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When Opposites Attract?

- Cultural Diversity and Innovation Performance in R&D Collaboration -

최상의 결과를 이끌어내는 다양성의 정도 -

연구개발팀의 문화다양성과 혁신성과

2023 년 7 월

서울대학교 경영대학원

경영학과 경영학전공

찬원치에

When Opposites Attract?

- Cultural Diversity and Innovation Performance in R&D Collaboration -

지도 교수 송 재 용

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찬원치에의 경영학 석사 학위논문을 인준함

2023 년 7 월

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Abstract

Difficulties associated with team diversity tend to be particularly salient in international R&D collaboration. There is still a lack of consensus and limited understanding on the innovation performance of culturally diverse team. I examine the impact of cultural diversity on an R&D team's innovative outcomes and under what conditions cultural diversity facilitate and impede their innovation performance. I propose that the cultural diversity of an R&D team has a curvilinear relationship with the team's innovation performance. By analyzing the U.S. patent data from the global pharmaceutical industry over the period from 1995 to 2014, I find the team's cultural diversity not only enhance but also hinder their innovation performance. Where the culturally diverse inventors of the R&D team have more common language and less experience of prior collaboration enjoy the optimal innovation performance. These findings suggest that organizations' manager should consider the appropriate design of the team composition to benefit from demographic heterogeneity and avoid potential conflict associated with diversity.

Keyword: cultural diversity, common language, prior collaborative experience, innovation performance, team composition

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1. Introduction

A growing body of literature reveals how the overall design of collaborative teams within multinational corporations (MNCs) is correlated of innovation outcomes (Guler & Nerkar, 2012; Lazer & Friedman, 2007; Seo, Kang, & Song, 2020), especially in knowledge-based industries within MNCs (Khanna, 2021). The fundamental challenge for MNCs is how to generate synergies and sustain competitive advantage by operating diverse knowledge from their global research and development (R&D) subsidiaries concerning the knowledge generation, knowledge flow, and innovation outcomes (Nobel & Birkinshaw, 1998; Govindarajan & Gupta, 2001; Kogut & Zander, 1992; Mors, 2009; Bartlett & Ghoshal, 1989; Westney & Zaheer, 2008; Barsh, Capozzi, & Davidson, 2008). In the strategic management literature, an extensive body of research on multicountry knowledge generation within MNCs has focused on the dispersed knowledge management from their global R&D subsidiaries, i.e., how to integrate and transfer knowledge across geographical distances (Szulanski, 1996; Teece, 1977). In spite of the increasing interests in understanding the collaborative effectiveness of research teams (Von Zedtwitz & Gassmann, 2002), extant research still provided limited evidence on the design and effective implementation of R&D configurations at teams' attributes or characteristics level (Seo et al., 2020).

Cultural diversity is a salient factor which plays a crucial role on the performance of international collaboration. Cultural diversity refers to origin or country-based culture (Earley & Mosakowski, 2000). Existing studies still provide contradictive consequences of cultural diversity for innovation performance (Horwitz & Horwitz, 2007; Reagans & Zuckerman, 2001; Hajro, Gibson, & Pudelko, 2017; Pieterse, Knippenberg, & Dierendonck, 2013; Stahl et al., 2010) because cultural diversity not only facilitates creativity and knowledge generation but also impedes communication and efficiency among teams (Hofstede, 1986; Zhan et al., 2015). On the

other hand, international business literature has recognized that language difference among members of collaborative teams within MNCs impedes the effectiveness of their knowledge management and value creation (Peltokorpi & Vaara, 2014; Welch & Welch, 2019). The stream of research has neglected the role of language as a strategic choice at the team level such as multinational R&D teams (Tenzer, Pudelko, & Zellmer-bruhn, 2021).

Given this limited understanding of the R&D collaboration within MNCs, the paper aims to answer the question of when and under what conditions cultural diversity of an R&D team enhance or hamper innovation outcomes. The more origins the R&D team members come from, the more inefficient in transferring the knowledge. It still remains ambiguous what the effect of cultural diversity in R&D teams' processes and outcomes. To address such inherent tension between the positive and negative consequences of cultural diversity for innovation performance, it is necessary to develop a better framework for understanding the role of cultural diversity in an R&D team within MNCs.

In this paper, I analyze when and under what conditions cultural diversity of an R&D team facilitate or impede innovation performance. Based on previous literature related to the organizational learning theory, resource-based view and knowledge-based view of the firm, I argue that cultural diversity of an R&D team can both enhance and hinder knowledge transferring on the cross-border collaborative process within MNC, thus impact their innovation performance. Specifically, the maximum effect of cultural diversity on innovation outcomes will occur when an R&D team has the moderate level of cultural diversity. Moreover, the role of the common language and the prior collaborative experience among team members can moderate their curvilinear relationship.

