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A Longitudinal Study of the R&D Partnership Development between Firm and Academia

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Abstract R&D collaboration with academia is widely perceived as the important way to develop breakthrough innovation and sustain competitive advantage in the knowledge-intensive industry. The outcome of collaborative innovation depends on the firm's strategy and management to overcome the challenges from different institutional logic and different disciplinary of knowledge domains. Based on literature review and a longitudinal study, we explored how firm effectively develop and maintain R&D partnership with academia. We highlighted the dynamics of collaborative sensemaking in the interdisciplinary collaboration. This study provided inspiration for practitioners to manage R&D partnership and achieve the desired outcome of industry-academia collaboration.

Keywords: *R&D, collaboration, moral hazard, cognitive distance, collaborative sensemaking*

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1. Introduction

In the age of discontinuous technology evolution, firm's innovative capability has become the driver of growth, competitiveness and sustainability. Innovation relies on the confluence of different technology and knowledge. It's hard for most of firms to possess whole technology and knowledge in-house to response radically transformation of competitive environment [1]. R&D collaboration with external organization has becoming an important source to obtain, combine and leverage different knowledge and technology [2]. Academic institutions possess various experts, knowledge and latest inventions that may lead to innovative products near future [3]. R&D collaboration with academia for new product development has become increasingly common [4]. It is also a way for firm to reduce R&D cost and risk by stretching limited resources such as human, equipment and facility [5]. Despite significant potential benefits that come from R&D partnership with academia, firm faces various challenges to achieve a satisfying and productive collaboration [6].

The intent behind R&D collaboration involves a desire for actors to discover new opportunities by pooling complementary knowledge, resources, expertise and skills. Organizational learning and knowledge exchange process is complex. Different from unidirectional knowledge-transfer, R&D collaboration can be viewed as a process that seeks bidirectional knowledge-creation, where new knowledge and invention that neither of actors previously have possessed are created [7]. The interorganizational relationship of unidirectional knowledge-transfer is a predictable process that the goal, scope and involvement can be specified in advance. The interorganizational relationship of bidirectional knowledge-creation is an unstructured process where the partnership and outcomes will evolve naturally due to continuous interactions.

Previous studies have investigated various kinds of obstacles to the collaboration between firm and academia from the perspectives of interorganizational relationship or public-private partnership [6,8]. The industry-academia collaboration confronts the "two-worlds' paradox" [9]. Cultural differences and tensions between academic and commercial activities are the main obstacles impeding the collaboration between firm and academia [10,11]. Ankrah et al. (2015) summarized the issues in the industry-academia collaboration, including capacity and resources, legal issues, institutional policies and contractual mechanisms, management and organizational issues, issues related to the technology, political issues, and social issues.

Previous studies have focused on the typology of industry-academia collaboration [12] or the antecedences and consequences of the collaboration [13]. Few studies pay more attention to the process of R&D partnership development and leave best practices undefined [14]. Our research questions are that how firm can successfully develop R&D partnership with academia and ensure the benefits from industry-academia collaboration. To answer these questions, we conduct a longitudinal study because this method permits in-depth interpretation when it is necessary to understand the dynamic mechanisms.

We focused on the interdisciplinary collaboration between firm and academia in the biomedical sector. The biomedical sector is underpinned by accumulation of

knowledge and the breakthrough inventions usually built on distant knowledge domains [15]. For example, the commercialization of DNA array is derived from the combination of knowledge from molecular biology and photolithography technology in semiconductor industry [16]. We regard this a viable research context to explore the effective management of the interorganizational and interdisciplinary collaboration.

2. Theoretical Background

The interaction between firm and academia is commonly considered to take the form of the strategic alliance, and the collaborative agreement is initiated voluntarily for exchange [17]. Firm that seeks to involve academia in innovation processes face this paradox. Academic researchers are likely to provide the most complementary knowledge or newest insights; however, they are also the most challenging collaborators to work with [18]. Industry-academia collaboration is more complex than inter-firm collaboration [19]. From the perspective of transaction cost economics, control mechanism are important to prevent opportunism behaviors or prevent inconsistent behaviors and achieve the collective goal. The goal of R&D collaboration is to extract valuable knowledge and skills from partners to create value. Collaborators needs to deal with the understanding, recombining and transferring of inbound and outbound knowledge between each other. Drawing on the theory of transaction cost [20], knowledge-based view [21] and sensemaking theory [22], the inhibitors to the interorganizational and interdisciplinary collaboration are discussed to constitute a conceptual framework for studying the dynamics of R&D partnership development between firm and academia.

