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The Impact of Workspace Environment on Creativity and Innovation: Empirical Evidence from Makerspaces in China

HUANG Yijing

Doctor of Management

Supervisors:
PhD Fernando Alberto Freitas Ferreira, Associate Professor with Habilitation,
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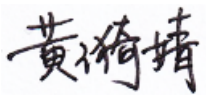
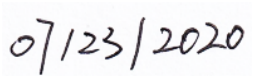
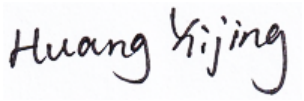
Signed:  Date: 

Name: 

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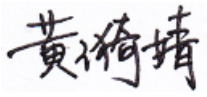
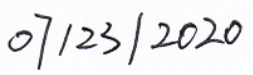
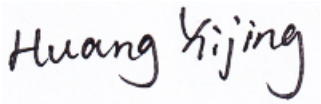
作者签名:  日期: 

姓名（拼音）: 

Abstract

Numerous studies have identified the critical role of creativity and innovation on the sustainable development of an enterprise especially facing with uncertain and complex external environment. Among the various aspects affecting the creativity and innovation, workspace environment is a factor that has not been fully considered for most of organizations. Compared to the existing literature on innovation, few empirical studies have investigated the influence of workspace environment on creativity and innovation. Based on the previous literature, this thesis first develops a theoretical framework, i.e., workspace environment-employee's conduct-innovation performance paradigm to reveal the mechanism. We differentiate between the physical and non-physical environments to examine their roles on creativity and innovation performance, respectively. Then taking Ucommune as example (i.e., one of the largest makerspaces in China), this study empirically explores to what extent workspace environment affects the individual and team creativity and innovation in an organization. The main results include: (1) physical and non-physical workspace environments positively contribute to employees' individual and team behaviors; (2) individual behavior can help to improve employee creativity and enhance team behavior, but its direct impact on innovation is not significant; (3) team behaviors can improve organizational innovation performance. Our findings empirical support the increasing importance of workspace environment – particularly the physical one – on creativity and innovation, providing both theoretical and practical implications. In particular, the main theoretical contribution is to enrich both the environmental psychological theory and innovation theory by providing a mechanism on how workspace environment influence creativity and innovation within an enterprise.

Keywords: Workspace environment, Creativity, Innovation, Makerspace.
JEL: M13, M12

Resumo

São vários os estudos que identificam o papel crítico da criatividade e da inovação no desenvolvimento sustentável de uma empresa, especialmente em ambientes externos incertos e complexos. Entre os vários fatores que afetam a criatividade e a inovação, o ambiente do espaço de trabalho é algo que não é tido em consideração pela maioria das organizações. Nesse sentido, a presente tese apresenta, em primeiro lugar, um enquadramento teórico que projeta o paradigma do desempenho individual e organizacional face ao ambiente de trabalho, tendo em conta a conduta do empregado e os determinantes de inovação. De seguida, procede-se à distinção entre ambiente físico e não-físico para examinar as suas influências na criatividade e na inovação. Por fim, tendo o *Ucommune* como exemplo (i.e., um dos maiores espaços partilhados de fabricantes da China), este estudo explora empiricamente até que ponto o ambiente de trabalho afeta o indivíduo e a criatividade e a inovação da equipe nas organizações. Os principais resultados alcançados sustentam que: (1) ambientes de trabalho físico e não-físico estão positivamente relacionados com os comportamentos individuais e de equipe dos colaboradores; (2) o comportamento individual pode ajudar a melhorar a criatividade dos colaboradores e da equipe, mas o seu impacto direto na inovação não é significativo; e (3) o comportamento da equipe pode melhorar o desempenho da inovação organizacional. Estes resultados suportam ainda a crescente importância do ambiente do espaço de trabalho – particularmente o espaço físico – na criatividade e na inovação, trazendo implicações teóricas e práticas para a gestão empresarial.

Palavras-Chave: Ambiente de trabalho, Criatividade, Inovação, Espaço de produção.
JEL: M13, M12

摘要

许多研究已经确定了创造力和创新对企业可持续发展的关键作用，尤其是面对不确定和复杂的外部环境。在影响创造力和创新的各个方面中，工作空间环境是大多数组织尚未充分考虑的因素。与现有的创新文献相比，很少有实证研究调查工作空间环境对创造力和创新的影响。本文在先前文献的基础上，首先建立了一个理论框架，即工作空间环境—员工的行为—创新绩效范式，以揭示其机制。我们区分物理环境和非物理环境，分别研究它们在创造力和创新绩效中的作用。

然后以 Ucommune（即中国最大的创客空间之一）为例，本研究从经验上探索了工作空间环境在多大程度上影响个人和团队的创造力和创新。主要结果包括：（1）物理和非物理工作区环境为员工的个人和团队行为做出了积极贡献；（2）个人行为可以帮助提高员工创造力和增强团队行为，但其对创新的直接影响并不显着；（3）团队行为可以提高组织创新绩效。

我们的发现为工作空间环境（尤其是物理环境）对创造力和创新的重要性日益提高提供了经验支持，同时提供了理论和实践意义。主要的理论贡献是通过提供工作空间环境如何影响企业内的创造力和创新的机制来丰富环境心理学理论和创新理论。

关键词：工作空间环境，创造力，创新，创客空间

JEL: M13, M12

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Chapter 1 Introduction

1.1 Background and significance

In an economic environment marked by fierce competition, innovation has been described as a fundamental competence and driver for sustainable business (Ahmed & Shepherd, 2015; Sheykhan & Saghaee, 2011). The importance of innovation has been illustrated by numerous successful companies that rely on their creative and innovative capabilities to achieve improvements (Guo, Su, & Zhang, 2017). Especially in the current turbulent global environment, only companies that continually re-evaluate their operations and innovate can survive (Lewin, Välikangas, & Chen, 2017). In the present dynamic – and indeed chaotic – global context, organizations must create new products or services and adopt state-of-the-art managerial thinking and technology to maintain their competitive advantages (Anderson, Potočnik, & Zhou, 2014).

In China, the orientation toward innovation has been promoted to a national strategy aimed at achieving long-term development. In light of rapidly changing external circumstances, and of the fact that the Chinese economy has been evolving from an extensive economy to an intensive one, traditional competitive advantages are rapidly disappearing, leading to the pressing need to find a new and more sustainable engine of growth. Innovation has been identified as such an engine (Ahmed & Shepherd, 2015). The transition from a dependence on resources to having an innovation-driven economy entails unprecedented transformational challenges for the Chinese economy. In March 2015, Premier Keqiang Li made repeated reference to “mass entrepreneurship and innovation” in the government’s work report, describing them as “twin engines” of China’s economic transformation and growth, highlighting the significance of entrepreneurship and innovation to the Chinese economy (Zhang & Bai, 2017).

Innovation is a complex and high-risk process, in which creativity is both an antecedent and a critical factor. Creativity refers to the ability of discovering connections between various ideas or items and integrating them in a unique way (Amabile et al., 1996). As Sheykhan and Saghaee (2011) point out, creativity and innovation are the two most important items in leading any organization to a value-added position. A creative or innovative enterprise can better compete against its rivals and is more capable of surviving in unfavorable circumstances.

Fariborz (1996) asserts that innovation needs a good atmosphere in which to develop. If workers or employees are expected to deliver innovative outcomes, there should be favorable surroundings that can foster the related creative activities.

There is currently an increase in the demand for creativity and innovation in business. Because of global competition, as well as disruptions caused by emerging technologies, all enterprises are experiencing unprecedented competitive pressures (Amabile, 1996; Amabile & Pratt, 2016; Ghosh, 2015; Sarooghi, Libaers, & Burkemper, 2015). For instance, the 2008 global financial crisis changed the business landscape in China, leading to increased competition requiring intense innovation (Leung et al., 2014). To maintain market shares, companies should develop new products and services in a globally competitive environment to meet the changing demands of their customers. Indeed, this has been a strategic imperative for organizations (Moultrie et al., 2007). In a survey conducted by Lin, Gao, and Gao (2016), over one-third of the respondents were found to regard innovation as the most important strategic driver. Considering the irreplaceable position of innovation for any organization, the stimulation of innovation has become an urgent question facing Chief Executive Officers (CEOs). Hu and Liu (2007) emphasize the role of an environment in which creativity and innovation can be fostered as an ever-present reality. Leung et al. (2014) suggest that a space of creative freedom in an organization can enhance and flourish creativity, leading employees to engage in various innovative activities.

Although the characteristics of work, as well as employee demands, have changed dramatically over the past half century, the working conditions offered by companies have, by comparison, lagged behind, being unsuited to the new patterns of work expected by today's employees. Indoor design has been left relatively unchanged, with cubicles and private spaces being predominant in most offices (Zhang, 2017).

According to an Internet survey on employee resignations conducted in 2016 in the three largest cities in China (Beijing, Shanghai, and Guangzhou) (https://mp.weixin.qq.com/s/v-6lQOdqBdKcrtq2U8ufhg), the workspace environment is a significant cause for resignations, just after salary and work pressure. This survey also indicated differences in the way different age groups select their workplace environments. As shown in Figure 1.1, 60% of employees born in the 1980s decade consider the workspace environment as the most important factor for their decisions to resign, whereas only 33.3% indicate work pressures and 28.6% indicate salary as the primary reasons. By contrast, the percentage of employees indicating the workspace environment as the most important factor for their decisions to resign is 20% for employees born in the 1990s or the 1970s.

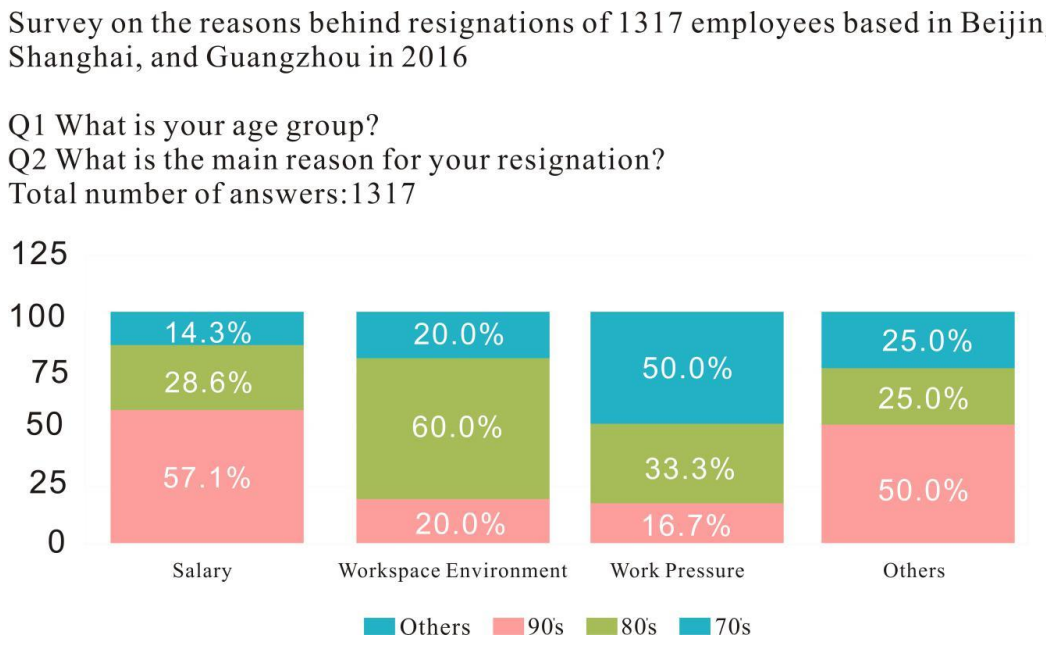

Figure 1.1 Internet survey on the reasons for resignation

Source: https://mp.weixin.qq.com/s/v-6lQOdqBdKcrtq2U8ufhg

An increase in the attention paid to workspace environment may play an important role in fostering creativity and innovation, and help retain talented employees. The above survey indicated that the question of workspaces has become a practical problem for companies in China. By contrast, existing literature on innovation does not focus on the influence of the workspace environment, nor is there much empirical research into the influence that workspaces have on the creative process and innovation. Indeed, the impact of the workspace environment on innovative outcomes is still unknown, for which reason further research is necessary on this topic.

A number of scholars started researching the impact of environment on individual psychology and behavior in the 1960s, gradually shaping environmental psychology into a new field of research. Environmental psychology, also known as environmental behavior science, is a discipline that combines human behavior and its corresponding environment to analyze the relationship between them (Gifford, 2014). The key research object of environmental psychology is the relationship and interaction between human behavior and city, architecture, and environment. Russell and Ward (2003) indicate that it is necessary to study the interaction between human beings and their surrounding physical environment. As far as daily life is concerned, environmental psychology is committed to making architecture more humanized and improving the relationship between humans and their environment.

1.2 Research objectives

While there is abundant research into factors driving innovation, empirical data on the influence of the workspace environment on the creative process is still limited (Moultrie et al., 2007; Sarooghi, Libaers, & Burkemper, 2015). In light of the ongoing changes in employee expectations, the workspace environment has remained an underrated element that employees often complain about as being a key barrier to creativity (Sarooghi et al., 2015; Sheykhan & Saghaee, 2011). Among the various aspects affecting creativity and innovation, workspace environment is one that has not been fully explored by most Chinese businesses.

As a result, the main purpose of this thesis is to analyze the impact of workspace environment on creativity and innovation and to discuss how to provide more favorable workspace environment conditions (both physical and non-physical) to employees, encouraging them to be creative and innovative. Taking makerspaces in China as a sample, this study empirically examines the extent to which the workspace contributes to innovation performance in an organizational setting, as perceived by knowledge workers in China.

There are also a number of secondary objectives in this study. First, we will try to distinguish the physical environment from the non-physical one. Second, the extent to which the physical and non-physical workspace environments influence employee behaviors and affect creativity and innovation will be studied.

To achieve the study's main and secondary objectives, data will be collected through surveys and in-depth interviews, and structural equation modelling (SEM) will be employed to examine the hypotheses that are proposed. Based on the empirical results, this study also provides recommendations to guide the development of makerspaces in China, to help enhance creativity and innovation performance.

1.3 Research problem and questions

The key research problem is to analyze how the workspace environment affects individual and team creativity and innovation in an organization. Specifically, this thesis aims to address the following research questions:

(1) To what extent does the physical environment affect individual and team behaviors?

(2) To what extent does the non-physical environment affect individual and team behaviors?

(3) To what extent does individual behavior affect creativity?

(4) To what extent does team behavior affect innovation performance?

(5) To what extent does individual creativity affect innovation performance?

1.4 Methodology and epistemological background

The main research methods in this thesis include literature review and empirical study. The literature review is the basis of this study and the empirical research aims to examine the relationship between workspace environment and innovation.

1.4.1 Literature review

The literature review served to better judge whether the research problem has significant value and, beyond this, to guide the definition of the relationships between the variables. After clarifying the research issues, by using the electronic Chinese set of databases CNKI and international databases such as Elsevier, ABI, JSTOR, Research GATE, Springer, and Web of Social Science, we searched, read and collected the literature related to *workspace environment*, *creativity*, *innovation*, and *makerspace*. We combed through a large amount of literature and summarized the existing research topics, paradigms, and conclusions. The literature review played a key role in shaping research problems and clarifying their significance. It was found that the existing research on the impact of workspace environment on creativity and organization innovation is still insufficient, adding significance to the present study. Moreover, this review also provided a theoretical basis and support to the proposed hypotheses and modeling that was carried out.

1.4.2 Empirical study

This research employs SEM to examine the theoretical model. SEM, known as latent variable model, is a multivariate statistical method integrating factor analysis and path analysis, which can be used to test relationships between dominant variable, potential variable, and disturbance or error variable, and then obtain the direct or indirect influence of independent variables on dependent variables and the path effect. In SEM, one generally starts by developing a basic model which reflects the relationship between potential variables based on previous knowledge and existing hypothesis and, then, by introducing the data observed by the explicit variables. Through the structural equation model's operation, we first test the fitting degree of the measurement model. If the model fitting degree is good, the model is accepted and it is considered that the research problem has been empirically tested. If the fitting degree is poor,

the model needs to be modified according to the relevant theory until the model is accepted or completely rejected. Structural equation model is a confirmatory analysis method, which usually must be supported by theory or experience. Generally speaking, the estimation method used in structural equation modeling is that of maximum likelihood, which requires that the sample data conform to a multivariate normal distribution. In this thesis, the application of structural equation modeling is mainly done in confirmatory factor analysis, multiple intermediary effect test and path analysis.

This thesis mainly employs two statistical software tools, SPSS 20.0 and AMOS 24.0, to conduct the empirical analysis. First-hand data was collected through questionnaire surveys and in-depth interviews. Considering the difficulty of objective quantitative data collection, this research mainly uses the multi-dimensional subjective index measurement method, through the subjective evaluation by respondents, to obtain the relevant data. It should be noted that, although there is a certain deviation between the data obtained by the subjective evaluation method and objective data, scholars generally believe that this deviation is not sufficient to affect the correlation and concurrent validity between the subjective data and the objective data. As such, the subjective data is considered a valid measurement of the variables.

First, using SPSS 20.0 software's correlation, regression analysis and other empirical methods, the reliability and validity of the formal survey scale were tested, the correlation between variables was analyzed, and the hypothesis between variables was tested by regression analysis. Then, AMOS 24.0 software was used for empirical tests. Employing structural equation modeling to analyze the confirmatory factors of the scale, our study tested the theoretical model of the workspace environment and its impact on creativity and innovation. Based on the reliability and validity tests of each construct, the validity of the model was tested and the multi-collinearity problem was analyzed. Then the structural model was used to test the direct and indirect effects in the theoretical model. Finally, the bootstrap method was employed to examine the mediating effect.

1.5 Structure of the thesis

As shown in Figure 1.2, this thesis is divided in seven chapters.

Chapter 1 presents the study's background and significance, research objective, the statement of the main problem, detailed questions, and structure, overviewing the whole thesis and highlighting its importance. Chapter 2 reviews the related literature, including the concepts of workspace environment, creativity, innovation, and makerspace. The literature is analyzed

to identify the research gap. Chapter 3 proposes the conceptual model and the hypotheses to be tested. Base on the comprehensive literature review in Chapter 2, this chapter puts forward a "workspace environment – employee conduct – organizational performance" framework to explore the impact of the workspace on creativity and innovation. Distinguishing between the physical and non-physical environments, we propose ten hypotheses to show the mechanism through which the workspace affects innovation performance. The study first distinguishes between the physical and non-physical environments of the workspace and then examines their impacts on individual and team behaviors respectively, going on to test these influences on creativity and innovation. Chapter 4 describes the research method. Ucommune, one of the largest chains of makerspaces in China, was chosen as a sample to conduct the empirical study. The profile of Ucommune is introduced in this chapter, as is the questionnaire that was designed to collect the necessary data. The pre-test and survey processes are described in detail. In this chapter, we also explained the measurement of different variables. Chapter 5 presents the empirical results of this study. Employing structural equation modeling, this chapter presents the detailed outcomes of the empirical survey. Respondents' statistical data was obtained to show their basic information. The validity and reliability were tested to confirm that the data could be used for further statistical analyses. After that, confirmatory factor analysis was conducted through the software AMOS 22.0 to test the role of all the indicators. Lastly, the structural model was tested to obtain the relationships between different variable and examine the proposed hypotheses. Chapter 6 discusses the main findings in this study. We focused on the impacts of the physical and non-physical environments on creativity and innovation to analyze our empirical results. A case study on Walnut, a local leading makerspace, was also conducted to provide some qualitative complementary explanations to the empirical outcomes. Chapter 7 concludes the thesis with recommendations and a discussion on limitations and guidelines for further research.

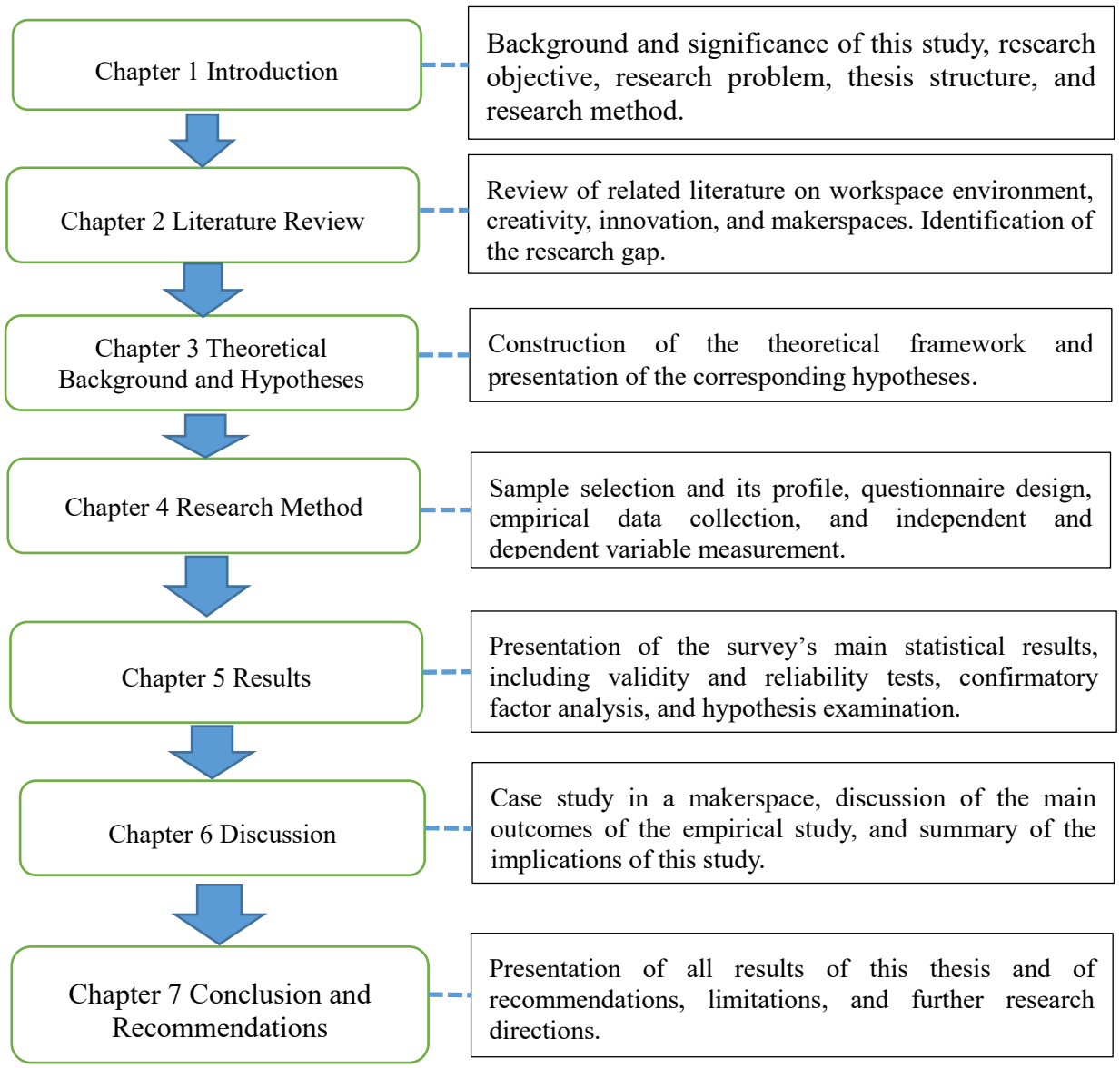

Figure 1.2 Structure of this thesis

Source: Author's own elaboration

1.6 Expected results

This study aims to explore the workspace environment's impact on creativity and innovation, with the expectation that it be able to add a useful contribution to the existing research on workspaces – a concept that has been considered as an important element in organizational development but would appear to be under-researched by scholars. Additionally, after the conclusion of the study, it is expected that the insights obtained can support Chinese managers and decision makers by providing guidance to innovation and creative practices based on their workspace environment. Considering the research context of this study, it is also expected that

the results obtained can help Chinese managers to understand patterns of firm development, enabling them to formulate well-adjusted innovative strategies to achieve growth. The publication of the results obtained in this study in a prestigious academic journal is also an expected outcome.

Chapter 2 Literature Review

This chapter reviews the literature pertaining to basic concepts of workspace environment, creativity, innovation and makerspaces, as a foundation for this research and to identify gaps between previous studies and ours.

2.1 Workspace environment

Workplace environment mainly refers to the office and related spaces where employees work. There has been a number of studies exploring the role of the working environment on creativity and innovation (Reilly, 2008; Schneider, 1987). Sheykhan and Saghaee (2011) distinguish between the physical and non-physical working environments to examine their respective impact on creativity. The present study classifies workspaces into physical and non-physical, following Sheykhan and Saghaee's (2011) approach.

2.1.1 Physical environment

The physical workspace environment relates to the architectural dimension of offices, including aspects such as light, sound, furniture, materials, and decorations (Hou, 2011; Loomans et al., 2018), that may affect people’s work activities and behaviors. There has been some research into the physical environment, supporting the development and transfer of knowledge and skills (Cho, 2017; Hatam et al., 2014). Niaros, Kostakis, and Drechsler (2017) point out that workplaces affect the efficiency of knowledge exchange, in that some may facilitate this process whereas some may hinder it.

Sheykhan and Saghaee (2011) use eleven items to describe the physical workplace: (1) diversity of the working facilities; (2) arrangement of furniture; (3) a working environment with sufficient light; (4) good phone communications; (5) the availability of natural plants; (6) comfortable chairs; (7) computers with the necessary software packages; (8) some paintings and pictures; (9) good air-conditioning; (10) quality of communications; and (11) the availability of a good library. These items describe the interior design of workspaces. These authors found that the computer, sufficient light, diversity of working items and library are the most important considerations for increasing worker creativity, whereas good communications and pictures hanging on the walls have the least impact.

Although the characteristics of work, as well as the demands and expectations of workers, have changed dramatically over the past half century, the work environments provided by companies have, by comparison, lagged behind, not being suited to the new patterns of work and preventing workers from performing to their full potential (Saorín et al., 2017). The physical design of work environments have undergone a marginal evolution over the last fifty years, remaining largely stable, with cubicles and private office spaces being predominant in most environments (Ghosh, 2015; Levin, 2005). Despite burgeoning trends to elevate the work environment, workspace design typically lacks a formal process to measure the value of design investments or their impact on the process of innovation (Brown, 2008). To be successful in the era of complex and cognitive knowledge, organizations need to have a culture and corresponding physical environment that consistently reinforces and yields creativity and innovation (Kim, Jonghyun, & Lee, 2015; Moultrie et al., 2007; Samani, Rasid, & Sofian, 2014). Hence, more information is necessary to determine the return on design investments so that physical design can more effectively be used as a tool for innovation (Chang, Liu, & Jing, 2016; Peponis et al., 2007; Wang et al., 2016). Amabile et al. (1996) emphasize that innovation can flourish when organizations ignite their workers' creativity, stating that creativity by individuals – as well as by teams – is a starting point for innovation: a necessary, though not sufficient, condition. Successful innovation depends on other factors as well. It can stem not only from creative ideas that originate within an organization but also from ideas that originate elsewhere (as with technology transfer). Pieters, Baumgartner, and Bagozzi (2006) suggest that the lack of creative organizational space may stifle workers' imaginations. Unfortunately, for most offices, traditional design provides only an office desk with a computer. If a person would like to hold discussions with co-workers, they would seek special creativity and innovation rooms for communication, which have become more popular in many companies (Zhou & Hoever, 2014). In other words, innovation benefits from having a breeding ground: surroundings that can spur imagination, creative thought, and innovative outcomes. Marrapodi (2003) highlights the need for organizations to scrutinize their workplaces and to carefully consider how to design offices that support innovation. While creativity is not the only path to innovation, it is nevertheless a critical precursor to it (Akif, Audretsch, & Slaper, 2019). As companies delve into the topic of workspaces, insights as to how the workspaces of individuals and teams can contribute to companies' innovative goals need to be examined at a deeper level. Insights about what stimulates and what creates barriers in the physical workspace can further inform organizations in their decisions regarding physical environment.

2.1.2 Non-physical environment

The workspace environment is not limited to the physical characteristics of offices (Han et al., 2017). It is also important to recognize their social-psychological dimensions or intangible. Workspaces can be warm and welcoming, instill a sense of ownership, foster identity and have (or lack) clear behavioral guidelines (Leung & Wang, 2015). Sheykhan and Saghaee (2011) measure the non-physical working environment from the following aspects: (1) feeling of freedom; (2) the extent to which feedback is accepted; (3) peacefulness and joyfulness; (4) purposefulness and enjoyment; (5) confidence to design new ideas; (6) dynamics and appropriate changes; (7) availability of discussions; (8) lack of conflict; (9) tolerance and acceptance of new ideas regarding the organization; and (10) opportunities for creative ideas and processing. Their empirical study shows that joyfulness has a great impact on creativity – less so with tolerance for new ideas.

Cooper (2008) found that the use of collaborative work tools and cloud-based software systems increases the likelihood that employees choose flexible spaces other the office to carry out their work. When employees are away from the office, individual productivity rises but meaningful output declines. It is often difficult to meet deadlines and the quality of work suffers, making work from home an unattractive option for most companies. Thus, Cooper's research highlights the importance of the office environment – in particular, the non-physical environment – for organizational success and more specifically for work that contributes to progress and value differentiation (Hua et al., 2011). The fact is that most companies continue to invest heavily in their real estate while failing to question their underlying paradigms about what kind of workspace is actually needed for employees (Jensen et al., 2016). Indeed, compared to physical design, the non-physical environment is intangible and difficult to measure (Boyle et al., 2016). While employers wrestle with the economic aspects of providing specific types of workspaces, questions about the extent to which the workspace is a tool to drive innovation remain to be fully researched. For future success to be realized, organizational leaders should understand the specific characteristics that lead to innovation rather than relying on ad hoc measures in order to be more strategic (Moultrie et al., 2007). As modern perspectives see the physical workspace evolving from a container for work to a strategic driver of productivity and innovation, more data needs to be analyzed to inform leaders on what strategies and tactics are most effective to stimulate, and reduce barriers to, innovation (Liu et al., 2016).

2.2 Creativity

2.2.1 Conceptualization of creativity

Creativity and innovation are two of the most important items in leading an organization to a value added position. The concepts of "innovation", "creative idea", "creativity", and "creation" are often mistaken for one another in academic research and managerial practice, being regarded as interchangeable nouns (Amabile, Hadley, & Kramer, 2002; Scott & Bruce, 1994). In the more than half a century since the term creativity was proposed by American psychologist Guilford in 1950, researchers have yet to form a unified definition for creativity, mainly because researchers have different research focuses, research paradigms and theoretical bases on creativity. There are, therefore, many definitions for creativity. For example, some scholars regard creativity as a kind of ability to have unusual, unique or new views that differ from existing patterns (Amabile et al., 1996; Park, 2015) or produce new and valuable things (Dahlén, Rosengren, & Törn, 2008). These new ideas may not be entirely original: they can be reconfigurations of old ideas (Beth, Altringer, & Moran, 2013). Shalley et al. (2015) view creativity as an ability such as intelligence, considering that, as is the case with intelligence, different individuals have different degrees of creativity.

Thus, creativity is indeed vague and difficult to explain since it can be used as a noun (creativity) or as an adjective (creative), representing either the outcome of an action or a process (Adler & Chen, 2011). According to the definitions found in the Webster Dictionary, when the adjective "creative" is used, it refers to "creation" or "ability to create" new products, expressions of imagination, and artistic talent. When the noun "creativity" is used, it means "the ability to create" or "the development of intelligence and intelligence". It can mean creation or ability to create, generation or production of new things, imagination and artistic or intellectual inventiveness, or stimulation of the imagination and inventive powers (Guo, Su, & Zhang, 2017). According to the same dictionary, creation is related to both imagination and invention. Imagination is the ability to use mental images to create things that do not exist in reality. The ability to imagine enables the mind to create, to think about things that have never been experienced before, and to combine previous experiences to create new phenomena and ideas and motivate innovation. Zhang and Bartol (2010) define creativity from a psychological perspective, including the following aspects: (1) in difficult situations, in order to solve problems, individuals create new ideas, beyond their own experience, through imagination; (2) guided thinking or extraordinary abilities that are not illusions but attempts to break through

the restrictions of experience. They further remark that the two aspects are similar in that both entail a problem-solving psychological activity, while they are different in that the former regards creativity as a thinking process, whereas the latter considers creativity as a thinking ability. Therefore, the study of creators in psychology also includes two aspects: one is the study of creative thinking, aiming to understand what the process of creation is, and the other is the study of creativity, aiming to understand what abilities are part of creativity.