By leveraging the patent data granted by top pharmaceutical MNCs during the period between 1995 and 2014, I examine when

and under what conditions cultural diversity of an R&D team enhances or hinders innovation outcomes. I conduct my analyses at the patent level as the patent data retrieved from PatentsView database shown detailed information of each inventor listed in the patent. In the final stage of the sampling, 936 observations with 3,630 inventors, including 1,825 unique inventors without repetition, were developed in my study. Regression results are corresponding with my arguments, suggesting there is an inverted U-shaped relationship between the cultural diversity and innovation performance but strengthened by the common language and weakened by the prior collaboration.

The paper clarifies when and under what condition, the role of cultural diversity on an R&D team could most effectively affect cross border knowledge transfer and innovation outcomes within units. The impact of cultural diversity on innovation performance increases when team members all have the common language, but decreases with the frequency of the prior collaboration among members. The results of my study shed new light on the determinants of international R&D teams' innovative performance by identifying the role of cultural diversity, the usage of the common language and prior collaborative experiences among team members.

2. Theory and Hypotheses

2.1. Cultural diversity and innovation performance

Does cultural diversity matter? Cultural diversity in teams can be both an asset and a liability (Stahl et al. 2010). Cultural diversity, general known as nationally/ethnically diversity (Staples and Zhao, 2006; Thomas, 1999; Vodosek, 2007). In this paper, however, I define the cultural diversity of each inventor listed on the patent based on his/her name of origin, rather than his/her country of birth (Nathan and Lee, 2013). This approach is chosen because

nationality can be changed, and other cultural experiences may influence their behavior and values. Cultural refers to different values or divergent communication styles (Winkler and Bouncken, 2011). Different cultural backgrounds of an R&D team' s members affect their behavior. Knowledge embedded in the interactions of people has been seen as a key driver for innovations within firms. Innovation performance are fundamentally derived from processes of sourcing diverse knowledge and the knowledge sourced integration (Seo, Kang & Song 2020). It is important to maintain the access to diverse knowledge sources for R&D teams to achieve sustainable novel and valuable innovations.

As noted in the Gruenfeld et al. (1996), the success of knowledge transfer through moving people from a unit to another, depending on social influence processes. (Argote and Ingram, 2000). According to social identify, social categorization theory (Turner et al., 1987; Tajfel, 1981), individuals prefer to interact with people who has common in several attributes, such as cultural, ethnic, or educational background, and may further categorize others as outsiders or part of other groups. Cultural values and attitudes refer to cognitive styles, working patterns, personal interaction, coordination of task, all are influential on innovation performance (Winkler & Bouncken, 2011). Through social interactions with other team members, R&D team members' cultural values might also change. Integrating diverse knowledge resources is often seen as significant driver of innovative outcomes. MNCs can gain the diverse knowledge from their global teams and then recombined it with existing knowledge to develop its capabilities (Penner-Hahn and Shaver, 2005; Singh, 2005), through a multicountry collaboration (Berry, 2014). Diverse teams have greater absorptive capabilities to integrate new knowledge and apply it to generate novel ideas than homogeneous groups (Cohen and Levinthal, 1990), thus stimulating creativity and innovation (Backmann et al., 2020).

Resource alignment and coalignment issues are crucial for the context of innovation (Teece, 2007). Culture diversity can help firms engaged in cross-border business to overcome organizational inertia, develop unique and valuable resources and capabilities, and stimulate organizational learning and innovation outcomes (Morosini, Shane and Singh, 1998; Berkema & Vermeulen, 1997). Economic theory suggests that the effects of diversity on business performance are ambiguous. Culturally diverse teams may be better at generating new ideas or solving problems, particularly in knowledge-intensive environments (Fujita & Weber 2003), for example, Elron (1997) found that while national cultural diversity may increase conflict, it is positively related to overall team and subsidiary performance. On the other hand, diverse organizations may face higher communication and coordination costs and lower trust, and ultimately hindering innovation (Alesina & La Ferrara, 2004).