2.1. Moral Hazards

In the industry-academia collaboration, firm and its academic partner essentially remain the independent economic actors and retain control over their own resource-allocation decisions. Both of firm and academia have different mission, interest and incentive system based on the different institutional logic [23]. The disparities between private and public organizations may cause conflicts, misunderstanding, and distrust [24]. Academic researchers in the university will tend to use the novel concepts and new resources to explore new technology and disclose new knowledge as earlier as possible for scientific publication. However, knowledge generation in the industry is to create the economic value and to gain competitive advantage by controlling the knowledge and resources that are not available to their competitors [25]. R&D engineers in the industry will prefer to develop new technology and product by practical approaches.

Besides, there is a profound impact on the subtle relationship between firm and academia when university becomes economic actor in its own rights and proactives to pursue technology transfer opportunities for financial gain after Bayh-Dole Act in 1998 [25]. The government has encouraged university to play an active role in fostering technology commercialization which involves licensing of inventions [26] or academic entrepreneurship [27]. Academic faculty can become entrepreneur or receive the right to become shareholder in the academic spin-off [28]. This third mission of the university brings the business behaviors and firm-like decision making [29]. While the research results of R&D collaboration are jointly owned as the patents, one party must obtain counterparty's consent to dispose of the patents by the nature of co-ownership. Any party is capable to obstruct the practical application of joint-research results by simply asserting its rights [30]. Firm may perceive the risks of competing business from academic spin-off or technology transfer to competitors [31].

Interdisciplinary innovation is an exploratory process through pooling different and distant knowledge domain. It is almost impossible to specify all efforts and predict final results in advance [32]. The nature of divergence and dynamic change of R&D progress would make the objectives or the scope of joint-research project which had ever agreed on between the partners gradually changed, modified or extended [14]. Meanwhile, the uncertainties in interorganizational and interdisciplinary collaboration make it difficult to evaluate counterparty's intentions. Once one of the collaborators perceives exchange risks and moral hazards, the interactions may be cut down and the collaboration may break down.

2.2. Cognitive Distance

Even if the motivations and objects between the collaborators are overlapped or well aligned, some challenges still exist in the collaboration since firm and faculty usually aim at more ambitious target such as the technological frontier, novel technological fields or radical innovation [33]. The interdisciplinary collaboration from distant knowledge domain will provide new insights for breakthrough innovation [34]. However, integrating various sources of practices and expertise requires overcoming obstacles of knowledge embeddedness and tacitness [21]. As higher cognitive distance, there is an increasing novelty value but at the same time low level of mutual understanding may lead to unproductive frictions and conflicts [35].

Due to institutional heterogeneity, academic researchers in the university and R&D engineers in the industry may have different mindsets in ways of doing things. Academia focusing on basic research rather than on applied research presents a greater cognitive distance from industry [36]. It holds the problem of communicability since the two parties lack a common ground of expertises, experiences and skills enabling them to speak a mutual understandable language. The more novelty the joint-research project aims at, the greater is likely to be the amount of random trial and error from the full use of all knowledge sets [37]. Large cognitive distance may lead to conflicts and frictions in trial selection and diminish the possibility to efficiently identify valuable solution. This would slow or possibly halt the progress of the joint-research project and ultimately the collaboration may break down due to the accumulation of inefficient and disharmonic coordination.

Small cognitive distance allows comprehensibility but yields redundant knowledge since partners have similar

perceptions, interpretations and evaluations [38]. Certain degree of cognitive distance between the collaborators creates the advantages in knowledge pooling and the development of new and unexpected ideas [39]. The cognitive distance yields an opportunity for innovation as well as acts as the obstacle against interorganizational and interdisciplinary collaboration. Dissimilarity of norms and knowledge may constrain the collaborators' abilities to effectively combine the resources and knowledge they bring to the table, to synchronize their actions, and to realize the expected payoffs [40].

