Exploring High-technology Firms' Open Innovation Strategy and Performance from Knowledge-based View

Chun-Hsien Wang[1], Chih-Cheng Lo[2], Pei-Yu Chien[3]
[1]Department of Bio-industry and Agribusiness Administration, National Chiayi University, Taiwan,
[2]Department of Industrial Education and Technology, National Changhua University of Education, Taiwan
[3]Department of Business Management, National Sun Yat-sen University, Taiwan

Abstract--**Many studies have indicated that open innovation is critical to superior performance, yet findings have demonstrated the importance of different sources of abundant external knowledge to innovation efforts. In this study, we attempt to link open innovation view and knowledge-based view to explain how a firm's external technology acquisition ability influences its innovation deployment, as well as performance. That is, grounded in the open innovation view and knowledge-based view literatures, this study identifies key factors that allow for inbound open innovation and increase its efficacy and effects in a high competitive environment contingency. Based on a survey of high-technology firms, the results support the expectation that the ability to build well-developed collaboration channels with external connections in a competitive environment will increase the efficacy of inbound open innovation in achieving superior performance.**

I. INTRODUCTION

A firm's ability to acquire complementary resources from outside organizations is a key ability ensuring continued survival and competitiveness, specifically in high-technology sectors [36]. To answer the question of how incumbent firms access and even pursue external knowledge and technology resources, one stream of research highlights the role of inbound open innovation [14],[48],[56] in interfirm collaboration for resource acquisition from external partners [35][1]. As a response to shifting knowledge and technology-intensive environments, inbound open innovation has been linked to a variety of positive outcomes, including greater in-house R&D and innovativeness and performance [14],[43],[29]. A number of empirical analyses have provided support for the notion that inbound open innovation has played a crucial role in the promotion of growth and increases in competitive advantage, as well as that outbound open innovation is a key source of external resources and a vehicle of internal technology commercialization [14][16]. In addition, the increasing engagement of firms in open innovation activities has been one of the more competitive interactions occurring in the rapidly changing, dynamic environment. Specifically, in a highly competitive environment, firms are likely to pay more attention to innovation efforts in enhancing their competitive advantage through collaboration with external partners [60][64]. As such, firms that face high levels of competitive intensity have a greater incentive to collaborate to become able to reduce competitive pressures. Accordingly, collaboration formation is likely to be contingent on the competitive intensity that a technology-intensive firm faces [3]. It is therefore likely that competitive pressure is crucial, as it influences the likelihood that a firm will use an inbound openness strategy and the outcomes of such collaboration. Exploration of these implications will facilitate further understanding of how competitive contingency impacts the formation and outcomes of open innovation in such environments.

An important consequence of engagement in inbound open innovation is that firms with more external connection and collaboration relationships can extract more benefits than firms that rely on closed innovation systems [14][45]. These benefits are possible because repeated engagement in inbound open innovation activity allows firms to advance knowledge, to capture ideas and technology from outside a firm, and to reduce the liability of limited resources for future engagement in the innovation activity [48][46]. Accordingly, recent developments in the domain of innovation management indicates that firms' inbound open innovation may result from the external collaboration partners obtained through involvement in collaboration relationships [1],[50],[56],[43]. Such inbound open innovation, which is distinct from closed innovation, can influence firms' behavior and outcomes by increasing and integrating external collaboration with multiple partners in the pursuit of innovation activity co-development. Research in the innovation literature, however, has suggested that a firm's relationships with external collaborative partners can influence its research and development (R&D), and in turn, performance [20],[1],[59],[50]. In essence, firms engage with different types of partners to acquire ideas and resources for in-house R&D and innovation outcomes when searching for external technologies and resources and then integrate these ideas and resources into the firm's existing product/service development procedures to achieve competitive advantage. The use of abundant external knowledge resources may provide firms with internal knowledge development activities with which to develop and create value and thus enhance firm performance because knowledge is the most strategically important of the firm's resources [33].

This study builds on the knowledge-based view (KBV), which explains the external knowledge resource acquisition activities firms use to acquire valuable knowledge and develop new capabilities beyond firm boundaries through collaboration with external partners [34]. Knowledge creation and innovation result from new a combination of knowledge and other resources [20], which means that a firm's innovation already has an external focus. External sources must be considered means because it is important to enhance their innovation [50][43]. This study therefore explores two

crucial vehicles for external knowledge and technology sourcing–horizontal and vertical technology collaboration. The present study focuses on horizontal and vertical technology collaboration because in high-technology sectors, they are particularly crucial to timing and because novel technologies and knowledge acquisition reside beyond firm boundaries, which is the most valuable new discovery [13]. From the KBV perspective, horizontal and vertical technology collaboration is complementary vehicles that cultivate firms' capabilities and deploy them in inbound openness strategies to achieve competitive advantage. However, both types of collaboration seek to explain the hidden knowledge-based innovation activities that underlie a firm's value, and both are grounded in KBV logic. These types of collaboration primarily involve recognizing and acquiring external knowledge resources for innovation while increasing the firm's ability to develop new capabilities and access knowledge from beyond firm boundaries [13]. The KBV provides a new lens through which to suggest that firms not only use different knowledge bases and capabilities in developing new knowledge but also have differential access to multiple external sources of knowledge [23], which are the main determinants of performance differences. Specifically, this disparity exists because the high-technology industry is based on highly complex and specific knowledge, for which it is not easy to rely on internal generation, and firms thus must continually collaborate with external actors [23][34]. Firms therefore need an open, inbound way to access and source expertise from external actors such as competitors, suppliers, and customers.