Based on the resource-based view of the firm (Barney, 1991) and organizational learning theory (Levinthal and March, 1993), the differences in knowledge structures can be a key source of synergistic benefits for global organizations. With respect to technologies, R&D activity can be seen as a form of 'search' for new products and processes (Teece 2007). Prior evidences suggest that diversity, while often hindering exploitation --refers to the use of existing knowledge, efficiency, and implementation, but may be beneficial for exploration—refers to the pursuit and acquisition or discovery of new knowledge (e.g., Cantwell & Mudambi, 2005; Gibson & Birkinshaw, 2004; Stahl & Tung, 2015, Gupta, Smith, and Shalley 2006). However, both exploration and exploitation are important for R&D teams' innovation process. Moreover, knowledge-based resources depend upon large numbers of people or teams engaged in coordinated, creative action providing a firm a competitive advantage because such rare and valuable resources are difficult for competitors to imitate and substitute (Barney, 1991). The ability to transfer knowledge from

one unit to another can contribute to the organizational performance of firms (Argote and Ingram 2000).

Culture diversity has also been identified as a key influence on operational management, where the need to adjust to a different cultural background and to the routines of a foreign partner is a daunting task and an obstruction to performance (Kogut and Singh, 1988; O' grady and Lane, 1996). The R&D team members within cultural difference allows firms to have better access to the international market and legal information necessary to adapt local market needs and meet competitive challenges (Richard 2000; Winkler & Bouncken, 2011). Culturally diverse R&D teams can have better and more creative ideas by integrating different viewpoints and recombing the diverse knowledge of international markets than those non-culturally diverse teams. For instance, Cox, McLeod & Lobel (1991) show that teams with ethnic diversity generate higher quality ideas in brainstorming tasks than homogeneous groups.

On the other hand, the higher cultural difference still contributes higher and coordination and commitment problem (Jehn, Northcraft, and Neal, 1999). Negative effect of cultural diversity on the teams' collaboration such as coordination conflicts in the beginning of the process that can delay the innovation outcomes (Winkler and Bouncken, 2011), but such negative effect can weaken over time and thus even change into a positive outcome until certain time (i.e., at the moderate level). However, because the more cultural diversity, the higher communication and coordination costs and lower trust, the effect of the cultural diversity will turn to hinder innovation outcomes. Therefore, I hypothesize as follows.

Hypothesis 1: The level of cultural diversity in an international R&D team has an inverted-U-shaped relationship with its innovation performance.

2.2. The moderating role of a common language

Common language refers to an interpretive tool in the cross-border collaboration (Neeley, 2013). Traditional perspective suggest that language is embedded within the construct of cultural distance (Kogut & Singh, 1988). Individuals interact and make interpretations within their cultural and linguistic context (Von Glinow et al., 2004). Cultural diversity, however, may facilitate or impede internal interaction and coordination (Stahl et al., 2010a; Stahl, Maznevski, Voigt & Jonsen, 2010b), whereas language diversity has only negative effect on communication (Harzing et al., 2011). In this view, language should be taken "out of the 'culture box" because this distinctive effect on the teams' collaboration (Welch & welch, 2008).

Language as a social category shapes people's self-concept. Employees feel a stronger connection to those who are a part of their linguistic ingroup and a weaker one with those of their linguistic outgroup. MNCs are a multi-lingual environment and every MNC may experience a language barrier when collaborating with workers who from country that do not share its home country language (Harzing & Pudelko, 2013; Luo & Shenkar, 2006). Effective coordination within MNCs is a basis to better manage the knowledge transfer cross border (Argote and Ingram, 2000). Language similarity or the use of the common language among members can be a key driver for knowledge transfer process among MNCs, which can shape collaborative processes, information exchange, global coordination, and intra-corporate value creation (Luo and Shenkar, 2006). Thus, an appropriate language design (i.e., common language) is crucial for diverse R&D teams within MNCs because it can facilitate inventors' motivation for willing to present creative ideas (Wiseman and Shuter, 1994; Zaidman, 2001), especially when there is a need for cross-border knowledge integration.

The resource dependence logic is that an organization's

dependency on its internal (home country) resources buffers its dependency on external (host country) resources. When resource sharing within a globally diversified MNC is a must, a common language that can stimulate internal communications is critical to decrease negative effect derived from cultural diversity (Zaidman, 2001). Specifically, language differences can also have an impact on conflict management in cross-cultural teams (Von Glinow et al., 2004), knowledge transfer and diffusion (Ghoshal and Nohria, 1989), and the efficiency of the multicountry collaboration (Govindarajan and Gupta, 2001). Following on this logic, the common language can increase effectiveness of knowledge sharing cross-border collaboration by overcoming misunderstandings, reducing costs and creating a sense of belonging and cohesion within the unit (Marschan-Piekkari et al., 1999a). Thus, the benefits of cultural diversity on performance may be enhanced when the inventors all have the common language in collaborative process.