John (2001) argues that "creativity" is different from "innovation". The author defines creativity as *"the process of developing and expressing novel ideas that may be useful"* and innovation as *"knowledge in novel, meaningful, valuable new products, processes or services"* (pp. 103-105). In other words, innovation has practical or commercial value, while creativity may not. From the perspective of results, creativity is generally defined as something new. Marrapodi (2003) defined creativity as a novel and related output due to the uniqueness of individuals and situations (such as environment, events, and people). Roni et al. (2018) suggest that creativity is embodied in a novel and appropriate idea generated by individuals or small working groups. In subsequent research, creativity is defined as being something novel and practical, including appropriate processes or procedures (Thayer, Petruzzelli, & Mcclurg, 2018). Creativity is the connection and rearrangement of knowledge in the minds of those who allow themselves to think flexibly to generate new, often surprising but useful, ideas (Barrett et al., 2014; Roni et al., 2018; Shalley & Perry-Smith, 2008).

2.2.2 Creative process

According to the definition of creativity given by John (2001), creativity is a process in which a sequence of thoughts and action gradually leads to novel, adaptive productions (Lubart, 2001). This process can be made up of different stages (Proudfoot & Fath, 2020), rather than consisting of a single unitary process. Creative processes are involved in cognitive and motivational labels such as perceiving, imagining, thinking, and can also consist of ordinary tasks such as calendaring and responding to emails. Time for thinking, meeting or reporting may stimulate creativity (Hitt, Zhou, & Shalley, 2015).

Wallace (1926) developed a four-staged model for the development of new ideas. This model, based on an individual thought process, has now been widely used in creativity research (Lubart, 2001). The first stage is to prepare all necessary information or data and then investigate the problem from all possible directions. The second stage is an implicit cognitive process characterized by unconscious thinking about the problem. The third stage is the exciting moment of the appearance, in a flash, of ideas. Then, one preferred idea is tested and applied to

the goal, validating it for solving the problem. Indeed, the creative process is a complicated one, leading to constant overlaps for different problems. Wallace's (1926) model only considers the problem-solving process, while some scholars find that the creative process should cover problem finding as well (Woodman, Sawyer, & Griffin, 1993). Kang and Tucker (2018) consider that creativity is akin to a bilateral social process. After careful consideration, two unrelated ideas or concepts are linked together to generate new insights and discoveries. The authors emphasized that creativity is a kind of capability to see things in a unique way and to distinguish new information for problem solving. Kim and Kim (2018) divide the creative process into three stages: hypothesis formation, hypothesis testing, and communication. Noller and Parnes (1972) proposed a five-stage model for the process of creative thinking: finding facts, finding problems and defining problems, generating ideas, finding solutions, and accepting solutions. Hitt, Zhou, and Shalley (2015) point out that creativity includes continuously finding and solving problems and implementing new solutions.

2.2.3 Factors influencing creativity

Many factors affect creativity. In the early study of creativity, especially in the field of psychology, researchers mainly focused on individual characteristics and on their creative results (Simonton, 2014). Amabile and Pratt (2016), for example, suggest that personality traits or intelligence types, among other factors, have a particular impact on creativity. Simonton (2014) focuses on the creative achievements of famous musicians, artists, scientists and philosophers throughout history, using archive data. Kaufman, Cole, and Baer (2009) compare the working methods of famous scientists to those of ordinary individuals, finding that famous scientists paid more attention to strategic methods and problems.

John (2001) points out that creativity requires four important characteristics: (1) there must be divergent thinking in order to abandon familiar and fixed ways of doing things and looking at things and to produce novel ideas – novelty being a very important factor in the early stages of creative development; (2) these novel ideas must be able to be expressed or communicated to others to test whether they are indeed novel; (3) there must also be convergent thinking, through a decision is made regarding which of these novel ideas are worth pursuing; and (4) those ideas that will pursued must have a practical potential.

In addition to the psychological factors, the physical workplace also affects the creative process (Christensen, Kristensen, & Reber, 2014). Kristensen (2004) employs a case study to show how physical space can support the different stages of a creative process, in which a studio with a big room and clustered workshops is designed next to the departmental work stations.

The results indicate that, out of the four-stage model, Phase 1 need not be carried out collectively as workers can do all the required preparation individually. However, in Phase 2 the collective aspect is important for thorough communications and effective collaboration, leading to the generation of new ideas that are well prepared and expressed to other workers. Based on this study, Amabile and Pratt (2016) developed what they refer to a trumpet model to explain the match between the product development process and the spatial requirements of the different creative phases. In this trumpet model, the three phases are: (1) phase 1: when freewheeling is at its highest, physical space needs are minimal due to the limited number of people in the production process; (2) phase 2: for regular thinking, much larger spaces are needed; and (3) phase 3: for more creative activities, physical spaces should be flexible enough to accommodate expansion as well as contraction and changes in the nature of interaction.

A creative firm can more effectively compete with its rivals and more easily survive in turbulent environments. There is, as such, a need to set up a good environment to build better working conditions that help employees become more creative (Dahlén, Rosengren, & Törn, 2008).

John (2001) believes that the creative process may result in innovation. El-Murad and West (2004) also hold the same view. They believe that creativity is the first stage of the process of innovation. Creativity is the development of ideas, while innovation is the application of ideas in practice. In other words, creativity is to create new things, and innovation is to implement new things. Innovation consists of two stages: the development of ideas (i.e., creativity) and then the implementation of ideas (i.e., the implementation of new and improved products and services). Therefore, they believes that innovation includes these two elements (creativity and the process of implementation of innovation) and that, while creativity used to be considered the main element, the process of implementation of innovation has now taken on particular relevance.

With the deepening of the research on creativity, researchers studying the creativity of employees have gradually come to realize that all individuals have creativity (West & Wind, 2007). The creative component model constructed by Agarwal (2016) puts forward the necessary and sufficient components of creativity in all fields, in which creative products are the outcome of the interaction of three basic components: professional skills, creativity-related skills and work motivation. Professional skills refer to knowledge in specific fields; creativity-related skills, also referred to as creativity-related processes, include explicit or implicit knowledge related to strategies for creative thinking, appropriate cognitive styles, and creative work methods (Yuan & Woodman, 2010); work motivation is mainly the individual's attitude

towards, and perception of, work. Compared to this creativity component model, Woodman, Sawyer, and Griffin (1993) convey a more comprehensive review of the factors influencing creativity, arguing that individual creativity is a function of personality factors, cognitive style and ability, related task skills, motivation, and social situation. Their study emphasizes that the interaction of personal character and situational factors in work environments can predict creative behavior, highlighting the importance of cognitive ability or style, personality, intrinsic motivation, and knowledge. Ford (1996) proposes an individual creative activity model, indicating that a person's creative activity is a combination of motivation, knowledge and capability. Drazin, Glynn, and Kazanjian (1999) investigate long-term large projects, finding that individuals have their own reference framework and that creativity is the psychological participation of individuals in creative activities. Sternberg and Lubart (1993) develop a three-dimension model to explain the psychological process of creativity from the aspects of intelligence, intellectual style, and personality.

Yu et al. (2014) analyze the cognition (knowledge, cognitive ability and preference) and non-cognition factors (personality factors) on creativity, including a person's character, individual motivation, relevant knowledge and skills, creative skills (cognitive style, cognitive ability, and creative style), personality factors (self-esteem), prior environmental background (life and work experience), contextual effects (physical condition, task and time constraints), and social effects. Among these factors, a person's character, individual motivation, relevant knowledge and skills, and creative skills have a strong impact on creativity, whereas the impact of prior environmental background and contextual effects is not strong and the role of social effects is not fully clear.

Future research may better understand the measurement, design and methods of factors influencing creativity. The development of scales and the selection of relevant factors should be nuanced to take into account the diversity inherent to different industries and cultural backgrounds. Much empirical research is still necessary to refine and enrich these scales and methods.

2.2.4 Team creativity

2.2.4.1 Significance and conceptualization of team creativity

As research into creativity develops, group creativity has become a new area of interest. Zhang, Xu, and Sun (2020) point out that, in the era of the knowledge economy, creativity has become much more important. In the 21st century, with the rapid development of a global economy and

fierce business competition, innovation has become the core competence of firms, creativity being its starting point and essence. Shalley and Gilson (2004) further suggest that creativity may lie in any person. Behind drastic changes in the industry, enterprises as well as research institutes need to deal with a significant amount of information and make complex decisions in the process of innovation in order to pursue their own sustainable competitive advantages, which are far beyond the ability of individuals. As Bergman et al. (2012) point out, individuals rarely solve problems on their own, since no one person can have all the resources, technologies and knowledge needed for creation and innovation. Therefore, group creativity has played a much more significant role in the process of innovation. The effective transformation of individual creativity into group creativity has become a focus in group creativity research (Shalley, Zhou, & Oldham, 2004). Research on creativity has gradually examined group creativity from the perspective of the characteristics individuals should have. In early research into social and personality aspects in psychology, the main research object consists of individual characteristics. With the recognition and attention given to innovation, the research focus of creativity changes into how to stimulate individual creativity and ultimately maximize the efficiency of group creativity to achieve a synergistic effect.

Based on multi-level research on creativity, Chen and Wang (2012) suggest that team creativity results from individual creative behavior, team creativity, and team execution; organizational creativity is determined by group creativity, organizational characteristics, and environmental disturbances. Recently, research on creativity has been gradually paying more attention to team creativity, which is an important means for organizations to solve difficult and complex problems, and is the first step of team innovation (Amabile et al., 1996; Scott, Lonergan, & Mumford, 2005; Shalley, Zhou, & Oldham, 2004; Woodman, Sawyer, & Griffin, 1993). Thus, research on team creativity attempts to explore how to stimulate individual creativity and ultimately maximize team creativity to achieve synergistic effects.

Research on multi-level creativity, based on implicit coordination, is becoming a key trend (Wu & Cormican, 2017). It has been found that the fundamental reason for the coupling or aggregation of individuals into teams is the increasingly detailed nature of labor (Woodman, Sawyer, & Griffin, 1993). With the increased importance of cooperation, especially across professions, implicit coordination can enhance the operations of individuals of different levels of creativity. It can change group creativity, creating a model that can integrate several modules such as individual creativity, team creativity and intermediate variables (Yu & Zellmer-Bruhn, 2018).

2.2.4.2 Relationship between individual creativity and team creativity

The essence of team creativity is that the team integrates the knowledge and abilities of different individuals, in the form of organization, to improve overall performance through a synergistic effect (Li & Yue, 2019). From the perspective of cognitive theory, and especially that of implicit cognitive research in promoting team collaboration – such as the concepts of internal collaboration, shared mind and collective understanding – it is of great significance to explore the interaction between individual creativity and group creativity. The empirical study of team creativity began in the 1990s, and it was not until the 21st century that researchers began to pay more attention to it (Li, Lin, & Tien, 2015). Team creativity consists of an innovative and practical idea, service, process or product, jointly produced by team members through various team activities and socialization (Carmeli & Paulus, 2015; Hoever et al., 2012; Shalley & Gilson, 2004). The key difference between team creativity and individual creativity is that the former is the result of group process (Shalley & Gilson, 2004; Woodman, Sawyer, & Griffin, 1993). These group processes include common goal setting, decision-making participation, effective conflict management, and the development of team members' integration capabilities (West, 2002). The relevant empirical research explores and explains the formation process of team creativity from a cognitive path, emotional path, motivation path and coordination path (Li & Yue, 2019).

Although researchers have reached the consensus that team creativity is not a simple sum of the creativity of individuals, there are different starting points for different studies (Carmeli, Dutton, & Hardin, 2015). Some set the starting point for their research at individual creativity (Drescher & Garbers, 2016). They think that creativity often originates from individual cognitive process and is stimulated and screened by interactive processes (Somech & Drach-Zahavy, 2013). For example, Woodman, Sawyer, and Griffin (1993) believe that team creativity is a function of individual creativity but is also affected by the interaction of situational factors. Drazin, Glynn, and Kazanjian (1999) argue that team creativity starts from the participation of individuals in creative activities and occurs between individuals and teams in an alternate way. Having analyzed differences between individuals, Taggar (2002) states that individual creativity is the decisive factor behind team creativity, even if team processes have a regulatory effect. Mendez, Howell, and Bishop (2004) point out that team creativity is the aggregation of the creativity of individuals at a specific point of time. The research of Feng et al. (2016) show that the creativity of scientific research teams is determined by individual creativity, and team structure. All these studies emphasize that individual creativity is an important input to team

creativity. Team creativity comes from the selection and evaluation of individual creativity. The specific creative process includes problem identification and construction, information retrieval and collection, idea formation, idea evolution and selection, implementation plan and control (Gilson & Shalley, 2004).

Another group of researchers set the starting point of their research in the team itself, believing that team creativity is the attribute of the team and the product of complex interpersonal interactions within it. They view the process of building team creativity as being integral, dynamic, and non-linear (Jiang & Zhang, 2014; Leenders, van Engelen, & Kratzer, 2003). This approach shows that the biggest difference between team creativity and individual creativity lies in that team creativity is more dependent on the complex interactions between multiple team members (Smith & Tushman, 2005). West (2002) believes that team creativity is a creative product, process and service into which team members invest their unique knowledge, ability and problem-solving perspective under the influence of external needs, transforming team task characteristics, team knowledge and team heterogeneity into a series of team processes. This kind of research considers that integrated team processes are key to transforming the knowledge and skills of team members into creative results (Amabile et al., 1996; Harvey & Kou, 2013; Zhou & Hoever, 2014). According to Tiwana and McLean (2005), a team's process of creation is essentially an improvisational process, a combination of intentional creation and quick response. In contrast to the traditional sequential model of evaluation of creative proposals, in which individuals put forward a series of ideas, and then the team carries out an evaluation and selection on this basis, Harvey and Kou (2013) believe that team creativity is the result of collective activities and that is generated and evaluated at the same time. Different ideas interact until a collective understanding is reached. Harvey (2014) then proposes a more detailed creative synergy model that emphasizes team creativity as being a process of integrating cognitive resources, social resources, and environmental resources, in which collective attention, the enablement of ideas and building on similarities can effectively facilitate this process. The model again emphasizes that there is not a sequential relationship between the key elements of the creative collaborative process, and that they occur simultaneously and circularly.

It is by now clear that there is no consensus on the definition of team creativity. Several scholars are currently approaching the topic directly from the level of the team, exploring influencing factors that can enhance team creativity. A key question has to do with whether team creativity is mainly determined by individual creativity or by unique attributes or mechanisms of action at the team level. Tjosvold (2008) believes that individual differences

lead to different views and then lead to multiple perspectives, divergences and conflicts. If such information-based conflicts occur on the premise of making effective decisions and performing tasks, rather than on the premise of winning or conflict of interest, they will in turn promote performance and creative behavior (Tang & Ye, 2015).

Therefore, while research based on the individual focus on the relationship between the creativity of individuals and that of the team, regarding individual creativity as an important basis of team creativity, studies based on teams hold that complex team interactions are the real driving force behind team creativity. Both lines of research, however, do consider that team creativity comes from the joint efforts of many people in the team, as a kind of crystallization of the collective creation effort.

2.2.4.3 Factors influencing team creativity

Researchers considering individual creativity as a starting point note that the principal element of team creativity is the team members. As such, they address the relationship between individual characteristics and team creativity. Through a number of empirical studies, it has been shown that individual creativity endowments, personality traits, cognitive styles, creative motives, emotions and past experiences are all closely related to team creativity (Grant & Berry, 2011; Nikitin & Freund, 2010; Ocker, 2005; Parayitam & Dooley, 2007; Perry-Smith & Shalley, 2003; Somech & Drach-Zahavy, 2013; Srikanth, Harvey, & Peterson, 2016; Zhang & Bartol, 2010). By contrast, some scholars suggest – and indeed this is the perspective of mainstream empirical research on team creativity – that the main element of team creativity is the team itself. This kind of research mainly focuses on the influence held by team characteristics, team processes, team leadership, team real-time status, and team network (Hu et al., 2017; Joshi & Roh, 2009; Leung & Wang, 2015; Lord et al., 2017).

Although a large number of studies try to explore the effect of team heterogeneity (including professional background, function, knowledge, and skills) on team creativity, no consistent conclusion has been reached so far (Hu et al., 2017; Perry-Smith & Shalley, 2014). For example, some researchers believe that heterogeneity confers teams with additional knowledge and skills, enabling them to be more successful in information processing (Barczak, Lassk, & Mulki, 2010; Taylor & Greve, 2006). In particular, cognitive heterogeneity can expand the team's information pool, stimulate diversified thinking, and promote creativity processes (Horwitz & Horwitz, 2007; Nicolaides et al., 2014). Others argue that large heterogeneity, such as demographic heterogeneity, is more likely to trigger social classification processes and violate the principle of similarity attraction, thus cause the team to consciously carry out social

classification and lead to relationship conflicts as well as disorder, ultimately hindering team creativity (Pearsall, Ellis, & Evans, 2008; Shin & Zhou, 2007). Harvey (2013) shows that deep heterogeneity can intensify divergent processes and hinder the aggregation process of team creativity. Hoever et al. (2012) find that heterogeneity in the knowledge of team members can stimulate team creativity only when team members are empathetic in their thinking. Liu et al. (2014) show that the coordination level of task knowledge is an important aspect when there is knowledge heterogeneity. When there is high coordination, there is a positive correlation between knowledge heterogeneity and team creativity; when there is little coordination, there is an inverted U-shaped relationship between knowledge heterogeneity and team creativity.

Although some early researchers consider that team leadership is a potential obstacle to team creativity, most researchers agree that leadership plays a key enabling role in team creativity (Hoever et al., 2012; Hu et al., 2017). There are complex factors and mechanisms whereby leadership influences team creativity. The current research mainly focuses on leaders' characteristics, leadership style, and leadership network. Hu et al. (2017) find that, although the humility of leadership does not have a direct effect on team creativity, it can indirectly affect it creativity by promoting exchange of information within the team. Liao, Liu, and Raymond (2010) argue that the humility of leaders positively affects both horizontal communication between team members and vertical communication between team members and team leaders, thus improving improve team creativity. The positive effect of leadership humility is especially marked in the case of high cognitive heterogeneity if the team. Li and Yue (2019) point out that the creativity of leaders can positively affect team creativity, especially when task complexity is high and the leaders' level of authority is low.

In terms of the influence of leadership style, researchers mainly focus on transformational leadership. Unlike research on transformational leadership at the individual level, the research at the team level focuses on the role of transformational leadership in promoting team interactions. Zhang, Cao, and Tjosvold (2011) believe that transformational leadership can promote knowledge sharing and the team's collective effectiveness. Furthermore, Xie and Chu (2016) suggest that transformational leadership can stimulate the team's structural authorization, which is helpful to enhance team creativity. Based on the perspective of social network, Cai et al. (2013) think that although consistent transformational leadership in a team can promote team creativity, differentiated transformational leadership in a team is not conducive to the construction of a dense communication network and to knowledge sharing, inhibiting team creativity. In addition, and considering samples of Chinese firms, researchers found that, in China's management context, charismatic leadership, authentic leadership, paternalistic

leadership and inclusive leadership all contribute to improving team creativity (Chang, Liu, & Jing, 2016; Luo, Zhao, & Zhang, 2013; Peng & Jin, 2018).

As for the effect of leader member exchange (LMX) quality on individual creativity (Gu, Tang, & Jiang, 2015; Liao, Liu, & Raymond, 2010; Pan, Sun, & Chow, 2012), researchers agree that LMX differences at the team level will limit team creativity. Zhao (2015) finds that LMX differences can increase relationship conflicts within teams and reduce team creativity. Especially in the case that the quality of relationships within the team is already poor, LMX differences can inhibit team creativity more markedly. Li et al. (2015) conducted an empirical test on 59 teams and found that there is an inverted U-shaped relationship between LMX differences and team creativity. This relationship is stronger when the average value of LMX is low. They stated that the perception of LMX differences is an important social comparison process in a team, which may trigger poor team interactions (Hooper & Martin, 2008), thus hindering team creativity (Leenders, van Engelen, & Kratzer, 2003; Taggar, 2002).

From the perspective of social capital, researchers generally believe that the position of formal leaders in the internal and external networks of the team will affect team creativity. Taking 39 engineering design teams in the space industry as a sample, Kratzer, Leenders, and Van Engelen (2008) found that when formal leaders' position in the workflow is too central or too marginal, team creativity does not benefit from it. Their results show that, in the problem-solving network, the central position of a leader will inhibit team creativity. As for the external communication network, Wang, Luo, and Chang (2014) point to the fact that both the internal and external social networks of formal team leaders have positive impacts on team creativity: the external social networks of team leaders may regulate other aspects of formal leaders between the internal social networks of team leaders and team creativity. Bai et al. (2015) believe that leaders with a higher level of dialectical thinking will welcome team members to put forward novel or even completely different ideas and communicate openly, which can reduce hostility between team members through critical decision-making. Mohammed and Angell (2004) found that the clarity of team leaders helps to improve team processes, including team members' participation, its quality, and their commitment. Chen et al. (2011) believe that team leaders' help to team members would help improve the latter's individual performance and behavior. All of the above contribute to the improvement of team creativity.

Although formal leaders can improve team creativity by reducing the uncertainty and ambiguity of goals and tasks through coaching and structured behaviors, shared leadership, as a special kind of leadership model in which multiple people share the leadership role, power and responsibility, can also allocate team resources effectively (Li & Yue, 2019). Researchers

point out that shared leadership can encourage team members to participate more in management, thus boosting team confidence and optimizing team decision-making (Lee et al., 2015). Luo, Zhao, and Zhang (2013) confirm that, compared to a traditional hierarchical structure, a more mobile and dynamic leadership structure is more conducive to the integration of individual team resources to match a dynamic team's objectives. In addition, shared leadership broadens the width of team information processing and improves the speed of information exchange. Lee et al. (2015) find that shared leaders can find multiple solutions by stimulating more knowledge sharing. Kulkarni and Shanbhag (2014) also argue that shared leaders can adjust plans and objectives to increase team adaptability through team reflection. Wang et al. (2017) further confirm that, in the context of the Internet, shared leadership can more effectively manage team boundaries and promote team creativity through boundary strengthening behavior and boundary buffering behavior. Wu and Cormican (2017) examine the impact of density, centrality, and intensity of shared leadership on team creativity and find that, while density and centrality have a positive effect on team creativity, intensity has an inverted U-shaped relationship with team creativity.

Beyond the impact of different kinds of leadership, some scholars suggest that both the internal and external social networks of the team affect team creativity. Zhao (2015) finds that high centralization and a high level of interaction in team networks can enhance team creativity by strengthening team learning. Chen (2009), examining 54 project teams in Taiwan and in the context of Chinese culture, concludes that although teams' internal and external networks can enhance their creativity, teams should ensure that they have a dense internal network before expanding their external network. Han, Han, and Brass (2014) indicate that teams' internal and external networks can jointly affect team creativity. From the perspective of network structure, Jia et al. (2014) examine the density and centrality of the internal network, showing that density has a positive effect on team creativity through enhanced coordination among members and the rapid and accurate development of ideas. Tang and Ye (2015) find a negative relationship between the centrality of the internal knowledge network and team creativity. Their research shows that the existence of large nodes in the network may hinder teams' information exchange and reduce their cohesion and creative motivation. In other words, teams with equal or similar amounts of power are more creative than teams with greater power differences.

The cognitive mode of individuals is regarded as an integral part of creative skills. The characteristics of cognitive mode that are conducive to creativity include breaking perception stereotypes, understanding and appreciating complexity, keeping openness of choice as much as possible, delaying evaluation, and being good at multi-channel classification of information,

(Tang & Naumann, 2016).

In the process of team innovation, team atmosphere will affect the motivation, behavior and attitude of its members. A team's atmosphere will vary according to the team's composition and task scenarios. Wang and Chen (2008) suggest that the characteristics of members and their frequent interactions have an important impact on creativity through information sharing and mutual influence. This interaction may set up a team atmosphere that affects each member's creativity. The different atmospheres created by different teams indirectly affect the creativity of research and development (R&D) teams through the complete or partial mediation of task-based and collaborative-shared mental models (Li & Yue, 2019). Beyond this, Tjosvold (2008) believes that the proper handling of the competitive perspective is the key issue for creativity and innovation. Intentional disputes related to tasks will improve the quality and creativity of decision-making in the context of cooperative groups. Conflicts related to tasks will enable group members to reassess the status quo and adjust goals and processes to better adapt to the current situation. Zhou (2006) believes that feedback has a strong impact on individual creative performance through the stimulation of recipients' internal motivation and the clarification of the standards of creativity output. The existing research tends to solve the input end of team creativity, rather than consider the black box of its inner workings (Wang & Chen, 2008). While the research on the influence of feedback on creativity is still in its infancy, it already shows that feedback related to creativity can, in a way, become an effective catalyst for group creativity, and managers should deliberately cultivate and improve the ability of individuals. In an atmosphere of active participation by individuals, appropriate task-related conflicts and minority dissenters will generate innovation by encouraging debate, and at the same time, individual members will obtain useful information through transposition thinking, generating creative ways to solve problems (Zhu et al., 2018).

Team creativity requires the team to show related cognitive ability through extensive participation in a cognitive process. Currently, a number of scholars propose different models such as the shared mental model, interactive memory system, or transposition thinking to reveal the mechanism of team creativity from a psychological cognitive perspective.

(1) Shared mental model

There are different effects of shared mental model on team creativity. Some researchers believe that shared mental models can lead team members to avoid extremely diversified views that would stifle team creativity (Skilton & Dooley, 2010). By contrast, others think that shared mental models may promote team creativity since they will strengthen the team's identity and lead to members better understanding it. This would, in turn, lead to each team member

adjusting their work style to cooperate in the complex task environment (Bledow et al., 2009; Burke et al., 2006; Jay, Paul, & Jennifer, 2016; Resick et al., 2010; Uitdewilligen, Waller, & Pitariu, 2013). Chang, Liu, and Jing (2016) find that team creativity is at its highest when the shared mental model is high in accuracy and low in similarity, but at its lowest when the shared mental model is high in similarity but low in accuracy.

(2) Interactive memory system

Interactive memory system, as an effective means of enhancing team creativity, not only provides knowledge accumulation that improves team creative activities, but also sets a good foundation for team coordination (Gong et al., 2013; Hargadon & Bechky, 2006; Srivastava, Bartol, & Locke, 2006; Tiwana & McLean, 2005). Researchers agree that both knowledge sharing and knowledge integration help teams to clarify and expand the value of the team's knowledge reservoir so that they can relink and build new knowledge on this basis (Cai et al., 2013; Lee et al., 2015). In contrast to knowledge sharing, knowledge hiding can inhibit team creativity by reducing absorptive capacity, though this negative correlation is weaker in settings of strong team interdependence (Fong et al., 2018). Zhang et al. (2014) suggest that, when compared with explicit coordination, implicit coordination is more successful in promoting creativity, and that this positive effect is particularly significant in the context of strong task convention and high task interdependence.

(3) Transposition thinking

Transposition thinking can not only promote social integration but also improve the team's communication satisfaction and enhance its positive emotions and social motivation (Zhang, Tsui, & Wang, 2011). Hoever et al. (2012) find that empathy can help a team to turn heterogeneous perspectives into team creativity. Jiang and Zhang (2014) also confirm that team transposition thinking can improve team creativity by influencing the team's in-depth information processing.

(4) Task conflict

Task conflict may play a positive role in team creativity in some situations. Jehn, Rispens, and Thatcher (2010) believe that task conflict has a positive effect on team creativity when task uncertainty is high or routine is low. De and Carsten (2006) take two experimental studies to show that, compared to extreme task conflict, moderate task conflict will bring about more team creativity. Farh, Lee, and Farh (2010) also point out that there is an inverted U-shaped relationship between task conflict and team creativity. In the early stage of team formation, the relationship is stronger, while in the latter stage of team development, there is no significant relationship between task conflict and team creativity.

In addition, positive team emotions are the glue of team, effectively promoting social integration (Farh, Lanaj, & Ilies, 2017). The sharing of emotional experience among team members can increase team cooperation, weaken team conflict, and reduce team reversion behavior (Chi, Chung, & Tsai, 2011; Hogg & Gaffney, 2018; Sy, Côté, & Saavedra, 2005). Greer et al. (2018) point out that positive team emotions can directly affect team creativity. Compared with emotionally neutral teams, emotionally positive teams do better in both creative generation and implementation. However, there are still differences on the effect of negative team emotions on team social integration (Hareli & Rafaeli, 2008; Katherine et al., 2019). As Tsai et al. (2012) point out, in some complex situations, team trust is the boundary condition for team negative emotions to promote team creativity.

2.3 Innovation

2.3.1 Innovation characteristics

The significance of innovation has been studied widely. Continuous innovation in scientific discovery, engineering as well as social sciences is a critical driving force to promote the development of a country or civilization. With innovation being the soul of the progress of human society, differences in innovation abilities may provide an important explanation for the diversity in phases, levels and speeds of development (Ghassan, Chris, & Stefan, 2020; Rafique et al., 2017). Indeed, when compared to creativity, innovation focuses more on results more than on process. Unlike ordinary thinking, innovation integrates the existing knowledge, skills or materials to create new things that can meet the demands of society and people. The word innovation has originated from a Latin term with three meanings: to update, to create new things, and to change things or ideas. Its essence is to break conventional precepts and produce novelty. In business, the core of innovation activity is the “new”, including changes in a product’s structure, performance and external features, or in organizational design (He, Rayman-Bacchus, & Wu, 2011; Wu, Chen, & Li, 2015). Chesbrough (2003) views innovation as a conceptualization process in which novel things are created by new thinking, new inventions, and new descriptions.

George, McGahan, and Prabhu (2012) believe that inclusive innovation covers any development or implementation of new ideas that can improve social and economic welfare or performance. Thus, it includes all novel forms of products, processes, and services, ranging from politics, military, economy, society, culture, science, technology, and other fields. When

defined more narrowly, innovation pertains to a specific area or range. For example, in management research, the definition for innovation proposed by (Colby, 2020), which emphasizes the way of achieving innovation, has been widely used. He considers innovation to be a process that combines various production factors and conditions to produce a new product; to introduce a new approach; to open up a new market; to access a new source of inputs; and to design a new organizational form.

2.3.2 Types of innovation

Innovation can be classified into different types according to diverse criteria. According to Schumpeter's definition, innovation can be roughly divided into two types: technological innovation and managerial innovation (Prahalad & Hamel, 2010). In terms of disciplines, it includes technological innovation; artistic innovation; political innovation and so on. In terms of source of productivity, it contains scientific innovation and technological innovation (Zhang & Baden-Fuller, 2010). Most scientific innovations are developed by universities and other research institutions, with enterprises being responsible for technological changes (Pitelis & Teece, 2010). In terms of enterprise function, innovation includes procurement innovation, marketing innovation and finance innovation (Ahmed & Shepherd, 2015). Doz and Kosonen (2008) emphasize the importance of innovation in competition in the long run. As for industrialization process, Wu, Chen, and Li (2015) define technological innovation as a kind of dynamic organizational spontaneous capability, the enterprise's access to technological innovation.

2.3.2.1 Technical innovation and managerial innovation

While technological innovation often concentrates on improving the approaches and skills behind products and processes, scientific innovation focuses on basic scientific achievements (Kauffman, Liu, & Ma, 2015). Scholars further classify technological innovation into two main streams: (1) revolutionary, discontinuous, radical, unexpected or leapfrog; (2) change, continuous and gradual. Each classification serves a specific and different phenomenon (Adner & Kapoor, 2016). Sucet and Jaume (2020) propose a series of criteria for analyzing the reliability and validity of the degrees of disruption. Reliability analysis, exploratory factor analysis, confirmatory factor analysis and statistical tests all support their measurement, which shows that disruptive innovation should have the following characteristics: (1) provide new value, attract a new customer segment or set higher objective price in the existing market; (2) sell at a lower price; (3) use a niche market to penetrate the mainstream market.

Much empirical evidence has been found by scholars to show the significance of technological innovation, such as R&D expenditure (Ai & Yin, 2015; Chen et al., 2011; Huang, Zhou, & Zhu, 2017; Wang, 2013). Damanpour (1996) suggests that there are many types of organizational innovation, one of which is technological innovation, which greatly helps enterprises to attain profits. Using fixed assets and growth ability to measure corporate performance, Tzokas and Saren (1997) indicate that technological innovation has a great impact on corporate performance. Bosworth and Rogers (2001) examine the data of Australian enterprises, using Tobin Q as an indicator to measure performance, and find that technological innovation has a significant positive impact on enterprise performance, showing that technological innovation has a continuous impact on corporate profits. Sougiannis (1994) shows a positive relationship between R&D investment and corporate performance, showing a lag effect. Ai and Yin (2015) analyze large and medium-sized enterprises and find that R&D investments have a significant effect on enterprise performance. Furthermore, Falk (2007) asserts that the impact of R&D expenditure on corporate performance varies in different stages of development. In the middle stages of enterprise development, R&D expenditure has a strong role in promoting enterprise performance but, over time, the degree of this effect will gradually decrease. Sun and Yu (2014) observe companies in the IT industry, finding that if R&D expenditure is a strategic investment, the relationship between R&D expenditure and corporate performance in the current period will have a negative impact. Wang (2016) points out that organizational innovation and technological innovation ability have a positive impact on enterprise performance. According to Huang, Zhou, and Zhu (2017), strategic planning ability and technological innovation ability have a significant positive impact on enterprise performance.

