domestic customers, suppliers, competitors, and consultants is associated with an increased probability of collaborating with the same types of foreign partners by 23.5%, 16.1%, 23.7%, and 6.6%, respectively (all significant at the 1% level).

Innovation Outputs: Second Innovation Stage

Table 4 reports the findings of the probit model (for radical innovation—model 5) and the multinomial logit model (model 6). The coefficients represent marginal effects for the case of the probit model and represent odds ratios for the multinomial logit model. The first column of the multinomial logit (model 6) differentiates between being a noninnovator and an incremental innovator, and the second column differentiates between being a radical product innovator and an incremental innovator. The results in both models in Table 4 (model 5 and second column of model 6) show that collaboration with foreign customers is associated with an increase in the likelihood of introducing radical products. In contrast, a positive link was not observed in the case of collaboration with foreign suppliers and competitors. Therefore, H2a is only partially

Table 4. Innovation Output

Variables	Model 5 Probit New to Market or Significantly Improved	Model 6 Multinomial Logit Model Base: Innovated at a Company Level	
		Non-innovators	New or Significantly Improved to the Market Products
Constant		9.418*** (4.376)	5.362*** (2.372)
R&D activities			
Internal R&D (% of sales)	0.00337* (0.00196)	0.976 (0.0207)	0.999 (0.00944)
External R&D (% of sales)	0.00486 (0.00528)	1.103* (0.0617)	1.11* (0.06)
Domestic knowledge sources			
Domestic customers	−0.004 (0.0349)	0.9 (0.257)	0.904 (0.244)
Domestic suppliers	−0.0434* (0.0366)	0.688 (0.189)	0.611* (0.16)
Domestic competitors	0.0881* (0.05)	3.62** (2.366)	4.482** (2.8)
Domestic consultants	0.0252 (0.041)	2.072 (0.96)	2.056 (0.908)
Domestic universities	0.05 (0.04)	1.267 (0.515)	1.511 (0.595)
International knowledge sources			
International customers	0.0274* (0.0164)	1.643*** (0.319)	1.717*** (0.32)
International suppliers	0.0272 (0.0285)	0.864 (0.194)	0.993 (0.2)
International competitors	−0.0232 (0.0264)	0.808 (0.168)	0.748 (0.138)
International consultants	−0.00152 (0.0423)	0.593* (0.185)	0.677 (0.183)
Resources			
Size	0.000135** (0.00006)	0.999 (0.0005)	1 (0.00044)
Size squared	−0.000000034** (0)	1 (0.000000098)	1 (0.000000092)
Domestic group	0.0946 (0.0005)	1.0287 (0.556)	1.598 (0.823)
International group	0.0466** (0.0437)	0.555 (0.201)	0.77 (0.253)
Firm age	0.065* (0.0523)	0.973 (0.449)	1.3 (0.58)
Percentage of workforce with degrees	0.0217* (0.00049)	0.984*** (0.00383)	0.996 (0.00357)
Training	0.0991*** (0.0326)	1.188 (0.301)	1.736** (0.421)
Market strategy			
Exporter	0.0163*** (0.00963)	1.001 (0.0828)	1.066 (0.0846)
Niche market	0.0617*** (0.0379)	0.816 (0.27)	1.099 (0.338)
Cost reduction	−0.054* (0.0421)	0.753 (0.236)	0.632 (0.186)
N (observations)	1429	1429	
Log-Likelihood	−908.99	−1162.78	
Pseudo R^2	5.13%	6.26%	
Likelihood ratio test Chi-square/p-value		152.18/0.00	

Notes: Standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Model 5 coefficients represent marginal effects. Model 6 coefficients represent odds ratios. All models include industry dummies.

corroborated. Interestingly, the first column of the multinomial logit model (model 6) also shows that collaboration with foreign customers is associated with an increased probability of a firm being a noninnovator compared with an incremental product innovator.

Furthermore, the first column of the multinomial logit model (model 6) shows that collaboration with foreign consultants and private research institutes appears to enhance the likelihood of a firm introducing incremental product innovations rather than not innovating at all (odds ratio of 0.593); hence, H2b is confirmed. Because the independent variables for foreign knowledge sources in Table 2 refer to the number of countries, H2c is also partially supported (partially as H2c is linked to H2a, which was partially supported).