Inbound openness has attracted much attention from innovation researchers and practitioners because a variety of innovation studies have argued that the character of a firm's inbound openness strategy can significantly influence its performance [1],[50],[43]. Despite the importance of inbound openness in the context of firms' performance, very little research has explored the influence exerted by external collaborative partners on inbound open innovation with regard to approach and vehicle. More specifically, little is known with regard to what key factors of inbound open innovation such as technology scouting and horizontal and vertical technology collaboration would drive superior firm performance. This study therefore leverages and extends the work of [48],[16],[46] who argue that inbound openness is a key factor in achieving superior firm performance. In doing so, this study develops the concepts of technology scouting and horizontal and vertical technology collaboration and indicates that they are the three most fundamental and distinct components of inbound open innovation because they reflect the influence that the external technology acquisition method has over innovation performance [17],[46],[59]. Therefore, this study empirically links inbound openness strategy to firm performance, exploring how they affect performances.

As firm engage with different types of partners to acquire knowledge and capabilities from the external environment to leverage innovation efforts, the competitive contingency may increase in response to the fast-changing environment [15][43]. Firm engagement in innovation efforts can be used as a means of competing [64]. This simple notion, that external technology and knowledge sources underlie open innovation, has important implications for the development of competitive advantage. As a consequence, the performance effects of open innovation strategies are likely to depend on the environmental context [46]. In a similar vein, competitive pressure in technology markets may affect the outcomes of open innovation strategies [28]. Because open interfirm collaborative relationships provide a myriad of opportunities for participating firms to acquire crucial resources, they are primarily associated with the direct or indirect availability of complementary resources. Thus, there is significant competitive pressure for them to adopt openness strategy quickly, both internally and externally, to realize innovation deployment, and in turn, increase competitive advantage. Accordingly, the reasons for these arguments were the technological sources and solutions that directly influenced the competitive abilities of a firm in a technology-intensive environment. This study thus introduces a contingency perspective by examining how competitive intensity moderates the inbound open innovation and performance of firms.

II. THEORETICAL FRAMEWORK AND HYPOTHESES

A. Nature of inbound open innovation

As mentioned above, extending the KBV using ideas regarding inbound open innovation, this study explains the vehicles of abundant external knowledge resource acquisition. Drawing on these perspectives, emphasis on collaboration behaviors can increase the likelihood that innovation activities will be successful [1][62]. As such, this study proposes horizontal technology collaboration and vertical technology collaboration as mechanisms for external knowledge sourcing, establishing a link between inbound open innovation and the knowledge-based view. This link lends depth to the notion that a firm's inbound openness strategy determines the external resources available to the firm, which in turn, determine performance differences [43].In contrast to previous studies, the present study explores the role of horizontal versus vertical technology collaboration in external sourcing in the open innovation environment. Specifically, this study proposes that under horizontal and vertical technology collaboration lie crucial vehicles for seeking and sourcing knowledge-based innovative resources.

Inbound open innovation indicates that the innovation resources of firms can be acquired by exploring and integrating external knowledge for technology development and exploitation [21][48]. In light of the importance of inbound open innovation in the firm's innovation processes, some researchers have explored and examined their content and effects on innovation outcomes (e.g., [17],[46],[63]), which points to a multidimensional concept of inbound open innovation, including technology scouting, horizontal technology collaboration, and vertical technology collaboration. However, previous researchers rarely examined

the antecedent of horizontal and vertical technology collaboration (technology scouting) and how external technology collaboration interacts with competitive intensity to influence firm performance.

This study therefore builds on [48] inbound open innovation framework and the work of [16] and [46],who distinguished between inbound open innovation, which is an outside-in process of acquiring knowledge from external sources, and outbound open innovation, which is an inside-out process related to the commercialization of technological knowledge. Consistent with the KBV, inbound open innovation theory indicates that internal innovative knowledge generation is an outside-in process and that firms integrate abundant external resources into innovation efforts. The key assumption here is that firms exploring inbound openness strategy attempt to increase competitive advantage by acquiring external technological know-how from external collaborative partners. This study extends these inbound openness principles to the innovation process, which involves technology searching, scanning, and strategic collaboration with a firm's operational environment. Additionally, the application of the KBV lens to external technology acquisition provides a more fine-grained understanding of the inbound openness context in high-technology firms. Specifically, this integration mechanism is a relatively new addition, connecting the innovation research to the literature on interfirm collaboration contexts.

As the prevailing innovation literatures indicates, the primary sources for inbound open innovation are characterized as being scattered among different types of external actors, which are critical to the development of innovation deployment [20],[16],[21]. In particular, as technology becomes so complex and sophisticated that it becomes difficult to generate internally and relevant technological know-how and capabilities are scattered among different technology- and science-based firms, external collaborators are increasingly regarded as a vehicle for acquiring such innovation resources [59]. This outlook has stimulated a more fine-grained analysis of the specific types of inbound openness in a specific industry, through which the effects of innovation activity on firm outcomes may be explored. As a consequence, this study is devoted to the use of an integration theoretical framework to explore the inbound openness block box and shedding new light on the critical issue of why some firms can achieve superior performance. Thus, an integrative model was developed with which to examine how firms acquire external knowledge through various methods of technology collaboration that may affect the performance of firms in competitive environments.