The use of common language in a R&D team is beneficial for shaping key capabilities in global integration and local adaptation that contribute to innovation performance (Luo and Shenkar 2006). However, the same language used by different cultural background may evolve into different interpretive mode, such as: (1) English native speaker from U.S., England and Australia; (2) formal English taught as a second language and the informal English spoken by native speakers) (Koçak & Puuranam, 2022, p.20). The former group can create more conflict than latter one (Harzing and Feely, 2008). Recent findings by Kang (2022) also point out the existence of heterogeneity of the common language among different cultural-based inventors. Thus, the use of common language in collaborative teams may also strengthen the negative effect of cultural diversity on innovation performance.

Taken together, the use of a common language can affect the relationship between cultural diversity of a R&D team and innovation performance, Specifically, the use of a common language amplifies

the both the negative and positive effect of diversity on the multicountry collaboration within MNCs. Thus, I hypothesize as follows.

> Hypothesis 2: Common language used by members of an R&D. team strengthen the effect of cultural diversity on innovation performance; that is, the more common language used in an R&D team, the steeper the inverted U-shaped curve between cultural diversity and innovation performance.

2.3. The moderating role of prior collaboration

The moderating role of prior collaboration is predicted to be opposite to that of common language. Through prior collaboration with inventors, an R&D team of MNCs can enhance local and distant search as both types of innovation. (March, 1991). The innovation process involved in divergent thinking among culturally diverse inventors and the combination of the diverse knowledge. An R&D team consists of diverse cultures not only impact search behaviors divergently but also contribute to several coordination and commitment challenges. Prior collaboration can enhance the greater similarity among culturally diverse members by facilitating internal knowledge sharing and transferring (Cohen & Levinthal, 1989). In the instance where the culturally diverse teams, prior collaborative experience with other inventors enables them to overcome the initial coordination failure and achieve mutual learning between members over time (March, 1991; Argote & Miron-Spektor, 2011; Kogut & Zander, 1992). Therefore, when culturally diverse team members have the experience collaborating with each other in prior patenting activities, the contradictions rising from different cultural backgrounds weakens.

On the other hand, the higher the frequency of the collaboration with other members, suggesting the R&D team has better to develop their own routines and communicative way to

deliver the knowledge. In the context of the culturally diverse R&D team, in spite of the prior collaboration improves the commitment and coordination challenges among members (Nelson & Winter, 1982), the heuristics may also develop over time. Since the extensive prior interaction with each other can constrain creativity among members due to the progressive familiarity with strategies and heuristics when coping with problems (Argote and Miron-Spektor, 2011). Thus, the higher prior collaborative experience with other members can weaken the positive effect of cultural diversity on collaborative outcomes.

To sum up, prior collaborative experience can hamper creative ideas and divergent knowledge which are required for the innovation processes, but improve the negotiation cost arising from the culturally heterogeneity. The more prior collaboration among inventors within an R&D team, the fewer the both negative and positive effect of cultural diversity on innovation outcomes. Hence, I propose:

> Hypothesis 3: The degree of repeated collaboration weakens the effect of cultural diversity on the innovation performance; that is, the higher the degree of an R&D team repeated collaboration, the flatter the inverted U-shaped curve between cultural diversity and innovation performance.

3. Methods

3.1. Data and Sample

To test the hypotheses, I use the data from the PatentsView database as it retrieved from the United States Patent and Trademark Office (USPTO). Since patent documents provide detailed information of inventors within the R&D team for analyzing firms' innovative activities and have been extensively used as a

criterion of innovation performance (Sampson, 2007; Seo, Kang, & Song, 2020; Boone et al, 2018). I collect and analyze patents registered by top pharmaceutical MNCs during the period between 1995 and 2014. The reasons I chose pharmaceutical industry are as follows. Firstly, pharmaceutical industry is belonging to the high technology-intensive area, where relevant knowledge is both highly localized and distributed worldwide (Khanna, 2021; Castellani, Perri, & Scalera, 2022; Cockburn & Griliches, 1988; Jaffe, 1986). Secondly, patents registered by the pharmaceutical firms represent most part of the innovations in the industry (80%) compared to other industries (Arundel & Kabla, 1998). Therefore, the pharmaceutical industry is the most ideal testing room for my framework.