Collaboration with domestic competitors (model 5 and second column of model 6) is positively related to the introduction of radical products. At the same time, domestic competitor collaboration (first column of model 6) also appears to be linked with an increased probability of a firm being a noninnovator rather than being an incremental innovator. By contrast, collaboration with domestic suppliers was found to be negatively associated with radical innovation (model 5) and, more specifically, to lead to the development of incremental rather than radical innovation (model 6, second column).[12]

[12]We also considered (Jiang, Tao, and Santoro, 2010) that geographic diversity in collaborations might result in curvilinear effects. The possibility of such effects is tested by including the square of the number of countries in which collaboration occurs with each partner type. It was found that those effects do not arise in our study. The reasoning for this is included in the online supporting information.

Table 5. Sales Growth Estimators

Variables	Model 7 Sales Growth	Model 8 Sales Growth
Constant	−8.095 (9.8)	−7.778 (9.895)
Innovation activities		
New to market/significantly improved product	14.543** (6.198)	
New to company product	4.447 (10.159)	
Process innovation	9.839 (6.095)	9.669 (6.184)
Innovation activities by degree of geographical openness		
New to market/significantly improved product with international partners		16.266** (7.7610)
New to market/significantly improved product with domestic partners		15.962* (8.292)
New to market/significantly improved product developed internally		12.346* (7.353)
New to company product with international partners		−0.479 (17.588)
New to company product with domestic partners		0.785 (15.96)
New to company product developed internally		9.867 (14.1)
Resources		
Size	−0.0197 (0.0103)	−0.02* (0.104)
Size squared	0.00000356 (0.0000021)	0.00000362* (0.00000212)
Domestic group	−13.294 (9.627)	−13.467 (9.647)
International group	23.315*** (7.926)	23.061*** (8.069)
Firm age	10.456 (10.484)	10.245 (10.5)
Percentage of workforce with degrees	0.182** (0.0875)	0.18** (0.0878)
Market Strategy		
Exporter	2.686 (1.779)	2.58 (1.79)
Niche market	−8.623 (7.034)	−8.734 (7.051)
Cost reduction	−4.097 (7.585)	−4.264 (7.61)
Observations	1631	1631
Adjusted R^2	3.94%	3.74%

Notes: Standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. All models include industry dummies.

Innovation and Growth: Third Innovation Stage

Table 5 presents the findings regarding the relationship between innovation outputs and sales growth. Model 7 reports the results for the two different types of product innovation. Model 8 differentiates the results according to the collaborative (if any) approach that firms adopted for the development of radical or incremental product innovations. Model 7 reports a positive and significant association between radical product innovation and sales growth. The importance and strength of this relationship are maintained in model 8. In contrast, none of the incremental product innovation variables in either model 7 or 8 appears to affect growth.

Model 8 indicates that products developed in collaboration with foreign partners are strongly associated with sales growth, followed by products developed with domestic collaborators and by situations with no collaboration. Nevertheless, a Wald test showed no significant difference among the coefficients of those variables. Thus, these findings support H3. Hence, firms can achieve similar levels of sales growth regardless of whether they choose a path in which the development of radical new products relies heavily (or almost exclusively) on internal technological strengths or on domestic or international collaborative agreements.

Discussion

Our analysis provides a set of interesting results about the three innovation stages. From a knowledge sourcing perspective, the findings overall show that domestic collaborations assist in the formation of foreign collaborations but only when the partner type is the same. This finding can be attributed to firms being able to transfer the mechanisms and routines developed by collaborating with a domestic partner (Nieto and Santamaría, 2007; Un et al., 2010) to collaborations with a foreign partner of the same type.

It was also found that the complementarities that prior studies (Love et al., 2011; Roper et al., 2008) uncovered between different types of external partners do not take place between different domestic and foreign partner types, most likely due to the increased complexity, and managerial effort required (Park and Ungson, 1997; Parkhe, 1991). The only other linkage between domestic and foreign partner types is between domestic KIBS and international customer and

suppliers. This is because KIBS, apart from brokering services, also often collaborate with manufacturing firms in order to assist in matching technology sources and technology recipients and by assisting in technology exchanges and collaboration between different manufacturing firms themselves (Lichtenthaler, 2013). This result therefore does not contradict H1, because it is likely to arise as a result of the matching service that KIBS provide and not because of firms being able to transfer the knowledge gained from collaborating with domestic KIBS to foreign customers and suppliers.

Regarding the relationship between different partner types and product innovation novelty, collaborating with foreign customers across different countries although it increases the likelihood of introducing a radical in relation to incremental product innovation, it also leads to no innovation taking place at all in comparison to introducing an incremental product innovation. This contradictory finding can be explained by the context of collaboration. Prior research suggests that firms benefit more from collaborating with lead rather than mainstream users (Enkel et al., 2005). Collaboration with foreign lead users helps to identify future needs and access knowledge that is not only country specific but also specific to foreign clusters of which these customers are a part (Tsai, 2009; van Beers and Zand, 2014). By contrast, collaborations with mainstream foreign customers usually involve the exploitation of existing technology, which increases path dependency and constrains the development of any type of product innovation (Harhoff et al., 2014; Nijssen et al., 2012).