B. Technology scouting and horizontal technology collaboration

For innovation processes, firms must identify the value of external knowledge and technology resources; thus, technology scouting is needed when searching and scanning valuable technology and opportunities. A firm that cannot fully develop its own knowledge and technologies often sources from outside its boundaries [15]. The aim of technology scouting is to assist firms in building search mechanisms for identifying opportunities and discovering potential emerging technologies in the external environment [53]. Effective technology scouting can facilitate advanced technology acquisition, and thus, the integration of new technologies into internal innovation. According to the work of [14] and [43], external ideas, technology, and knowledge are useful and valuable to internal innovation development. These arguments redefine innovation deployment between the firm and its surrounding environment, which makes firms more porous and embedded in collaboration with different firms, institutions, and customers, allowing for movement toward solutions to current problems and the creation of new ones. At the center of the inbound open innovation model is how firms use ideas and knowledge of external partners in their innovation development. Specifically, the idea behind the inbound open innovation approach is to reflect a wider trend in studies of firm behavior that suggests that the collaboration relationships between firms and their external environment shape performance [43]. In a similar vein, according to the open network perspective proposed by [11], a firm can obtain important performance advantages when exploiting relationships to external partners that are connected to heterogeneous sources of information and access to diverse opportunities. Consequently, these arguments imply that innovative development and the opportunity for inbound openness effects depend on what is acquired from various external collaboration partners.

As a consequence of the advanced, novel technology acquisition approach, firms must assess and observe different external technology sources for integration into internal innovative efforts [43]. The search for external new ideas is not just about scanning a large set of sources; the ability to collaborate with competitors is crucial to acquiring innovative related technologies and knowledge. Thus, firms possessing advanced scouting mechanisms are likely to search for and scan new technology sources from the external environment. The use of technology scouting as a technology seeking and solution approach can lead to increases in the use of various external partners as sources of novel technology. As such, firms engage in horizontal collaboration with competitors as a way to acquire novel ideas that can lead to the development of products and services. Hence, technology scouting refers to a systematic firm approach whereby horizontal collaboration can be used to gather information in the field of science and technology and to facilitate or execute innovation deployment.

The crux of the above argument is that a firm's decision to acquire external sources of technology and capability through horizontal technology collaboration involves pooling complementary resources with competitors to jointly develop innovation resources that they would be unable to produce internally. Indeed, because of increased competition and rapidly advancing technologies in high-technology sectors,

firms are often forced to develop new products faster and more effectively. High-technology firms have exhibited a tendency to collaborate with competitors to develop or research new products/services because of complementary technologies [49]. Therefore, high-technology firms must be able to create co-operative or co-developed capabilities that allow for the building of horizontal technology collaborations (HTCs) with multiple partners. Firms frequently seek to collaborate with competitors to learn their rivals' competencies [38] and thus discover new opportunities, especially where these opportunities are viewed as being outside the realms of competition [60]. In essence, horizontal collaboration is a frequently used and efficient method of technology collaboration with competitors. Thus, consistent with the KBV, collaboration with external partners can deploy existing knowledge and thus create value [34]. Moreover, reliance on horizontal collaboration with competitors allows firms to tap into advanced technology, thereby providing a preemptive advantage that accelerates firms' capability development opportunities and allows for the monitoring of competitors' technology levels. The arguments above imply that collaboration with competitors is therefore increasingly viewed as a novel and crucial technology acquisition alternative. This argument leads to the following hypothesis:

Hypothesis 1: Technology scouting is positively related to horizontal technology collaboration.

C. Technology scouting and vertical technology collaboration

A growing body of research demonstrates that firm collaboration with customers is an important method of improving innovation efforts [9][30]. Innovation ideas originate from the customer perspective of the value chain [64] and have been declared one of most important openness strategies for firms [18][52]. They enable firms to extract innovative ideas and novel knowledge from their customers to improve products/services during R&D and innovation processes. By interacting with customers, firms can not only capture market trends and enhance new technology applications but also facilitate the identification of technology development and market opportunities. Scholars have demonstrated that collaboration with customers may yield significant benefits, such as the improvement of existing core competencies, the identification of market trends, and the monitoring of technological development directions [10][64]. Collaboration with customers can significantly increase the likelihood of well-designed new product development and technology development processes, which in turn, can eventually translate the needs of customers into commercial development. Along similar lines is the research argument that firm collaboration with customers may facilitate the realization of new solutions and support innovation efforts [65]. As such, firms that collaborate with customers have two distinguishing features. First**,** collaboration with customers allows a firm to develop appropriate technologies and customer-based innovation efforts while allowing for improved interactions with external customers embedded in the innovation development processes. Customers are often considered especially valuable and novel knowledge sources because their specific demands may anticipate the contribution of innovation efforts [47][64]. Second**,** firm adoption of customers as collaborative partners or co-producers is a significant trend in such an era of co-creation value [52]. Customer participates in value chain activities, because value co-creation has become a new source of new competence and thus increases in competitive advantages [52]. Customers are viewed as important external sources of open innovation inputs when a firm increases customers' knowledge in the modification of product or service development [30].

According to these arguments, firms collaborating with larger customers can enhance new technology applications and quickly identify market trends, a process that is considered vertical technology collaboration (VTC). VTCs involve collaborative relationships with customers, particularly those in high-technology firms that enhance innovation efforts [6]. Using this approach, firms can simultaneously accelerate their technological development and increase innovativeness. Thus, firms can identify market trends and technological development levels by increasing interactions with customers via vertical technology collaboration methods. VTCs are one method wherein firms acquire technology and knowledge from external collaborators, namely, suppliers and customers. One may think of VTCs involving external technology acquisition as requiring more frequent collaboration with existing suppliers, customers and potential customers for improvement in the internal innovation process [31][17]. In particular, VTCs are the most important method of obtaining valuable and novel knowledge sources and can thus provide unique insights critical to the internal innovation process [66]. Accordingly, this study argues that firms need VTCs to make the most of inbound open innovation.

VTCs are therefore often argued to lead to more customer-oriented innovation efforts, which in turn, result in more positive openness outcomes than closed innovation. Because VTCs are in accordance with customers' values and interests, they increase the ability of a firm to create value and innovate [24]. That is, the inbound open innovation paradigm goes beyond simple utilization of external customer sources of innovation, and as such, is a change in innovation method and innovation employment, as it directly strengthens firms' technological innovation competences and opportunity discovery. These arguments imply that collaboration with customers may not only allow for the attainment of new competence but also directly impact firms' innovation deployment, which differs significantly from the traditional innovation approach. This implication is consistent with the arguments regarding inbound open innovation, as the sourcing of external ideas and knowledge from customers is crucial to the development of innovation efforts [14][43], which leads to Hypothesis 2.