I conduct my regression analysis at the patent level, regarding inventors listed in a granted patent as a successful invention and a research unit. The final sample used in this empirical setting is identified as follows. First, I chose the top 5 pharmaceutical firms in 2015 according to the ranking from *Pharmaceutical Executive*, a digital and print magazine offering commercial insights for pharmaceutical and biopharmaceutical executives. At the initial stage of the sampling results, the dataset contains 16,420 inventions over a 20-years period granted by Novartis AG, Pfizer Inc., Roche, Sanofi, Merck & Co. I first identified the focal patent during the 2000 to 2005 based on its granted date as it means the invention has been admitted by the patent office. I constrained the focal period between 2000 and 2005 due to the increasing presence of immigrants around the United States, as well as the shift towards more diverse inventor origins based on their names listed on the patent, following Foley & Kerr (2013) approach.

On the other hand, to well capture the prior collaboration of an R&D team, I took at the initial application date of the focal patents in a 5-year window. Using the patent data based on its application date allows me to capture the early stage of the invention and the factors

that contribute to its collaborative process. Since the measurement on patent applications are a more comprehensive indicator of the presence of the R&D activities than granted patent, as the latter ignore collaborative efforts and inventions that finally do not result in grants. Regarding the innovation performance, however, the granted date is most appropriate for the measurement, as it represents the patent actually granted by the USPTO or other patent office, enabling us to track the legal protection of the invention.

The final estimation sample contains observations from 1995 to 2014. This yielded a total of 936 patents including 3,630 inventors in global pharmaceutical firms.

3.2. Dependent Variable

I use the number of forward citations that each patent has been cited in the first 10 years after the granted date to measure the innovation performance. Instead of the application date, the granted date of the patent means the commercial success of the invention, since not all patent applications contribute to granted patents, despite using the granted date may lead to some delays, because of it can take several years for a patent to be granted.

3.3. Explanatory Variables

Cultural diversity. The PatentsView database provides each inventor's information, including first name, last name, gender and residence. To measure the cultural diversity of the team, I follow the recent approach of Jung, Lee, & Park (2021) and Santamaria & Mihaljevic (2018). I first collect each inventor's first name and last name and identify each name respectively to obtain the data of their origin by using NamSor(https://www.namsor.com/), which offers individuals' first name and last name, enabling me to indicate their

probable ethnic/origin background. Following the prior research (Seo er al., 2020), I use the Blau index of diversity to measure cultural diversity in my study, as follows:

$\boxed{Diversity_i = 1 - \sum_{o=1}^{O} P_{io}^2}$, where P_{oi} is the proportion of inventors' origin o in the same team I, and O is the number of origins. Furthermore, concerning about the potential underestimated bias when the team size (i.e., numbers of inventors in each team) is small, I use the following equation to solve this potential problem,

$\boxed{Cultural\ Diversity_i = Diversity_i \times \frac{N}{N-1}}$, where N is the team size (i.e., the number of inventors of the same patent).

Common language. Refers to the degree of the common spoken language among team members. The use of the language by inventors is based on his/her residential country's official language. I first investigated a total of 3630 inventors' residence, and identified his/her country's official language by using the *Central Intelligence Agency (CIA)* (https://www.cia.gov/the-world-factbook/field/languages/) and *Ethnologue Database.* Then I distinguish the patents where the inventors either have the same language or not, and separate them into two sections. Because of the instance where the patent listed inventors who all share the same official language, it implies that there is a common language between team members. Thus, I exclude the team in which all team members use the same language, then I calculate the non-native-English speaking countries' English proficiency by following Kang's approach (2023). I use Education First's English Proficiency Index (EF EPI) to measure the distance of the spoken language among inventors listed in the patent who does not have the common language. The EF EPI index provides five levels (Very high, High, Moderate, Low, and Very low proficiency) of which non-native-English speaking countries. In my sample, there is no very low proficiency' level, thus instead of the index, I included 'native

level' for the native-English speaking countries, (as well as Australia, Canada, England and United States in my sample) to other indexes to identify the difference of the common language used by inventors of the team.

Prior collaboration. I measure the prior collaboration by calculating the number of prior collaborative experiences of each paired inventors on the patent over the past 5 years. I classified paired inventors of the team and then counted the number of prior patenting collaboration of each pair over the backward 5 years from the application date of the focal patent. Prior collaboration of an R&D team is captured by the number of all possible pairs within the team. The measurement of prior collaboration is as follows:

$$Prior\ Collaboration_i = \frac{\sum_{r=1}^{R} Pair_{ir}}{R}$$

, where $Pair_{ir}$ refers to the number of prior experiences of collaboration of paired inventors on the patent **i**, and **R** means the number of all possible pairs in the patent, determined as $\frac{N(N-1)}{N}$.