However, some scholars believe that there is not a positive correlation between technological innovation and corporate performance. For example, Qiu (2008) finds that R&D investment is negatively correlated with present business performance, but has a positive impact later on. Liu and Ren (2018) suggest that, in the context of open innovation, the R&D investment of enterprises is negatively correlated with corporate performance. Zhao and Feng (2015) believe that irrational increased expenditures in science and technology funds and personnel have a negative impact on the improvement of innovation performance. Qiu (2008) examines the relationship between technology investment, R&D investment, and performance based on the data of the listed companies in 1998, showing that technology and R&D investments do not have a significant effect on current corporate performance.

Therefore, both theoretically and empirically, the existing literature shows that there is a

mixed role between technological innovation and company performance, and a delayed positive impact by R&D investment on corporate performance.

2.3.2.2 Open innovation vs. closed innovation

Another important type is open innovation. Chesbrough (2003) first defined open innovation from the enterprise level. The author believes that innovation resources can flow through organizational boundaries from the outside to inside, allowing the enterprise to obtain innovative ideas or effective technology commercialization paths. Since then, the term open innovation has been widely used in academia, being defined from the perspectives of economics, management and sociology. some scholars consider it from the perspective of innovation process, and believe that open innovation is a process in which enterprises use internal and external technologies and ideas to develop products and services, and in which technology transfer, asset allocation and information feedback take place (Franke & Piller, 2003). Another definition focuses more on internal and external cooperation, that is, not only the integration of internal and external knowledge and channels in the innovation process, but also the convergence of internal and external knowledge for the purpose of innovation (Huizingh, 2011).

From the perspective of technology resources, if an enterprise wants to survive and develop in the process of rapid changes in the information society, it should fully integrate the internal and external high-tech and innovation thinking, and promote technology providers through technology transfer or asset allocation (Enkel, Gassmann, & Chesbrough, 2009). The intermediary role of technological capability is also reflected in the relationship between open innovation and enterprise performance. However, the adoption of open innovation may also have a negative impact on technological innovation. Lichtenthaler (2008) argues that open innovation can also cause various problems, such as obstacles in the development of external technology, high cost of technology transactions, and difficulty coordinating technical cooperation subjects. Therefore, enterprises should seek an innovation mode and strategic planning that meet their own needs.

As Lewin, Välikangas, and Chen (2017) point out, open innovation may reduce the uncertainty of internal and external technological elements and of the instability of the market environment. Wang et al. (2012) suggest that open innovation can integrate internal and external resources to promote the improvement of enterprise technology capability. Technological commercialization capability has enhanced the role of open innovation in promoting the growth of enterprises. Making use of its intermediary effect on technology capability, open innovation has both a direct and an indirect positive impact on enterprise performance (Qiu, 2008). Toh

(2008) believes enterprises using open innovation can update scientific and technological knowledge to develop new products and improve product manufacturing processes, but also create suitable opportunities for technical cooperation inside and outside the enterprise to improve the technical ability of the enterprise by obtaining the resources of technological innovation from the outside.

In addition, Akif, Audretsch, and Slaper (2019) point out that customers are the main external source for open innovation putting forward a revolutionary view to highlight their importance. Researchers have further studied customer innovation and put forward ways whereby customers participate in open innovation, including user participation in communities and platforms, crowdsourcing and open source software – through which users' participation can improve the quality and design of new products. Most studies have shown that open innovation has a significant positive correlation with technological innovation (Zhao & Feng, 2015). Some scholars believe that technological innovation has an intermediary role, while others think that open innovation needs a reasonable choice to avoid negative impact. There are also some limitations for adopting open innovation. For example, Chen and Wang (2012) indicate that enterprises should carry out open innovation selectively according to the purpose of R&D and international competition. In the process of implementing open innovation, enterprises need to choose diversified external organizations and act in a timely manner according to the different needs of the innovation stage.

Some studies also discuss the factors influencing open innovation. The literature in this area mainly focuses on the ability of enterprises to carry out open innovation (Wang, Huang, & Zhou, 2016). The factors that affect the acquisition of external knowledge may include enterprise scale, enterprise development stage, R&D intensity, absorptive capacity, and complementarity of internal and external R&D (Zhou & Sun, 2016). In addition, external knowledge sources on enterprise performance, including the impact of R&D cooperation on enterprise performance, also relate to the importance of cooperation with external partners. It is generally believed that enterprises with high technology level, strong innovation, and strong internal R&D ability have more opportunities to cooperate with other enterprises. In this way, creation ability, absorption ability, transformation ability, connection ability, innovation ability and desorption ability of an enterprise can play an important role in the development of open innovation (Qiao, 2017; Zhao & Zhang, 2016). Meanwhile, trust, good communication, and advanced information technology, as abilities of the enterprise itself, can reduce transaction costs between enterprises, thus promoting the development of open innovation and cooperation among various firms (Chen, Jiang, & Chen, 2011).

2.3.2.3 Disruptive innovation

Recently, disruptive innovation has received significant attention in the domain of management innovation. Disruptive innovation has changed the established technology paradigm, guided by customer value (Christensen et al., 2018; Markides, 2006) – it helps customers create value. Therefore, it has an impact on the old technology systems and business models, resulting in changes to the whole market structure (Paap & Katz, 2004). Based on Christensen's definition of disruptive innovation, technology and market are two important dimensions for disruptive innovation: technology embodies continuous improvement or new technology, and market emphasizes the development of low-end markets and emerging markets (Christensen et al., 2006).

Markides (2006) also points out that disruptive innovation should not only include disruptive technology, but also managerial model innovation. Hwang and Christensen (2008) divide it into two types: low node and new market. The low node refers to subversive innovation that gains low profits and serves large consumers in the lowest value network. Disruptive innovation in new markets refers to the creation of new value networks, which must face the difficulties of market development. Disruptive innovation is expanded to include not only technology products but also service and model innovation, such as discount stores, low-cost and point-to-point air routes and online business education (Christensen et al., 2018). However, it is also a relative phenomenon and does not always mean that existing business will be replaced by new business, nor does it necessarily cause interference to existing enterprises. Disruptive innovation is not equal to destructive innovation. Disruptive technological innovation with high performance and low cost can quickly occupy the mainstream market (Assink, 2006).

Destructive innovation theory has attracted wide attention in the area of economics (Christensen et al., 2006). As a new generation of innovation theory, destructive innovation theory is the development of mainstream innovation theory. In the mass consumer market, destructive innovation may bring about the advantages of simple standards and price, as catalysts for the rapid popularization of new products and new technologies (Guttentag, 2013). Studies show that, along with the traditional concept of sustaining innovation and imitating innovation, it will seriously affect the efficiency and performance of innovation (King & Baatartogtokh, 2015). Destructive innovation is a new starting point of innovation theory research in recent years, meaning that innovation theory plays a key role in the transformation of economic growth modes and the promotion of industrial competitiveness (Zhang & Zhang,

2017). Thus, disruptive innovation has been given much attention in the process of industrial development.

Disruptive innovation is the theoretical paradigm or thinking framework of how to effectively enhance the competitiveness of late developing enterprises (Yu & Hang, 2011). This theory integrates technological innovation and business model innovation, as a new starting point for the development of innovation theory (King & Baatartogtokh, 2015; Schmidt & Druehl, 2008). Christensen et al. (2006) initially proposed that disruptive innovation refers to technological innovation, pointing out that disruptive innovation is not aimed at the customer groups of mainstream markets, but at consumer groups of low-end markets, emerging markets, or mixed markets. Therefore, disruptive innovation should combine technology and market demand for research (Su & Hu, 2009).

2.3.2.4 Exploration and exploitation innovation

According to March (1991), exploration innovation refers to a kind of innovation which is large-scale, radical, knowledge-based, long-term oriented, and new knowledge based. Since it focuses on the future demand of customers and market, exploration innovation is generally faced with highly uncertain returns and high investment risk. By contrast, exploitation innovation is an incremental innovation, mainly considering the current demand of customers and market by using existing knowledge and technology. Thus, it is predictable, with low external risk, focusing on short-term benefits.

The existing research on the consequences of dual innovation mainly focuses on their impact on enterprise performance (Rhee & Kim, 2019). There is a difference between exploratory innovation and development innovation in the impact of enterprise performance. Jansen, Vera, and Crossan (2009), approaching this question from the perspective of organizational structure, find that, while exploitation innovation can strengthen the organization's procedures and regulation, leading to definite and stable benefits, exploration innovation can make the structure more flexible. Wu, Chen, and Li (2015) show that exploratory innovation has a significant role in promoting performance and that exploitation innovation promotes the short-term interests of enterprises and brings stable benefits to enterprises in a low-cost way. Lin, Gao, and Gao (2016) examine the relationship between innovation investment and enterprise performance, finding that the use of innovation investment has a positive impact on enterprise performance. In addition, Huang, Zhou, and Zhu (2017) study this topic from the perspective of redundant resources and suggests that absorbed and unabsorbed redundant resources are respectively conducive to exploitation and exploration innovation

investments promoting enterprise performance.

Therefore, dual innovation can improve enterprise performance. Specifically, exploitation innovation is more conducive to the short-term performance of enterprises, while exploration innovation is more conducive to the long-term performance of enterprises (Li et al., 2018). According to Jiao (2011), when the organization scale is large and resources are abundant, there is a complementary relationship between high-level exploitation and exploration innovation. The synergy of the two types can integrate, reorganize and transfer the ability and resources possessed by the enterprise, making the resources constructed by the enterprise difficult to be imitated by the competitors, thus improving the enterprise's market competitiveness. In the same way, Wang and Rafiq (2014) also point out that dual innovation plays an important role in improving the short-term performance and long-term development of enterprises, and that both should be balance in order to achieve the sustainable development of an enterprise. Furthermore, Jansen, Van Den Bosch, and Volberda (2006) suggest that the informal social relation existing in enterprises is a more flexible enterprise mechanism, which may promote the exploratory innovation of enterprises and also shows a positive correlation with exploitation innovation. Kollmann and Stöckmann (2014) propose that entrepreneurial orientation is a factor that enhances dual innovation in the same direction, analyzing the intermediary role of dual innovation. Jiao (2011) studies the factors that affect exploratory innovation investment and the development innovation investment. He found that the dynamic capability of enterprises can improve the adaptability of enterprises to the external dynamic environment, showing that the dynamic capability of enterprises is a positive correlation between the exploratory innovation investment and the development innovation investment.

2.3.2.5 Collaborative innovation

Ansoff (1957) puts forward the concept of collaboration in strategies for diversification. He pointed out that collaboration refers to symbiotic and long-term relationship between enterprises based on the sharing of enterprise resources. Based on physical laser research, Jiang and Zhang (2014) point out that coordination, synchronization and cooperation among subsystems in complex systems can help to achieve orderly development among subsystems and produce a certain stable structure. The coordination formula is $1 + 1 > 2$, that is, the whole is greater than the sum of parts (Jiang & Zhang, 2014). With the introduction and wide application of innovation theory and collaboration theory, research on collaborative innovation has become especially pertinent. Collaborative innovation has been discussed and empirically analyzed with regard to its motivations, operation mechanisms, influencing factors and other

aspects (Xu & Xie, 2004).

According to the theory of collaborative innovation, system optimization and collaborative innovation can optimize resource allocation and improve innovation efficiency. Thus, regional and national innovation systems have been proposed and quickly attracted the attention of scholars (Xie & Xu, 2014). Cooke, Gomez, and Etxebarria (1997) creatively put forward the concept of regional innovation system, which emphasizes the interaction between systems through vertical or horizontal modes. Khan et al. (2020) believe that the national innovation system emphasizes all participants as constituting networks to inspire, introduce and spread new technologies to achieve a series of common social and economic goals. Based on previous studies, Loet (2012) suggests that enterprises, governments, and universities are the three important elements of the environment of society's internal innovation system. They cooperate closely in the innovation process, forming a triple helix relationship whereby the three cross and influence each other (Loet, 2012). This theory provides a new paradigm for the study of collaborative innovation and makes up for the shortcomings of traditional research on collaborative innovation.

Furthermore, Xu and Xie (2004) think that the essence of collaborative innovation lies in the behaviors formed by the interaction of system and technical elements. In the industrial cluster, He, Rayman-Bacchus, and Wu (2011) point out that collaborative innovation is a process in which enterprise clusters compete and cooperate through complex non-linear interaction, producing a synergistic effect that enterprises on their own cannot achieve. Chen and Wang (2012) believe that collaborative innovation is a process in which enterprises, governments, universities and scientific research institutions take value-added knowledge as the core and make innovation subjects and resources flow freely. Song, Kang, and Zhao (2018) point out that collaborative innovation is in the process of innovation networking, in which, based on mutual trust, the four parties of government, industry, universities, and research institutions jointly cooperate to achieve common goals. Most literature on collaborative innovation is based on theories such as the triple helix theory, system theory, or complex adaptive system (CAS) theory (Xie & Xu, 2014; Xie, Zuo, & Liu, 2014). Based on the CAS theory, Ai and Yin (2015) think that collaborative innovation is a complex adaptive system driven by factors such as economy, science and technology, market, culture and service, aiming at establishing an ecosystem for innovation.

2.3.3 Stimulators of innovation

Innovation is a complex process that may be stimulated by a number of factors. Figure 2.1 lists

some important variables for innovation. Innovation, as a valuable result, involves transferring inputs, which can be summarized to three aspects: organizational structure, human resource, and culture variables. Even if the core of innovation is creative people, the environment also plays an important role helping transfer various inputs into innovative products, methods, or services.

As Gong, Fletcher, and Bolin (2015) point out, organization structure is the base and guarantee of any innovation activity in any enterprises. Innovation is a high-risk activity and needs time and financial support from the organization. Many studies suggest an organization's structure can have a huge impact on innovativeness (Gong, Fletcher, & Bolin, 2015; Li & Ren, 2018; Toh, 2008). Research shows that five factors are key to organization innovation:

(1) Organic structures, characterized by low formalization and centralization and high flexibility (Camarinha-Matos et al., 2012);

(2) Abundant resources that enable managers to afford the necessary investments and costs in institutional innovation (Huang et al., 2004);

(3) Frequent communication between organizational units, to help break down barriers to innovation (Chen, Li, & Tian, 2019). Cross-functional teams, task forces, and other such organizational designs can facilitate interactions across departmental lines (Qin & Shao, 2019);

(4) Manageable deadlines, as extreme time pressures on creative activities should be minimized for any innovative organizations, notwithstanding the demands of white-water rapids environments. Although time pressures may spur people to work harder and make them feel more creative, numerical findings suggest that it actually causes them to be less creative (Han, 2015);

(5) Explicit beneficial work and nonwork support that enhance innovation, such as encouragement, open communication, readiness to listen, and useful feedback (Li et al., 2018).

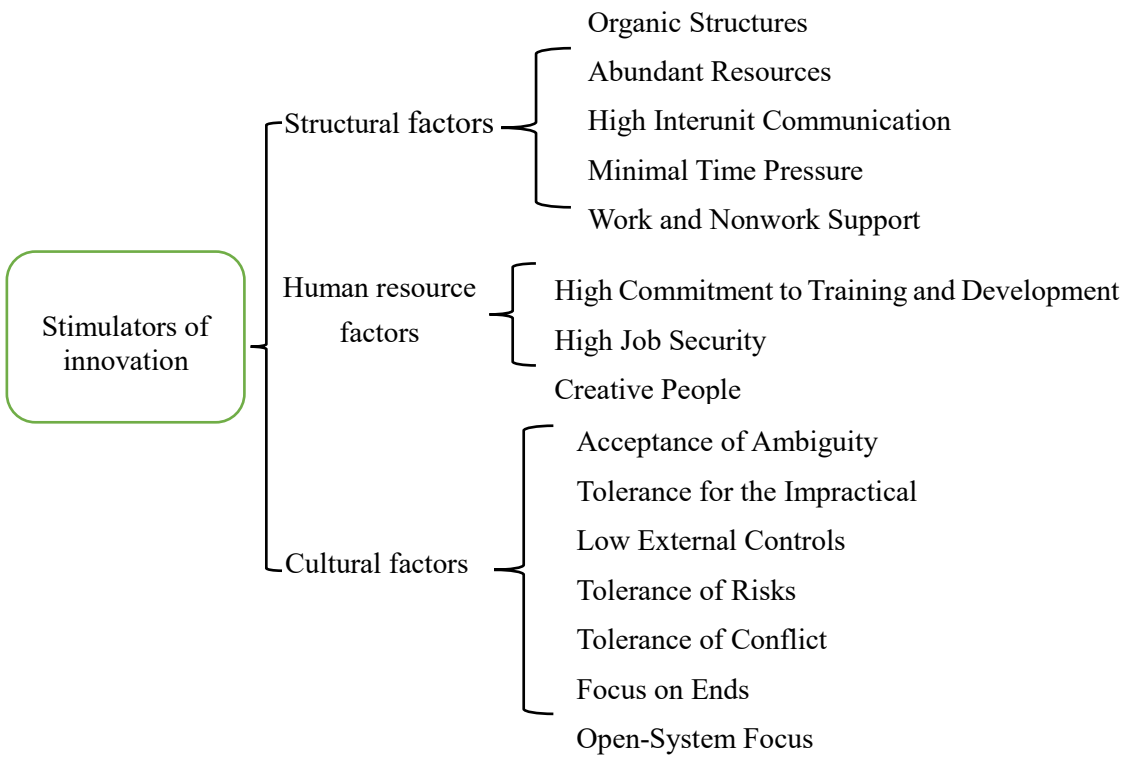

Figure 2.1 Stimulators of innovation

Source: Hülsheger, Anderson, & Salgado (2009); Woodman, Sawyer, & Griffin (1993)

Innovative organizations tend to have similar cultures, encouraging experimentation, rewarding both successes and failures, and celebrating mistakes (Guan & Wang, 2002). The following characteristics may foster an innovative atmosphere:

(1) accept ambiguity. If an organization gives excessive emphasis to objectivity and specificity, innovative activities will be constrained (Hawkins & Davis, 2012);

(2) tolerate the impractical. Many creative ideas look impractical or even foolish at first sight (Perry-Smith & Mannucci, 2017);

(3) lower external controls such as the intervention of existing rules, government regulations and policies, as well as similar organizational aspects (Hitt, Zhou, & Shalley, 2015);

(4) tolerate risk. Mistakes are regarded as learning opportunities and employee are encouraged to experiment without fear of bad results (Shalley & Perry-Smith, 2008);

(5) tolerate conflict. Innovative organizations often view diversity of opinions as a common thing that may lead to new thinking. They believe that harmony or agreement between individuals or units do not necessarily lead to higher performance (Scott & Bruce, 1994);

(6) pay more attention to ends rather than means. Diverse approaches are encouraged to achieve goals in innovative organizations (Yuan & Woodman, 2010);

(7) establish an open system. Managers are always monitoring the external changes and

adjusting strategies or approaches (McGregor, 2006);

(8) provide positive feedback. Employees are often encouraged to access their managers easily (Neumann, Riel, & Brissaud, 2013);

(9) exhibit empowering leadership. Leaders may provide organizational members with some power to make decisions for themselves, which will make employees confident and help them achieve better outcomes and more creative products (Zhang & Bartol, 2010).

If structural and cultural variables are the environmental stimulators of innovation, human resource factors can be viewed as pertaining to employees themselves (Beckmann-Dobrev, Kind, & Stark, 2015). In the human resource category, training and development may be the most common mean for organizations to enhance innovative activities. Research also shows that the idea of champions should be encouraged since they have extremely high self-confidence, persistence, energy, and a tendency toward risk taking (Ji, 2020). Thus, they may inspire and energize others with their vision of the potential of innovation and help implement it in an enterprise (Perry-Smith & Mannucci, 2017).

2.4 Makerspaces

In light of the rapid development of the Internet, as well as of the sharing economy, makerspaces have become a trend around the world, particularly in China, where it has been regarded as an important platform to achieve the national strategy of “massive entrepreneurship and innovation”. In this section, we will review international and Chinese literature on makerspaces (Zhao & Qian, 2017). The concept of “makerspace”, widely used in China, originated from “hacker space” in the United States, and there is still no unified expression across different countries (Li & Ren, 2018). Thus, in this thesis, the term makerspace covers these various designations.

2.4.1 International research on makerspaces

With the widespread use of information technology and the Internet as well as the rapid growth of the service economy and of personalized demand, the creativity of ordinary persons around the world has been activated (Niaros, Kostakis, & Drechsler, 2017). This has led to the creation of many makerspaces such as “Chaos Camp” (Germany), “Hacker Space” (US), “TechShop” (US), “NoiseBridge” (US), “FabLab”(US), “AccessSpace” (UK), and “Metalab” (Austria). Each of these amounts to a new and open form of organization or service platform, in which various equipment items are provided and co-working spaces exist to promote knowledge

sharing, cross-boundary collaboration and the realization of creativity and even products (Kostakis, Niaros, & Giotitsas, 2015; O'Donovan & Smith, 2020; Zhou & Pei, 2016). Although they have different names, recent research has gradually used the term makerspace to generalize and represent the emerging trend of spatial agglomeration (Niaros, Kostakis, & Drechsler, 2017).

While early makerspaces such as Chaos Camp and Hacker Space have existed for over ten years, not much attention has been paid to them by researchers, as a result of their relatively small scales. Current theoretical research focuses on the function of the creation space. For example, Kera (2012) analyzes the conditions of makerspaces for shared technology, tools and places, including a series of governance processes and values related to the elements of open sources software and hardware. Holm and Eric (2015) explore the role of makerspace on entrepreneurship in three different ways: (1) to attract more individuals to participate in the design and innovation of the product, thus increasing the probability of accidental entrepreneurship; (2) to create a large and heterogeneous high-density network that is conducive to the formation of innovative thinking and the emergence of innovative ideas; and (3) to reduce the cost of product model design, providing convenience for initial user access and financing. Boyle et al. (2016) study the role of the Australian public library on the establishment of makerspaces, particularly the common characteristics of a successful makerspace, which include promoting cooperation in the community; forming a larger user library; learning and fostering social connections between generations; promoting the transmission of information; cultivating the concept of lifelong learning; and constructing social and economic advantages in the community. Niaros, Kostakis, and Drechsler (2017) study the process of building makerspaces from the perspective of intelligent cities, analyzing creation and interaction in the community, as well as the advantages and disadvantages of practice and innovation, and point out the importance of creating guest spaces for the creation of an inclusive, participatory and shared intelligent city. Walsh et al. (2017) point out that creating makerspace will change the innovation practices of biological microfluidic technology (microfluidics) by lowering the cost of innovation through sharing materials and tools to reduce the cost of microfluidic control and to create an atmosphere of innovation.

Based on the available theoretical research, some scholars also carry out empirical research on the working environment, competitive advantages and sustainable development of makerspaces (Shao & Ni, 2017). Since makerspaces have a relatively short history, the related empirical research has emerged only gradually, and in recent years. Currently, this research is no longer limited to American and European countries, but also extend to other regions such as

South Korea. Empirical research, based on case studies, has gained interest internationally. *Table 2.1* provides some typical studies on makerspace.

Table 2.1 Empirical case studies on makerspaces

Reference	Methodology	Research problem and main results
Jensen et al. (2016)	□ Interviewing 13 makerspace users and 11 potential users in Norway, Denmark, and United States; □ Surveying 25 international makerspaces.	This paper studies the status of the makerspace, its inner design elements, the industry, workplace design, target groups, mode of operation, staffing activities, profiles of users. The main factors to be considered in establishing a new makerspace include the creation of ideas, core activities, training and counseling for entrepreneurs.
Mortara and Parisot (2016)	□ Interviewing 12 entrepreneurs in the United States and European Union; □ Reviewing the data found on 73 Fabspace Internet websites	This paper studies the role of Fabspace as a provider of equipment, knowledge and production skills to creator and how it can help users gain competitiveness. It shows that the contribution of Fabspace to innovation mainly pertains to geographic agglomeration. Although a reasonable geographical distribution of several types of makerspaces is beneficial to the innovation process, it cannot fully support the whole manufacturing process. For makers, it is necessary to choose a suitable manufacturing space, while government needs to guide the optimized layout of the makerspace from the whole innovation ecosystem.
Han et al. (2017)	□ Surveying 121 users from 12 makerspaces in South Korea	This paper studies factors affecting the sustainable development of makerspaces from the user perspective. It points out that technical support, economic support and social communication support are 3 important aspects. By impacting the user's freedom, ability to work and relationship network, makerspaces will enhance the intrinsic motivation of innovation so as to form a dependence on makerspaces.
Saorín et al. (2017)	□ Surveying 44 students majoring in engineering at La Laguna University	This paper studies the influence of the creative environment on student creativity. It shows that digital editing tools and 3D printing enable students to transform innovative ideas into products, impacting their innovation ability.

2.4.2 Research on makerspaces in China

As makerspaces are a relatively new concept in China, officially put forward in 2015, the related research in the country started later than abroad (Wu, Zhan, & Zhou, 2017), even though it has significantly grown in recent years. Domestic research on makerspaces in China mainly concentrates on the following three aspects: definition; function and classification, operation

mode and mechanism.

2.4.2.1 Definition of makerspace: Connotation and extension

At present, there is no unified and clear understanding for the definition of makerspace in China. The main open questions have to do with the relationship between makerspace, traditional incubator and new incubator (Liu, Chen, & Xue, 2015; Wu, Zhan, & Zhou, 2017). Some scholars believe that the concept of makerspace contains that of hackerspace, while others consider the two to be different (Yin, 2015). A hackerspace is a fully tooled space, such as a brainstorming salon, focused on bringing people together to carry out innovative activities, in which a group of amateur creators use a variety of advanced equipment for manufacturing to further their personal hobbies. By contrast, makerspaces highlight entrepreneurship: activities are related to creativity, product design, business plan drafting, road shows, financing, recruitment, sales, expansion, etc. (Sang, 2015). Thus, most scholars believe that the concept of makerspace is broader than that of hackspace, there being an inclusion relationship between the two concepts (Shao & Ni, 2017; Yin, 2015).

As for the relationship between makerspace and incubator, some scholars believe that makerspaces are different from traditional incubators and science and technology parks (Li, 2017). Traditional incubators serve specific audiences, emphasizing entrepreneurship, whereas makerspaces pay more attention to acceleration. They provide a lower cost entrepreneurial environment for entrepreneurs, providing start-ups with a platform (Wang, Tian, & Sheng, 2016). Makerspaces offer a physical space in which innovation can take place, being well suited for the entire value creation chain, starting from commodity trading, in order to promote enterprise growth and promotion (Li, 2015). Others suggest that makerspace include traditional incubators (Qiao & Wu, 2017). They hold that makerspaces are an upgraded version of traditional incubators, reflecting the innovation of the incubator itself in the new Internet environment (Wang, 2015). In a broader definition, makerspaces are grouped into some major categories: existing science and technology parks; incubators; various online virtual public creation space, creative space, entrepreneurial coffee, Innovation workshop, and other new type of space category (Zhao, 2016). Others believe that makerspaces are self-organizing incubators or, in other words, that makerspaces are a subset of incubators – a new type of incubator (Liu, Chen, & Xue, 2015; Shao & Ni, 2017).

Despite this argument, the relevant research generally considers that "crowd creation" is an entity or virtual space based on the sharing economy (Ren, 2017; Yang, 2017); Zhou and Zhang (2017) that develops into a new type of entrepreneurial integrated services platform (Li, 2017).

It is an innovative platform (Wang et al., 2016) that may eventually form a complex entrepreneurial ecosystem (Yang, Ying, & Ye, 2017).

2.4.2.2 Characteristics, functions and types of makerspaces

Although different understandings remain regarding the connotation and extension of the makerspace, a basic consensus has been reached on the function and characteristics of makerspaces.

The main roles of the makerspace include: (1) the popularization of the innovative and entrepreneurial group (Wu, Zhan, & Zhou, 2017); (2) the marketization of the main body of operation (Gui, Zhang, & Wang, 2016); (3) the diversification and specialization of the forms (Yang, 2017); and (4) the openness and inclusiveness of the atmosphere (Shao & Ni, 2017). Makerspaces are a new kind of platform that are low-cost, convenient, and open to all entrepreneurs (Yang, 2017). They can be described as “four modernizations”, “three combinations” and “four spaces”, in which "four modernizations" refers to the marketization, specialization, integration and networking of functions (Yang, Ying, & Ye, 2017); “three combinations” refers to the combination of operation innovation and entrepreneurship, the combination of online and offline, and the combination of hatching and investment (Gui, Zhang, & Wang, 2016; Shao & Ni, 2017); the “four spaces” are the work space, Internet space, social space, and resource sharing space (Li, 2017; Yang, 2017).

Based on these characteristics, Wu, Zhan, and Zhou (2017) believe that the makerspace may integrate innovative entrepreneurial resources and improve the efficiency of innovation and entrepreneurship (Gui, Zhang, & Wang, 2016). The components of a makerspace should include 5 elements: space, innovation and entrepreneurship, new venture activities, resource elements and institutional rules. In addition, as a new physical space, the makerspace plays a role in urban planning and may reshape the spatial distribution of cities. The foundation and core of a makerspace is the building of informal innovation networks. Thus, interior design is critical for the makerspace (Zhou & Pei, 2016). Ren (2017) points out that the makerspace is born to cultivate a new economic growth model and to meet new innovation and business demand. It contains three indispensable elements: open concept, open shared community and open source software and hardware. Table 2.2 shows the classification of makerspaces.

Table 2.2 Category of makerspace by Chinese scholars

Author	Criterion for classification	Types of makerspace
Wang (2015)	The function of the makerspace	(1) Activity agglomeration (2) Entrepreneurial guidance (3) Investment-driven (4) Entrepreneurial real estate (5) Industrial chain (6) Comprehensive ecosystem
Li (2015)	Service provided by the makerspace	(1) Activity agglomeration (2) Training and guidance (3) Media driven (4) Investment driven (5) Real estate thinking (6) Industrial chain service (7) Comprehensive entrepreneurship ecosystem
Chen, Xiang, and Yu (2015)	Organization of the makerspace	(1) Industry-university-research cooperation (2) Platform by large enterprise (3) Innovation service by large enterprise (4) Industry-city combination (5) Consultation and investment
Wang and Ye (2015)	Stages of makerspace evolution	(1) Primary mode (2) Upgraded primary mode (3) Integrated entrepreneurship ecosystem.
Shao and Ni (2017)	Makerspace business model	(1) Enterprise platform (2) Investment-driven (3) Media-based (4) Vertical industry (5) Open space (6) Real estate

Given the relatively recent development of makerspaces in China, research into their operation in that country is still scarce. Most of the relevant empirical studies focus on makerspaces' positioning, status quo and profit models (see Table 2.2). Yang (2017) sets up the overall framework for the linkage mechanism between investment, lending, and insurance. Shao and Ni (2017) believe that the current revenue of a makerspace mainly comes from rent income, value-added services (i.e., entrepreneurial training, agency services, intermediary services, etc.) and equity investment. Ren (2017) proposes that makerspaces have the characteristics of entrepreneurial ecosystems: they are borderless, self-organized and customized. Unlike previous incubators, designed for specific audiences, makerspaces provide a comparatively cheap and convenient platform for ordinary individuals. Thus, they represent a massive bottom-up process; public innovation has promoted innovation towards networking and democratization. Zhang and Bai (2017) argue that the makerspace is a complex adaptive system with a dissipative structure and that it can be dynamically divided into a construction

phase and a self-organization phase, from the ecosystem perspective. The core elements of the construction phase include government policy, market, finance, culture, support systems and human resources, etc., which are the prerequisite and necessary conditions for the development of the entrepreneurial ecosystem. The self-organization stage is mainly dominated by a multi-agent cooperative governance.

Empirical studies of makerspace have gradually become of interest to Chinese academics. For example, Chen, Xiang, and Yu (2015) explore the case study of Zhumeng town in Hangzhou. From the perspective of entrepreneurship ecosystems, they compare the differences between the makerspace and traditional science and technology parks, suggesting that the ecosystem structure of crowdsourcing spaces includes the spirit of the makerspace, user ecosphere, resource ecosphere, basic platform and entrepreneurship policy, which form the culture of entrepreneurship ecosystem, as well as the essence and vitality of makerspaces. The operating mechanism of makerspaces includes the following sub-mechanisms: ecosystem metabolism; nesting of multi-level entrepreneurial networks; integration of heterogeneous entrepreneurial resources; enhancement of dynamic entrepreneurial abilities.