Hypothesis 2: Technology scouting is positively related to vertical technology collaboration.

D. External technology collaboration in inbound open innovation

Inbound open innovation advocates collaboration with competitors and customers and enables firms to acquire multiple sources of knowledge synergy and renew their ideas for creating competitive advantage. The search for new ideas is not simply about scanning different technology and knowledge sources; firm must build well-developed collaborative vehicles to draw heavily on useful and valuable knowledge from these sources. However, previous studies do not explore or provide any technological collaboration methods, including horizontal (competitors) and vertical (customers) technology collaboration with diverse collaborators, the analysis of which could shed light on how technology scouting influences performance. According to these arguments, this study suggests that technology scouting positively affects performance by increasing HTCs and VTCs. This study argues that HTCs and VTCs are germane to this influence because simultaneous inbound openness innovation approaches and inbound open innovation reflect how external collaborators interdependently interact and exchange in taking advantage of the effect of innovation outcomes.

Furthermore, from the inbound open innovation perspective, a firm relying on HTCs (competitors) and VTCs (customers) may acquire more and possibly external knowledge that can be pooled into its innovation efforts [8],[38],[49],[9],[30]. Previous studies have recognized the importance of external collaborators to firms' innovation performance (e.g., [43][1],[56]. When firms regard their collaboration relationship with competitors and customers as being involved in innovative processes, they are more likely to access new ideas and knowledge for their innovation efforts. This access is argued to be clearly likely to lead to a positive synergy effect on external collaborators and innovation efforts, and as a result, improved firm performance. The acquisition of external knowledge offers firms the opportunity to not only add new and more advanced technologies and opportunities but also increase the likelihood of discovering novel technologies and commercialized opportunities, thereby improving competitive advantage [24][27]. This improvement occurs because collaboration with external partners may easily allow for the identification, acquisition, and replication of advanced technologies as a complement to the internal innovation process.

External knowledge acquisition can occur through the various vehicles that are important innovative knowledge sources for firms. External knowledge provides firms with access to complementary resources in innovation efforts incorporating existing resources, as does the abundance of external knowledge that can be used for innovation [29]. In this respect, external knowledge resource acquisition for inbound open innovation may be relevant in two ways**.** First**,** external knowledge resource acquisitions are important to the support and acceleration of innovation efforts, particularly in high-technology sectors [15],[16],[56]. Moreover, collaboration with external partners may facilitate flows of ideas and knowledge between partners, as it would facilitate innovation deployment. The employment of multiple external knowledge sources can aid firms in collecting broad ideas and is associated with increases in innovation outcomes [44]. These arguments suggest that if a firm wants to increase its ability to improve innovation performance, it must access multiple external sources of knowledge. Second, firm acquisition of external knowledge resource ability and its integration into internal processes is crucial to firm innovation efforts. Research on external knowledge sources has demonstrated that firm collaboration with competitors, suppliers, and customers can strengthen their ability to support innovation [4][39], through which this collaboration impacts the performance of the firm. Moreover, abundant external knowledge resource acquisition capability and integration ability, which produce high innovativeness, may drive firms to generate an abundance of innovation outcomes. Therefore, consistent with the argument of regarding open innovation, abundant external knowledge resources render the firm's engagement in innovation efforts more profitable [17]. Accordingly, this study proposes that HTCs and VTCs mediate between technology scouting and performance.

Hypothesis 3: Horizontal technology collaboration is positively related to performance.

Hypothesis 4: Vertical technology collaboration is positively related to performance.

E. HTCs and VTCs as mediators

This study suggests that HTCs and VTCs mediate the link between technology scouting and performance. When firms pursue knowledge resources beyond their organizational boundaries for knowledge and technologies required for innovation, they become receptive to new ideas and potential commercialized opportunities [43] [29]. Indeed, a firm that can fully search for and acquire a wide range of external knowledge and technologies in deploying new innovation opportunities, including horizontal and vertical technology sources, can significantly influence its performance [17][66]. From the knowledge acquisition perspective, HTCs and VTCs are important mechanisms employed to acquire external resources and thus increase firm innovation capability. The KBV of firms holds that firms' critical advantage over markets is the provision of a superior context for supporting knowledge integration mechanisms [34]. Such a variety of knowledge sources provides opportunities for firms to open their external channels separately in their quest to improve their ability to obtain innovation opportunities. These channels of external knowledge and technologies provide firms with access to multiple sources in helping firms to not only find external sources of knowledge but also integrate them into internal innovation efforts. The inbound openness process is itself a form of outside-in acquisition activity, and associated technology collaboration processes involve linking to competitors, suppliers, customers, and a wide range of multiple sources as part of innovation efforts.

Together, these arguments shift attention toward the hypotheses linking the relationships between technology scouting and HTCs and VTCs to firm performance; HTCs and VTCs can be assumed to have a mediating role in the technology scouting–performance relationship. Consequently, these arguments imply that technology scouting would indirectly influence firm performance through HTCs and VTCs.

In addition to HTCs and VTCs, however, both approaches to technology collaboration play important roles in inbound openness for the acquisition and exploitation of external resources. First, in a rapidly changing and competitive environment, external knowledge and technology scanning can facilitate the capture of an opportunity to produce new innovative outcomes. The new innovative outcomes offered by competitors further improve the possibility of attaining more opportunities for the commercialization of a product or service. As the number of collaborations with competitors increases, complementary knowledge and advanced technology acquisition opportunities increase as well [39][64], improving innovation capability, especially in high-technology sectors in which cooperation and competition relationships frequently emerge for the purpose of innovation [56].