Although collaboration with domestic competitors was associated with radical innovation, no such linkage was found for foreign competitors. Firms often collaborate with competitors to solve complex, knowledge-intensive problems (Miotti and Sachwald, 2003) and identify synergies that can increase the effectiveness of developing radical innovations (Xu et al., 2013). Because of the increased risk that characterizes agreements of this type, these might be more successful when greater trust exists between the two partners. This is more likely to arise at the domestic level due to stronger social ties and similarities in the institutional regime. Nevertheless, collaborations with domestic rivals can also lead to a lack of innovation occurring, which can be explained by the purpose and aims of the collaboration. Competitors can also collaborate for reasons that are indirectly linked to NPD, such as to solve problems associated with new regulatory constraints or to conduct research at early, precompetitive stages of technology development that lead to generic results (Harhoff et al., 2014).

Collaboration with domestic suppliers appears to be beneficial for incremental innovation but at the same time to constrain radical. Although suppliers may assist in process and product design improvements (Pittaway et al., 2004), they might also, willingly or unwillingly, diffuse knowledge derived from the firm to other domestic customers. Some of those firms might be existing rivals, thus reducing the novelty of a product within a firm's home market (Corsten and Felde, 2005). Finally, results showed that the problem of inertia that can emerge due to collaborations with the same partner type (Jean et al., 2014) does not apply, at least for customers and consultants, when a firm collaborates with the same types in multiple countries. Findings are therefore consistent with recent qualitative evidence that show that managers acknowledge that in regard to same partner types, collaborating in different countries provides access to a more valuable knowledge set (Wirsich et al., 2016).

Regarding the third stage, the relationship between radical innovation and sales growth does not appear to be influenced by whether the innovation is developed internally, in collaboration with domestic or with foreign-based partners. The results therefore show that collaboration is not a necessity to achieve growth and that firms can also achieve similar levels of sales growth by developing radical products internally (Almirall and Casadesus-Masanell, 2010). Nevertheless, this finding by no means suggests that collaboration is not relevant to growth. At this stage, it is important to consider all stages of the innovation process together (West and Bogers, 2014) rather than the final stage in isolation, because this underestimates the relationship between collaboration and sales growth. For instance, the second innovation stage showed that collaborations with foreign customers and domestic competitors increase the probability of a firm developing a radical product that in turn enhances firm sales. Without collaboration, therefore, some firms would not be able to develop radical products, which would in turn have an adverse effect on their level of sales (Tsai, 2009).

Theoretical Contributions

Using organizational learning theory as our theoretical foundation, our analysis makes a number of contributions.

First, the literature acknowledges the significance of international collaborations but does not sufficiently specify whether collaborations with domestic partners assist in the formation of foreign collaborations (Parkhe, 1991). Our findings improve our understanding in regards to why the knowledge gained from domestic collaborations allows firms to form foreign collaborations with similar partner types. Our work also extends the literature on the complementarities between external partner types (Roper and Arvanitis, 2012; Roper et al., 2008) by showing that such complementarities do not occur from the domestic to the foreign level; rather, the main linkage is through similar partner types.

Second, the study contributes to organizational learning theory by showing that in certain situations, it is not only double-loop learning that changes the rules for single-loop learning (Argyris and Schon, 1978; Huber, 1991) but also that single-loop learning can redefine what can later be considered double-loop learning. More specifically, the study showed that single-loop learning (collaboration with a certain type of domestic partner) makes double-loop learning (collaboration with the same type of foreign partner) requires less effort and therefore increases its likelihood. Nevertheless, this is the case only if single-loop learning has occurred within a context/frame (Huber, 1991; Levitt and March, 1988) similar to the one that double-loop learning takes place (i.e., similar types of domestic and foreign partners), as this situation enables an organization's single-loop routines to be transferred and applied to double-loop efforts and learning.

Third, our analysis contributes to the innovation literature for the second innovation stage by revealing a complex relationship between different types of domestic/foreign collaboration and the degree of product innovation novelty (Slater et al., 2014). The study showed that certain partner types allow firms to become incremental innovators rather than not innovating at all, whereas collaboration with other partners enables firms to introduce radical rather than incremental product innovations. Furthermore, the study contributes to organizational learning theory by showing that although some interorganizational linkages lead to a higher level of learning, the same linkages can also lead to no learning taking place at all and that it is not only double-loop learning (foreign collaborations) that can change a firm's frame of reference, but that this can also be achieved via single-loop learning (domestic collaborations).