2.3. Collaborative Sensemaking

The sensemaking can be characterized as continuous effort to understand ambiguous and uncertain context that may involve the individuals, objects, places, and events. The sensemaking usually occurs when individuals face an unfamiliar problem or situation. It is a process of overcoming knowledge gaps that prevents people from moving forward in a time-space situation [22]. During the sensemaking processes, individuals search for appropriate knowledge structures and try to fit available data or information to the knowledge structures. The sensemaking process can be characterized as the interplay of searching for information, creating explicit representations of problem, organizing and encoding information to overcome the obstacles. The sensemaking can occur at the individual level as well as the group level. The sensemaking process that involves a group of people get together to collectively engage in making sense of chaotic and ambiguous situation and reach consensus on possible course of actions is known as collaborative sensemaking. It is important in interorganizational relationship and enable collaborators with different experiences and ways of operating to jointly develop common understandings [41]. The industry-academia collaboration requires a diverse group of people with different backgrounds to develop a shared understanding of the context, make sense of the problems collaboratively and make group decisions about actions to be taken. Collaborative sensemaking enables collaborators to jointly specify what data and information are important and how these should be interpreted and enhances organizational innovativeness by coping with uncertainty and knowledge accumulation [42].

3. Methodology

The complexity and limited understanding of the development of R&D partnership between firm and academia, where the collaborators have different institutional logic and dissimilar background knowledge, suggests that in-depth interview and observation approach of qualitative methodology would be valuable to explore emergent concept and develop theoretical framework [43]. We adopt the longitudinal case study design to explore the processes underpinning the evolution of R&D partnership of an industry-academia collaboration that have lasted for 6 years. There was no prior collaboration between focal firm and it's academic partner to avoid influence from prior collaborative experience identified by literature to enhance trust [44] or reduce coordination costs [16].

3.1. Case Background

The biomedical sector is underpinned by accumulation of knowledge and new innovations. The participants of biomedical innovation must deal with a higher rate of unpredictability of tasks to be accomplished and research outcomes [45]. We studied an interdisciplinary industry-academia collaboration which consisted of R&D engineers at firm in the optical-electronic industry and academic research team at university in the biological field. The focal firm planned to diversify into biomedical sector to pursue next growth opportunity based on its existing optical-electronic knowledge and experiences. The faculty at one of top universities in Taiwan happened to have an idea to utilize optical method for developing medical device of the "Point of Care Test (POCT)" which has been limited by electrochemistry method for a long time. However the expertise of faculty's research team was clinical pathology especially in hematology and they didn't have the experiences about product development of medical device. The two parties had complementary expertise so that they hit it off and started a formal joint-research collaboration.

R&D engineers and academic researchers worked in the same city. The budget of joint-research project was totally funded by focal firm. Considering both parties were not familiar with each other before the collaboration and the joint-research project was full of uncertainties, the contract was just for one year and the renewal depended on the willingness of the two parties. Due to the satisfying outcomes of every one-year collaboration, both parties have sustained the R&D partnership from January in 2014 to December 2019. The efforts of the two parties were converged to figure out a novel medical device of POCT. Three inventive patents and one design patent were applied to US, China and Taiwan. One domestic and two international journal papers were published. The six-year ongoing collaboration lets us had chance to observe its operation and development of R&D partnership.

3.2. Data Collection and Analysis

Face-to-face interviews with key informants were semi-structured to ensure that we covered the same issues in each interview but still allowed for emergent topics. Interviews were conducted in Chinese (local language) and each interview lasted for approximately 60–120 minutes. Key informants included managers responsible for the management of the joint-research project, and engineers who had executed the specific tasks in the collaboration. Each informant was interviewed in private and independently. The informants had the willingness to share more information when we promised that the raw materials (audio recordings and transcripts) were only for authors' study.