3.4. Control Variables

To partial out the potential confounding factors related to the effect of cultural diversity and innovation performance, I control for several patent-level control variables in the regression model. First, I control for the team size as the numbers of the inventors on the patent, because the size of the team may lead to underestimation of the effect of cultural diversity on the innovation performance.

Second, prior literature has primarily recognized the geographic diversity among team members impact the internal knowledge transfer and collaborative process (Kogut & Singh, 1988). Thus, I also control for the *geographic distance* to exclude the effect of geographic heterogeneity. Following prior literature (Seo et al., 2020), I also use the Blau index of diversity to identify geographic

distance in my study. Since the PatentViews database provides each inventor's residence at city level and state/country level, I use city level location instead of the state/country level (applied by the prior approach) to decide the proportion of inventors on the same team. The measurement of geographic distance as follows:

$$Geographic\ Distance_i = Diversity_i \times \frac{N}{N-1}, Diversity_i = 1 - \sum_{g=1}^{G} P_{ig}^2$$

, where and P_{ig} is the proportion of inventors listed on the patent I in city-level location g, and G the number of cities, $Diversity_i$ is the Blau index of diversity, and N is team size as mentioned above.

Third, I control for the expertise of the inventors listed in the patent, as well as the scope of knowledge covered by the focal patent itself by leveraging the CPC data. Specifically, I calculate the team's prior patent experience as the *team knowledge scope* by the total number of CPC subclasses of the patent. Furthermore, I also control for *the number of claims,* as it represents the quality of the invention and the scope of the patent rights (Lanjouw & Schankerman, 1999).

3.5. Estimation Model

I conduct the analysis by using the negative binomial regression model as my dependent variable, *innovation performance*, is a count variable. Because the negative binomial regression model has broadly used for estimating the countable dependent variable. And in the usage of patent data, concerns may arise due to conditional variance being larger than the conditional mean, generating an overdispersion problem (Song, Almeida, and Wu 2003; Seo et al., 2022). Thus, the negative binomial model is most suitable for the estimation in this study. Furthermore, I use the negative binomial models for the robustness check of the results. The results are consistent with the main arguments. The *full* specification of the

model is determined as:

$$(\beta_0 + \beta_1 Cultural\ Diversity_i + \beta_2 Cultural\ Diversity_i^2 + \beta_3 Common\ Language_i + \beta_4 Prior\ Collaboration_i + \beta_5 Cultural\ Diversity_i \times Common\ Language_i + \beta_6 Cultural\ Diversity_i^2 \times Common\ Language_i + \beta_7 Cultural\ Diversity_i \times Prior\ Collaboration_i + \beta_8 Cultural\ Diversity_i^2 \times Prior\ Collaboration_i)$$

4. Result

4.1. Data Description

Table 1 presents the descriptive statistics, including mean, standard deviation, and minimum and maximum values for the variables in this study. Table 2 shows the correlations of these variables, suggesting no large correlations between the variables. I further checked for the multicollinearity by conducting the variance inflation factor (VIF) analysis. The highest VIF score was 1.70, implying no multicollinearity issue in my model.

Table 3 shows the results of the estimation using the negative binomial regression analyses. Model 1 in Table 3 includes only control variables for isolating the effects of the treatment from the potential influence of other factors. The model 2 in Table 3 test Hypothesis 1, which examines that the relationship between the cultural diversity of an R&D team and its innovation performance, The coefficient of *Cultural Diversity* is positive and highly significant (β=2.6048, *p-value* < *0.001*), while the coefficient of *Cultural Diversity*^{2} is negative and also highly significant (β=-2.3785, *p-value* < *0.001*), which support our Hypothesis 1. There is an inverted U-shaped relationship between cultural diversity and innovation outcomes, indicating the cultural diversity of a team at the moderate level has the greatest effect on innovation performance.

In model 3, the coefficient of *Cultural Diversity* × *Common Language*

is negative and highly significant (β=-10.7953, *p-value < 0.001*), while the coefficient of *Cultural Diversity*^{2} × *Common Language* is also positive and highly significant (β= 13.3871, *p-value < 0.001*). The findings imply that the common language used in the culturally diverse team hinders both the negative and positive effect of cultural diversity on innovation outcomes. It supports the hypothesis 2. The advantage and disadvantage of the cultural diversity on the innovation performance both increases when culturally diverse inventors of the team all have the common language.