Furthermore, this study also presumes that VTCs play a mediating role between technology scouting and superior firm performance. From the KBV and inbound open innovation perspective, external knowledge and technology sources can collaborate with not only competitors to access advanced technologies but also suppliers and customers to monitor and scan market development trends. That is, collaboration with suppliers and customers could enhance firms' ability to recognize market opportunities, manage unanticipated events during innovation efforts, and boost firms' business activities [25]. Using the various external knowledge and technology resources available, firms can combine knowledge and other resources to produce new knowledge and innovation results [20]. Technology- and science-based firms are heavily dependent on the combination of their specific knowledge with that of external partners intended to enhance their ability to innovate [55][59]. Therefore, both HTCs and VTCs aid firms in upgrading knowledge and technology resources, scanning market development trends, and achieving innovation deployment. A firm possesses HTC and VTC abilities that may allow for co-creation with complementary partners through alliances, cooperation, acquisition, and joint ventures, during which innovation processes for joint development and commercialized innovation success occur. Indeed, external resource acquisition from competitors, suppliers, and customers enhance firms' capability to solve technology problems and encourages technology breakthroughs, applications, and discovery opportunities, which ultimately facilitate improvement in firm performance. In light of the aforementioned reasoning, the following hypothesis is developed.

Hypothesis 5a: The link between technology scouting and performance is mediated by horizontal technology collaboration.

Hypothesis 5b: The link between technology scouting and performance is mediated by vertical technology collaboration.

F. The moderating role of competitive intensity

Strategic scholars have argued that market competition is an important contingency factor that must be addressed when developing collaboration (e.g., [3][67]) because through its benefits, it contributes significantly to innovation [1][64]. Collaboration with other competitors can facilitate the reduction of technological uncertainty and the acquisition of novel technologies [50]. Many researchers have argued that intensified market competition stimulates firm engagement in collaboration with external partners for the acquisition of knowledge and technology resources. As [3] suggests, intense competition stimulates a firm to adopt a collaborative strategy, and collaboration with competitors can aid the firm in reducing competitive pressure and obtaining timely knowledge and technology resources, and thus increase firm performance. A firm's performance is greatly influenced by the market competition intensity in which the firm operates [5]. A firm's collaboration with competitors and other firms not only makes access to knowledge and technology resources more efficient and timely but also makes it easier to mitigate competitive pressure and thus co-opt their collaboration activities.

From a co-opetition perspective, collaborative and competitive relationships are critical sources of innovations [1],[32],[64], and in high-technology contexts, make a significant contribution to innovation efforts [32]. Firms that simultaneously pursue co-opetition strategies to acquire and create new knowledge and technology resources use the resources to discover new opportunities and pursue innovation. The co-opetition strategy is popular in high-technology sectors [32] because there is high pressure to innovate in the high-technology business market [56], and thus, co-opetitive relationships can stimulate innovation outcomes. The co-opetition relationship between Apple Computer, Inc. (Apple) and High Tech Computer Corporation (HTC) is a significant example of this type of association. Apple and HTC are highly competitive in terms of smartphone technology, but they also collaborate with each other to develop new patenting technologies. Through their collaboration agreement, they have become tight partners to obtain crucial knowledge and technologies through joint R&D, produce new technological developments, and participate in joint technological innovation efforts to achieve better outcomes in terms of market shares and technological innovation. Moreover, co-opetitive relationships may produce relevant resources and enable firms to acquire and create new technological knowledge and use the knowledge in pursuit of innovations [54]. Innovative collaboration with competitors may have a more positive effect on firm performance [8].

Co-opetitive relationships may thus generate benefits allowing participating firms to access, acquire, and leverage knowledge and technology resources in pursuing innovation. Therefore, it is important and necessary to examine the contingency condition of competitive intensity, in which firm engagement in co-opetition relationships may generate positive outcomes.

Although the main aim of a high-technology firm is to strengthen innovation efforts, the development of co-opetition relationships encourages knowledge and technology flow across firm boundaries, increasing their competitive advantage. The different types of external partners play different roles in complementing a firm's own resources and capabilities related to potentially different goals of interfirm collaboration and innovation [26][7], which may not only have different implications for a firm's proclivity to engage in such open innovation activities but also may yield potential interrelationships between them. As noted above, for competitors such as Apple and HTC, it is not only their individual capabilities to advance technologies to the optimal point but also their co-opetition capabilities to enhance their respective alignments of innovation capabilities that determines outcomes. The value of highly intensive competition is reflected in how firms such as Apple, HTC, Sony, and Samsung have used their co-opetition relationships as competitive weapons to gain advantages. Such a tremendous surge in high-technology market competition has led to greater firm engagement in collaboration with one another for the acquisition of knowledge and technology resources. Thus, market competition intensity is an important environmental stimulus, and the challenges of collaborative relationships enhance firms' innovation efforts. These arguments suggest that firms in intensely competitive environments are likely to expend considerable effort on open innovation strategy with partners to strengthen their integration with competitors, suppliers, and customers that could provide them with competitive advantage.

Hypothesis: 6: Competitive intensity has a positive influence on the relationship between horizontal technology collaboration and performance.