Wang, Tian, and Sheng (2016) study the location and evolution process of Alibaba Group's Baichuang makerspace. Their research reveals symbiotic relations between public space platforms and service providers and newly joined enterprises. That makerspace's strategic goal is to produce new applications (apps) as well as new service models. Therefore, it is a typical bilateral innovation platform. Its evolution has gone through three stages: infrastructure; network effect; and finally ecosystem.

Furthermore, resorting to 123 questionnaires from a makerspace in Suzhou, Jiang et al. (2017) empirically explore the nature of the Chong Chuang makerspace. The results of the questionnaire show that there are four main construction modes for makerspaces in Suzhou: government-initiated, enterprise-initiated, university-initiated or mixed. They also show that the main sources of income are rent income, intermediary services income, or venture capital income. The average number of enterprise interactions per month is 10.

Zhang, Fu, and Yi (2017) investigated the status of development and characteristics of 35 makerspaces in Shenyang. By determining the operational efficiency index for the makerspace, 35 Zhongchuang spaces were ranked. According to the centralization index, the agglomeration characteristics of these Zhongchuang spaces were measured and some practical implications were discussed to promote the localization choice of makerspaces.

Su and He (2017) analyze the spatial distribution of makerspaces in 21 cities of Guangdong province, including their sizes and business models. Their study indicated that the growth rate

of makerspaces has exceeded that of the traditional incubators in the Guangdong province. Jensen et al. (2016) employ case study methodology to examine the role and influence of information and communication technology (ICT) in enhancing the spatial effects of makerspaces. From the survey of 3 makerspaces, including Shell Club, Peking University Business Training Camp, and Sugar Town, they construct an analytical framework to analyze the way in which ICT influences the community structure and the interactions of various agents in these makerspaces.

2.5 Synopsis of Chapter 2

This chapter reviews the related literature on physical and non-physical environment, innovation, creativity and makerspaces. This review suggests that, while there is a vast amount of literature in the area of innovation, creativity and makerspaces, more research is necessary to add to the body of literature regarding stimulators (factors that promote) and barriers (factors that inhibit) in environments where innovation thrives. In particular, empirical research on the relationships between the workspace environment and creativity – as well as innovation – is still in its infancy even though some scholars have mentioned the impact of office conditions on the efficiency of work. As Moultrie et al. (2007) suggest, firms that have dedicated innovative spaces maybe perform better than those without, whereas there is limited research on physical elements (lighting, furniture, and visual stimuli) as a means of driving creativity in the workspace. Meanwhile, Peponis et al. (2007) also assert that if the physical environment can potentially support the delivery of the innovation strategy, then it is fair to assume that there should be explicit motivations behind the design of the innovation environment. Therefore, the topic of workspace influence on innovation has not been applied to enough samples or in enough situations to be considered a reliable phenomenon (Samani, Rasid, & Sofian, 2014). Many uncertainties remain about how exactly innovation can be brought about, especially in the face of persistent pressure to stay lean and do more with less. This emphasizes the importance of finding what best incubates innovation. This thesis makes a contribution in this regard, taking makerspaces in China as a sample to examine whether and how the interior design of workspaces, and the characteristics of environments, affect firms' creativity and innovation. Based on prior research on the importance of creativity and innovation in organizations, this study will empirically explore the extent to which physical and non-physical factors impact innovation performance. In addition, in-depth interviews will also be used to verify the results of a survey. This study is significant as it will provide direct evidence on how

workspace environment affects individual creativity and organization innovation. The following chapter will establish the theoretical foundations of the empirical component of the present study, as well as the related hypotheses that will be tested at a later stage.

Chapter 3 Theoretical Framework and Hypotheses

In this Chapter, the theoretical framework will be presented to illustrate the logic of the empirical part of this study. Accordingly, hypotheses will be proposed for further examination. Based on the literature review in Chapter 2, a novel theoretical model, containing ten hypotheses, is put forward to show how the workspace environment influences creativity and organization innovation through employees' behaviors.

3.1 Theoretical framework of this study

Based on the above, we developed an "environment-conduct-performance" theoretical framework to analyze the impact of the workspace environment. Figure 3.1 illustrates the theoretical model and all the proposed hypotheses that need to be examined in our study.

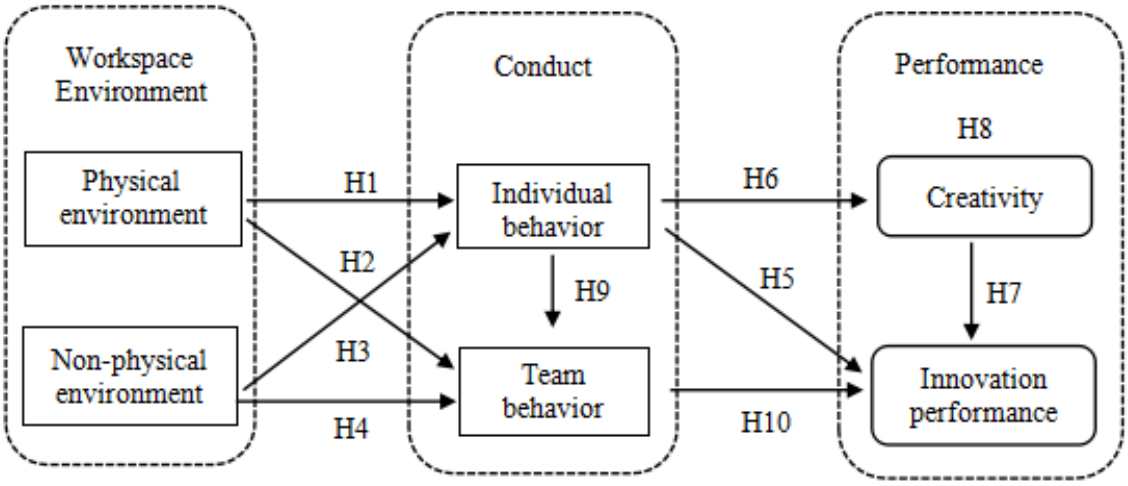

Figure 3.1 Theoretical model of this study

3.2 Relation between physical environment and behavior

Physical environment, as an external factor, plays an unavoidable role on individual behavior. Proper design of the physical environment can affect an individual's emotions and affect their performance to some extent (Cho, 2017; Hatam et al., 2014; Loomans et al., 2018). According to environmental psychology, there is an interactive relationship between human beings and the physical environment. The physical layout of the workspace can have an important impact on employee productivity and on organizational performance (Yerkes, 2003). Some studies have

pointed out that the working environment in an organization will influence employee behavior (Aoki, 2009; West & Wind, 2007). For instance, Liu (2008) suggests that the organization's performance – including aspects such as work efficiency and productivity – can be improved in a well-designed office that makes people comfortable. Zhang (2017) emphasizes the impact of the physical work environment on individual behavior or group activities, affecting the level of efficiency in the organization.

In the knowledge era, a good working environment also reinforces creativity and innovative activities (Branco et al., 2019; Moultrie et al., 2007). The interior design in an office may be regarded as one of the most important elements to influence people's behavior (García-García, Chulvi, & Royo, 2017; Moultrie et al., 2007). Comfortable and relaxing offices can stimulate various proactive behaviors, which may affect employees' self-evaluation and exert a positive effect on organizational innovation (Wang & Zheng, 2016). Specifically, the physical environment – such as the layout of the office – may influence the means, frequency, duration, and convenience of communication (Boutellier et al., 2008) and be a key factor for the development of a company (Levin, 2005; Lindholm & Leväinen, 2006). As such, we propose the following hypotheses:

H1: Physical environment is positively related to individual behavior.

H2: Physical environment is positively related to team behavior.

3.3 Relation between non-physical environment and behavior

Like the physical environment, the non-physical environment in the workspace is essential as it affects employees' feelings, perceptions or emotions (Taube et al., 2014). From its social-psychological dimensions, the organizational climate is a set of subjective or psychological factors such as freedom, trust, openness and risk tolerance, which can determine individual and team behaviors (Samani, Rasid, & Sofian, 2014). Self-determination theory holds that motivation is a key mediator for external environment affecting people's behavior (Aoki, 2009). As Akif, Audretsch, and Slaper (2019) indicate, the atmosphere of trust in the workspace may provide a general impression of good communication or failure tolerance to employees. In the context of freedom, employees like to do something proactively and show a confident attitude with regard to their own thinking or actions. By contrast, when employees feel controlled or constrained in an office, their internal motivation will be weakened, making them less likely to engage in different kinds of activities (Sheng, 2012). During the process of innovation behavior formation, an appropriate atmosphere provides external motivation to

promote internal creative behavior (Liu, Chen, & Xue, 2015). Thus, individual creative behavior could be encouraged in a relaxed context, implying that an atmosphere in which there is a willingness to try novel things or methods could improve creativity (Hao et al., 2016). The fewer constraints there are in the environment, the more helpful that environment is to breaking cognitive inertia and form a new paradigm. Therefore, creative behavior is the result of the interactions between individuals and their environment (Jung & Chang, 2017).

Taking 172 resource and development (R&D) team members as a sample, Scott and Bruce (1994) find that individuals' perception of innovation support is positively related to their innovation behavior. There are some critical external indicators, including idea-support, challenge/involvement, idea-time, playfulness/humor, conflict and debate, which can promote or influence individual and team behaviors (Chang et al., 2018). Meanwhile, George and Zhou (2001) find that when a creative atmosphere is supported in an organization, there exists a higher positive mood and employees' creative activities are more frequent and more efficient. According to the above, we outline the following hypotheses:

H3: Non-physical environment contributes to individual behavior.

H4: Non-physical environment contributes to team behavior.

3.4 Relationship between individual behavior and performance

Some studies have considered both organizational innovation climate and personal factors in achieving firm innovation (Fu, 2018; Xie & Wu, 2013). The act of daring to take risks, motivated from a person's sensitivity to the external environment, is a precondition to individual creativity and organization innovation (Anderson, Potočnik, & Zhou, 2014; Bledow et al., 2009; DiLiello & Houghton, 2006). As DiLiello and Houghton (2006) emphasize, individuals' creative behavior is significant to an enterprise's innovation output. For knowledge workers, most innovative products are the outcome of their continuous efforts (Klane, 2011). These innovative processes may consist of several feedbacks, namely: developing novel ideas, sharing them with others, learning from feedback, improving them, and presenting them once more (Dewett, 2004). The activities through which employees develop new products or services, using either explicit or implicit knowledge, constitute the process of innovation (Jagtap et al., 2014; Lubart, 2001).

Creativity is a capability in which a series of thoughts and actions gradually leads to novel or adaptive ideas or ways (Anne, 2011; Lubart, 2001). This process can consist of different stages, rather than being a single unitary process (Hao et al., 2016). Creative processes are

involved in cognitive and motivational labels such as perceiving, imagining, thinking, or even consist of ordinary tasks such as calendaring and responding to emails (Amabile et al., 1996). During this process, various activities such as thinking, meeting, reporting, or writing may facilitate creativity. Employees' novel ideas are often the basis of innovation, change and competitiveness (Hao et al., 2016). The existing research shows that the feedback related to creativity can become an effective catalyst for group creativity in a certain way, and managers should deliberately cultivate and improve the ability of individuals (Anderson, Potočnik, & Zhou, 2014). In the atmosphere of active participation of individuals, appropriate task-related conflicts and minority dissenters will generate innovation by encouraging debate, and at the same time, individual members will obtain useful information through transposition thinking, generating creative ways to solve problems (Baer, 2012). For employees to acquire and digest relevant knowledge, they must study continually (Hao et al., 2016). This individual behavior may help them identify problems in work system at the source and provide constructive suggestions for improvement (Jung & Chang, 2017; Liu et al., 2016). Thus, based on the discussion, we propose:

H5: Individual behavior can improve innovation performance.

H6: Individual behavior can enhance creativity.

3.5 Relationship between creativity and innovation performance

Creativity is regarded as one of the most important ingredients for innovation. While creativity emphasizes the novelty of an idea, innovation aims to achieve different kinds of new improvements adopted in the market (Amabile et al., 1996; Yuan & Woodman, 2010). Innovation may focus on commercialization, indicating the successful integration of various creative ideas (Amabile et al., 1996; Coade, 1997; Sarooghi, Libaers, & Burkemper, 2015). When individuals have a high level of creativity, they tend to make use of existing knowledge to develop some new skills in order to solve practical problems. As an important antecedent of innovation, the individual ability to create knowledge is necessary for the organization's innovation performance (Sarooghi, Libaers, & Burkemper, 2015; Shalley & Perry-Smith, 2008) – indeed, their close relationships have also been examined in many studies. Shalley and Perry-Smith (2008) point out that knowledge creation positively enhances product innovation performance in an enterprise. Bledow et al. (2009) state that employee creativity, as a starting point, can further drive employee innovation performance. Employee innovation performance is the concrete implementation and successful application of employee creativity. Therefore,

employee creativity can promote the improvement of employee innovation performance (Fu, 2018).

Janssen (2000) suggests that innovation performance largely relies on the level of individual creativity, as well as on the specific implementation of individual innovation behavior. Furthermore, Blakey (2015) argues that surroundings that can foster employee motivation, proactive behaviors and creativity are critical for innovation. From the knowledge management perspective, most knowledge is implicit and exists at the individual level. During the knowledge sharing process, individuals try their best to make tacit knowledge explicit. The continuous interaction between tacit and explicit knowledge will enhance individual creativity and contribute to final outcomes in innovation (Johannessen & Olsen, 1999). Other individual activities, such as knowledge learning and sharing, can expand innovative thinking and promote the generation of creativity, finally resulting in higher innovation performance (Sheng, 2012). Thus, the active behavior of employees may help increase their creativity and further lead to high innovation outcomes (Ghosh, 2015). Accordingly, in the present study, we propose the following hypotheses:

H7: Individual creativity helps improve innovation performance.

H8: Creativity plays a mediating role between individual behavior and innovation performance.

3.6 Relationship between individual behavior and team behavior

According to social network theory (Sih, Hanser, & McHugh, 2009), people with similar values or interests tend to form a group or team for information and knowledge sharing in which their interactions can promote the search, identification and development of new opportunities (Chang et al., 2018). To implement any idea, an individual always tries to find partners for discussion or support, which may gradually form a group. Informal cliques are popular in any organization. This stable social relationship system formed by the interaction among members of creative team is the social security of teams' creative ability (He, Zhou, & Wang, 2019).

In the workspace, team cohesion may come from two channels, task cohesion and interpersonal cohesion. In task teams, employees are attracted to specific objectives and their commitment to the work will allow their goals to be achieved. By contrast, interpersonal teams are often established through social relations with common backgrounds, habits, and hobbies (Demir, Cooke, & Amazeen, 2018; Wei et al., 2019). All these teams can significantly promote interaction and coordination between team members. Frequent knowledge sharing between

individuals stimulates the generation of more knowledge and creative ideas, conversely enhancing team attraction (Chang et al., 2018; Liu et al., 2019; Moorman & Miner, 1997; Rodan & Galunic, 2004). In particular, the open workspace can encourage communication between individuals, facilitating information sharing.

In terms of conflict and feedback, the proper handling of the competitive perspective is the key issue. Intentional disputes related to tasks will improve the quality and creativity of decision-making in the context of cooperative groups (Yu & Zellmer-Bruhn, 2018). Conflicts related to tasks will enable group members to reassess the status quo and adjust goals, strategies, and processes to better adapt to the current situation. Moreover, feedback has a strong impact on individual creative performance, stimulating the internal motivation of recipients and affect employees' emotions (Wan et al., 2019). Empirical research shows that knowledge sharing among team members promotes team creativity in innovative teams (Pratoom & Savatsomboon, 2012; Sheng, 2012), which can enhance the initiative and curiosity of the members in a group, thereby promoting their individual creativity (Amabile et al., 1996; Chang et al., 2018). Thus, to successfully fulfill the complex innovative process, individuals in an enterprise have a strong propensity to initiate a group to enhance interaction and then promote team performance and innovation (Fu, 2018; Xu, 2019). Therefore, we posit that:

H9: Individual behavior helps improve team behavior.

3.7 Relationship between team behavior and innovation performance

Team learning can promote knowledge sharing between team members and effectively enhance their creativity and innovation; individual innovation performance provides a good basis for team innovation (Chen, Li, & Tian, 2019). When individuals work together to solve problems, their creativity will be enhanced and team members can better cooperate (Baer, 2012). Sharing between team members is a process whereby different ideas or knowledge interact to generate novel ideas or provide practical ways to complete creative thinking, rather than a simple addition of individuals' knowledge (Demir, Cooke, & Amazeen, 2018; He, Rayman-Bacchus, & Wu, 2011).

Some researchers also explore team behavior from perspective of psychology. In general, when individuals feel relaxed and safe, they tend to be willing to reveal their thinking (Shin & Zhou, 2007). As Brown and Leigh (1996) suggest, organizational psychological safety is also a shared belief of organizational members, demonstrated by three properties: (1) supportive management; (2) clear role; and (3) self-expression. Meanwhile, team psychological safety,

introduced by Edmondson (1999), addresses the group level. Recently, scholars have been giving more attention to the role of team passion on innovation (Shalley et al., 2015). Indeed, passion can be expressed both at the individual and team levels (Long & Haiying, 2014). Team passion, as an environmental component, can show the strong preference of team members for team tasks (Shalley et al., 2015). Jay, Paul, and Jennifer (2016) point out that team passion is related to the characteristics of team members' cognition, emotion and behavior, magnified through the interaction between members and summarized at the collective level. Work passion is a kind of strong interest and pleasure in work that is of great significance to individuals and team (Ho, Sze-Sze, & Chay Hoon, 2011; Song, Yuan, & Zhang, 2011).

Team innovation climate is a shared perception of the working environment that influences the exertion of team members' innovative ability (He, Rayman-Bacchus, & Wu, 2011; Li, Wang, & Zhao, 2016). It positively affects innovation self-efficacy (Garivani, Devin, & Farbod, 2016). Similarly, in the cooperation process, positive interaction, including the exchange of knowledge, information and opinions among different individuals, can meet individuals' knowledge needs and further mobilize their enthusiasm for innovation activities (Carmeli, Dutton, & Hardin, 2015). Zhou and Pei (2016) confirm a positive relationship between team behavior and innovation outcomes. Garivani, Devin, and Farbod (2016) also find, through empirical research, that a good team cooperation atmosphere has a positive impact on the creativity of employees. Thus, team behavior can be more efficient in transforming creative ideas into valuable products or services. Accordingly, we suggest:

H10: Team behavior helps improve innovation performance.

3.8 Synopsis of Chapter 3

Since the purpose of this study is to examine the impact of workplace environment on organization performance, the theoretical framework with an "environment-conduct-performance" logic was developed in this chapter to reveal their impact mechanism. According to previous studies, environment has natural, social, and psychological attributes. The natural attributes of an environment are its essential qualities, meaning its physical characteristics such as size, density, height, quantity, and layout. By contrast, the social attributes of an environment, such as history, culture, and customs may reflect its psychological and spiritual attributes (Li et al., 2018). Thus, in this study, the workspace environment is divided into two categories: (1) physical environment; and (2) non-physical environment. It will explore whether, and how, physical and non-physical environments affect creativity and innovation. We suggest that

persons' behaviors are critical in this process. While previous research on working conditions suggest that they influence employee satisfaction, few studies empirically investigate the extent to which the physical environment may affect organization performance. Internal motivation is also critical to creativity and innovation. To further explore employee behaviors, we distinguish between individual and team behaviors. While there is an abundance of literature exploring the relationship between creativity and innovation, there is much less research into the role of workspaces. From the proposed model, we find whether the workplace environment – consisting of both physical and non-physical aspects – affects individual and team behaviors and, furthermore, how these behaviors may affect performance indicators such as individual creativity and organization innovation. Ten related hypotheses were thus proposed in this chapter, and the workspace environment is expected to exert a positive impact on employee behaviors which will then positively affect creativity and innovation. In this framework, individual creativity serves as a mediator between individual behavior and organization innovation performance. Given that the focus of this study is to examine the role of the workspace environment, this model does not examine the role of team creativity.

Chapter 4 Research Method

To examine the hypotheses proposed in Chapter 3, this study employs questionnaires and semi-structured interviews to collect the necessary data. Considering that the aim of this study is to examine the impact of the workspace on creativity and innovation, we select makerspaces as a sample since they are a new phenomenon in China providing various well-designed workspaces to numerous innovation group and start-ups.

4.1 Makerspaces in China

4.1.1 Emergence and development of makerspace

Information technology and the Internet provide new ways for the individual and team creativity (Niaros, Kostakis, & Drechsler, 2017). Makerspaces are mainly a new and open form of organization or service platform in which diversified equipment is provided and co-working spaces promote knowledge sharing, cross-boundary collaboration and the realization of creativity and even products (Zhang & Bai, 2017).

In recent years, the wave of “mass entrepreneurship, mass innovation” represented by makers has been rising rapidly in China. In 2014, Premier Li Keqiang proposed that the Chinese government should vigorously promote mass entrepreneurship and innovation and turn it into a new engine of economic development. He stressed that the market should live, innovate and be practical, and that policy should focus on cultivating a more favorable institutional environment conducive to public entrepreneurship and market innovation (Chen, Xiang, & Yu, 2015). As a national science and technology innovation center, Beijing made use of its central position and established several makerspaces with high standards, playing a leading role in this trend.

In January 2015, Premier Li Keqiang presided over the executive meeting of the State Council to determine policies and measures to support the development of makerspaces. In March 2015, the general office of the State Council issued guiding opinions on the development of makerspaces and the promotion of mass innovation and entrepreneurship, clearly proposing to accelerate the development of makerspaces. The Ministry of science and Technology issued guidelines for the development of makerspaces, which clearly recommended in-depth development of makerspaces in all regions (Shao & Ni, 2017).

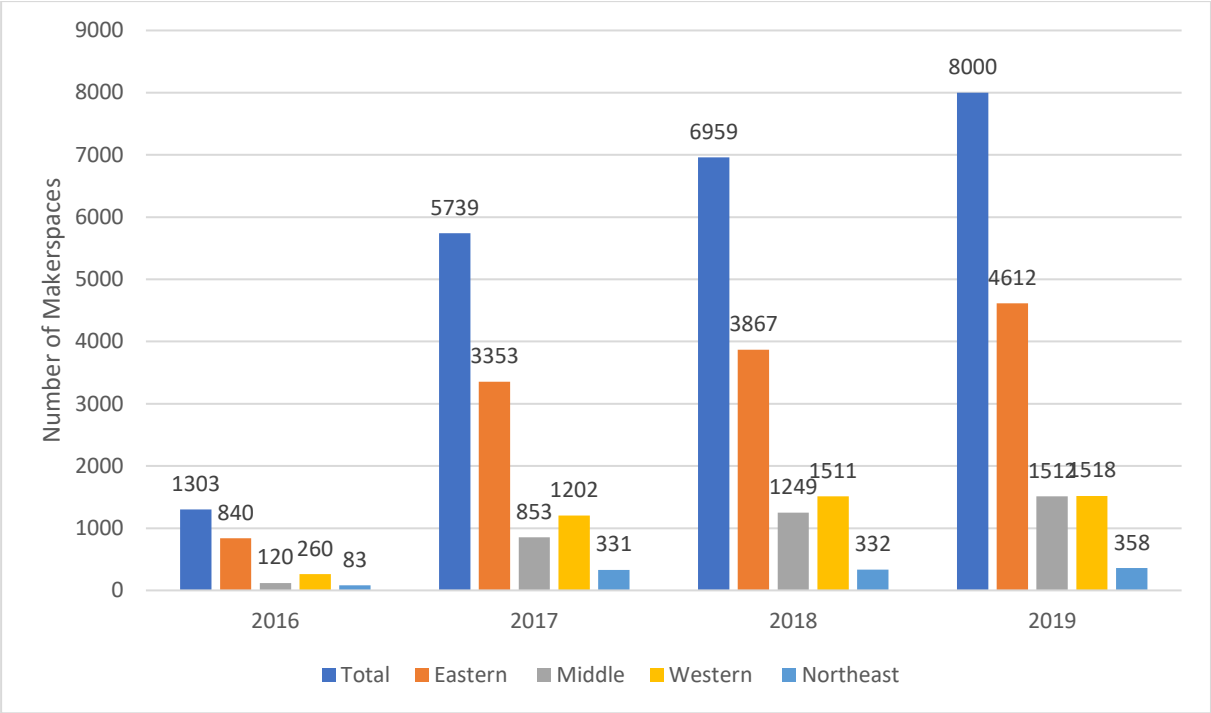

Figure 4.1 Number of makerspaces: 2016-2019

Source: Torch High Technology Industry Development Center Ministry of Science & Technology, China Torch Statistical Yearbook in 2017-2020, Beijing: China Statistics Press.

As shown in Figure 4.1, it is easy to find that the total number of makerspaces first increased sharply in 2017 with more than 340% growth rate, and then maintain a stable growth with average 18% annual rate. Considering the huge economic gaps among various regions in China, Figure 1 further exhibits the number of makerspaces in four areas including eastern, middle, western, and northeast, respectively. To be the most developed regions in China, east area covering Shandong, Jiangsu, Zhejiang, Fujian, and Guangdong provinces, as well as Beijing, Tianjin, and Shanghai cities have showed many distinguished advantages in entrepreneurial activities, which accounts for about 57% Chinese makerspaces.

By contrast, the northeast exhibits slowest increasing from 2017 to 2019, with less than 360 makerspaces. The number of makerspaces in middle and western regions are nearly at the same level. Although at the very beginning in 2016, there are more makerspaces in western areas, the middle provinces covering Hubei, Anhui, Jiangxi, Inner Mongolia, and Henan provinces gradually catch up with the west region. In 2019, both regions have more than 1500 makerspaces and their together accounts for 37.9% of all Chinese makerspaces. From Figure 4-1, we may also find the positive relationship between economic level and makerspace development and the impact of government policy. Since the economy of western and middle regions are in the similar level, though the number of makerspaces in western region shows a faster increasing in 2016 and 2017 than that in the middle area, the later one grew sharply in

2018 and reached 1512 in 2019.

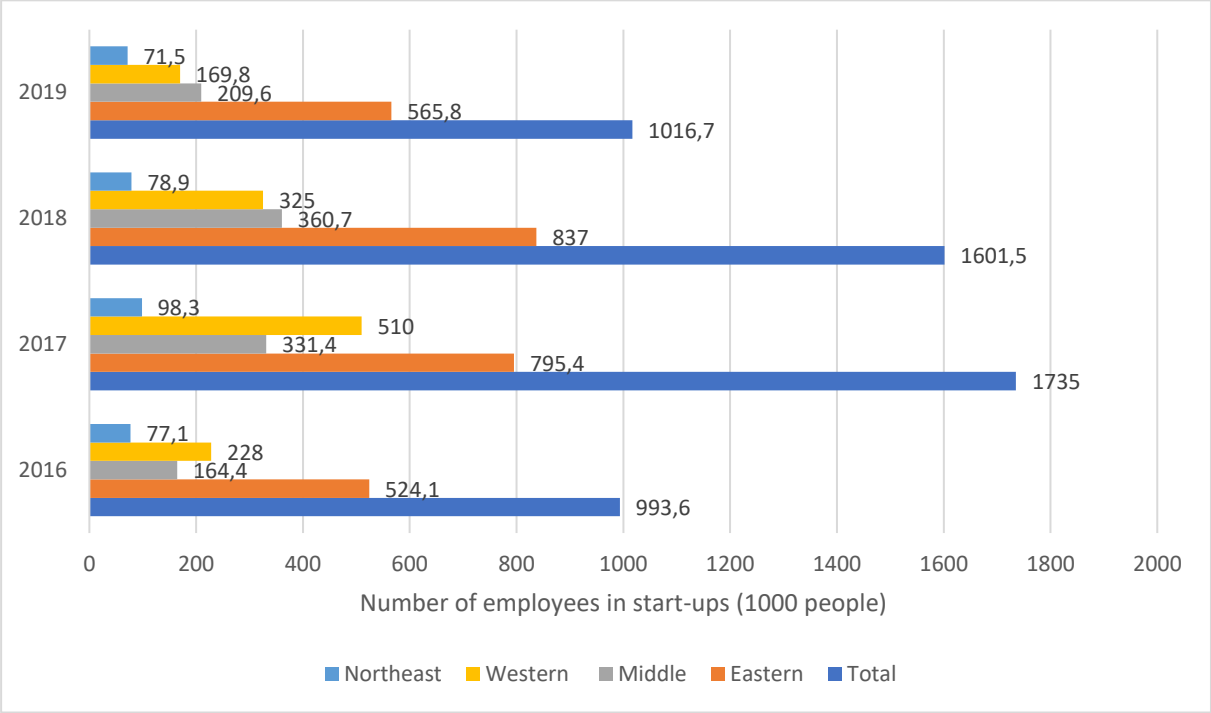

Figure 4.2 Number of employees in start-ups

Source: Torch High Technology Industry Development Center Ministry of Science & Technology, China Torch Statistical Yearbook in 2017-2020, Beijing: China Statistics Press.

As shown in Figure 4.2, within makerspaces, the total number of employees in start-ups kept an upward trend before the industry reshuffle in 2018 and reached more than 1.6 million at the end of 2018. The corresponding data of eastern and middle regions have the similar trend with the total number of employees in start-ups and reached 837 thousand and 360.7 thousand, respectively at the end of 2018. As for western and northeast region, the number of employees in start-ups shows a downward trend after 2018.

Recently, makerspaces have become an important carrier of innovation and entrepreneurship activities for small and medium-scale enterprises in China. Numerous start-ups are interested in makerspaces. Compared with some traditional office environment like commercial office buildings, makerspaces maintain mobility in physical space design and also provide customers with shared functional areas, making employees stay longer in makerspaces after they finish their work. The multifunctional design within makerspaces can better service space users. The combination of employees' work, leisure as well as social activities also provide many chances for their companies to find partners and link upstream and downstream resources. Makerspaces are popular with start-ups with different industrial backgrounds and are conducive to solving the employment problem.

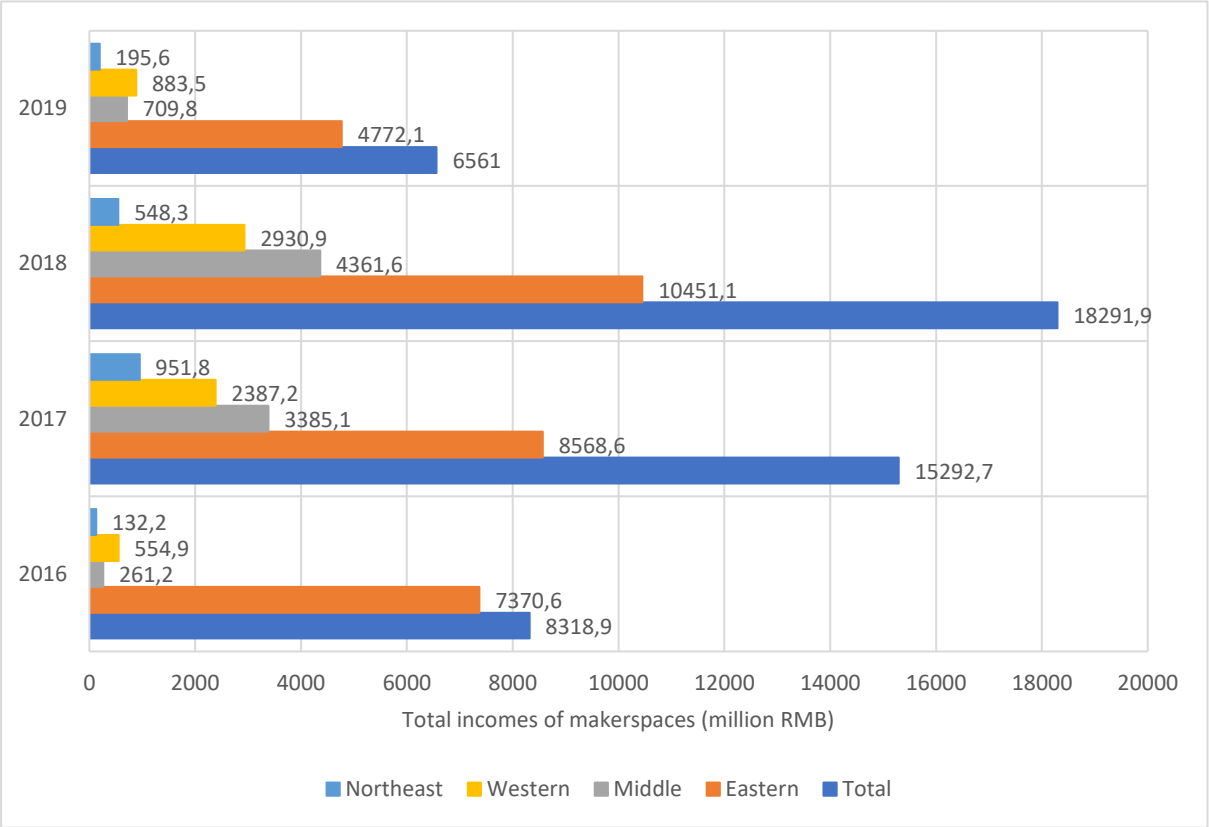

Figure 4.3 Total incomes of makerspaces in China

Source: Torch High Technology Industry Development Center Ministry of Science & Technology, China Torch Statistical Yearbook in 2017-2020, Beijing: China Statistics Press.