We performed the triangulation using information from relevant written documents (e.g., experiment reports, meeting minutes or contract) and directly observation in project meetings, R&D activities and interactions [46]. This study generated the noticeable results by observing the individual and group activities across the focal firm and faculty's research team. The data was coded, recoded and grouped by the emerging themes. Iterative analyses

allowed further categorization of data by the subthemes derived from the main themes [47].

4. Findings

The motivation of the focal firm to engage in industry-academia collaboration was to acquire new technology and buildup R&D capabilities for business diversification. The faculty not only intended to secure stable research funding but also pursued new inventions which were fundamental to science and practical to society. R&D engineers were responsible for the development of optical-electronic measurement system based on the requirement from the faculty's research team. The faculty's research team focused on the hematology methodology, the reagent modification, the micro-channel strip development and clinical test. Both parties aimed at exploring a novel detection method through pooling their skills, experiences and complementary knowledge.

1st stage: prevent and control moral hazards

Considering the interdisciplinary collaboration which knowledge domain was far from R&D engineers' existed knowledge base, the focal firm decided to start the joint-research project from short-term and small scale to let both parties got familiar with each other and evaluate whether this partnership can benefit each other or not. The period of the collaboration was just for one year and the renewal depended on the willingness of two parties.

The focal firm though it was necessary to establish mutual trust. Contracting formally was a good starting point to signal mutual commitment and create trust for the two parties who didn't know each other well before. Project management, payments, milestones, deliverables, dispute resolution, confidentiality, ownership of the intellectual property (IP), were crucial contractual terms to complement trust-building behavior and make the collaboration work solidly. The contract also included the clauses that obliged the faculty's research team not to collaborate with the competitors during the period of the joint-research project and tree years after the collaboration termination to appease the concerns from focal firm's competitiveness.

Both firm and university attached importance to the value of the IP and it took much time to discuss the co-ownership of the patents from the results of joint-research project. To prevent disputes, the clauses about IP rights were much more specific to clarify the scope of foreground and background patents and leave less room to misinterpret the co-ownership of new patents. What the focal firm mostly concerned was the competitiveness once university licensed the right of co-own patents to its competitors or if some of the faculty's research team set up competing business since technology transfer office in the university aggressively encouraged academic spin-off. At first, there had ever been a little misunderstanding when the master students of faculty's research team attended an academic entrepreneurship competition. This event initiated a deeply discussion about self-interests and mutual interests among firm, faculty, and university. They finally realized the agreement that the company had priority to acquire the full right of co-own patents with favorable transfer fee and the focal firm had three years to make decision after project closeout or termination.

Since scientific publication in high ranking biomedical journals was also important marketing strategy to launch a new product in the medical device industry, the focal firm encouraged the scientific publication but the scope of disclosure should be negotiated with firm to meet mutual interests and this term was specified in the contract of the collaboration. The focal firm clearly expressed its targets and simultaneously gave space to the academic partners. The reciprocity between the two parties was based on mutual trust.

The progress meeting and reports were the main tools to measure participants' involvement and commitment. Midterm reports accompanied with milestone payments were used to formally control the outputs of the joint-research project to meet the original objectives which had been mutually agreed by the two parties. The partial scope of the joint-research project was also the master student's research topic for his master's degree. Joint supervision of the master's thesis by faculty and R&D director at firm was one of the means to ensure that the joint-research results simultaneously met the academic and industrial requirements.

2nd stage: bridge cognitive distance

The joint-research between focal firm and faculty's research team aimed at exploring a novel measurement method through pooling their skills, experiences and complementary knowledge. Since neither of them had the prior experiences on medical device development, it was difficult for them to plan all tasks in detail and foresee the outcomes in advance. The process of new technology exploration was full of uncertainties and new problems to be solved by joint efforts. Faculty's research team was used to present the clinical experiment results with biological terminology, the abbreviated form or even the nickname which R&D engineers with optical-electronic background were not familiar with. One of R&D engineer said that *"It's hard for me to know what to do when faculty's description was full of pharmaceutical and clinical terminology, even the nickname of experiment equipment which was I never heard." "It took us much time to inquire the meaning of these terminology."* Without the overlapping of knowledge domains, the two parties lacked common language and shared meaning to effectively and efficiently coordinate their tasks. Task uncertainty and complex task interdependence made the coordination failures such as misallocation of resources and overlook of crucial activities.