In support of our hypothesis 3, the results of the model 3 shows the coefficient of *Cultural Diversity* × *Prior Collaboration* is positive and significant (β= 0.1759, *p-value < 0.005*), whereas the coefficient of *Cultural Diversity*^{2} × *Prior Collaboration* is negative and significant (β= -0.1692, *p-value = 0.004)*. When the more frequently culturally diverse inventors of the team have collaborated with each other on prior patenting activities, the positive and negative effect of cultural diversity on innovation outcomes become weaker.

Thus, the results are corresponding with my arguments. When the more the common language used by global inventors, both advantage and disadvantage of cultural diversity on innovation performance strengthens. In contrast, the more the prior collaborative experiences among inventors, the lower the relationship between cultural diversity and the innovation performance.

4.2. Robustness Check

Since it exists other potential observations of the team composition, I further checked the robustness of my results for enhancing the stability and consistency of my findings. I conducted a sensitivity test with longer year windows than five years for *prior collaboration* among paired inventors in the patent as one of the moderating variables in this study. I classified samples with different time

windows as six, seven, and eight years before the application date of the focal patent. The results are still consistent with my arguments across longer period from six to eight years.

5. Discussion and Conclusion

5.1. Contributions

The aim of this study is to provide another insight for understanding the global collaborative team within MNCs in the strategic management and international business literature. As the prior literature has extensively recognized the orchestration of the cross-border (i.e., geographically dispersion) innovative team due to the firm's increased oversea R&D laboratories or subsidiaries. Following the enhanced globalization of innovation activities, the R&D team within MNCs has more opportunities to collaborative with other laboratories located in different city or country. On the other hand, the phenomena of diverse environment have also increased, it leads to the global talent have the higher possibility to gather together and work with each other than before. However, the stream of the literature still remains limited understanding.

In the presence of mobility of geographically dispersed inventors of research teams within MNCs, cultural factor as well as ethnicity or origin, take much longer to change than geographic factors. Thus, I shed new light on the demographic attributes of cross-border teams by clarifying under what conditions cultural diversity enjoy the greatest performance. By leveraging the detailed information of inventors provided by the PatentsView to conduct the analyses, I find that there is an inverted U-shaped relationship between cultural diversity and the innovation outcomes. Furthermore, the degree of the use of common language and the frequency of prior collaborative experience among the R&D team members moderate the effect of cultural diversity and innovation

performance. Specifically, the greatest effect of cultural diversity on the performance occurs when the team members have more common language and less prior collaborative experience.

This study contributes to the literature related to the cross-border innovation, international business, learning theory at the team-level, and international language. I illustrate the role of cultural diversity and common language in the cross-border collaboration within MNC R&D teams at the patent level. Furthermore, I distinguish the difference between the cultural and linguistic factors in my findings, suggesting that language should be taken "out of the 'culture box", which contribute the prior literature (Welch & Welch, 2008; Tenzer, Pudelko, & Harzing 2013). The current paper enhances the understanding of the team-level demographic characteristic heterogeneity in innovation outcomes.

5.2. Limitations and suggestions for future research

This paper has several limitations that can provide approach for future research. First, I do not directly observe how culturally diverse teams interact and work with each other to generate their innovative outcomes. Analyzing the origin of inventors may not capture the full diversity of an R&D team, as some members may have multiple culture backgrounds. Also, the language spoken by an R&D inventor may not rely on his/her residence or nationality' s official language. In an international team, multilinguistic ability may exist in their collaborative process, especially in the culturally diverse units. In 936 observations of study, only 36% (2789 paired inventors listed in 520 patents) inventors have prior collaborative experience with each other. Regarding to the prior collaboration among members, a larger observation or other knowledge-intensive industry can be considered for the future study. Despite the pharmaceutical industry is most suitable for my framework, following the globalization of the innovative activities around different industry, such as Semiconductor industry. Future work

that considers other measurement of cultural diversity in the R&D team, or the mobility of culturally diverse talent may also an interesting approach.

In spite of the limitations exist, this study contributes to the understanding of the orchestration of cross-border collaborative team. The managers within MNCs should concern the overall design of the team composition in order to enhance the synergy by blending diverse talents around the world.