Furthermore, VTCs are easily mapped onto activities that occur during the later stage involving customers, in which a firm's existing knowledge, which includes customer needs and market trends, is utilized. VTCs refer to collaborative relationships with suppliers, customers, and/or end users allowing for the timely obtainment of technologies and knowledge of market development trends. However, as market competition intensifies in high-technology contexts, firms tend to focus on established markets and pay close attention to the needs of existing customers [19] rather than focusing on leveraging and extending technological development. Because competing firms possess relevant resources, face similar pressure, offer very similar products, and employ similar technology, firms experiencing such intensive market competition are likely to motivate giants to engage in existing market shares rather than heavily invest resources in R&D. As a result, firms are often unable to respond effectively to the emergence of new technologies [61]. In addition, high market competitive intensity is often characterized by greater rivalry among market actors, which depend heavily on price wars and intensive advertising, which causes products or services to gain increased market shares [51]. Therefore, as competition intensifies, firms face more intensity in pricing and promotion such that inefficiencies in technological innovation or operations lower firm performance. However, multiple price wars are undesirable because if un-coordinated, a firm may price too low, constraining its profit potential [12]; thus, intense competition mitigates the motivation to fulfill customers' needs. As a result, these pressures increase the costs of innovation efforts.

The negative effects exerted by VTCs on performance may be intensified in conditions of fierce market competition for two reasons**.** First, as competitive market pressure increases, the uncertainty that each firm faces rises, as does the likelihood of incongruent goals and innovation resource allocation problems that must be addressed. As noted by [42], competitive intensity is a crucial source of environmental uncertainty that may affect firm performance. In highly competitive market environments, firms are thus required to develop adaptive responses quickly and expand their scope of information acquisition and gathering [57]. Indeed, firms operating in such a market may increase competitive costs such as search cost, customer maintenance cost, and market development cost, which require responsiveness and flexibility. The key reason for these increases is that given the aforementioned requirements of highly competitive markets, the marginal costs of operation are likely to increase at a faster rate than they do in weakly competitive market environments. Specifically, coordination, collaboration, information gathering, innovative competence and so forth become more costly and difficult to manage at high levels of market competition because of rapidly materializing conditions and contingencies. Second, when operating under the conditions of high levels of competition, firms focus on short-term benefits to acquire existing market shares in response to earnings pressure, rather than pursuing a long-term goal and thus developing patience and commitment over time [22][67]. To gain short-term benefits in their current market position, firms tend to strengthen their short-term results orientation and are likely to behave opportunistically by committing such acts as cheating to increase market sales, promoting aggressively to acquire customers, and disseminating distorted market information. Under such conditions, a firm finds it difficult to discover potential customers, discover new market opportunities, and even develop advanced technology to comply with market technological trends because under fierce market competition conditions, each firm tends to satisfy existing customers by maximizing their existing products and services in the marketplace rather than developing advanced technologies in

the long-term. When there exist difficulties in integrating advanced technology and in determining technological development trends in future returns, firms may lose their advantages in such a market.

Hence, high levels of competitive behavior exhibited by competitors attempting to gain short-short benefits may hinder technological progress because under high levels of market competition, the firm tends to earn short-term profits by maximizing its market share as soon as possibly by responding to market requirements ahead of competitors. As a result, a firm may become frustrated in collaboration with supplier and customers and thus, tends to be concerned about losing its short-term benefits rather than pursuing long-term technological development. Altogether, firms at high levels of market competition are likely to engage in opportunistic behavior, which may weaken the benefits of advanced technology acquisitions and joint technology and knowledge development. These arguments suggest that the negative effect exerted by VTCs on firm performance will be reduced under high levels of competitive intensity, which leads to the following hypothesis:

Hypothesis: 7: Competitive intensity has a negative influence on the relationship between vertical technology collaboration and performance.

III. RESEARCH METHODS

A. Sample and data collection

High-technology firms were selected for the sampling frame using the following criteria: (1) registration with the Industrial Development Bureau (IDB) of the Ministry of Economic Affairs (MOEA) and Taiwan Over-the-Counter Securities Exchange (TOSE), (2) the availability of detailed financial data from Taiwan Economic Journal (TEJ), (3) status as R&D and innovation-oriented manufacturers that collaborate with global partners, suppliers, and customers to upgrade their technological innovation competences within their internal systems. These criteria allowed us to control for variability in firm age, size, industry types, R&D expense and capital, which should increase the external validity of our findings. In total, this study identified 1,079 population firms matching the selection criteria.

A stratified random sampling method was used to select 650 high-technology firms, or approximately 60 percent of the high-technology firms in Taiwan. Research assistants used Telephone contacts and E-mail to ask high-technology firms' CEOs or senior managers to participate in this study. Then, questionnaires were sent to the 650 high-technology firm CEO and senior managers who were included in the abovementioned sampling frame. Of the 182 returned questionnaires, 32 were excluded because of incomplete answers and missing data, resulting in 150 usable responses and yielding a response rate of 22.56 percent. On average, the high-technology firms in the sample were 27 years old, had 87.22 million in annual R&D expenses in new Taiwan dollars (TWD) and had 3,530 employees.

B. Constructs and measures

All constructs were measured by the average of the responses on a 7-point Likert scale (from 1 = strongly disagree to 7 = strongly agree).

C. Variables

Firm performance. Two proxies reflect the construct performance of firms: performance and new product performance [58]. Firm performance was measured by asking respondents to assess their firm's sales growth, market share growth, return on investment, and profit level relative to their major competitors. Furthermore, new product performance is measured as the degree to which a product performs well in the market relative to its major competitors in terms of sales, market share, ROI, and profit [41].

Technology scouting. Consistent with [48], five scale items were adopted to measure the external technology sources and trends for high-technology firms. A confirmation factor analysis with varimax rotation and Kaiser normalization resulted in a five-factor solution in which the items showed clean loadings on the technology scouting constructs [37]. The five-item scale captured a high-technology firm's activities in new and advanced technological scanning and monitoring.