The conflicts often happened when the two parties reviewed experiment results from different perspectives. The faculty' research team was not familiar with the optical-electronic principle and was usually suspicious of the accuracy of measurement system when the experiment failed. The R&D engineers had confidence in their design and questioned the validity of reagent or micro-channel strips. The two parties got frustrated with the unproductive discussion. The engineering training made R&D engineers perform their work step by step with a clear causal relationship. However, the discovery experiences made

academic researchers sometimes design the experiment just based on intuition and sometimes directly move to next step with leaving the problems behind. The cognitive distance between the two parties not only came from the heterogeneity in knowledge domains but also came from the different working style between engineers in industry and scientists in academe.

For moving the progress of the joint-research project forward and expanding the internal R&D capabilities to biomedical field, the focal firm finally hired two graduates with biomedical background in the mid-term of the collaboration. A project manager (PM) in the focal firm was fully designated to facilitate the rich knowledge and information exchange for solving problems and conflicts. The PM helped R&D engineers to obtain the necessary information by translating clinical requirement to optical-electronic specifications. Thus, the R&D engineers could modified the measurement system to meet faculty's needs. She also carefully explained the design of measurement system to faculty's research team in order to avoid misuse, misunderstanding and unrealistic expectations.

The frequency of face-to-face meeting was increased to make sure the two parties have sufficient time to discuss the failures thoroughly by sufficiently exchanging the domain knowledge and personal experiences. The format of experiment and project reports was also standardized to enforce the detail and complete information disclosed and archived. The free IT-platform "Google Drive" was implemented to be an interorganizational information system to facilitate sufficient knowledge and information exchange across the two parties. It ensured the two parties simultaneously to access the same information and share knowledge which could be documented and archived such as experiment reports, project reports, meeting minutes, journal papers, e-books and regulation documents. The function of group discussion in Instant Messaging (IM) - Line was used to inform the issue, exchange first-hand information and adjust the sequence of tasks.

The two new employees with biomedical background worked in the faculty's laboratory to carry out some clinical experiments but reported to the focal firm, so exiting R&D engineers with optical-electronic background could learn biomedical knowledge from new colleagues. Higher frequency of the online and offline communication enabled the two parties to understand the counterparty's capability, expectation, and ways of doing thing and thus reduce the conflicts and coordination loss. The PM and communication tools, as conduit across the professional and organizational settings, bridged the cognitive distance between two parties and facilitated effective coordination.

3th stage: build collaborative sensemaking

The PM and R&D engineers participated in clinical training at the faculty's laboratory to learn the operation of clinical instruments and setup a biomedical laboratory in the R&D center. They also openly shared the experience and skills of the optoelectronic product design with the academic researchers for jointly transforming the concept of new detection method to the producible medical device. The exploration process to develop novel medical product was full of random trial and error and new problems came one after another continually. With adequate exchange of the biomedical and optical-electronic knowledge, the two parties finally could investigate the experiment failures thoroughly, negotiate how much adjustment to join up their efforts and make decision efficiently. The two parties further attended the training course of the medical device regulation together and then jointly planned the product development plan through their common knowledge and information to comply the medical device regulation.

Trustworthiness between the two parties was built through the co-planning, negotiation, shared vision and appreciation of the contributed value. As the satisfying and productive results were accumulated, both parties increased the willingness to continue the collaboration, exchange more tacit knowledge, share more experiences and contribute more efforts to realize the goal of the collaboration. The project team between focal firm and academic researchers worked cooperatively to solve the complex technical issues and brought different experience and expertise towards a shared understanding about the new technology field resulted from the combination of biological and optical-electronic field. The two parties continually come up with many new ideas for new patent application and inspired themselves new research agenda for further development of new products.