Figure 4.3 shows the total incomes of makerspaces in China. We may find that before 2019, the total incomes of these four regions keep growing trends and the industry reshuffle happened in 2018 makes some makerspaces been eliminated. Meanwhile, this reshuffle also led to the decrease of makerspaces' total incomes in 2019. The corresponding data of western, middle and eastern regions also show a similar trend with the total value from 2016 to 2019, and they reached 883.5 million RMB (about 136 million U.S. dollars), 709.8 million RMB (about 109.2 million U.S. dollars), 4772.1 million RMB (about 734.2 million U.S. dollars) at the end of 2019 respectively.

Makerspaces develop for a short time in China and this new type of workplaces also exhibits some problems during the developing processes especially in term of their profit modes. More specially, nowadays most makerspaces in China do not possess the capability to gain profit by themselves and many spaces still rely on the local governments subsidies to maintain the operation of the whole space. Their incomes mainly come from the subsidies of the local government, and the rent of their cubicles. It is difficult for them to form a sustainable profit mode to gain more incomes. When faced with the sudden shock of the COVID-19 pandemic,

many makerspaces suffer from the difficulties of capital turnover and delayed resumption of work, and they do not have the ability to copy with the crisis. Therefore, for their long development, makerspaces should explore more cooperative relationships with makerspaces' multi-participants such as space users, the third-party service organizations and other participants in order to form their unique operational modes.

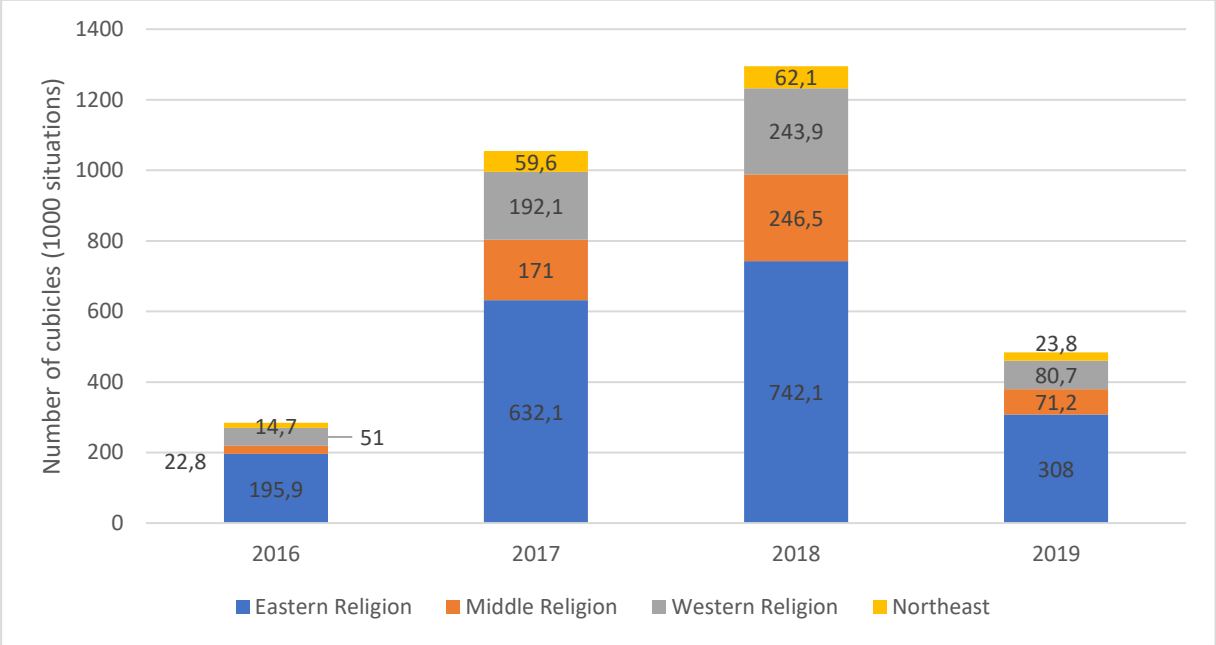

Figure 4.4 Number of cubicles offered in makerspaces

Source: Torch High Technology Industry Development Center Ministry of Science & Technology, China Torch Statistical Yearbook in 2017-2020, Beijing: China Statistics Press.

With the rapid development of maker movement in China, both start-ups and entrepreneurial teams show great demand on makerspaces and the number of cubicles provided by makerspaces is increasing. Especially after China's government put forward "mass entrepreneurship and innovation", innovation and entrepreneurial activities are carried out rapidly and makers actively participated in these related activities. From Figure 4.4, we may find that before 2019, the number of cubicles of each year keeps a trend of growth. After the industry reshuffle of makerspaces happened in 2018, plenty of small-sized makerspaces were forced to closed and therefore, the corresponding data in 2019 shows this obvious decline. Compared with the other three regions including middle, western as well as northeast, the data of eastern region always has the largest proportion. Among the four regions mentioned above, western region and middle region also offered relatively more cubicles than northeast region. We consider that due to the level of economic development and entrepreneurial culture within these regions, the development of makerspaces in eastern, middle and western regions are better than that in northeast of China.

Meanwhile, it is easy to find that before 2019, the average growth rate of the cubicles offered in eastern region is about 94.6%. In middle, western and northeast regions, the average growth rate is 228.8%, 118.7% and 105.5%, respectively. All the data reflect that the office cubicles located in various Chinese regions present a vigorous growth in recent years.

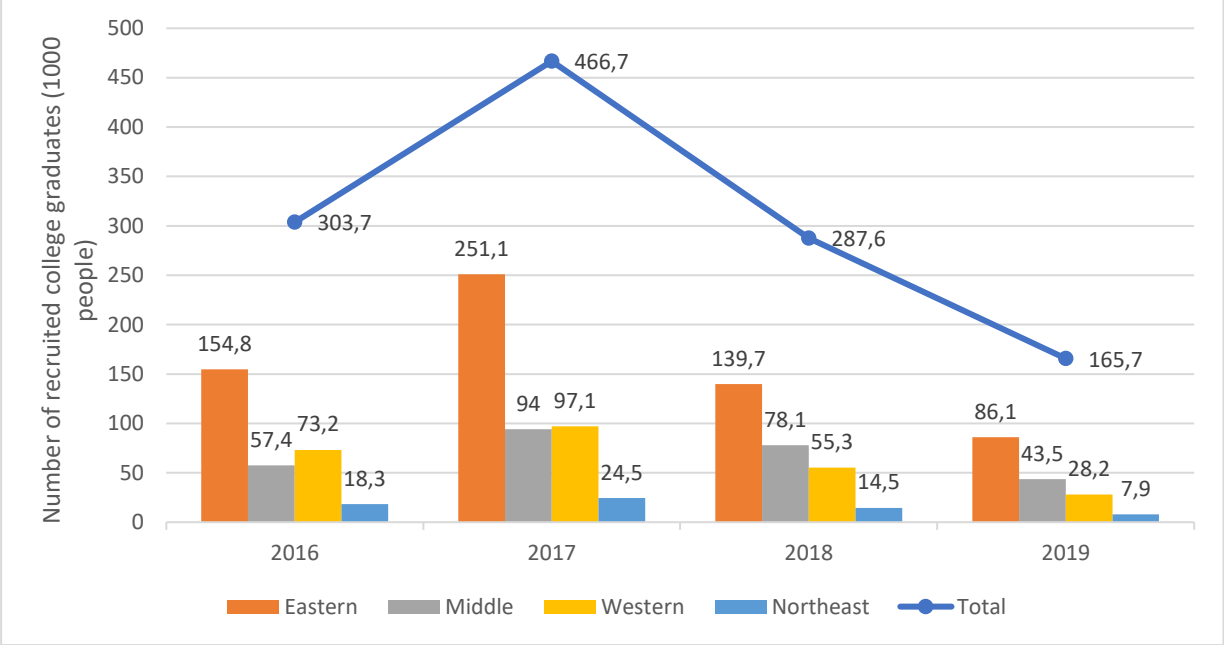

Figure 4.5 Number of recruited college graduates in makerspaces

Source: Torch High Technology Industry Development Center Ministry of Science & Technology, China Torch Statistical Yearbook in 2017-2020, Beijing: China Statistics Press.

Figure 4.5 presents the number of recruited college graduates in makerspaces. As shown in Figure 4.5, east provinces always account for the largest proportion. Two significant factors may bring about this outcome: one is the very good education condition and the other is the local government perception on makerspaces. Most of Chinese famous universities are located in the eastern China such as Tsinghua university, Peking university, Shanghai Jiao Tong university, and Nanjing university. These colleges establish cooperative relationships with many organizations including some financial institutions and R&D groups, which offer their students easy channels to plenty of resources. After graduating from these colleges, students with entrepreneurial dreams tend to find jobs and start their own businesses in the makerspaces. Many of them can continue to gain various entrepreneurial supports from important stakeholders based on their promising entrepreneurial projects and the development of their teams. Therefore, the makerspaces in these cities and provinces in eastern region possess a large number of recruited college graduates. On the other hand, in eastern China, numerous supportive policies and resources offered by the local government have been given so as to encourage college students to start businesses. These two factors may account for the results

that recruited college students in eastern region are more than the corresponding data in middle, western and northeast regions from 2016 to 2019.

Although makerspaces were officially put forward in 2015, they have multiplied in recent years. In China, the innovation-oriented strategy has been regarded as a key national strategy to achieve long-term development. Since the traditional competitive advantages of Chinese firms (i.e., cheap labor and natural resources) are rapidly disappearing, there is a push to develop new sustainable drivers for economic growth (the growth rate has slowed down in recent years). The opportunity being pursued is innovation (Holm & Eric, 2015). The Chinese economy is thus facing unprecedented challenges as its economy is transformed and upgraded from a previous position of dependence on resources to a new innovation-oriented national strategy.

As a new phenomenon, makerspaces in China have experienced rapid growth with the adoption of mass entrepreneurship and innovation as part of this new national strategy. The emergence of open-source software and hardware, 3D printing, and other technologies, as well as the deep integration of the Internet and traditional industries in makerspaces, have made innovation and entrepreneurship accessible to larger numbers of people. Furthermore, with the central government vigorously promoting administrative reforms, the cost for innovation achievements to reach the market has also been reduced, greatly stimulating enthusiasm various entrepreneurial activities.

Currently, a large number of young people who driven to creativity, innovation and entrepreneurship are part of the trend of the digital technology transformation of traditional manufacturing, using their own “desktop factory” to produce a large number of new products that are both dazzling and marketable, subverting the traditional manufacturing, consumption, and financing models. Innovation and entrepreneurship have become the lifestyle of these young people who are generally unafraid of setbacks. Instead, overcoming a number of difficulties, their entrepreneurial experience has become their most valuable asset. Over the past five years, China’s makerspaces have multiplied exponentially. Various types of innovative spaces, such as innovation workshops, garage cafes, and creative spaces, have sprung up all over the country. The makerspace has become the main platform for creative and innovative activities in China. Over the past five years, various makerspaces in China have achieved remarkable outcomes, including:

(1) to provide entrepreneurship and employment services, becoming an important platform for promoting entrepreneurship as well as stable employment;

(2) to promote scientific and technological entrepreneurship, becoming an effective

platform for the commercialization of science and technology products;

(3) to spawn a large number of scientific and technological small and medium-sized enterprises (SME), becoming an important platform for mass entrepreneurship and innovation enterprises;

(4) to promote innovative industry, becoming an important platform for the cultivation of the new economy;

(5) to help the implementation of preferential tax policies, becoming an important platform for policies benefiting the majority of science and technology-based SMEs.

In 2019, there were nearly 7800 makerspaces in China, forming a comprehensive innovation and entrepreneurship chain with 5,200 technology business incubators and more than 700 enterprise accelerators to provide entrepreneurs with good entrepreneurial and employment services. More than 440 000 entrepreneurial teams and enterprises were in China's makerspaces with 1.91 million employees and 127 000 university student teams, growing at an annual rate of 20% to achieve a virtuous ecosystem of innovation, entrepreneurship and employment (Torch High Technology Industry Development Center (THTIDC), Ministry of Science & Technology of China, 2019).

Makerspaces actively connect with the innovation achievements of colleges and universities. Incubated enterprises rapidly gain new intellectual property rights, and their innovation ability continually improves. In 2019, the number of effective intellectual property rights owned by enterprises and teams resident in China's makerspaces reached 343,000, with a dramatic increase of 41.8% compared to 2018. In addition, the number of invention patents reached 39,500, a year-on-year increase of 58.8% (THTIDC, 2019). This reflects that incubating enterprises attach great importance to technological innovation and that technology-oriented start-ups have gradually become an important part of mass entrepreneurship in makerspaces. There are 3,083 overseas high-level talents and 30,500 overseas students in the start-up team and enterprises of China's makerspaces, which provide a strong impetus for the technological innovation of enterprises (THTIDC, 2019).

Current, there are many famous large-scale makerspaces in China such as Zhongguancun Entrepreneurship Street, Hangzhou Dream Town, Shenzhen Bay Chuangye Square, Suzhou Jinji Lake Corridor, Chengdu Jingrong Start-up International Square, Xi'an Chuangye Block, and other mass innovation clusters, achieving a high degree of aggregation of innovation and entrepreneurship resources. A large number of innovation and entrepreneurship enterprises in the fields of sharing economy, Internet, big data, artificial intelligence, virtual reality, and biomedicine have been set up in the makerspace, among which a large number of innovative

high-growth enterprises such as DJI-Innovations, Ruoyu Technology, Didi Taxi, Guokr.com, Zhihu.com, and ZBJ.com have been established.

In addition, local governments also provide valuable support to makerspaces. For example, Jiangsu Province carried out a strategy termed as “entrepreneurial Jiangsu” aiming to support the construction of makerspaces. The Guangdong government actively supported the building of an incubation chain of “makerspace-incubator-accelerator” to further support the development of local industries and the real economy. The Ministry of Science and Technology has also promoted specialized makerspaces. CITIC Heavy Industry, Haier Group, China Telecom, and other specialized makerspaces have promoted industrial transformation and upgrading. Daan Gene has established a biomedical makerspace and iFLYTEK has created an artificial intelligence makerspace. At present, there are 663 listed enterprises incubated by makerspaces across the country. These enterprises are involved in industries such as artificial intelligence, biomedicine, integrated circuits, and new materials, which are at the center of development (THTIDC, 2019).

4.1.2 Significance of makerspace to mass entrepreneurial and innovation

Chinese makerspaces help start-ups enjoy tax relief, financial subsidies, and other preferential policies, especially in the case of high-tech enterprises. They also provide services such as the evaluation of technology-based SMEs and the application of intellectual property rights. At the same time, central and local governments have issued financial and tax policies to support the development of makerspaces, and eligible makerspaces can benefit from concessions in real estate, urban land use and value-added taxes. In 2019, the implementation of makerspace tax preferential policies achieved remarkable results. The total tax savings resulting from these policies reached RMB 223 million in 2019, an increase of 192% over the previous year (THTIDC, 2019). From 2016 to 2018, the number and the total revenue of makerspaces have increased rapidly. According to the statistics of the Ministry of Science and Technology, in 2018, there were 6,959 makerspaces in China, with a total revenue of 18.3 billion RMB. It is estimated that revenue will reach 20.7 billion RMB in 2019. Data released by the Torch center of the Ministry of Science and Technology on March 26, 2020 indicated that 5,512 companies in makerspaces have resumed work after the COVID-19 crisis, indicating strong resilience (88.5% recovery rate) (THTIDC, 2019).With the high level of attention and strong support by the Central Party Committee and the State Council in recent years, China’s innovation and entrepreneurship ecosystem has been continuously improved and optimized.

Makerspaces can be both government-oriented and market-driven. With the development

of the modern market system, a large number of market-driven makerspaces have emerged, providing value-added services such as investment roadshows, consulting, entrepreneurship training and guidance, and technology transfer. In addition, some makerspaces also provide financing services such as angel investments or access to venture capital. Internet financing has also developed rapidly, providing strong capital support for start-ups. Moreover, makerspaces provide a favorable platform to the public, stimulating interest in entrepreneurship. With the development of new technologies and the opening up of the market, innovation and entrepreneurship have become widely accessible to the public. A number of major actors have entered this space, such as young entrepreneurs, senior executives of large enterprises, scientific and technological personnel, and entrepreneurs returning from overseas. More and more grassroots groups are engaged in entrepreneurship. Innovation and entrepreneurship have become a value system and lifestyle for many.

Makerspaces promote entrepreneurial activities through internal organization and open collaboration. The Internet and open-source technology platforms reduce the marginal cost of entrepreneurship, enhancing communication among entrepreneurs. Through the establishment of open innovation platform, large enterprises gather the strength of mass innovation entrepreneurs. The factors behind innovation and entrepreneurship are operating more rapidly around the world, leading to a rapid increase in cross-boundary entrepreneurship activities. The rapid development of the technology market promotes the effective connection of technological achievements with social needs and capital. Compared to traditional offices, makerspaces in China pay more attention to the physical environment, providing much more comfortable working conditions to employees. The attractive office designs largely enhance both intra- and inter-organizational communication, significantly increasing employee satisfaction.

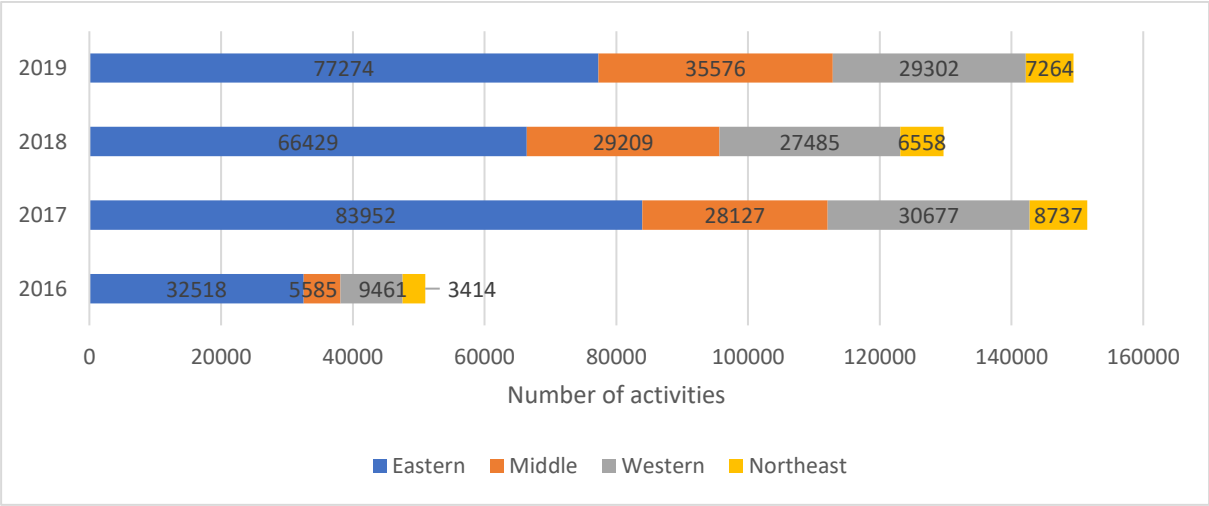

Figure 4.6 Number of creation and innovation activities organized by makerspaces

Source: Torch High Technology Industry Development Center Ministry of Science & Technology, China Torch Statistical Yearbook in 2017-2020, Beijing: China Statistics Press.

As shown in Figure 4.6, the number of activities for business creation and innovation in east area always account for the largest proportion from 2016 to 2019. The corresponding data of middle region keeps an upward trend in recent years, which may imply that the local government gradually pays great attention to various activities related to innovation and entrepreneurship activities. As for northeast region, the number of related activities remain stable after 2016 and the average value from 2017 to 2019 is about 7520 activities. It is obvious that before 2018, the related activities of west region are more than the middle region, which may relate to support under the national west developing strategy, however, this situation was changed in recently years. In 2018 and 2019, creation and innovation activities organized by makerspace in middle China had exceeded those in west region, showing a rapid growing trend of makerspaces in middle provinces.

As we know, makerspaces provide multifarious activities each year including entertainment and social activities, resource link activities and so on. Those activities held by space founders not only create many chances for multi-participants to share and cooperate. Through attracting people outside makerspace to participate kinds of activities, more potential customers can know this new work environment. Then, these potential space users may consider to settle in makerspaces, which is conducive to enriching the resources of makerspaces. That is, to some extent, holding activities can make both spaces founders and multi-participants obtain benefit. In most activities, participants have chances to contribute their wisdom to makerspaces, boosting spaces to produce cooperation results in the long term.

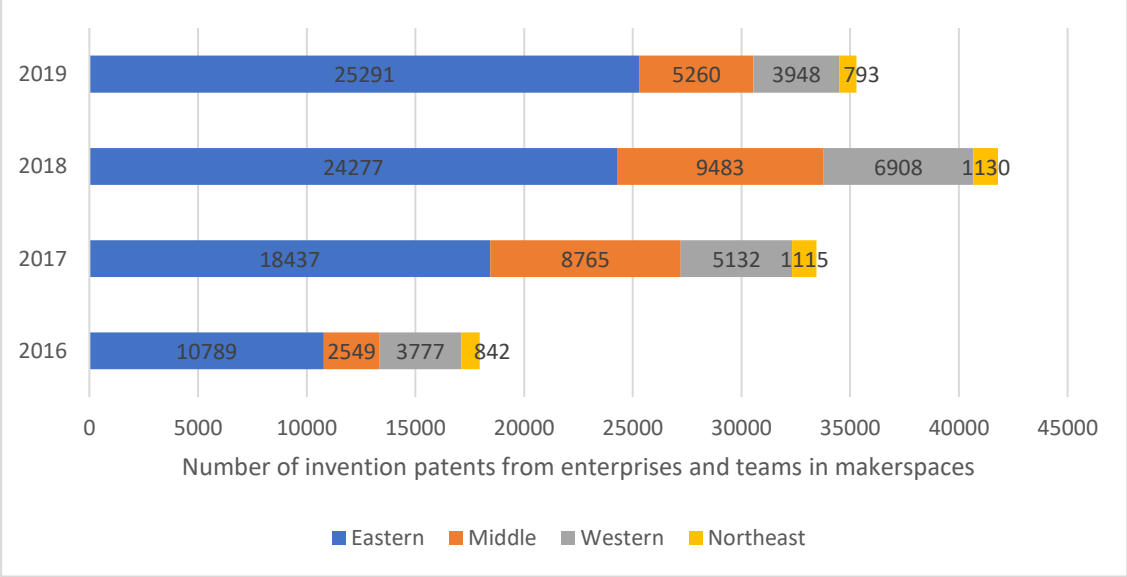

Figure 4.7 Number of invention patents from enterprises and teams in makerspaces

Source: Torch High Technology Industry Development Center Ministry of Science & Technology, China Torch Statistical Yearbook in 2017-2020, Beijing: China Statistics Press.

Invention patents is an important index to measure the innovation performance. In China, patents are divided into three types: invention, utility model and design. The Chinese government encourages invention and creation activities, and has promulgated relevant laws and regulations to protect the intellectual property right (IPR). The China National Intellectual Property Administration is the agency directly under the State Council in charge of the national patent work and the overall coordination of foreign-related intellectual property matters. Currently, along with the continuous improvement of the IPR system and the strengthening of the implementation measures, the cognition of IPR for all the people and enterprises has become a consensus. Without the permission of the patentee, other people are not allowed to use this patent. Moreover, obtaining a patent must go through strict procedures, and not every patent can be protected by law. Among the three types of patents, invention is the most difficult one that mainly refer to new product and method. Product invention is a kind of technical creation about all kinds of new products, new materials and new substances that people have developed through research. According to Chinese patent law, a product can be an independent and complete product, or a component in an equipment or instrument, which may include manufactured products such as machinery, equipment, various materials such as chemicals, compositions, and other products with new uses. Method invention refers to the operation method, manufacturing method, technological process, and other technical solutions developed by people to manufacture products or solving a technical problem. A method can be a single step or a complete process composed of a series of steps, which mainly consist of the manufacturing method aiming to a specific product, and other methods such as measurement method, analysis method, communication method and new uses of products.

Compared to the other indexes, invention patent is more reasonable predicator to exhibit the creative and innovation capabilities. Figure 4.7 presents the number of invention patents in different areas including eastern, middle, western, and northeast China. From Figure 4.7, we find that the number of invention patents in eastern region has kept growing with the 32.8% average growth rate during the four years. Compared to the other three regions, the middle, western and northeast regions, their numbers of invention patents present the trend of growth before 2019. As mentioned earlier, east area of China covering Shandong, Jiangshu, Zhejiang, Fujian, and Guangdong provinces, as well as Beijing, Tianjing, and Shanghai cities. In these provinces and cities, the economy develops quickly and local government also provides a large number of supportive policies to accelerate the development of innovation and entrepreneurial

activities. Therefore, all kinds of resources including skilled employees gather in these cities and provinces. These favorable conditions help makers turn their ideas into products, thus more invention patents are developed.

Different from the eastern region, the number of invention patents of the other three regions including middle, western, and northeast all showed some fluctuations from 2016 to 2019 with the peak in 2018. The western and northeast areas covers many under developed provinces like Guizhou, Gansu, Qinghai, Tibet, Heilongjiang. Considering the local climate and geographical environment of these regions, entrepreneurs tend to start their businesses in China's east area. Entrepreneurial culture of western and northeast areas is also needed to be strengthened. In short, the successful rate of entrepreneurs should be improved in these regions and develop more invention patents in the future.

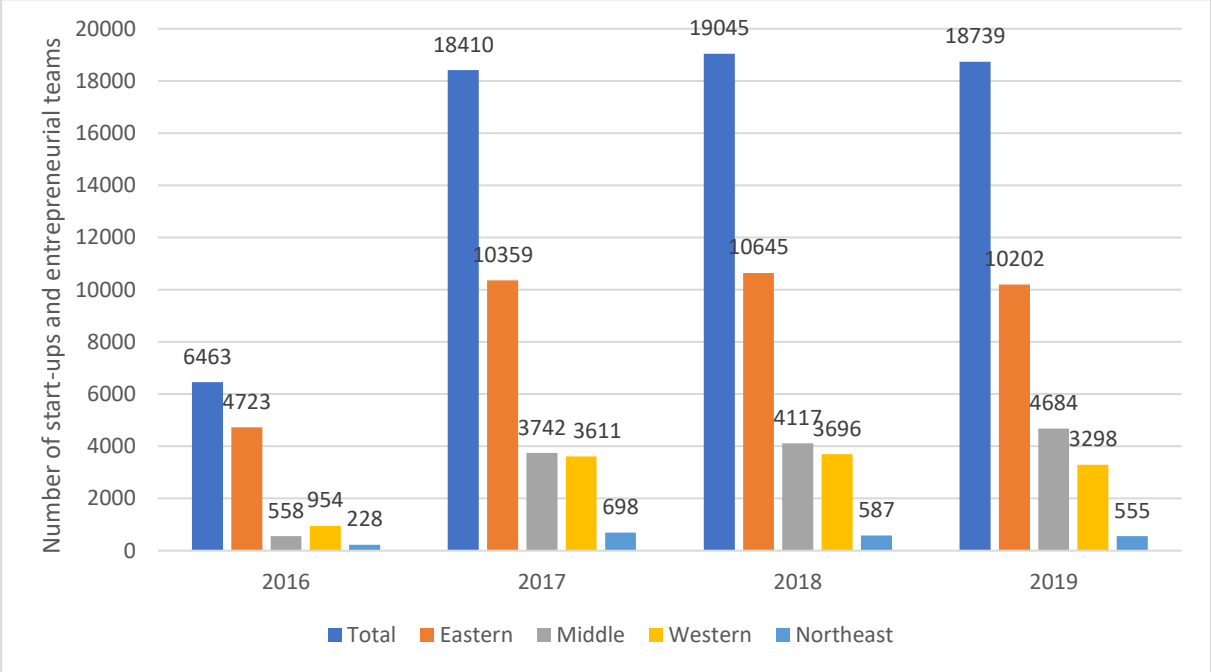

Figure 4.8 Number of start-ups and entrepreneurial teams received investment

Source: Torch High Technology Industry Development Center Ministry of Science & Technology, China Torch Statistical Yearbook in 2017-2020, Beijing: China Statistics Press.

As shown in Figure 4.8, before 2019, the number of start-ups and entrepreneurial teams receiving investment kept growing with the average growth rate about 71.7%. It is clear that in eastern and western regions, the number of those start-ups and teams kept increasing from 2016 to 2018, exhibiting the similar trend with the total data. As for middle region, the corresponding data increased from 558 to 4684 within two years with average growth rate more than 103%. In northeast area, the number of these start-ups and teams receiving investment maintained a stable level. The average value of the three-year (from 2017 to 2019) data is about 613. It is to

find that eastern area accounts for the largest proportion and this may relate to the following reasons. First, as mentioned earlier, many famous makerspace brands chose to operate their spaces in east area and these shared spaces gather numerous start-ups and entrepreneurial teams which are much more than other regions. Second, considering the regional economy, the local governments put forward many supportive policies and meanwhile attracts a number of venture capital institutions. Many small-sized companies can obtain more opportunities to build connections with these financial institutions and gain investment. Based on the above two considerations, there are more small and medium-sized enterprises as well as entrepreneurial teams got financial support. In western and northeast regions, relatively few makerspace brands and venture capital institutions chose to conduct their businesses in these areas, and thus the number of start-ups and entrepreneurial teams receiving investment is less than that in eastern region.

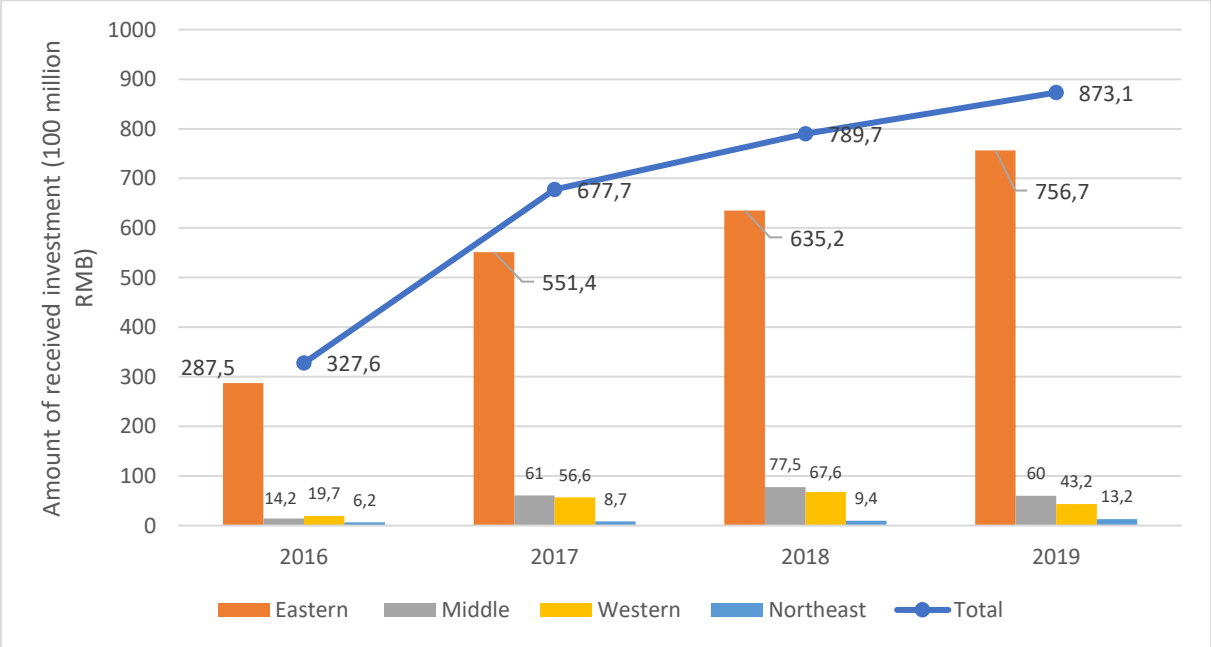

Figure 4.9 Amount of investment received by start-ups and entrepreneurial teams

Source: Torch High Technology Industry Development Center Ministry of Science & Technology, China Torch Statistical Yearbook in 2017-2020, Beijing: China Statistics Press.