An interrelated contribution pertaining to foreign collaborations is that this relationship depends not only on a firm's choice of partner type but also on the geographic breadth of such partners. Our findings extend research that emphasizes the benefits of tapping into foreign countries (Cantwell and Mudambi, 2005; Hitt, Hoskisson, and Kim, 1997) by showing that these advantages become stronger as the number of countries (geographic diversity) that a firm collaborates with in the same partner type increases. In this regard, the study also contributes to organizational learning theory by showing that the problem of "competency traps" or knowledge inertia that occurs when firms repeatedly use the same interorganizational linkages (Faems, Van Looy, and Debackere, 2005; Jean et al., 2014) does not arise, if those linkages are formed in different countries (at the very least for the case of foreign customers and consultants).

Our next contribution is derived from the third innovation stage. It concerns the question of whether firms should collaborate in order to introduce an innovative product (Almirall and Casadesus-Masanell, 2010) and the ultimate value that collaboration has for a firm's performance (West and Bogers, 2014). Our results extend prior thinking about the value of collaboration by showing that regardless of whether firms that have commercialized a radical product innovation collaborated—and, if so, regardless of whether this occurred domestically or in a foreign country—they can achieve similar growth. In that respect, the article also extends organizational learning theory by showing that it is not only double-loop learning (foreign collaboration) that is ultimately linked with higher performance but rather, similar levels of performance can also be achieved via single-loop learning (domestic collaboration).

Overall, our contributions regarding the first, second, and third stage show that within the context of inter-organizational learning, single- and double-loop learning are not particularly different across three dimensions: (1) double-loop can redefine single-loop learning but also under certain conditions, single-loop can also redefine what can later be considered as double-loop; (2) both types of ability can alter a firm's frame of reference (cognitive map) and allow a firm to develop radically new products; and (3) ultimately, both types of learning can enhance a firm's overall performance. Indeed, organizational learning theorists (Huber, 1991) have suggested that although the theoretical distinction between the two types of learning might seem critical within the theory, future studies might not find the two learning types to be distinct. Our study is the first to theorize and empirically verify

that this is actually the case across all innovation stages and within the context of interorganizational learning.

Managerial Implications

A practical implication of the findings pertaining to the second innovation phase is that firms that develop incremental innovations may benefit from engaging in collaboration with foreign consultants and private research institutes. By contrast, firms that focus on radical innovation could benefit more from collaborations with foreign customers as well as domestic competitors. In regard to collaboration with foreign customers, firms should carefully consider the purpose of collaboration and its long-term innovation effects. As the literature suggests and as indicated in this study, collaboration can occasionally constrain the exploration of new technological and commercial opportunities (Nijssen et al., 2012). Firm managers should also consider that collaboration with domestic suppliers appears to be beneficial for incremental innovation while constraining radical innovation.

Results from the third innovation stage suggest that although collaboration is relevant to sales growth, similar levels can also be achieved by developing products internally. Therefore, the decision that firms make about whether to collaborate should be guided by whether they need access to complementary knowledge. Firms that do need such access should engage in collaborations to codevelop the knowledge required (Un et al., 2010; van Beers and Zand, 2014). Conversely, for firms that possess the knowledge needed to develop unique products, it might be in their best interest not to engage in collaboration (e.g., for reasons such as reducing risk and cost), as this might erode their competitive advantage (West and Bogers, 2014).

Limitations and Future Research

First, as our analysis relies on sales growth, it should be acknowledged that the results might differ for profitability measures of performance that are influenced by factors such as collaboration costs. Another limitation of this research relates to its cross-sectional nature (Roper et al., 2008), although some lags between the dependent and independent variables are incorporated into the survey that allow the estimation of the innovation stages. Longitudinal data will enable the investigation of how over time changes within the innovation process impact innovation and performance. The use of cross-sectional data, however, does not reduce the value of our hypothesized relationships that advance theory across all stages of the innovation process.

The second stage of this study explored the relationship between different types of partners and product innovation novelty, but we should also acknowledge that the data set did not allow us to distinguish between lead users and mainstream customers or to categorize suppliers according to their level of innovativeness. Future studies should thus differentiate between those groups while also distinguishing between foreign and domestic-based partners. Finally, as also acknowledged in Un et al. (2010), it was not possible to observe the routines and mechanisms firms used to support the different types of collaborative agreements.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S2.1. Knowledge sourcing estimations

Table S2.2. Knowledge sourcing estimations

Table S3.1. Sales from innovative products

Table S3.2. Patent