5. Discussion

It is imperative for actors in collaboration to enforce partners to jointly pursuit of agreed-on goals and reducing behavioral uncertainty in the interorganizational and interdisciplinary collaboration. The firm and university have individual objectives (academia pursues scientific publication and firm aims at the commercialization of new technology) and common objectives (creating impact to economic and society). The firm should figure out the complementarity of interest which is sufficient to benefit either party. Psychological contract, as the implicit understanding of the mutual obligations under mutual beneficial relationship, is a set of unwritten perceptions including reciprocal promises and obligations. It plays an important role in binding partners to some action for implicit and/or explicit promises of future exchange.

When the collective action is executed in a reciprocal fashion, partners will continue or expand their mutual commitments. Joint accomplishments can create a feeling of strategic interdependence and anticipation of great gains in the future. Industry-academia collaboration may involve the disclosure of the sensitive or confidential information and tacit knowledge. Not all of information and knowledge can be safeguarded by the legal contract. Explicit trust development activities should be undertaken at the launch of the collaboration instead of allowing it implicitly developing as time passes, it is also necessary to monitor how trust increases over time. When collaborators trust each other, they can focus on the R&D challenges at hand instead of devoting precious time and efforts to haggling over rights to potential inventions or on the process for dealing with unexpected issues. The mutual trust from psychological contract increases collaborators' willingness to work together continually and promotes their commitment to pursue the common goals. Written agreement from legal contract and mutual trust from

psychological contract are complementary in industry-academia collaboration. The safeguard of legal contract makes actors dare to initiate a new collaboration with minimization of loss but trustworthy partnership facilitates actors to complete a collaboration with maximization of gain.

Certain degree of cognitive distance between partners in R&D collaboration creates advantages in knowledge pooling and the development of new and unexpected ideas. Cognitive distance between partners can be crossed, bridged and overcome by the sufficient exchange of knowledge and information which entails a mapping from one's cognitive range to another's cognitive domain. For dealing with uncertain and interdependent tasks, actors require rich, fast and responsive communication to help them understand status and counter party's activities for adjusting their actions in response. Face-to-face meeting, mutual training, in-depth discussion and jointly decision-making would facilitate the transfer of knowledge and increase comprehension on counterparty's capabilities, expectations, and ways of doing things. The means to bridge cognitive distance involves the policy, rule, tool and platform of information-sharing and decision-making.

Recipient's capacity to deal with information loads and assimilate the new knowledge is also the key issue to achieve effective mutual understanding and coordination. It implies that the organization's investment in internal knowledge capital. More diversity of knowledge sets will enable organization to effectively identify, assimilate, transform and apply the newly acquired knowledge. Organizational absorptive capacity may increase through the accumulation of new knowledge, new skills and new experiences and thereby cognitive distance between partners is gradually reduced along with the progress of the collaboration.

Collaborative sensemaking occurs when a group of people with diverse background engage in the process of making sense of information rich, complex and dynamic situations. The process of collaborative sensemaking is often triggered by a host of problems to address, including issues of common ground, communication, hand-offs, and coordination. It is addressed in the context of group interactions within the rich and complex information. The process of collaborative sensemaking should be supported by providing collaborators' capability to infer some idea of what they have, what they want, why they can't get it, and why it may not be worth getting in the first place. Fundamental activities that are crucial to collaborative sensemaking process include constructing and sharing knowledge as well as developing shared understanding and communication. To ensure sufficient interaction among collaborators that is geared towards reaching consensus and achieving collaborative sensemaking, there should be adequate support for facilitating and moderating interactions. Along with mutual trust (prevent moral hazards) and adequate overlapping of knowledge (bridge cognitive distance), collaborators can jointly manage the task interdependence and fully negotiate how much alignment as well as how much adjustment each party undertakes to ensure their efforts "click" and yield the desired outcomes with minimal losses. Both parties are able to share frames of reference and understand when they interactively make sense of the sought information that is fragmented and messy. The process of collaborative sensemaking gives facts and experiences meaning, making the underlying information more salient. Collaborative sensemaking could entail innovation by joint learning about how to coordinate work in the collaboration and joint learning in how to present and instantiate the context that does not yet exist. A conceptual framework was proposed as Figure 1 to illustrate the dynamics of R&D partnership development in an interorganizational and interdisciplinary collaboration.