Tables

Table 1. Descriptive Statistics

Variable	Mean	Std	Min	Max
1. Innovation Performance	7.679	9.884	1	105
2. Cultural Diversity	0.478	0.252	0	0.857
3. Common Language	0.864	0.254	0.1	1
4. Prior Collaboration	6.764	18.958	0	256
5. Team Size	3.878	2.039	2	17
6. Team Knowledge Scope	11.290	10.569	0	76
7. Number of Claims	21.151	24.832	1	320
8. Geographic distance	0.204	0.316	0	0.992

Table 2. Correlations of Variables

Variable	1	2	3	4	5	6	7	8
1. Innovation Performance	1							
2. Cultural Diversity	0.126	1						
3. Common Language	-0.039	-0.260	1					
4. Prior Collaboration	0.031	0.104	-0.146	1				
5. Team Size	0.107	0.336	-0.255	0.459	1			
6. Team Knowledge Scope	0.035	0.0149	-0.027	0.091	0.183	1		
7. Number of Claims	0.153	0.154	-0.027	-0.001	0.135	0.148	1	
8. Geographic distance	-0.014	-0.236	0.206	0.011	0.199	0.0940	-0.005	1

Table 3. Results of Negative Binomial Regression

DV: Innovation Performance			
	Model 1	Model 2	Model 3
Cultural Diversity		2.605 [0.000]	10.198 [0.000]
Cultural Diversity^2		-2.379 [0.000]	-11.892 [0.000]
Common Language			1.547 [0.000]
Cultural Diversity × Common Language			-10.795 [0.000]
Cultural Diversity^2 × Common Language			13.387 [0.000]
Prior Collaboration			-0.041 [0.008]
Cultural Diversity × Prior Collaboration			0.1759 [0.005]
Cultural Diversity^2 × Prior Collaboration			-0.169 [0.004]
Team Size	0.055 [0.002]	0.130 [0.000]	0.0527 [0.022]
Team Knowledge Scope	0.0006 [0.861]	0.006 [0.054]	0.0027 [0.434]
Number of Claims	0.007 [0.000]	0.006 [0.000]	0.0059 [0.000]
Geographic distance	-0.138 [0.223]	-0.099 [0.424]	-0.071 [0.568]
Observaitons	936	936	936

Appendix. Sensitivity Tests with Different Year Windows

	DV: Innovation Performance		
	6 years	7 years	8years
Cultural Diversity	10.198 [0.000]	10.198 [0.000]	10.198 [0.000]
Cultural Diversity^2	-11.892 [0.000]	-11.892 [0.000]	-11.892 [0.000]
Common Language	1.547 [0.000]	1.547 [0.000]	1.547 [0.000]
Cultural Diversity × Common Language	-10.795 [0.000]	-10.795 [0.000]	-10.795 [0.000]
Cultural Diversity^2 × Common Language	13.387 [0.000]	13.387 [0.000]	13.387 [0.000]
Prior Collaboration	-0.041 [0.008]	-0.041 [0.008]	-0.041 [0.008]
Cultural Diversity × Prior Collaboration	0.1759 [0.005]	0.1759 [0.005]	0.1759 [0.005]
Cultural Diversity^2 × Prior Collaboration	-0.169 [0.004]	-0.169 [0.004]	-0.169 [0.004]
Team Size	0.0527 [0.022]	0.0527 [0.022]	0.0527 [0.022]
Team Knowledge Scope	0.0027 [0.434]	0.0027 [0.434]	0.0027 [0.434]
Number of Claims	0.0059 [0.000]	0.0059 [0.000]	0.0059 [0.000]
Geographic distance	-0.071 [0.568]	-0.071 [0.568]	-0.071 [0.568]
Observaitons	936	936	936

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국문 초록

최상의 결과를 이끌어내는 다양성의 정도 -연구개발팀의 문화다양성과 혁신성과

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연구개발팀의 구성은 혁신성과에 미치는 영향을 바탕으로 전개하는 연구가 늘어지고 있으나 문화적 다양성은 어떻게 최상의 성과를 창출할 수 있는지에 대해 선행연구에서 여전히 한계적인 관점이 드러난다. 본 연구는 문화적 다양성이 연구개발팀의 혁신 성과에 미치는 영향과 어떤 조건에서 문화적 다양성이 혁신 성과를 강화하고 약화하게 되는지 미국 특허청의 데이터를 통해 글로벌팀의 구성을 살펴보았다. 1995년부터 2014년까지 20년 동안 글로벌 제약회사의 특허 데이터를 분석을 통해문화적 다양한 구성원들이 구사하는 공통 언어가 많고, 이전 협력 경험이 적은 경우 최상의 혁신 성과를 이끌어 낼 수 있다. 이러한 결과는 글로벌 시대에서 다국적 기업의 관리자가 다양성을 추구하는 동시에 그에 따른 잠재적 충돌을 피하고 팀 구성의 적절한 설계를 고려해야 한다는 것을 시사한다.

주요어: 문화적 다양성, 공통언어, 혁신성과, 이전협력관계, 팀구성
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