Horizontal technology collaboration. The three-item scale was used to capture a high-technology firm's activities extending collaboration with competitors, noncompetitors, partners, and other actors for technology and knowledge resource acquisition. The scale for horizontal technology collaboration draws on [48].

Vertical technology collaboration. The measure of vertical technology collaboration is adapted from prior research that integrates collaboration with suppliers, present and potential customers, and end users into innovation efforts. Thus, the scale for vertical technology collaboration also draws on [48].

Competitive intensity. Consistent with [40], three items were adapted to measure competitive intensity for the high-technology context.

D. Control variables

Five control variables were included in this study. Firm size may affect innovation and performance because larger firms usually have larger knowledge bases. Therefore, this study controlled for firm size using a log transformation of the number of employees in each firm. This study controlled for firm age by calculating the number of years since the firms were founded. For the same reasons, this study also controlled for R&D expense and capital. The R&D expense and capital were measured in millions of new Taiwan dollars. In this study, I controlled for industry effects because different high-technology sectors may have different knowledge and technology strategies. Three dummy controls were used to represent different high-technology sectors.

IV. ANALYSIS AND RESULTS

Table I presents the correlations and descriptive statistics for the study variables. Table II provides the ordinary least square (OLS) regression estimates for the hypotheses test. After mean-centering of the interacting variables, the variance inflation factor (VIF) values are far below the threshold of 10: the VIF scores in this study range from 1.07 to 3.34, which suggest that multicollinearity is not a problem in these analyses [2]. In Table II, both Model 1 and Model 3 contain only the control variables. As shown in Models 2 and 4, technology scouting is positively and significantly related to HTCs ($\beta = .65$, $p < .001$) and VTCs ($\beta = .62$, $p < .001$), in support of hypotheses 1 and 2.

In Model 7 in Table III, the relationships among HTCs, VTCs, and performance were examined. As shown in Model 7 in Table III, both HTCs ($\beta = .22$, $p < .01$) and VTCs ($\beta = .27$, $p < .01$) are significantly positively related to firm performance. Furthermore, in Model 11 in Table III, both HTCs ($\beta = .16$, $p < .1$) and VTCs ($\beta = .40$, $p < .001$) are significantly positively related to new product performance.

Both hypothesis 3 and hypothesis 4 were supported. Then, integrating the Tables II and III regression results, the effects of the mediation analysis of HTCs and VTCs' effect on firm performance were examined. As observed in Tables II and III, after controlling for the effects of the control variables, HTCs ($\beta = .22$, $p < .01$) and VTCs ($\beta = .27$, $p < .01$) have a significant and positive effect on firm performance. Similarly, HTCs ($\beta = .16$, $p < .1$) and VTCs ($\beta = .40$, $p < .001$) have a significant positive effect on new product performance. Finally, as Model 8 of Table 3 demonstrates, the results show that the previously significant linkage between technology scouting and performance was no longer significant when HTCs and VTCs were added to the Model 8, but HTCs ($\beta = .23$, $p < .01$) and VTCs ($\beta = .25$, $p < .01$) remained significant with regard to firm performance. Following the same procedure in Model 12 of Table III, the findings from this set of analyses suggest partial support for Hypotheses 5a and 5b. Thus, HTCs and VTCs partially mediated the technology scouting and performance relationships.

TABLE I. CORRELATION MATRIX (N = 150)

Variables	1	2	4	5	6	7	8	9	10	11
1. Firm age										
2. Firm size	.10									
3. R&D expense	-.01	.59*								
4. Capital	.03	.79*	.53**							
5. Technology scouting	.03	.17*	.27**	.25**						
6. HTCs	-.08	.06	.18*	.09	.56**					
7. VTCs	-.01	.15	.17*	.17**	.61**	.49**				
8. Competitive intensity	-.05	.10	0.2	.04	.25**	.36**	.33**			
9. Firm performance	.09	.17*	.14	.16*	.32**	.30**	.33**	.01		
10. New product performance	.01	.10	.06	.08	.45**	.30**	.42**	.09	.78*	
Mean	27.28	3,530.64	87.22	3.67	5.45	4.95	5.82	4.97	4.39	4.47
S.D.	18.08	10,706.31	351.32	1.44	.85	.97	.85	1.07	1.14	1.02

Note: *$p < 0.1$; **$p < 0.05$

TABLE II OLS REGRESSION RESULTS (N = 150)

Variable	HTCs		VTCs	
	Model 1	Model 2	Model 3	Model 4
Industry dummy	Yes	Yes	Yes	Yes
Firm size(ln)	-.05	.00	.00	.06
	(.07)	(.06)	(.06)	(.05)
Firm age	-.00	-.01	-.00	-.00
	(.00)	(.00)	(.00)	(.00)
R&D expense(ln)	.09**	.03	.04	-.01
	(.04)	(.04)	(.04)	(.03)
Capital	.05	-.06	.08	-.03
	(.09)	(.08)	(.08)	(.06)
Technology scouting		.65***		.62***
		(.08)		(.07)
R^2	0.044	0.337***	.046	.382***
Adjusted R^2	0.011	0.306	.013	.356

Note: *$p < 0.1$; **$p < 0.01$;***$p < 0.001$

TABLE III OLS REGRESSION RESULTS (N = 150)