Based on the development of start-ups and entrepreneurial teams and the invention patents they received, some financial institutions may consider to invest in some promising entrepreneurial projects provided by start-ups as well as entrepreneurial teams. From Figure 4.9 we can find that the total amount of their received investment kept increasing from 2016 to 2019 and reached 873100 million RMB (about 1.34 million U. S. dollars) at the end of 2019. Regarding east area, the corresponding investment had always maintained an upward trend. Own to the regional economy development and policy support from the local government as

we analyzed before, start-ups and entrepreneurial teams are more likely to get financial support in the eastern area. Therefore, the amount of investment received by them are much more than those in middle, western and northeast regions.

In general, nowadays more makerspaces' founders, financial institutions and space users explore some special cooperation method to conduct value co-creation. Space users usually provide entrepreneurial projects and new ideas. Space founders and financial institutions offer substantial supports like industrial resources, and capital supports to increase the possibility of successfully incubating businesses. Entrepreneurs within makerspaces have more chances to gain financial support. For those entrepreneurs who have not yet settled in makerspaces, choosing this type of shared spaces is a good choice.

4.1.3 Co-working space

Presently, co-working spaces are the main type of makerspaces in China, which are in a period of high-speed expansion. As a new kind of platform organization, co-working spaces can build platforms for space firms to share resources, promoting connections and value co-creation among multi-participants. Co-working spaces have shown their important roles in promoting the development of the local economy, knowledge transfers and entrepreneurial activities. Through providing multi-functional physical spaces, co-working spaces are also considered to support space users' work and life balance. It is evident that researchers and practitioners pay great attention to co-working spaces and are deeply concerned about the multiple functions and advanced technology utilized in co-working spaces.

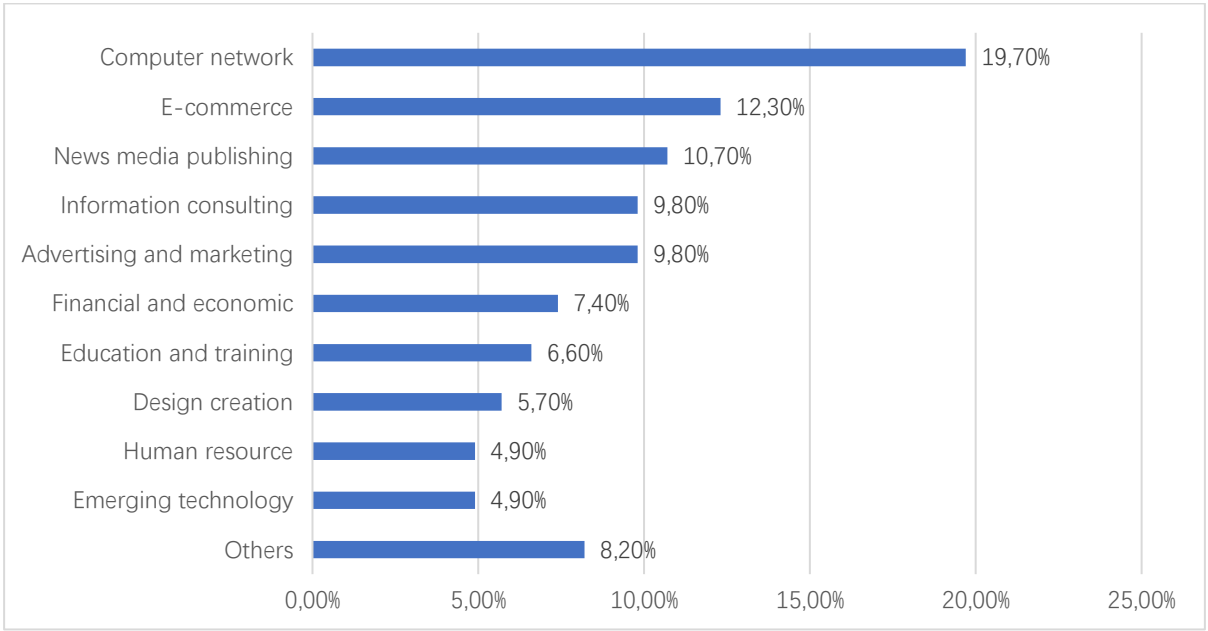

Figure 4.10 Industry Distribution of China's Co-working Spaces' users in 2021

Source: iiMedia Research, 2020-2021 China Coworking Office Industry White Paper

To our knowledge, numerous start-ups and entrepreneurial teams are willing to choose co-working spaces. From Figure 4.10 we can find that these co-working spaces' users come from various industries such as computer network, e-commerce, news media publishing, information consulting, advertising and marketing, financial and economic, education and training, design creation, human resource, and emerging technology. Some sectors are new industries, rather than the traditional ones. It is obvious that more and more entrepreneurs pay close attention to their workplace environment because of the current technological advances like artificial intelligence technology and online sharing.

In addition, young generations hope to get more from their workplaces including the balance of their work and life, open atmosphere, more social activities. Within co-working spaces, space users can share many functional areas such as fitness centers, meeting rooms, and thinking room to balance their work and personal life. But more importantly, the open atmosphere with co-working spaces makes knowledge and some other resources flow quickly among different organizations, which promotes the cooperation relationships between spaces users and the development of the whole space. Therefore, co-working spaces attract a growing number of entrepreneurs from various industries to settle in these shared spaces.

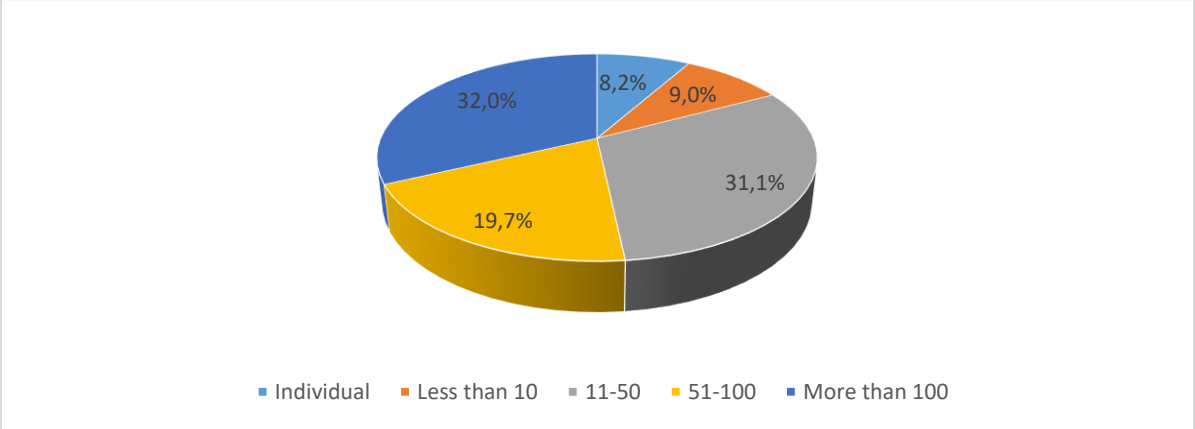

Figure 4.11 The scale of space users in China's co-working space in 2021

Source: iiMedia Research, 2020-2021 China Coworking Office Industry White Paper

As shown in Figure 4.11, we can see that about 32.0% space users are individual entrepreneurs. The entrepreneurial teams and start-ups containing 11 to 50 members account for 31.1% of the total sample. Additionally, the settled organizations consist of less than 10 members account for 19.7%. The others are the organizations more than 100 members (accounting for 8.2%) and less than 10 members (accounting for 9.0%).

Freelances and small and medium-sized enterprises (SME) tend to choose co-working

spaces as their workplaces which are much convenient for them to share the office equipment and public rooms provided by co-working spaces. Of course, these shared spaces have many kinds of innovation and entrepreneurial activities and build platforms for them to link different resources. As for some large-scale enterprises, they also have much interesting in co-working space due to the open atmosphere of co-working spaces, which can encourage their employees to learn from other organizations and to maintain rapidly respond to the changes of the business environment. In fact, a growing number of organizations including start-ups and large-scale enterprises choose to locate in co-working spaces.

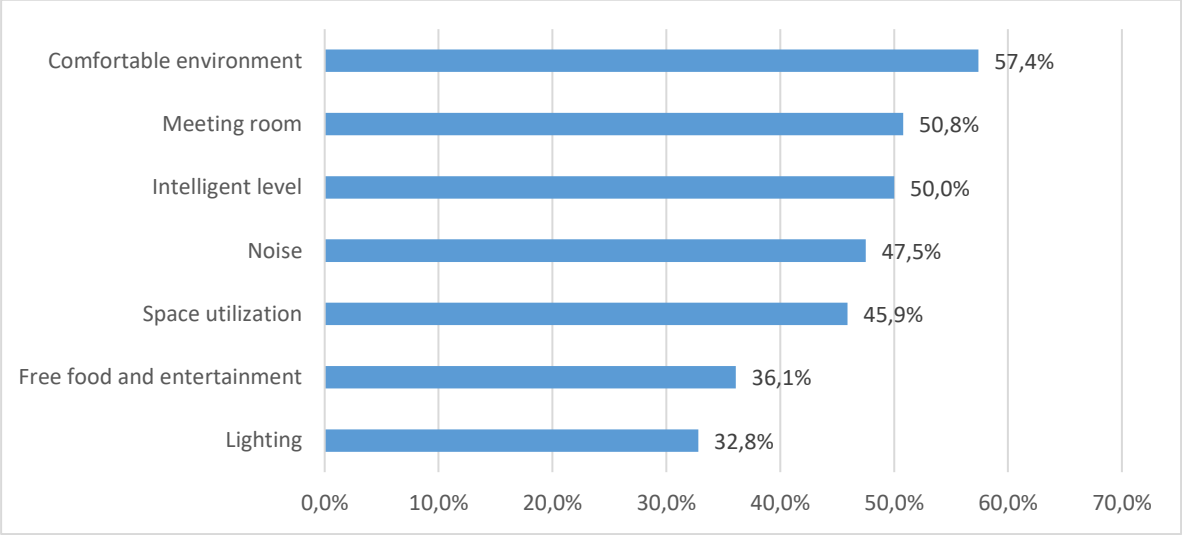

Figure 4.12 The factors concerning office environment of Chinese co-working space users in 2021

Source: iiMedia Research, 2020-2021 China Coworking Office Industry White Paper

Among various users involving freelancers, entrepreneurial teams, and individuals within co-working spaces, they may pay different attention to the office environment offered by the shared spaces. As illustrated in Figure 4.12, comfortable environment, meeting room and intelligent level ranked 1, 2, 3 to be the most significant consideration for the firms to choose the co-working space, respectively. In addition, noise situation, space utilization, free food and entertainment and lighting equipment are also the important concerns for the various enterprises and individuals.

According to this survey results, founders of co-working spaces should continuously improve these aspects so as to attract more potential customers to choose co-working spaces. As we know, in China, the homogeneity of these shared spaces is a serious problem. Many co-working spaces imitate some successful spaces' operational modes and space design. However, these spaces do not possess their own competitive advantage. These co-working spaces should form their own competitiveness according to these aspects mentioned in the Figure 4.12 to

provide their differentiated services.

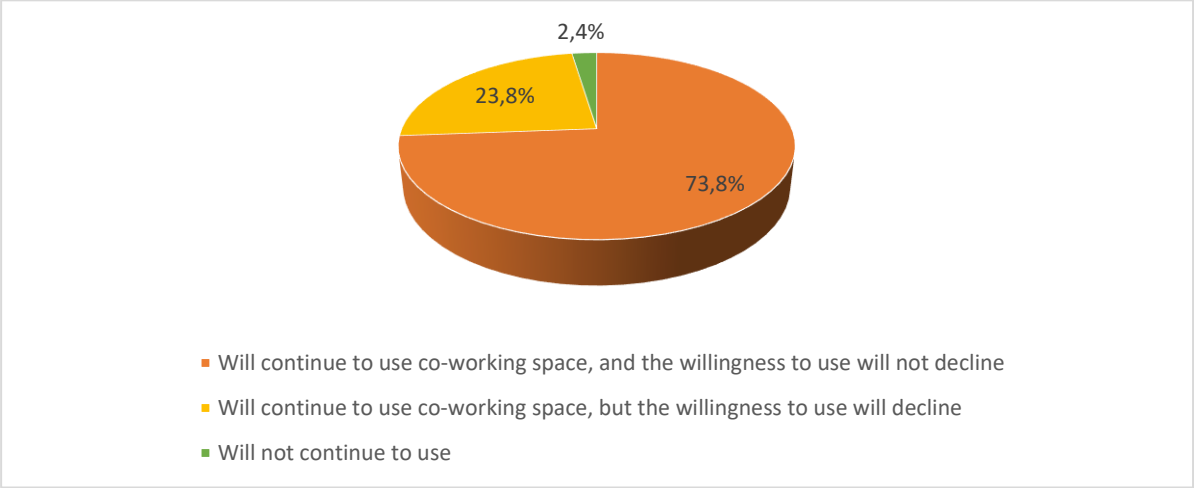

Figure 4.13 Service consumption intention of China's co-working space users in 2021

Source: iiMedia Research, 2020-2021 China Coworking Office Industry White Paper

The COVID-19 pandemic has caused serious losses to small and medium-sized enterprises. At the beginning of 2022, they were not permitted to work in co-working spaces to conduct innovation and entrepreneurial activities. Most of these start-ups were under the pressure of paying employees' salaries and suffered from the huge economic loss during the turbulent time. After the effort of the whole society in China, companies in different industries could resume work at the beginning of April 2020, and many small and medium-sized enterprises started to go back to co-working spaces and gradually conducted their operations in physical spaces offered by co-working spaces. Among the start-ups and entrepreneurial teams investigated by iimedia data center, about 73.8% of the space members would like to continue to choose co-working spaces and their willingness were still very strong. By contrast, 23.8% of enterprises will continue to use co-working spaces but their willingness to use co-working spaces will decline for some reasons. The remnant accounting for about 2.4% consider that they will not continue to choose this type of sharing office environment, which has the smallest proportion.

From the survey result of iimedia Research, we may find that in the "post epidemic period", lots of organizations continue to choose this type of office environment and hope to achieve more cooperation with other spaces users in the future. Within a co-working space, the geographical agglomeration among different organizations is quite obvious. Therefore, these companies have more chances to observe and know more about each other. Presently, although some businesses can be finished though online method, many organizations still have the willingness to work in co-working spaces. The open atmosphere of these shared spaces and the convenient face to face communication in co-working space can attract an increasing number

of companies and teams plan and show their dependence on co-working spaces. In this way, we can better understand why China's co-working spaces users are keen on working in such spaces and most of they do not change their choices after the shock of COVID-19 pandemic.

4.2 Sample selection: Ucommune

Ucommune, one of the largest makerspaces in China and to be the first IPO Chinese co-working space in NASDAQ , was selected in this study to examine the proposed hypotheses. This is due to the following reasons:

(1) Ucommune provides offices to various enterprises, especially entrepreneurial teams and start-ups. It offers different kind of workspaces to satisfy the needs of different firms, allowing to examine the relationship between workspace environment, employee behavior, creativity and innovation.

(2) There are more than 15,000 firms of different kinds in Ucommune. They vary in terms of size, age, industry, and background, increasing the applicability of this study by avoiding systematic bias due to similarity between enterprises.

(3) Ucommune has a presence in nearly all of China's largest cities, such as Beijing, Shanghai, Shenzhen, Hangzhou, and Chengdu. As we know, China is a large country with quite diverse cultures and levels of economic development, which may affect local perceptions. Variety in terms of geographic area can effectively reduce deviations, improving the robustness of this study.

Ucommune, located in Beijing, was founded in April 2015. As a co-working platform, it provides shared offices to various entrepreneurial and innovative companies or groups. As of November 2018, more than 15,000 start-ups and innovative enterprises chose Ucommune as their office spaces. Its investors include the Sequoia Capital China Fund, the Zhenge Fund, Gefei Assets, Yirun Investments, CIC Hanfu, and Innovation Workshop. Ucommune provides innovative enterprises with full industry services and builds a social platform and resource allocation platform for businesses, based on community. By June 30, 2019, it had over 200 co-working spaces in 44 cities around the world such as Beijing, Shanghai, Shenzhen, Xi'an, Hangzhou, Hong Kong, Taiwan, Singapore, New York, and Los Angeles.

On June 8, 2018, Ucommune completed the C+ round of financing, with a valuation of more than RMB 11 billion. On November 20, 2019, the company won the title of "China's Innovation Enterprise". Ucommune's offline products mainly include the standardized "U Space" workspace, the small "U Studio" workspace, and customized "U Design" workspaces.

For all these products, Ucommune also provides services to support and empower enterprises and individual members, including advertising and brand services, incubation, tax consultancy, financing, human resource management, legal services, interior design and construction. The corporate vision is to build a community-based social and resource allocation platform for business and its mission is to empower Chinese innovators with this vision. Its values include creativity, passion, integrity, gratitude, inspiration, and companionship. Key milestones in the company's history include:

- April 18, 2015: Ucommune was officially established.
- September 16, 2015: the first Ucommune co-working space was opened, under the name "Beijing Sunshine 100 Community".
- 2016: The Ucommune app was published online.
- April 18, 2016: a conference was held in Beijing to commemorate the company's first anniversary. The "Blue Book of China Makerspace Development" was published, a joint compilation by Ucommune, the Science and Technology Communication Center of China, Center for China & Globalization, Beijing Makerspace Alliance, and Business School of Ucommune.
- August 15, 2016: Ucommune obtained strategic equity investment from China Taihe Group, with a valuation of nearly RMB 5.5 billion.
- September 10, 2016: The "First World INS (Innovate-Network-Share) Conference", jointly sponsored by Ucommune and Standard Ranking Co., was held.
- April 18, 2017, Alibaba Cloud Computing Co., Ltd. and Ucommune signed a global strategic cooperation agreement to help the development of global start-ups in the Ucommune and Alibaba Innovation Center.
- June 23, 2017: the company's first overseas workspace opened in Singapore.
- September 9, 2017: The "Second World INS Conference" was held. The "2017 China Innovation and Entrepreneurship Report" was jointly released by Ucommune and Standard Ranking Co., with the support of the Tencent Research Institute.
- September 15, 2017: the Torch Center of the Ministry of Science and Technology of China and Ucommune jointly released the industrial standards like "Makerspace Service Specification (Trial)" and "Makerspace (Co-working Space) Service Standards" in Shanghai.
- January 3, 2018: Ucommune acquired the Hongtai Innovation Space.
- January 5, 2018: Ucommune released "Youke Classroom". Mr. Mao Daqing, the founder of Ucommune, served as its president.

- February 12, 2018: Ucommune received RMB 110 million in strategic investment from the Qianhai Industry Buyout Fund, leading to Ucommune's valuation being in excess of RMB 9 billion.
- March 26, 2018: Ucommune acquired Wedo and built a shared office platform in GBA (Guangdong-Hong Kong-Macao Great Bay Area).
- March 28, 2018: Ucommune entered the U.S. market.
- May 22, 2018: the "2018 World INS Conference – Xi'an" was held, jointly hosted by the Xi'an government and Ucommune.
- September 10, 2019: Ucommune completed the acquisition of Rocket Office.
- 2019: Ucommune established an online e-commerce and marketing platform.
- April 18, 2020: Ucommune initiated a five-year series of online conferences, announcing a strategic transformation designated "Light Assets, Heavy Empowerment", suggesting that the "lighter" Ucommune assets are, the more empowered its membership will be.
- November, 23, 2020: Ucommune IPO in NASDAQ, which is the first Chinese co-working space listed in NASDAQ.

4.3 Questionnaire design

In this study, both questionnaires and interviews were employed to collect data. A questionnaire with a 5-point Likert scale was designed to gather the necessary information, in which 1 and 5 stood for "completely disagree" and "completely agree", respectively. Appendix 1 shows the questionnaire in detail. The questionnaire was designed according to previous literature and to the Chinese context.

To evaluate the objectivity and reliability of the questionnaire, a pre-test survey was conducted with six companies in two makerspaces. As a first step, 3 companies located in three makerspaces were randomly selected and their managers and employees were asked to fill out the questionnaire separately. An interview followed each response to verify that the respondent had been able to easily understand all questions. These interviews lasted approximately fifteen minutes on average. As a result of these interviews, a number of unclear items were removed, such as "There is an environment of tolerance in the makerspace"; "The managerial level of the makerspace is good"; "I can find Chinese style in the makerspace design"; "I like the fitness equipment in the makerspace". Three companies were then selected in a different makerspace and the same process was repeated. It was then found that the updated questionnaire was

objective and clear, meeting necessary standards. The final questionnaire was thus defined.

4.4 Data collection

Large-scale survey was conducted through the Wechat system within Ucommune from July to August 2018. A small prize was offered to each respondent to encourage participation. A total of 850 questionnaires were sent out and 793 completed responses were received, corresponding to a 93.29% response rate. Among these, there were 745 valid questionnaires. Validation was supported on a number of reasons, such as obviously incorrect answers, missing values, etc.

4.5 Measurement

The indicators in this study were selected based on previous research as well as on interviewing questionnaire respondents. Table 4.1 shows the indicators of the dependent and independent variables in this study.

Table 4.1 Dependent and independent variables and their indicators

Variables	Items for Measurement	References
Physical Environment (PE)	PE1: The lighting design is good. PE2: The temperature and humidity are comfortable. PE3: The indoor layout provides convenience for communication. PE4: I like the office equipment and furniture. PE5: The interior design of the working space meets my needs for privacy in the working environment. PE6: The interior design of the communal spaces meets my need for a shared working environment. PE7: I like the interior design. PE8: The overall spatial layout of the multi-creation space is good. PE9: The color palette of the interior design adds to a pleasant atmosphere.	Liu (2008); Sheykhan and Saghaee (2011)
Non-physical Environment (NE)	NE1: I like the cultural atmosphere of the makerspace. NE2: Creating an open atmosphere in public spaces makes me feel relaxed. NE3: I like all kinds of activities held by the makerspace. NE4: I often communicate with members of other companies (teams) in the makerspace.	Sheykhan and Saghaee (2011)
Individual Behavior (IB)	IB1: After work, I would like to take my family and friends to visit the makerspace. IB2: I like the working environment of the makerspace. IB3: I like the cultural atmosphere of the makerspace. IB4: I would like to work in the makerspace. IB5: It's easy for me to exchange ideas with and get advice from my colleagues or friends in the communal spaces.	Farh, Lanaj, and Ilies (2017); Zigarmi et al. (2009)

	IB6: I can get help from other companies or friends in the makerspace. IB7: In the makerspace, I can coordinate and maintain good interpersonal relationships.	
Team Behavior (TB)	TB1: Our team often holds discussions in the makerspace. TB2: Members of our team often encourage each other. TB3: Members of our team help each other to solve problems at work.	Demir, Cooke, and Amazeen (2018)
Creativity (C)	CR1: I often come up with new ideas in my work. CR2: I often have new ideas to solve problems. CR3: I can come up with novel ideas about technology, management models or products (services).	Tierney, Farmer, and Graen (1999)
Innovation Performance (IP)	IP1: Our company continuously improves its existing products or services. IP2: Our company is constantly exploring new managerial methods. IP3: Our company has applied for new practical patents. IP4: Our company has applied for design patents. IP5: Our company launches new products (services). IP6: Our company is developing new technologies. IP7: Our company has applied for invention patents.	Yuan and Woodman (2010); Wan et al. (2019)

Independent Variables

Physical environment is related to the facility, building and other material systems, including temperature, humidity, illumination, vibrations, noise, odor, dust, space, cleanliness, and the time of daily contact with these factors (Liu, 2008). There are many factors affecting the entrepreneur's office, such as furniture design, color, material, light, sound, and high-level interior, which have an impact on users. The design of the items of the physical environment is mainly based on the matured scale used by Liu (2008) and Sheykhan and Saghaee (2011), and combined, revised, and supplemented based on feedback from field research. Non-physical environment refers to the atmosphere of the space, such as its cultural climate. Here, based on the measurement of Sheykhan and Saghaee (2011), we chose four indictors which are most suitable for the situation of makerspaces.

Individual behavior in this study refers to the individual's behavior in participating in innovative activities and exchanging opinions in order to promote the search for and identification of new opportunities. The indictors of individual behavior mainly include the willingness to stay in the office, have exchanges with others, and maintain good emotions (Zigarmi et al., 2009). Team behavior mainly refers to the interactions and innovative activities among individuals in a team, such as knowledge transfer and information sharing (Demir, Cooke, & Amazeen, 2018).

Dependent Variables

Creativity mainly represents the generation of new thinking or ideas (Cho, 2017). Amabile

et al. (1996) believes that creativity is a novel and useful idea issued by individuals, and innovation is the implementation of these ideas. Creativity is the first stage of the innovation process. However, creativity in employees' work cannot be equal to innovation performance. Therefore, it is very difficult for scholars to evaluate employees' creativity as a method to measure their innovation performance (Guo, Su, & Zhang, 2017; Li & Yue, 2019). From creativity to innovation behavior and from there to innovation performance is a gradual process. According to the connotation of creativity, it can be widely reflected as personality traits such as "capable", "humorous", "ingenious", "resourceful", and "unconventional" (Fong et al., 2018). This study followed the measurements found in Tierney, Farmer, and Graen (1999), and revised them according to the study's specificities to obtain the measures for creativity (Janger et al., 2017).

Innovation performance is the result of the interaction between organizational members and the innovation environment (Fu, 2018). Most scholars consider that performance is a combination of behavior and result, mainly measuring innovation performance from the two aspects of innovation behavior and innovation results (Lin, Gao, & Gao, 2016). Others measure innovation performance from the quality and quantity of innovation. Although existing innovation performance indicators combine both long-term and short-term aspects, there is a causal relationship between innovation behavior and results (Gong, Fletcher, & Bolin, 2015). From the perspective of dual innovation, exploration and exploitation innovation performance are quite different in what pertains to innovation risk, R&D cycle and outputs. While exploitation innovation can improve the short-term efficiency and increase current revenue, exploration innovation mainly enhances long-term competitiveness and future earnings (March, 1991; Perry-Smith & Mannucci, 2017). Daft (1978) proposed that innovation should be divided into two: technological innovation and managerial innovation. The measurement of innovation performance in this study mainly refers to the scale developed by Yuan and Woodman (2010), revised according to the characteristics of makerspaces (Wan et al., 2019).

Control Variables

Existing literature has abundantly examined the impact of firm size and age on innovation performance. One view is that large enterprises are more suitable for innovation. Colby (2020) suggests that the larger the enterprise scale is, the more technological innovation will occur. He believed that the R&D strength and risk tolerance of large enterprises play an important role in technological innovation. There is a positive correlation between R&D expenditure and the size of enterprises. Another view holds that the relationship between enterprise scale and technological innovation is more incremental (Chatterjee & Sahasranamam, 2018). The pursuit

of the reasonable expansion of enterprise scale is a key factor to improve the level of technological innovation. A third view is that the relationship between firm size and innovation is nonlinear. There is a U-shaped relationship between enterprise scale and R&D expenditure. It is found that there is an inverse U-shaped relationship between firm size and innovation investment. There is a positive correlation between R&D investment ratio and innovation performance in large-scale enterprises, but an inverted U-shaped relationship in medium-sized enterprises. Moreover, previous literature also confirms the significant relationship between firm's and age and size (Falk, 2007). Therefore, considering the potential impacts of firm size and age on innovation performance (Castro & Roldán, 2015; Schilke & Goerzen, 2010), this study takes these two variables as control variables.

4.6 Synopsis of Chapter 4

This chapter discussed the method to examine the proposed hypotheses. As discussed, makerspaces are a novel phenomenon in China. There are currently three types of entrepreneurial platforms in China: incubators, accelerators, and makerspaces (Zhang & Bai, 2017). Prior to the appearance of makerspaces, incubators were the dominant platforms to serve various start-ups, especially technology-oriented enterprises, providing them with funds and managerial support. As examples, Entrepreneurship Nursery, and High-Tech Industrial Development Zone, are two traditional incubators. Accelerators represent the expansion and continuation of incubators, and refer to institutions that provide space and professional services for enterprises throughout the incubation process, to help them achieve high growth. One of the characteristics of accelerators is that they help entrepreneurs refine their products, customize business models, and embark on entrepreneurial activities such as project roadshows, so as to help them obtain capital (Zhang, Fu, & Yi, 2017). Unlike traditional incubators and accelerators, makerspaces pay more attention to comprehensive services, ranging from the creation of an entrepreneurial atmosphere to the promotion of products. In strong competition with traditional offices, Chinese makerspaces offer notable interior design, location, cost as well as a wide variety of services. Makerspaces thus do not serve a traditionally narrower audience, instead being accessible to the general public without any constraints. As long as one has entrepreneurial ideas, one can enter the makerspace and take advantage of entrepreneurial services and resources. Since the physical environment is an important antecedent in this theoretical framework, makerspaces are suitable for this study. We first reviewed the phenomenon of makerspaces in China, in particular their recent emergence and development.

Ucommune was then chosen to test the impact of workspace environment on creativity and innovation. Because Ucommune has a presence in different cities in China, it will enhance the universality of this study. To collect related data, a questionnaire was designed based on existing literature as well as pre-test results. Ucommune's internal platform was then used to distribute the questionnaire and collect responses.

Chapter 5 Empirical Results

In this study, structural equation modeling (SEM) was employed to examine the proposed hypotheses. Considering that the dependent and independent variables are all latent and cannot be measured directly, SEM provides an effective way to explore existing causal relationships (Hu & Bentler, 1999). In general, there are two steps for SEM. First, to evaluate the fitness of indicators to variables by confirmatory analysis. Second, to estimate the parameters of the structural model (David, 2013). Here, we used SPSS and AMOS 22.0 software to conduct SEM analysis.

5.1 Profile of sample

Ucommune is a co-working space platform that provides various workspaces to different kinds of organizations, including entrepreneurial teams. Table 5.1 shows the profile of the sample in this study.

Table 5.1 Sample characteristics (*N*=745)

Item	Category	Frequency	Percentage (%)
Sex	Male	650	87.2
	Female	95	12.8
Age	20–30 years old	639	85.8
	31–40 years old	87	11.7
	41–50 years old	14	1.9
	Over 50 years old	5	0.7
Education	Up to high school	201	27.0
	Junior College	224	30.1
	Undergraduate	252	33.8
	Master’s degree	29	3.9
	Ph.D.	39	5.2
Ownership	Private	490	65.8
	State-owned	203	27.2
	Foreign-owned	28	3.8
	Joint-venture	24	3.2

	Category	Frequency	Percentage (%)
Office location before entering Ucommune	Commercial office building	385	51.7
	Enterprise	215	28.9
	Park or incubator	128	17.2
	Others	17	2.3
Portion of enterprise in Ucommune	Whole enterprise	381	51.1
	2 departments or more	175	23.5
	1 department	119	16.0
	Branch	59	7.9
	Others	11	1.5

With regard to gender, 87.2% of respondents are male. In terms of age, respondents were mostly in the 20-30 year old age bracket (639 people, accounting for 85.8% of the total), which indicates that people in makerspaces are predominantly young. Furthermore, nearly 64% of employees have either attended junior college or hold an undergraduate degree, indicating that well-educated young people are currently the main innovators in China.

From Table 5.1, we may also find that private enterprises and state-owned enterprises (SOE) account for 65.8% and 27.2% of firms, respectively. Considering that all SOEs in China are large enterprises, the higher percentage of private firms may explain why more than half of all firms (51.1%) are wholly located in the makerspace. Remarkably, over 80% of firms in Ucommune have moved there from commercial office buildings or their own offices, showing the attraction of makerspaces.

5.2 Validity and reliability test

5.2.1 Validity analysis

Prior to the confirmatory factor analysis, the Kaiser-Meyer-Olkin test (KMO) and Bartlett's sphericity test are usually used to examine whether the data is suitable for factor analysis. Wu (2003) points out that when KMO < 0.6, the data is not suitable for factor analysis; if 0.6 < KMO < 0.7, the data can be used for factor analysis, though it is not ideally suited for it; when KMO > 0.7, the data can be used for factor analysis; if KMO > 0.8, the data is suitable for factor analysis; when KMO > 0.9, the data is very suitable for factor analysis.

In this study, the KMO value of 0.929, and the results of Barlett's sphericity test ($\chi 2$ = 13074.669, DF = 528, P < 0.000) indicate that the data is suitable for factor analysis. The principal component analysis was used to extract the factor, and the common factor was

extracted when the eigenvalue was greater than 1. The factor was analyzed by the orthogonal rotation of the maximum variance when the factor rotated. The results are shown in Table 5.2.