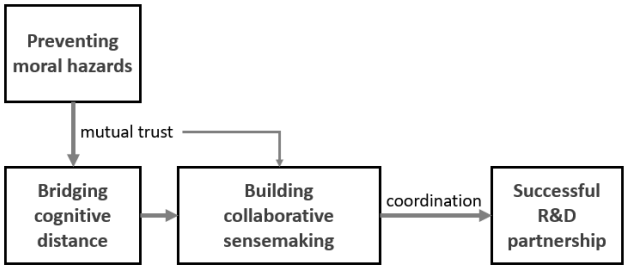

Figure 1. A conceptual framework of R&D collaboration management to develop successful R&D partnership between industry and academia

6. Conclusion

Instead of a snapshot investigation, we focus on the dynamics of the R&D partnership development during the period of the collaboration. R&D partnership in industry-academia collaboration establishes a bidirectional linkage to enable the diffusion of knowledge, creativity, skills and individuals with the aim of creating mutual value. The uncertainty in the exploratory process of interdisciplinary collaboration makes it practically impossible to establish a full set of rules for resolving future problems and conflicts. Moral hazards from the different institutional logic may lead to collaboration breakdown. Legal contract is a good starting point to signal mutual commitment and create trust. It prevents immoral behaviors and enforces the partners to fulfill their commitment. Mutual beneficial outcomes can signal promised benefits and required contributions in a win-win collaboration. It fuels the partners' morale and commitment.

There is a trade-off between the advantage of learning and innovation by pooling the heterogeneous knowledge from the collaborators and the disadvantage of low mutual understanding which make it difficult to deal with the highly interdependent tasks. The process of knowledge exchange is complex. Knowledge exchange routines are not sufficient to guarantee that the firm will benefit from it. Firm must develop optimal absorptive capacity to deal with the highest cognitive distance without deficits in understanding. With adequate overlap in knowledge base and common language, collaborators can jointly manage task interdependence and fully discuss how to integrate their efforts with minimal cost and loss.

The collaborative sensemaking is important when the collaborators are facing the complex situations which require team to cooperatively make sense of the problems and identify a solution. Group of people making sense of complicated and dynamic information, must coordinate not just their information sharing but also their intents,

their interpretations, and revisions of past experiences, information and knowledge based on newly arriving information. The collaboration mechanisms developed to reducing moral hazards and bridging cognitive distance will sustain the collaborative sensemaking. The collaborative sensemaking of complex information and dynamic situations make collaborators to perform specific work, coordinate mutual actions, make adjustment to technological changes, and reduce behavioral uncertainty.

The open innovation system, especially collaboration between industry and academia has been attracting considerable attention worldwide. We pay more attention to the operation of industry-academia collaboration especially for the interdisciplinary innovation. Our findings clarify potential challenges that corporate managers may encounter. We propose that creating a joint-research project with sufficient strategic interests to ensure counterparty's buy in at the highest level, strengthening in-house R&D capabilities through adequate investment in the organizational learning and building the collaborative sensemaking to overcome the uncertainty and problems in the technology exploration is crucial for a successful R&D collaboration.

Key successful factors such as trust, commitment and coordination have been shown in the literatures to be important to collaboration success. However, the dynamics or process of the development of these factors are seldomly further investigated. Via a longitudinal study, this paper would contribute to demonstrate new potential for combing different strands of theories to explore the development of R&D partnership in interorganizational and interdisciplinary collaboration. A means of systematically improving collaboration management practice (reducing moral hazards, bridging cognitive distance and building collaborative sensemaking) constitute a new contribution to the body of knowledge regarding the effective management of the industry-academia collaboration.

Limitation of this study is the under-investigation of the collaboration which had broken down. The investigation of the unsuccessful collaboration might provide further interesting insights. However, when analyzing the failures, it is necessary to distinguish if the data is distorted by emotion or personal bias and it may be difficult to study ongoing collaboration by observation. Further research will address limitations to provide more comprehensive insights.

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