	Firm performance				New product performance			
Variable	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm size(ln)	.09	.13*	.11	.14*	.07	.12*	.07	.12*
	(.08)	(.08)	(.07)	(.07)	(.07)	(.06)	(.06)	(.06)
Firm age	-.01*	-.01*	-.01	-.01	-.00	-.00	.00	.00
	(.00)	(.00)	(.00)	(.00)	(.00)	(.00)	(.00)	(.00)
R&D expense (ln)	.01	-.02	-.02	-.03	-.04	-.06	-.04	-.06
	(.05)	(.05)	(.05)	(.05)	(.04)	(.04)	(.04)	(.04)
Capital	.07	.00	.03	-.00	.045	-.05	.00	-.07
	(.10)	(.10)	(.10)	(.10)	(.09)	(.08)	(.08)	(.08)
Technology scouting		.41***		.15		.58***		.37**
		(.11)		(.14)		(.09)		(.12)
HTCs			.22**	.23**			.16*	.08
			(.10)	(.11)			(.09)	(.09)
VTCs			.27**	.25**			.40***	.25**
			(.12)	(.13)			(.10)	(.11)
Competitive intensity (CI)				-.18				-.08
				(.08)				(.07)
HTCs × CI				.16*				.16**
				(.09)				(.08)
VTCs × CI				-.14				-.17*
				(.11)				(.09)
R^2	.09**	.175***	.200***	.249***	.05	.262***	.232***	.319***
Adjusted R^2	.059	.140	.161	.190	.02	.231	.194	.265

Note: *$p<0.1$; **$p<0.01$;***$p<0.001$

This study also tested the interactive effects between collaborative technology methods and competitive intensity that were exerted on the performance of the firms. Models 8 and 12 of Table III indicate that firms operating under high levels of competitive pressures are likely to collaborate with competitors to increase their performance ($\beta = .16$, $p < .1$) and new product performance ($\beta = .16$, $p < .01$). This result is consistent with the prediction made in Hypothesis 6. The result indicates that competitive intensity interacts with HTCs to improve firm performance. In addition, the empirical results in Models 8 and 12 in Table III show that a firm is unlikely to collaborate with suppliers and customers in a highly competitive environment. As shown in Model 12 in Table III, this result indicates that there is a negative interaction effect between competitive intensity and VTCs ($\beta = -.17$, $p < .1$), which remained negatively significantly related to new product performance. This result provides partial support for Hypothesis 7. These findings imply that firms that operate in highly competitive environments are more likely increase their performance by having stronger collaborations with competitors than with customers.

V. DISCUSSION

This study presented a theoretical framework of inbound open innovation based on the KBV and proposed the use of concepts to guide our understanding of the different collaborative mechanisms underlying the acquisition of useful external resources. An important mediating mechanism of technology collaboration is the connection between technology scouting and performance in the high-technology context. Consistent with the KBV, the findings obtained with the present study suggest that abundant external knowledge and technologies can facilitate increases in internal innovation capability and thus lead to superior performance [33][34]. Following this line of thought, inbound open innovation based on the KBV and abundant external knowledge and technologies facilitate internal innovation efforts and allow for the obtainment of competitive advantage and superior performance.

In addition, this study elaborates an integrated model in which the manner in which different external technology acquisition channels affect firms' performance in a competitive environment is examined. The empirical findings indicate that a firm's horizontal and vertical technology collaboration facilitate external resource acquisition from competitors and customers, respectively, but these relationships have different effects in highly competitive environments. Specifically, the results indicated the circumstances under which a highly competitive environment may increase high-technology firms' collaboration with competitors but may mitigate their collaboration with customers. In addition, the evidence provided by the empirical results provides strong support for the KBV hypothesis in terms of the acquisition of external knowledge and technologies that can enhance the positive relationship between inbound openness strategy and performance. These findings facilitate exploration of the effect exerted by the block box of inbound open innovation on firm performance. Furthermore, this study supports [43],[48],[56] contention that inbound open innovation is more than an outside-in concept; rather, it can facilitate the identification and acquisition of external resources and enable a firm to achieve superior performance.

This study makes several theoretical contributions to

innovation research. First, this study offers an integrative model that examines the influence exerted by technology scouting, horizontal technology collaboration, vertical technology collaboration, and competitive intensity on firms' performance. This influence has led to an obvious concept, which has, in turn, allowed for engagement in openness strategy focused on external collaboration through different vehicles, increasing high-technology firms' ability to enhance their internal innovation and performance. These results suggest the importance of the connection between the existing knowledge base and both channels, through which a firm integrates its external knowledge into internal innovation. As such, this study is one of the first to concurrently consider the relative contributions of the KBV and open innovation to these outcomes. Second, drawing on open innovation and the KBV, this study enriches inbound open innovation theory by distinguishing between two types of external technology collaboration vehicles: horizontal and vertical technology collaboration. This distinction is important because horizontal and vertical technology collaboration allow for the acquisition of two distinct facets of external technology and knowledge acquisition. This finding indicates that a firm with a well-developed external knowledge acquisition channel is better able to achieve superior performance through the integration of external resources and internal innovation efforts. Many previous studies highlight the important role that knowledge plays in innovation efforts [20],[17],[46],[59],[63], confirming the view that abundant external knowledge can provide benefits for innovation (e.g., [46][55]). This study advances this line of inquiry, which explores the role of horizontal and vertical technology collaboration and critically supports open innovation activity. Third, this study investigates firms' reliance on inbound openness strategy for external technology and knowledge acquisition in a highly competitive environment, which acts as a moderator between inbound openness strategy and performance. The present study contributes by building on and extending existing research on the importance of abundant external knowledge and innovation relative to firms' performance [16],[43],[46],[50],[48] by examining multiple types of knowledge acquisition channels and examining these relationships within the context of high-technology industries. Fourth, this study specifies a measurement model of the determinants of inbound open innovation sources, reliant on previous studies. Thus, this study also contributes to the KBV of the firm and the open innovation perspective [14],[15],[33],[34]. Specifically, there is very little research that attempts to conceptualize and empirically analyze inbound open innovation through which different external knowledge-acquiring channels are used. Thus, by using the KBV to conceptualize the inbound openness process and by empirically validating and testing the process's impact on firms' performance, this research also contributes to the literature on the KBV of the firm and open innovation in general.

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