Table 5.2 Total variance interpretation

	Initial Eigenvalue			Extracted Sum of Load Squares			Sum of Rotation Load Squares		
	Total	Var. Pct.	Cum. Pct.	Total	Var. Pct.	Cum. Pct.	Total	Var. Pct.	Cum. Pct.
1	8.844	26.800	26.800	8.844	26.800	26.800	5.659	17.147	17.147
2	3.962	12.007	38.807	3.962	12.007	38.807	4.713	14.281	31.428
3	3.527	10.686	49.493	3.527	10.686	49.493	4.424	13.407	44.835
4	2.149	6.514	56.007	2.149	6.514	56.007	2.483	7.524	52.359
5	1.644	4.983	60.989	1.644	4.983	60.989	2.242	6.795	59.154
6	1.590	4.817	65.806	1.590	4.817	65.806	2.195	6.652	65.806
7	.665	2.015	67.821						
8	.612	1.854	69.676						
9	.593	1.797	71.472						
10	.565	1.711	73.183						
11	.521	1.578	74.762						
12	.510	1.546	76.307						
13	.488	1.478	77.785						
14	.471	1.427	79.212						
15	.454	1.376	80.588						
16	.445	1.349	81.936						
17	.434	1.315	83.251						
18	.423	1.281	84.532						
19	.417	1.265	85.797						
20	.411	1.244	87.041						
21	.395	1.196	88.236						
22	.394	1.193	89.429						
23	.368	1.114	90.543						
24	.361	1.093	91.636						
25	.345	1.047	92.683						
26	.336	1.019	93.702						
27	.324	.981	94.683						
28	.316	.957	95.641						
29	.311	.941	96.582						
30	.299	.906	97.487						
31	.281	.852	98.339						
32	.278	.842	99.181						
33	.270	.819	100.000						

Note: Var. Pct.: Variance Percentage; Cum. Pct.: Cumulative Percentage

From Table 5.2, we find six factors resulting from factor analysis, with an explanatory ability of 17.147%, 14.281%, 13.407%, 7.524%, 6.795% and 6.652%, respectively. The total explanatory ability reaches 65.806% (>50%), indicating that the six selected factors have good representativeness. The rotated component matrix is shown in Table 5.3.

Table 5.3 Rotated component matrix

Variable	Item	Component					
		1	2	3	4	5	6
Individual Behavior	IB1	.158	.784	.033	.010	.067	.017
	IB2	.132	.819	-.019	.042	.092	.013
	IB3	.092	.766	.104	.157	.094	.042
	IB4	.138	.774	.013	.100	.091	.068
	IB5	.081	.827	.063	.100	.108	.068
	IB6	.106	.796	.049	.047	.044	.065
	IB7	.112	.812	.054	.078	.044	.009
Creativity	C1	.150	.058	.072	.074	.110	.825
	C2	.139	.078	.047	.113	.065	.822
	C3	.113	.070	-.008	.100	.085	.836
Team Behavior	TB1	.137	.135	.094	.115	.823	.114
	TB2	.120	.188	.137	.059	.841	.083
	TB3	.195	.141	.085	.117	.816	.087
Innovation Performance	IP1	.072	-.015	.826	.079	.015	-.020
	IP2	.092	.071	.806	.060	.055	.011
	IP3	.067	.001	.759	.052	.055	.018
	IP4	.084	.071	.752	.039	.057	.023
	IP5	.086	.057	.828	.021	.020	-.049
	IP6	.063	.030	.776	.050	.047	.030
	IP7	.089	.062	.724	.006	.098	.132
Physical Environment	PE1	.771	.125	.086	.150	.049	.076
	PE2	.782	.123	.105	.030	.060	.076
	PE3	.765	.134	.049	.137	.044	.069
	PE4	.736	.101	.093	.175	.090	.111
	PE5	.755	.046	.097	.147	.138	.052
	PE6	.703	.119	.050	.132	.001	.043
	PE7	.783	.087	.082	.125	.091	.055
	PE8	.749	.087	.073	.154	.164	.081
	PE9	.779	.125	.052	.106	.020	.045
Non-physical Environment	NE1	.219	.104	.083	.725	.122	.080
	NE2	.265	.100	.062	.735	.030	.041
	NE3	.233	.150	.083	.719	.115	.118
	NE4	.196	.103	.051	.780	.042	.089

5.2.2 Reliability test

Reliability refers to the degree of consistency of the results obtained over repeated measurements of the same object using the same method. This reflects the internal consistency, stability and reliability of the items constituting variables. As for the Likert scale, the Cronbach alpha coefficient and composite reliability (CR) can be used to test its reliability. The Cronbach alpha coefficient is a number between 0 and 1 and, the greater the value, the better the internal consistency of the scale. According to (Gogol et al., 2014), Cronbach alpha is generally required to be at least greater than 0.7.

Table 5.4 Cronbach alpha coefficients for variables

	Individual Behavior	Team Behavior	Physical Environment	Non-physical Environment	Creativity	Innovation Performance
Cronbach α	0.916	0.843	0.922	0.806	0.813	0.899

As shown in Table 5.4, the Cronbach alpha coefficients of individual behavior, team behavior, physical environment, non-physical environment, creativity, and innovation performance are 0.916, 0.843, 0.922, 0.806, 0.813 and 0.899 respectively, which are all greater than 0.7, indicating that the six variables have good internal consistency and stability.

5.3 Confirmative factor analysis

This study uses the AMOS 22.0 software to conduct confirmatory factor analysis. This method is widely used and is considered to be a relatively conservative test for convergent validity tests (Sungho & young-soon, 2014). Researchers can impose conditional constraints on the model according to theoretical or practical needs, observe the fitness degree of different factor structure models and data, and test whether the known specific structure works in the expected way (Wu, 2009). When using confirmatory factor analysis validity test, it is necessary to evaluate the fit of the model and modify the measurement model to improve its fit. According to suggestions by (Hu & Bentler, 1999), the main parameters of model fit include χ^2/df (Chi-square/df fitness), GFI (Goodness of Fit Index), NFI (Normed Fit Index), AGFI (Adjusted Goodness-of-Fit Index), CFI (Comparative Fit Index), and RMSEA (Root Mean Square Error of Approximation). Confirmative factor analysis judges the degree of matching to the measurement model and data according to fit index. Common indices include the absolute fit index and the relative fit index. The absolute fit index is similar to R^2 in regression equations. It refers to the proportion of model covariance matrix to explain the sample covariance matrix.

The smaller the χ^2/df, the better the model fit. Generally, 2:1 or 3:1 is an acceptable indicator of fit. RMSEA < 0.08 indicates that the fit is acceptable and RMSEA < 0.05 indicates that the fit is very good. GFI and AGFI are generally greater than 0.8, which indicates that the fit is good, while if they are over 0.95 it indicates that the fit is very good (Wu, 2009). The relative fit index indicates the degree of improvement of the fit of the research model when compared to the independent model. CFI and NFI above 0.9 show that the fit is good, and when greater than 0.95 they indicate that the fit is very good. The acceptable values of each index (Hu and Bentler, 1999; Wen, Hou, & Marsh, 2004) are shown in Table 5.6.

5.3.1 Model fit analysis

From Table 5.5, we can see that χ^2/df is 1.369, less than 3, and GFI, AGFI, NFI, TLI, IFI, CFI all meet the standards above 0.9, RMSEA is 0.022, less than 0.08. Thus, all fitness indicators meet the requirements, showing that the measurement model is effective.

Table 5.5 Model fit summary

Type of Fit	Critical Value	Corresponding Value
CMIN		657.334
DF		480
χ^2/df	<3	1.369
GFI	>0.9	0.949
AGFI	>0.9	0.941
RMSEA	<0.08	0.022
IFI	>0.9	0.986
NFI	>0.9	0.951
TLI (NNFI)	>0.9	0.985
CFI	>0.9	0.986

5.3.2 Confirmatory factor analysis

Standardized factor loading is a critical index for convergent validity tests. Wu (2009) suggests that it is acceptable when standardization factor loading is greater than 0.5. From Table 5.7, we may find that the standardization factor loading in a single item is greater than 0.5, and the residual error is positive and significant, showing that the reliability of a single item meets the requirements. Composite Reliability (CR) greater than or equal to 0.6 indicates that the scale has good consistency (Marakanon & Panjakajornsak, 2017).

In confirmatory factor analysis, AVE (Average Variance Explained) is another important indicator for convergent validity, and its square root is also used to test the discriminant validity of the scales. Discriminant validity reflects the extent to which the observed items are mutually exclusive. When multiple items of a construct are aggregated, the measurement items of this construct should also be irrelevant to the measurement items of other constructs.

In general, there are two approaches for testing discriminant validity. One is to compare the relationship between the square root of AVE and the correlation coefficient between variables. When the square root of AVE is larger than the correlation coefficient between variables, the discriminant validity is high. Another way is to compare the model to the other alternative with chi square difference test and fit index. Only when the matching degree of the main model is better than that of the alternative model does it show that the main model is more appropriate for discriminating variables, and discriminant validity between variables is high (Wu, 2009). It is generally believed that, when the AVE value is greater than 50% (Marakanon & Panjakajornsak, 2017), the internal quality of the measurement model is good.

Table 5.6 shows that the scale of this study has good discriminant validity. As shown in Table 5.7, the composite reliability (CR) of individual behavior, creativity, team behavior, innovation performance, physical environment and non-physical environment is 0.916, 0.813, 0.845, 0.900, 0.923 and 0.806, respectively, which are all greater than 0.7. Meanwhile, the Average Variance Explained (AVE) is 0.609, 0.592, 0.645, 0.563, 0.572 and 0.510, respectively, which are all greater than 0.5. All of these values meet the criterion of discriminant validity.

Table 5.6 Reliability, convergent validity results

Variables	Items	Non Std. Factor loadings	Std. Error	C.R.（t-value)	P	Std. Factor loadings	CR	AVE
Individual Behavior (IB)	IB1	1				0.759	0.916	0.609
	IB2	1.082	0.048	22.604	***	0.8		
	IB3	1.058	0.05	21.215	***	0.757		
	IB4	1.084	0.051	21.366	***	0.762		
	IB5	1.159	0.05	23.331	***	0.823		
	IB6	1.082	0.05	21.523	***	0.767		
	IB7	1.089	0.049	22.289	***	0.791		
Creativity (C)	C1	1				0.77	0.813	0.592
	C2	1.008	0.055	18.293	***	0.766		
	C3	1.037	0.057	18.341	***	0.771		

Variables	Items	Non Std. Factor loadings	Std. Error	C.R.（t-value)	P	Std. Factor loadings	CR	AVE
Team Behavior (TB)	TB1	1				0.783	0.845	0.645
	TB2	1.013	0.047	21.478	***	0.831		
	TB3	0.886	0.042	20.943	***	0.794		
Innovation Performance (IP)	IP1	1				0.801	0.9	0.563
	IP2	1.003	0.043	23.519	***	0.791		
	IP3	0.943	0.046	20.683	***	0.714		
	IP4	0.932	0.045	20.67	***	0.714		
	IP5	1.017	0.042	24.056	***	0.806		
	IP6	0.954	0.045	21.259	***	0.73		
	IP7	0.84	0.043	19.712	***	0.687		
Physical Environment (PE)	PE1	1				0.777	0.923	0.572
	PE2	0.971	0.044	22.118	***	0.762		
	PE3	0.994	0.045	22.052	***	0.76		
	PE4	0.969	0.044	21.813	***	0.753		
	PE5	1	0.046	21.981	***	0.758		
	PE6	0.979	0.051	19.302	***	0.68		
	PE7	1.011	0.044	22.863	***	0.783		
	PE8	1.021	0.046	22.175	***	0.764		
	PE9	0.983	0.044	22.121	***	0.762		
Non-Physical Environment (NE)	NE1	1				0.698	0.806	0.51
	NE2	0.999	0.062	16.234	***	0.704		
	NE3	1.029	0.062	16.595	***	0.724		
	NE4	1.041	0.062	16.678	***	0.729		

Note: *** *p-value* is significant at 0.01 (two-tail)

Combination reliability and convergence validity are all in line with the requirements. As such, all subjects are retained for further analysis. Figure 5.1 shows the results of the confirmatory factor analysis in this study.

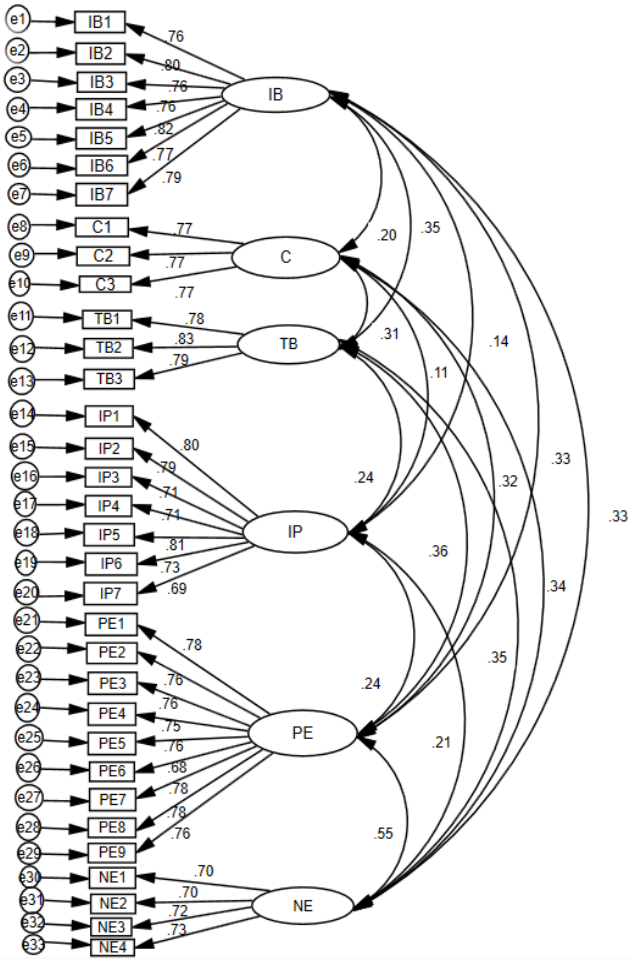

Figure 5.1 Confirmatory factor analysis in this study

5.4 Descriptive statistics analysis

5.4.1 Descriptive statistics of variables and measured items

Prior to using the structural model to examine the proposed hypotheses, a number of important premises should be tested to confirm that SEM is suitable for this study. Here we employed SPSS 21.0 software to conduct statistical analysis for the variables, identifying the minimum, maximum, average, standard deviation, kurtosis, and skewness of each item in the questionnaire. Following the suggestion of Hu and Bentler (1999), this study used kurtosis and skewness to conduct the normal distribution test. When the absolute values of kurtosis and skewness are respectively less than 10 and 3, the data follows the normal distribution. Table 5.7, shows that the absolute value of kurtosis of each item is less than 10 and that the absolute value of skewness is less than 3, showing that the data follows the normal distribution. Therefore, the collected data satisfies to the premises of structural equation modelling.

Table 5.7 Descriptive statistics

Variable	Item	Min.	Max.	Ave.	S.D.	Kurtosis		Skewness	
		Value	Value	Value	Value	Value	S.D.	Value	S.D.
Individual Behavior IB	IB1	1	5	4.14	.777	-1.481	.090	3.753	.179
	IB2	1	5	4.23	.797	-1.397	.090	2.808	.179
	IB3	1	5	4.30	.824	-1.608	.090	3.422	.179
	IB4	1	5	4.21	.838	-1.406	.090	2.585	.179
	IB5	1	5	4.25	.830	-1.423	.090	2.410	.179
	IB6	1	5	4.24	.832	-1.406	.090	2.412	.179
	IB7	1	5	4.22	.812	-1.368	.090	2.687	.179
Creativity C	C1	1	5	4.36	.680	-1.424	.090	4.377	.179
	C2	1	5	4.34	.689	-1.305	.090	3.712	.179
	C3	1	5	4.36	.705	-1.422	.090	3.853	.179
Team Behavior TB	TB1	1	5	4.06	1.003	-1.178	.090	.953	.179
	TB2	1	5	4.09	.957	-1.194	.090	1.207	.179
	TB3	1	5	4.19	.876	-1.430	.090	2.511	.179
Innovation Performance IP	IP1	1	5	4.19	.792	-1.442	.090	3.238	.179
	IP2	1	5	4.28	.804	-1.461	.090	2.859	.179
	IP3	1	5	4.17	.838	-1.384	.090	2.552	.179
	IP4	1	5	4.25	.829	-1.397	.090	2.460	.179
	IP5	1	5	4.30	.801	-1.498	.090	3.078	.179
	IP6	1	5	4.24	.829	-1.317	.090	2.192	.179
	IP7	1	5	4.23	.776	-1.497	.090	3.730	.179
Physical Enviornment PE	PE1	1	5	4.28	.746	-1.596	.090	4.471	.179
	PE2	1	5	4.21	.739	-1.492	.090	4.161	.179
	PE3	1	5	4.29	.759	-1.604	.090	4.175	.179
	PE4	1	5	4.28	.746	-1.607	.090	4.416	.179
	PE5	1	5	4.22	.765	-1.487	.090	3.689	.179
	PE6	1	5	4.17	.835	-1.243	.090	1.999	.179
	PE7	1	5	4.25	.749	-1.481	.090	3.904	.179
	PE8	1	5	4.33	.776	-1.677	.090	4.181	.179
	PE9	1	5	4.20	.748	-1.430	.090	3.768	.179
Non-physical Environment NE	NE1	1	5	4.28	.789	-1.352	.090	2.617	.179
	NE2	1	5	4.26	.782	-1.294	.090	2.450	.179
	NE3	1	5	4.24	.782	-1.302	.090	2.606	.179
	NE4	1	5	4.29	.786	-1.433	.090	2.960	.179

5.4.2 Pearson correlation

Table 5.8 shows the results of the Pearson correlation of the variables. Correlation analysis reflects the possibility of interaction between two variables without considering the role of other variables (such as control variables), not reflecting the causal relationship between variables. The purpose of correlation analysis is, on the one hand, to make a preliminary judgment on the rationality of model settings or hypotheses and, on the other hand, to make a collinearity test according to the degree of correlation. The correlation coefficient ranges from -1 to 1 and, the larger the absolute value is, the closer the correlation between variables is.

Table 5.8 Pearson correlation

	IB	C	TB	IP	PE	NE
IB	**1**					
C	.173**	**1**				
TB	.309**	.262**	**1**			
IP	.127**	.100**	.214**	**1**		
PE	.302**	.277**	.315**	.216**	**1**	
NE	.288**	.274**	.292**	.184**	.474**	**1**

Note: **significant at 0.01 level (two-tail).

As shown in Table 5.8, the correlation coefficient between PE and IB is 0.302 and the Pearson correlation between NE and IB is 0.288, whose *p*-values all reach the significant level of 0.01. Thus, both physical environment and non-physical environment have a significant positive relation with individual behavior. Meanwhile, PE and NE also show a positive relationship to TB with values of 0.315 and 0.292 (significant at 0.01 level), respectively, implying that physical and non-physical environments are bot also related to team behavior. IB and TB are also significantly associated with creativity and innovation. Table 5.8 shows that the strongest correlation is with physical environment and non-physical environment with 0.474, while the weakest is with creativity and innovation performance. However, all reached the significant level of 0.01, indicating that there was a significant positive correlation between individual behavior, team behavior creativity and innovation performance.

In addition, as shown by the correlation coefficient matrix in Table 5.9, the correlation coefficients between variables are not greater than 0.8. When there is a serious multicollinearity between independent variables in the study, it means that the independent variables have a common interpretation, which will lead to the inaccurate judgment of the independent impact of specific independent variables on dependent variables. Generally, two methods can be used

to check the multicollinearity problem. First, if the correlation coefficient between two variables exceeds 0.8, it indicates that there may be a multicollinearity problem between two variables. Second, the magnitude of multicollinearity can be examined by tolerance value. The tolerance value is usually 0-1. The larger the tolerance value, the smaller the multicollinearity problem. Indeed, it is usually examined by the reciprocal of tolerance value, namely Variance Inflation Factor (VIF). The smaller the VIF value, the smaller the collinearity problem. If the VIF value is greater than 10, it means that there is a serious multicollinearity problem between two variables (Akinwande, Dikko, & Samson, 2015).

Prior to parameter estimates, the Variance Inflation Factor (VIF) values of all variables were tested for multi-linearity. All VIF values are less than 2, much less than the critical value of 10, showing that the variables in this study do not entail serious multilinearity problems.

5.5 Structural model and hypothesis test

5.5.1 Structural model fit test

Prior to using structural equation modelling to examine the proposed relationships between variables, structural model fit should be tested. Similar to the measured model fit test, fit indices including χ^2/df, GFI, AGFI, TLI, IFI, NFI, CFI, and RMSEA are chosen to evaluate the fitness of the structural model. Table 5.9 displays the results of the structural model fit test. As shown in Table 5.10, χ^2/df is 1.931, less than 3, and RMSEA is 0.035, less than 0.08. The other indices (GFI, AGFI, NFI, TLI, IFI, and CFI) all meet the critical value 0.9. Therefore, it is reasonable to conclude that the structural model proposed in this study fits the actual measured data.

Table 5.9 Fit indices of structural model

Fit Index	Critical Value	Corresponding Value
CMIN		938.589
DF		486
χ^2/df	<3	1.931
GFI	>0.9	0.929
AGFI	>0.9	0.918
RMSEA	<0.08	0.035
IFI	>0.9	0.965
NFI	>0.9	0.929
TLI (NNFI)	>0.9	0.961
CFI	>0.9	0.965

Combining the results of confirmatory factor analysis and structural model fit test, we may find that both measured and structural models are effective for further hypothesis test, showing a showing a good model fit in this study.

5.5.2 Parameter estimates of the structural model

Having satisfied reliability, convergence, discriminant, and model fit requirements, AMOS 22.0 software was employed to examine the hypotheses proposed in the theoretical framework. Figure 5.2 illustrates the parameter estimation results of the structural model.

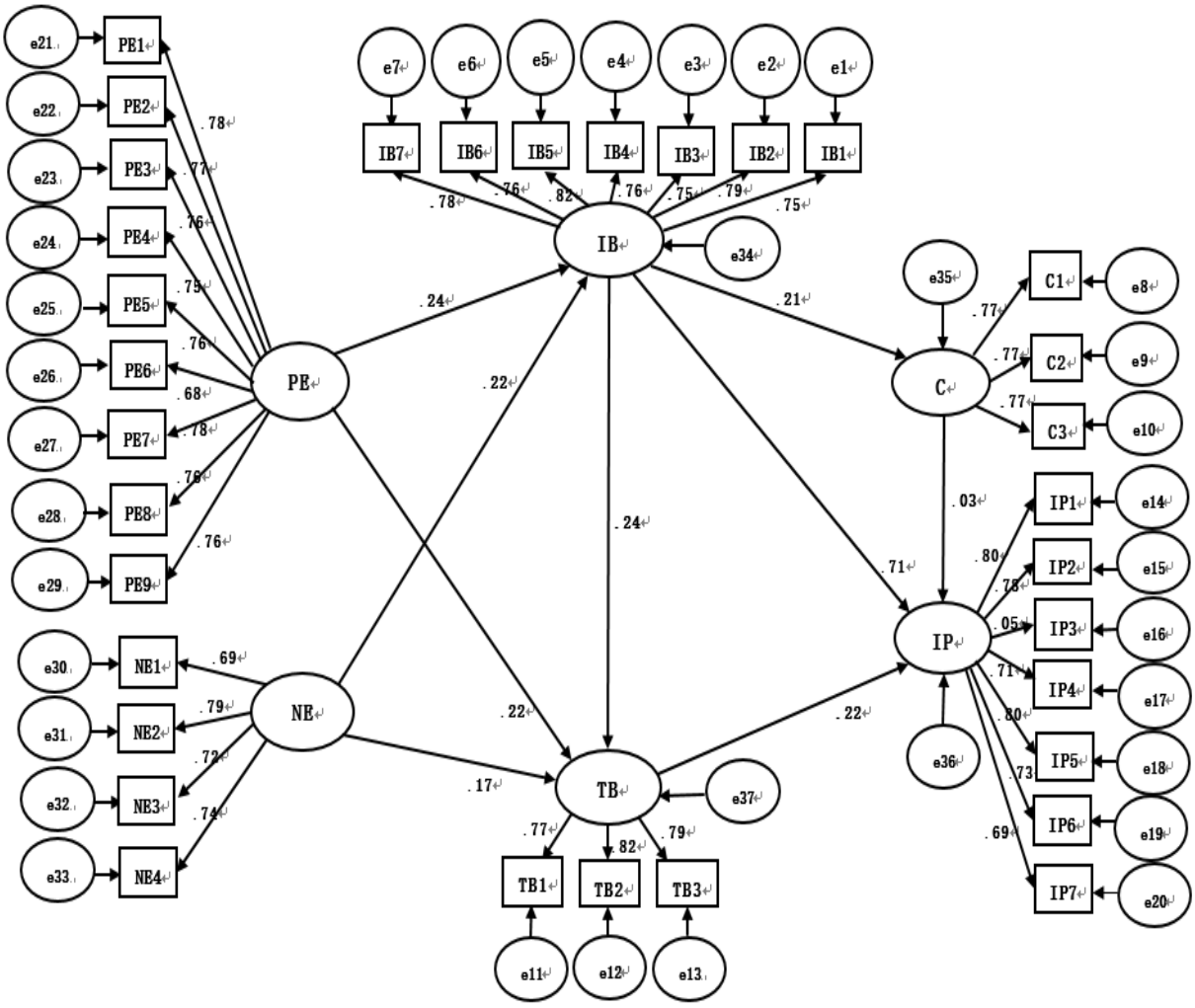

Figure 5.2 Parameter estimates of the structural model

5.5.3 Hypothesis tests

5.5.3.1 Direct path analysis

Based on the parameter estimate results shown in Figure 5.2, Table 5.10 indicates the path analysis of the structural model and the results of the hypothesis tests in this study.

Table 5.10 Direct path analysis and hypothesis test results

Path relation			Standard coefficient	Non-standard coefficient	Standard error	*t*-value	*p*-value	Hypothesis test
H1: IB	<---	PE	0.239	0.238	0.039	6.034	***	Supported
H2: TB	<---	PE	0.216	0.285	0.054	5.241	***	Supported
H3: IB	<---	NE	0.225	0.236	0.045	5.28	***	Supported
H4: TB	<---	NE	0.169	0.236	0.061	3.858	***	Supported
H5: IP	<---	IB	0.054	0.059	0.048	1.236	0.216	Not Supported
H6: CR	<---	IB	0.209	0.189	0.039	4.864	***	Supported
H7: IP	<---	CR	0.031	0.037	0.052	0.716	0.474	Not Supported
H9: TB	<---	IB	0.238	0.316	0.057	5.53	***	Supported
H10: IP	<---	TB	0.217	0.179	0.037	4.819	***	Supported

Note: *** p<0.001.

Figure 5.2 illustrates the parameter estimates of the structural model; Table 5.11 reports the results of causal path and hypothesis examinations of the relevant hypotheses. From this table, it can be seen that the standardization coefficients of physical environment on individual and team behaviors are 0.239 and 0.216 respectively with $p < 0.05$, indicating that the physical environment has significant positive effects on individual behavior. Thus, H1 and H2 are supported in our study. Similarly, the non-physical environment also has significant positive effects on both individual and team behaviors, showing that H3 and H4 are supported by the sampled data.

Figure 5.2 and Table 5.10 show that the standardization coefficient of individual behavior on innovation performance is 0.054 with $p > 0.05$, indicating that individual behavior does not have a significant positive relation with innovation performance. Therefore, H5 does not pass the test.

By contrast, the standardization coefficient of individual behavior on creativity is 0.209 with $P < 0.001$, implying that there is a significant positive relation between individual behavior and creativity. Thus, H6 is verified. In addition, H9, which describes the impact of individual behavior on team behavior, is verified with a standard coefficient of 0.238 and $p < 0.001$. Furthermore, our empirical results in Table 4 (coefficient = 0.217, $p < 0.001$) also support H10, showing that team behavior enhances innovation performance. This study thus considers that creativity helps improve innovation performance.

Table 3 shows that the standardization coefficient of creativity on innovation performance is 0.031 with $p > 0.05$, which shows that creativity does not have a significant correlation with

innovation performance. Accordingly, H7 is not supported by our data.

5.5.3.2 Mediation effect

This study used the Bootstrap method to test the hypothesis of the mediation effect. The results are shown in Table 5.12. The indirect effect of individual behavior on innovation performance was discussed. At a 95% confidence level, the confidence intervals of bias-corrected and percentile methods are [-0.029, 0.102] and [-0.026, 0.094], respectively, indicating that this indirect effect does not exist (Lau & Cheung, 2012; Sungho & young-soon, 2014). Therefore, the results show that creativity does not have a significant mediating effect between individual behavior and innovation performance. Therefore, H8 is not supported by the data in this study.

Table 5.11 Mediation effect test

Path	Effect	Bias-Corrected		Percentile	
		95% CI		95% CI	
	Value	Lower	Upper	Lower	Upper
Indirect Effects					
IB---> CR ---> IP		-0.029	0.102	-0.026	0.094

5.5.3.3 Summary of Hypothesis Test Results

Taking the Ucommune makerspace as an example, we examined the proposed model that represents the environment-conduct-performance relationship. Our results indicate that the workspace environment plays an important role on employee personal and team behaviors, which further affect innovation output in the organization. Table 5.12 summarizes the hypothesis test results. We have found that, while seven out of ten hypotheses were verified, three hypotheses (H5, H7, and H8) were not. This outcome may need to be studied further.

Table 5.12 Summary of hypothesis test results

Hypothesis	Test results
H1: Physical environment is positively related to individual behavior.	Supported
H2: Physical environment is positively related to team behavior.	Supported
H3: Non-physical environment contributes to individual behavior.	Supported
H4: Non-physical environment contributes to team behavior.	Supported
H5: Individual behavior can improve innovation performance.	***Not*** supported
H6: Individual behavior can enhance creativity.	Supported
H7: Individual creativity helps improve innovation performance.	***Not*** Supported
H8: Creativity plays a mediating role between individual behavior and innovation performance.	***Not*** Supported
H9: Individual behavior helps improve team behavior.	Supported
H10: Team behavior helps improve innovation performance.	Supported

5.6 Synopsis of Chapter 5

This chapter reported the empirical results and examined the hypotheses proposed in this study. Structural equation modeling (SEM) was employed to examine the theoretical framework. We first presented the sample profile to show some basic information in the survey. Most respondents are quite young and the firms originate from various sectors, a reflection of the characteristics of makerspaces. The validity and reliability of the questionnaire data were then tested to confirm that the empirical data could be used. Afterwards, confirmatory factor analysis was conducted to test the effectiveness of all indicators. Lastly, the structural model was tested and all hypotheses were examined. We found that the physical and non-physical workspace environments both have a positive impact on individual and team behaviors, and that the innovation behavior of employees determines the success of organizational innovation. Therefore, researches and practitioners of organizational innovation would do well pay attention to how employee innovation behavior could be cultivated. The related hypotheses in this study, H1 and H2, are supported by the sample data, showing the importance of workspace environment on employee behavior. Since the employee creative behavior is critical for the organization, the innovative atmosphere in the organization where the employees work. In this study, we also distinguished between the role of individual and team behaviors on organization performance. For an organization, in addition to the conscious efforts of employees, the organizational innovation climate is an important factor. In other words, a good organizational innovation atmosphere will not only encourage the employee innovation behavior but also encourage employees to strengthen their learning, so as to improve their own innovation ability. The extent to which individual behavior affects the organization's innovation performance has been examined in this study. As discussed in the literature review, although creativity has a significant positive impact on employee innovation performance, the positive relationship between individual creative behavior and organization performance does not be supported in this study, showing the inconsistency with most of previous studies. These results need to be further explored and investigated. In addition, our results show that the mediating effect between employee behavior and organizational innovation performance is not significant. This may bring about some new thinking on innovation performance in Chinese makerspaces.

Chapter 6 Discussion

In Chapter 5, a quantitative study was carried out to examine the proposed theoretical model in outlined in Chapter 3. To further explore how the workspace environment affects creativity and innovation, this study also employs qualitative approaches such as in-depth interviews to better understand the results of the hypotheses tests. Therefore, this chapter will combine both qualitative and quantitative results to interpret our "workspace environment – employee behaviors – organization innovation performance" model.

6.1 Case study: Walnut makerspace

6.1.1 Case selection and background

In addition to surveys, this study also employs interviews to further investigate the impact of workspace environment on creativity and innovation performance.

In contrast to Ucommune, which is a large chain of makerspaces located in many cities, Walnut makerspace is a leading local makerspace characterized by its novel workspace environment. Mike Zhang, the founder of Walnut, graduated from New York University with a double major in Economics and Psychology. He indicates that, during his undergraduate studies, he received three offers from Wall Street firms. He declined these offers, choosing to start a business with a friend – an experience that would provide him with entrepreneurial experience. Mr. Zhang indicates that he spent nearly a third of his time on matters related to the physical environment of the office.

In 2013, Mr. Zhang founded Fulai Capital in New York. After one year, the firm's revenue was 17 million US dollars. He again found that he was spending nearly a third of his time on issues related to the office. Inspired by the example of WeWork, and drawn to the favorable entrepreneurial context in China, Mr. Zhang decided to return to that country to set up a "Chinese WeWork" to provide a better environment to entrepreneurs. Chengdu was selected as Walnut's first location in light of its entrepreneurial potential and good environment. Walnut was founded in January 2015, aiming to providing a more favorable workspace and better services to freelancers, small and medium-sized companies, start-ups, and cultural and creative groups.

6.1.2 Interview questions and data collection

The interviews were conducted over the course of one week in August 2019. We first contacted Mr. Zhang, going on to make appointments with twenty-five companies in Walnut. Fifteen entrepreneurs from diverse sectors accepted to be interviewed by us. Prior to the interviews, we would briefly explain our purpose and send the questions to the interviewees. With the exception of personal and company identifiable information, all participants allowed the interviews to be recorded, facilitating the subsequent review process. Table 6.1 shows the profile of the interviewees.

Table 6.1 Basic information of interviewees

Makerspace	Interviewees	Year of Establishment	Industry
Walnut	1 Co-founder		
	1 General manager of company A1	2017	Education
	1 Vice general manager of company A2	2016	Food services
	1 Head of business department of company A3	2017	Insurance
	2 Heads of business department of company A4	2018	Healthcare
	1 Head of R&D department of company A5	2017	Manufacture
	2 Team leaders in company A6	2017	Communication
	2 Team leaders in company A7	2018	Internet of Things
	1 Team leader in company A8	2017	Recruitment
	1 Team leader in company A9	2017	Tourism
	2 Team leaders in company A10	2018	Logistics

Source: Author's own elaboration

Semi-structured interviews were used in this case study. The questions included:

(1) Why did you choose Walnut?

(2) What do you think of Walnut's physical environment? Are you satisfied with it?

(3) Do your employees or team members like the Walnut's physical design? Do they enjoy working in Walnut?

(4) Do you think the physical environment of Walnut affects the behaviors of your employees? Please provide some examples.

(5) How do you evaluate the non-physical environment in Walnut? How does it affect your employees' or team members' work?

(6) Do you think physical and non-physical environments are critical to creativity and innovation performance? Why/why not?

(7) What do you think of the relationship between individual creativity and organizational innovation performance?

(8) As for innovation performance in your company or team, which factors do you think are important to improving innovation performance?

6.1.3 Walnut's workspace environment

Walnut is a work community offering various value-added services including convenient and intelligent facilities, connected and shared offices, and open workspaces. It also has an online platform that integrate communication, culture, innovation, and intelligence. Walnut tries to construct a sharing economic circle with its unique sub-culture and community resources. From the start, Walnut has positioned itself as a makerspace rather than as a real estate project, focusing on developing a favorable environment. This model, pioneered by WeWork, has attracted many entrepreneurs and investors in the Chinese market.

In Mr. Zhang's words, "I worked for a month in WeWork, in New York, to enhance my experience on makerspaces. I then returned to China to establish Walnut with my friends. In the Internet era, we can feel the strong self-cultivation and passion of various entrepreneurs. In Chengdu, what I found was extremely rich resources and huge demand. I hope that Walnut can help young people exchange their ideas, cooperating with them through this makerspace, sharing resources, eliminating their loneliness and solving practical problems. We should achieve low-cost, flexible and efficient services, adopt a membership system, and realize a good business ecosystem".

Similarly to WeWork, Walnut's concept is a transformation of traditional commercial real estate. Walnut not only leases personalized office platforms to entrepreneurial teams and freelancers, but also pays more attention to outsourcing services in China, including company administration, and legal and finance affairs – in addition to meeting young entrepreneurs' demands for office space. The social activities, investment and financing opportunities in Walnut represent a form of intangible value for entrepreneurs. Walnut also addresses the pain point of financial investments.

The first Walnut makerspace has an area of 2 500 square meters and can accommodate 350 people working at the same time. Its interior design and environment and trendy and pleasant. Users can apply for membership on Walnut's Internet website and, following approval, can log in and with one another through an online application or communicate face to face in Walnut communities.

On the workspace environment, Mr. Zhang stated that *"Walnut provides its members with many free spaces such as conference and brainstorming rooms, cafeteria, and lockers. Members can use the app to easily register for various community activities or renew their*

membership, as well as other functions. We are not only a workspace, but also a social platform. We also organize many parties to mitigate stressful workloads. Our products can also be used to book the Walnut spaces, to serve as mobile office, or hold company meetings, private parties and group discussions. Here you will meet interesting freelancers, cutting-edge business teams, and become a member of a creative circle". Its Internet website advertises *"one city, one community, find your creative space anytime, anywhere"*. Walnut aims to become a national makerspace as well as a leader in the co-working space sector.

6.2 Increasing importance of workspace environment

6.2.1 Impact of physical environment on creativity and innovation

Workspace environment is one of the important topics in environmental psychological theory. From the perspective of interaction between people and things, the work environment can be divided into social environment and physical environment (Zhang, 2017). The social work environment mainly refers to a series of incentive and security factors related to work settings, such as encouraging employees to engage in risky innovation work, holding discussions on creativity, and establishing innovation performance evaluation system to better understand and reward innovation. The physical environment refers to the spatial layout, color, light, indoor plants, interior decoration, indoor climate, sounds and smells of the office space. Amabile et al. (1996) believe that the working environment can be divided into cultural environment and physical environment. He believes that culture mainly affects management incentives, working group support, autonomy and freedom. Innovation should not be aimless. Organizational innovation is constrained by the organizational environment. According to environmental psychology, the work environment can be divided into internal and external environment. Internal environment can further be divided into physical environment and non-physical environment. Physical factors such as building area, shape, furnishings, ventilation, lighting, and humidity have a significant association with people's psychological feelings, which may affect their behavior, attitude, work efficiency, and work satisfaction. Therefore, it is particularly important to design and create indoor working environment that meet different demands.

Liu (2008) believes that the physical environment refers to the material system around employees, such as facilities and buildings, and that it also includes the ecological environment such as temperature and humidity. It can be divided into the following categories: work facilities,

indoor and outdoor environment, and ecological environment. Work facilities refer to the equipment and tools required for work. Ecological environment refers to temperature, humidity, illumination, and noise. The physical working environment factors that affect innovation include interior design and architectural design elements such as furniture, green plants, color, private spaces, natural scenery outside the window, windows, light, sound, smell and indoor climate. The indoor climate here is similar to ecological environment, referring to temperature, humidity, air circulation, and air composition. Similarly, Zhang (2017) believes that the physical work environment can be divided into interior design and outdoor environment. In addition, the physical location attribute is also a catalyst for innovation. Bai et al. (2015) believe that local visual materials and stimulating resources, intensive social and cultural activities, and the established reputation of the region can be used as a source of inspiration. For example, Silicon Valley and its surrounding universities, venture capital companies, and innovation incubation bases have formed an innovation ecosystem to promote innovation. Chatterjee and Sahasranamam (2018) study the essential changes of innovation from technological progress to service innovation and value creation, considering that that physical space is a tangible physical environment for innovation. Generally, the literature considers the workspace physical environment from various aspects and mentions the potential effect of physical elements on organizational innovation. In this study, we focus on exploring the impact of the indoor physical environment and its effect on creativity and innovation.

The office is one of the most important workspaces of human beings. With the development of society, the progress of science and technology, fierce market competition, and the rapid development of high-rise office buildings, the office has become a central element of modern life. The quality of the office space environment has a great impact on users' mood. Humanized and living office spaces can let employees adjust their physical and mental balance at any time and experience joy at work. Certain office spaces can make employees feel proud and confident, which is conducive to good interpersonal communication. Favorable office design may facilitate information exchange, enhancing employees' creativities. In the era of knowledge creating wealth, both wise business leaders and interior designers should realize the importance of office space design. At present, the design of office spaces has not been given its due attention. Most traditional office environments lack consideration of human physiological and psychological needs.

Public spaces in makerspaces include: reception areas, traffic spaces, and supporting services spaces. Traffic spaces refer to spaces used for movements within the building. Generally, there are two types of such spaces: horizontal traffic spaces and vertical traffic spaces.

Horizontal traffic spaces mainly refer to halls, lobbies, corridors, and elevator halls; vertical traffic spaces refer to elevators and stairs. Supporting services spaces serve for the collection of information and data, the arrangement and storage of equipment, as well as assist staff with the management of living, health, and logistics services. Usually there are reference rooms, archive rooms, document printing rooms, computer rooms, photo rooms, staff restaurant, kitchenette, toilets, and a management office.

In this study, as shown in Appendix 1, we researched the physical environment from the perspective of lighting, temperature, indoor layout, furniture, and color, finding these to be important elements. In general, architects are more concerned about building a pleasant, grand and safe building in terms of function and aesthetics. For example, narrow spaces may lead people to interfere with one another and feel uncomfortable; excessively large spaces will also make people feel empty and uncomfortable. The interior decoration and layout of buildings will directly or indirectly affect the emotions and behaviors of the people who work in it. Therefore, people often change or even damage the existing indoor work environment to meet their needs.

Rooms and furnishings are basic elements of the indoor environment. They should be suited to the activities that will take place in each space. People's perceptions on room size are affected by many factors. For example, rectangular rooms are perceived as being larger than square rooms of the same size, and lighter rooms are perceived as being larger than darker rooms of the same size. According to environmental psychology, the harmony of the contents of a room is as important as the its size and shape. Natural light is very important: rooms without windows are usually disliked, and users decorate them with natural landscape photography or other items. The smaller the room, the more important are its windows. Natural light cast through windows adds an element of comfort to the room.

Three basic aspects have been describing as playing a role in the type of interior communication: the location of furnishings, the distance between furnishings, and the number of symbolic decorations (Oluremi & Neal, 2020). These factors determine the way indoor communication occurs and affect people's communication behaviors. Hua et al. (2011) have coined two new terms, social seeking and social evasion, to express the extent to which the environment encourages or discourages people to communicate. The environment sought by people often contains movable interior furnishings and seats facing each other. It facilitates interaction and promotes communication. We may detect these trends in the following interviewing results:

"My employees and I like the modern design in Walnut very much; it makes us eager to work here. You know, we used to work downtown, in office buildings that have a very standard

design and people are separated by walls". (A2, A3, A8)

"It is the open seat design that attracts my company. It enhances communication within the company and beyond. There are many public spaces, helping you relax and providing many opportunities to make new friends. I have found an outsourcing partner in Walnut, which saved us both time and money" (A1, A4, A5).

"We all like the color and furniture of Walnut, they make us happy and energetic. The brainstorming rooms are perfect. Before coming to Walnut, nobody liked meeting. But now, we all look forward to meeting in the brainstorming rooms. It is really great, and it improves our efficiency. There are many novel ideas and a lot of innovative thinking emerging in that room" (A6, A7, A9)

The problem of workplace design is not new to psychologists. The impact of the workplace's physical environment on productivity has long been a subject of attention. It can be traced back to the famous Hawthorne experiment in the 1920s-1930s. The original intention of the researchers was to establish the impact of factory lighting conditions on production, but the test results were unexpected: lighting had no obvious impact on production efficiency, unlike the emotions of the workers, the relationships between them, and the relationship between them and their managers. Some studies also show that there is a significant correlation between the physical environment of the workplace and job satisfaction (Liu, 2008; Moultrie et al., 2007). When staff are not satisfied with the physical environment of the workplace – temperature, humidity, noise, safety – their job satisfaction is greatly reduced. When these elements are met, staff will not be dissatisfied, though it is not guaranteed that they will be satisfied.

The physical environment of the office can affect job satisfaction, task operation and staff motivation. A poorly designed office will worsen occupational health. For example, those working on computers for a long time will often feel eye soreness, discomfort, and fatigue. In 1989, Crouch and others asked 56 managers working in offices to identify the factors promoting and hindering task operation. It was found that appropriate space, light and other factors promoted efficiency, while frequent disturbances (such as hearing other people in the same office) hindered it. Therefore, the design of the office environment should not only facilitate communication but also pay some attention to a level of privacy. In recent years, the ideas of open and closed office have been discussed in the theoretical research of Western management methods, attracting the attention of enterprise managers. According to psychological environment theory, if office staff work in an open office, it will lead to supervising each other's behavior, reducing the occurrence of private events, and improving work efficiency. By contrast,

closed offices meet the requirements of privacy.

Environmental psychology puts forward the concepts of "social centripetal space" and "social centrifugal space". The former brings people together and promotes interactions, such as in the case of cafes. The latter tend to separate people from one another and reduce exchanges, such as in the case of libraries. While social centripetal spaces meet people's demand for publicness, social centripetal spaces meet the demands for "privacy".

The layout of open offices emphasizes complex interaction between people in the office. Compared with the traditional (closed) offices, an open office has the following characteristics: (1) it can hold hundreds to thousands of people in a large space, making full use of large modern buildings, leading to savings in building components such as partition walls, doors, windows, shortening travel paths, and greatly improving the space utilization rate; (2) it is easy to configure various kinds of facilities comprehensively, facilitating information transmission, business contact and centralized management, and improving the working efficiency of staff; (3) the low partitions widely used in open offices are easily detachable and movable. Combined with modular systems, such office spaces can flexibly adapt to the needs of various functions.

The office space has become a focus of people's life and work. In the office, people not only pursue their physiological needs, safety needs, and need for belonging, but also their need for respect and self-actualization. The workspace is an environment created by people, and its design should take their needs into account. Considering the importance of the physical environment for creativity and innovation, creating a good workspace and meeting staff's physical needs are quite important elements.

6.2.2 Impact of non-physical environment on creativity and innovation

Over time, people have shifted attention from the natural attributes of the environment to its social and psychological attributes. These are an important factor in building a harmonious society.

The empirical results of this study verify the significant impact of the non-physical environment on individual creativity and organizational innovation performance. As illustrated in Appendix 1, the items that measure the non-physical environment include cultural atmosphere, open climate, various activities in the makerspace, and easy communication with other companies. They indicate that the non-physical environment is also critical to influence people's behaviors and lead to better innovation outcomes.

There are many factors that affect innovation performance. Although internal causes are decisive in affecting innovation, external causes also play an important role in promoting or

hindering it. Research has confirmed that job satisfaction and organizational resources will affect innovation performance: especially organizational innovation atmosphere, which not only affects employees' innovation outcomes but also plays an intermediary role in their relationship. Organizational environment factors will influence individual innovation through interaction with individual factors. Fu (2018) points out that the innovation performance of employees is related to the degree of support they receive from work. From the perspective of leadership, Chen, Li, and Tian (2019) conclude that innovation thinking and the leaders' personality will affect the innovation performance of employees. Organizational resources, innovation atmosphere, and organizational support and leadership are all important elements of the organizational context that affect employees' innovation performance.

In general, the non-physical environment of the workspace covers culture as well as the other "soft factors". Many scholars have emphasized the role of cultural factors in the organizational innovation environment. Corporate culture is the foundation of an enterprise's survival and the driving force of sustainable development. Hofstadter's definition, widely accepted by management academia, is that culture is the unique collective characteristic of the spiritual temperament of the organizational group. From the perspective of organizational learning, Han (2015) believes that organizational culture is the result of group learning, including the common principles of action and cultural values, the management atmosphere, and code of conduct. Organizational culture consciously or unconsciously influences employees in terms of values and behavior rules. Individuals determine their behavior based on what they observe around them. Therefore, under the environment of innovation culture, employees are more creative and have a more positive attitude towards innovation under the influence of innovation values. A number of scholars consider that entrepreneurship is an important part of corporate culture. Entrepreneurs are the first promoters of enterprise innovation. Entrepreneurs with an innovative spirit will actively mobilize and integrate various internal resources to carry out innovation activities and actively lead enterprises to carry out external cooperation and explore new opportunities.

Leung and Wang (2015) believe that non-physical environmental factors, including the support of managers, education and training, communication, and cooperation, will affect employees' innovative behavior. For example, a favorable innovative climate may lead to high innovation performance and great creativity. Amabile et al. (1996) consider that organizational innovation atmosphere is a kind of psychological cognition. Team members feel the level of support given by their organization for innovation. The stronger the organizational innovation atmosphere is, the more support is felt by team members. Research on the climate for innovation

can be traced back to the 1980s, when scholars began to pay attention to the innovation climate. Liu (2008) believes that innovation atmosphere plays an important role in innovation activities and has a significant impact on the performance of innovation. The innovation atmosphere can affect individuals' perceptions of innovative things, generate innovation willingness, and lead individuals to actively using their own knowledge to carry out innovation activities. Aoki (2009) thinks that the innovation climate is the individual's cognition of the work situation that affects the formation, development and exertion of their innovation ability.

When the organization has sufficient resources and everyone has a desire for innovation, the enterprise may exhibit a strong innovation climate, in which resources will be allocated to the related staff or team. When faced with difficulties, people will discuss with colleagues, using a brainstorming approach to generate more new ideas and viewpoints that may directly increase innovation performance. When employees perceive emotional support, they will be more motivated in their work to overcome problems. The support and recognition of leaders is also one of the important elements of organizational support. An innovative leader will be a strong motivation for creative behaviors. Employees are eager for breakthroughs in their work to bring about innovative results, and they appreciate other creative colleagues in the office. A flat organizational structure can also enhance the innovative climate in the workspace. A creative atmosphere will also encourage employees to think more and have innovative ideas. These organizational situational factors also affect innovation performance through individual behaviors.

The impact of the work itself should not be underestimated. Whether the work matches the personality of the individual, whether the work is of personal interest, and the degree of complexity of the work will all affect the individual factors. If work matches personal characters and values, employees can engage in it more actively. If the work is aligned with people's interests, they will feel relaxed and happy, leading to an increase in the generation of new ideas and in innovation results. If the complexity of work is appropriate, employees can not only make good use of their own knowledge but also think deeply about the parts beyond their own capabilities, which will generate innovation. However, if the complexity of work is extremely high and the personal load is exceeded, employees will be nervous and retreat because they feel strong pressure, which is not conducive to the divergence and opening of thinking. On the contrary, work that is very low in complexity can be easily completed through usual routines and will not inspire deep thinking and innovation. Thus, to inspire creativity and innovation, the complexity of the work should be higher than the individual's own abilities, encouraging the power of the team to complete the tasks.

In our case study, we find that many enterprises in Walnut move from commercial office buildings or from their own properties, as expressed by several managers throughout the interviews:

"The main reasons for us to choose Walnut are the well-designed office, especially the trendy style and the spaces for various functions and activities" (A1, A5, A10).

"Since most employees are young, they didn't like the previous office. But presently, they would like to stay in the office even in their leisure time. There are also many different kinds of activities which promote communication between various companies and make working much more attractive than before" (A2, A5, A7, A8, A9, A10).

The fact is that companies often prefer to invest on the external shape of tall buildings, rather than look into what kind of internal offices employees really need (Moultrie et al., 2007; Jensen et al., 2016). Makerspaces, as a new kind of office, have triggered attention being given to the workspace environment, especially the physical environment. From this perspective, our empirical results may provide an explanation for the rapid increase in the number of makerspaces.

6.3 Uncertain relationship between individual creativity and organizational innovation performance

This study also yields some unexpected results on the relationship between creativity and innovation: namely, the fact that H5, H7, and H8 are not supported by our sampled data. These hypotheses are related to the impact of individual behavior and creativity on organizational innovation performance. It seems that there is not a significant relationship between individual creativity and innovation output. Innovation is a complex process and many factors may stimulate innovation; creativity is a starting point and contributor to innovation but not a sufficient condition for it (Holm & Eric, 2015; Szakály, 2015). It is a complex and risky process to turn a creative idea into a finished innovative product or service, in that creative ideas are only a start and a wide range of complimentary resources and capabilities are necessary (Baer, 2012).

While the concept of creativity is complex, we suggest that it is a kind of ability that can be expressed to varying degrees, mostly as a reflection of individual personality traits. The process of thinking is the embodiment of creative ability. Creativity emphasizes the way and method of thinking, which is the necessary stage for the promotion or transformation of creativity. If creativity results in a certain product, then creativity becomes innovation and leads

to qualitative change. Therefore, this paper holds that creativity is an individual and team ability. The end result is the outcome of creation, transformed into innovation, and the thinking process is the intermediate state between creativity and innovation. According to Chen, Chang, and Lin (2018), creativity is a unique ability of each individual, reflecting each person's creative personality differently.

This uncertain relationship may be related to the narrow definition of innovation performance in our study. Performance has always been a focus of academic research on management. There are three main views on its definition. Yu et al. (2014) think that performance is a kind of behavior, including actions or behaviors related to organizational goals that can be measured according to the individual's ability (i.e., degree of contribution). Wu, Chen, and Li (2015) suggest that performance is a result, and that these work results are closely related to organizational strategy, customer satisfaction and invested funds. Based on the above two views, Wang et al. (2012) state that performance should cover behaviors as well as results. Behavior is not only a tool to achieve results, but also a result in itself. It is the result of mental and physical efforts to achieve the completion of the work and can be judged separately from the result. After analyzing various definitions of performance, Li (2015) suggests that if performance refers to results or outputs, the term becomes applicable to employees whose work is quantifiable, such as senior managers, sales personnel, and after-sales service staff; if it covers behaviors, the term becomes more applicable to all types of employees, which is too broad for the purposes of research.

Performance may apply to different subjects, individuals, teams, or organizations – as can innovation performance. Most scholars define innovation performance from the perspective of the organization or R&D departments, and only a few define it from the perspective of individual employees. Lim, Han, and Lee (2010) suggest that innovation performance refers to the innovation technology or product closely related to the survival and development of the enterprise as well as to a series of innovation activities that the R&D staff carry out to achieve the goal of innovation. Li et al. (2018) also believe that innovation performance mainly applies to enterprises and R&D units, as they are used to measuring the innovation input and learning from them. Fu (2018) believes that employee innovation performance includes innovation willingness, innovation action, innovation suggestions, innovation achievements, and the dissemination of innovation thinking. Hung, Anh, and Thong (2020) emphasize that innovation performance is the product of thinking activities, which does not include the concept of whether products can be accepted by the organization or become real productivity. According to these definitions, innovation performance joins together behavior and results, but one can only speak

of an improvement in performance when results are applied to work and produce value for the organization. Innovation performance includes the implementation of innovation activities, the output of innovation activities, and the application of innovation results to the work or the next stage of innovation activities, which is a continuous cycle of innovation activities. Employee innovation performance can be specifically expressed as a series of innovation activities of employees and outputs as the perceived or measured achievements of value to the organization or team. These innovation activities need to go through various procedures or stages to generate performance. These viewpoints suggest that innovation performance covers the whole process of innovation activities, including the evaluation of basic innovation activities and effects. Thus, innovation performance includes both innovation behavior and innovation results, and creativity will affect innovation behavior and innovation outputs.

Park and Lee (2017) argue that performance can be objectively measured and perceived through technological innovation activities, including their direct economic benefits (rate of sales and profits of new products) and indirect economic benefits (technology, patents). Following Shen's definition, in this study, we define innovation performance as the effectiveness of innovation activities, referring to valuable outcomes such as new products, new managerial ways, patents and new technology. Considering that most entities in makerspaces are start-ups, which are always faced with survival challenges, innovative outcomes are more critical to them. Therefore, the question of whether the workspace can affect the organization's innovation outcomes is of much greater concern for entrepreneurs. This can make our research more valuable in both theoretical and practical terms.

Indeed, after forty years of rapid development, competition is greater than ever before, in all markets. It is nearly impossible to innovate by depending only on individual efforts or ideas. Cooperation among individuals –teams or groups – has become the main element of the innovation process. In our study, H6 and H9 are supported, implying that, in a makerspace, individual behavior does enhance people's creativity, which may lead to high innovation performance through improving team activities. This idea finds support in the interviews:

"As you know, most of us are independent, with a good education background, and have many creative ideas. But in the old office, we were separate and it was difficult to communicate. Now, in the Walnut makerspace, the environment is comfortable and we like to work here. We can chat in the café during working hours, which encourages communication among us. Once somebody has a new idea, it is easy to find other like-minded people and form a group to improve it, because we all know it is nearly impossible to turn a creative idea into an innovation output. In fact, even when we work together, most of our ideas fail, let alone if someone does it

alone" (A1, A2, A5, A6, A8, A10).

Innovation may originate in different places, including internal employees' creative ideas and outside inputs such as technology transfer. Even if the core of innovation is creative people, the environment also plays an important role in helping turn various inputs into innovative products, methods or services (Ghosh, 2015). Our findings highlight the critical role of team cooperation on innovation, showing that the traditional approach of only relying on several creative individuals may be not suitable in the current situation. Therefore, to achieve better innovation output, leaders in organizations should pay more attention to fostering an innovative environment, in a physical as well as non-physical perspective.

6.4 Implications

6.4.1 Theoretical contributions

This study investigates the impact of workspace environment on creativity and innovation. Its main theoretical contributions lie in the following aspects:

First, this research develops an "environment – conduct – performance" theoretical paradigm to systemically examine the mechanism through which the workspace impacts creativity and innovation, thus enriching environmental psychological theory and innovation theory. In particular, we distinguish between the physical and non-physical environments to examine their roles on creativity and innovation performance. While previous research has discussed the role of the physical environment, few studies directly measure the extent and mechanism of its influence. Accordingly, the most significant contribution of this study is that it quantitatively tests the extent of the impact of workspace environment on individual creativity and organizational innovation performance, exploring the problem of whether and how the physical and non-physical environments in the workspace exert an effect on people's creativity and on the organization's innovation outcomes.

Compared to the physical design, the non-physical environment is intangible and difficult to measure (Boyle et al., 2016). From a social-psychological perspective, the workspace should be comfortable and relaxing, encouraging knowledge sharing (Blakey, 2015). Cooper (2008) indicates that co-working software enables employees to choose flexible spaces rather than an office to perform their work. Cooper's (2008) research highlights the importance of the office environment – especially the non-physical one – for corporate performance. The present study also provides strong empirical support to Cooper's (2008) result, highlighting the positive

effects of both physical and non-physical environments on individual creativity and organizational innovation outputs.

Second, our empirical results show that workspace physical and non-physical environments are both significant and have a positive impact on individual and team behaviors in organizations. Although many social psychologists who study the organizational environment suggest that it has an important influence on individual attitudes and behaviors, there is still little empirical evidence. This study helps fill that gap by providing strong support to previous explorations, answering the question posed in Chapter 1 regarding the extent to which the physical and non-physical environments affect individual and team behaviors in an organization.

Third, while existing research often discusses the positive relation between creativity and innovation, this present study goes further and finds that individual creativity does not have a significant impact on organizational innovation performance. This result is not consistent with previous studies, showing that there is a complex relationship between creativity and innovation. As such, our study not only enriches innovation theory and environmental psychology theory but also provides some measure of novel understanding on the paths from creativity to innovation performance.

Fourth, our empirical results also reveal that, although individual behavior does not have a significant relation with innovation performance, it can positively affect organizational innovation outcome through team behaviors. Thus, our study highlights the importance of team behaviors for innovation and firm survival, implying that a favorable workspace environment affects innovation outcomes. Therefore, from this perspective, our study develops the theory of environmental psychology on the aspect of how innovation outcomes are achieved, providing further understanding on the relation between employee behavior and innovation performance.

6.4.2 Practical implications

Despite the fact that employees increasingly ask for changes to workspace design, it is still difficult for managers to invest in the working environment due to a lack of direct evidence that supports that it can have a positive impact on organization performance (Loomans et al., 2018). Our findings indicate that the physical environment can influence individual and team behaviors, leading to improved innovation performance. Therefore, in light of the shift in employee expectations, well-designed physical environments should be viewed as part of good corporate culture, one that may enhance both creativity and innovation (Liu, 2008; Moultrie et al., 2007; Oluremi & Neal, 2020).

With advances in science and technology and changes in both production methods and

lifestyles, more and more people are engaged in mental work, and working time grow longer and longer (Kim, Jonghyun, & Lee, 2015). The office has gradually become the center of modern life. However, the office environment is not satisfactory. Equipment and facilities in the office such as computers, printers, air conditioners, or decorative materials, emit a great amount of physical, chemical, and biological pollution on a daily basis, seriously affecting people's health. High work pressures and interpersonal relationships in the office can also affect people's mental health. When the physical environment of the office is not suitable, individuals can go so far as to experience dizziness, drowsiness, memory loss, restlessness, dry throat, loss of appetite, and other problems. These symptoms are collectively referred to as "office syndrome". Despite growing awareness about office syndrome, people often respond to it by seeking medical treatment.

Our study provides a new way to address office syndrome, the emergence of which increases the importance of addressing the physical environment of workspaces. Interior and architectural design have not yet found their true meaning; they ignore the needs of users and excessively pursue cost savings, resulting in physical and psychological discomfort of the people in the office. As Sheykhan and Saghaee (2011) argue, traditional rigid and cold designs may deter employee imagination. In fact, most offices only provide an office desk with a computer. If a person wants to hold discussions with others, they have to find special creativity and innovation rooms for communication, which have become more popular in many companies (Saorín et al., 2017). Our empirical results indicate the need for organizations to carefully review their workplaces and consider how to design offices that support their goals.

Whether they are present in high-rise office buildings, in multi-functional buildings with various functions, or in renovated houses, open offices can be used to meet various functions, both known unknown. Open offices often give an active, transparent, efficient, and free visual impression. As work efficiency can be enhanced in the group, and open office is the most suitable for improving production efficiency at present. Comfortable office spaces should be a combination of art and technology that includes architectural design, interior design, environmental psychology, industrial design, graphic design and humanistic art.

6.5 Synopsis of Chapter 6

Focusing on the case study of the Walnut makerspace, this chapter provided detailed discussions on the hypotheses and main findings of this study, highlighting the significance of the workspace environment on creativity and innovation performance. The aim was to empirically

investigate the impact of the workspace environment on employee behaviors and innovation performance. In Chapter 5, taking the Ucommune makerspace as a sample, we examined the proposed theoretical model that represents the environment – conduct – performance relationship. Our empirical results indicate that the workspace environment plays an important role on individual and team behaviors, affecting organizational innovation output. Besides these quantitative outcomes, this chapter uses in-depth interviews to collect related data to analyze the importance of workspaces for enterprises. Organizational innovation environment refers to the collection of all factors that may affect organizational innovation activities and performance. A number of scholars define organizational environment more broadly, as the sum of cognition, emotion and physical resources. A generally accepted definition refers to the sum of consciousness and material factors that promote the generation, development, and realization of new and useful ideas within the enterprise. Thus, a workspace is not only the place where people work, but also the overall image of an enterprise. In the fierce competition that characterizes the global economy, a good corporate image constitutes that enterprise's standing in society. Through a positive image, the enterprise can more easily garner the public's trust, broaden its market, attract talent, enhance internal cohesion, improve competitiveness, and increase economic benefits. Therefore, a good workspace plays an important role in the development of enterprises. Based on people-oriented and increasing the economic benefits of enterprises, it is of great practical significance to conduct in-depth and detailed research on the psychological aspects of office space environment. There is little research to date on the environmental psychology of office space, whether in China or internationally. As such, this paper will start from interior environment design and environmental psychology, through the investigation and analysis of the office space, to explore how office design methods meet the psychological needs of office space users.

Chapter 7 Conclusions and Recommendations

Faced with rapid changes in technology and a new generation of employees, the question of how to inspire creativity to increase innovation performance has come to pose a significant challenge for leaders in any organization. This chapter will first summarize the present study's main conclusions and then provide some recommendations to improve the workspace environment in China's context, which may help managers to make decisions on the improvement of the workspace environment.

7.1 Main results of the study

This study examines the effect that the workspace environment has on creativity and innovation performance. The main results of this research can be summarized as follows:

1. This study establishes a theoretical model to explore how the workspace affects individual creativity and organizational innovation performance. A favorable workspace environment will influence employees' individual and team behaviors as well as enhance individual creativity and innovation performance. Our empirical results verify the proposed "workspace environment – individual and team behaviors – creativity and innovation performance" mechanism.

2. This study distinguishes between physical and non-physical environment. Both are positively associated with individual and team behaviors. A number of scholars believe that there may be a subtle relationship between physical environment and job satisfaction. Managers found that favorable working environments may influence the employees' attitudes and their working efficiency. It seems that just in a pleasant and high-quality work environment, self-value can be increased, as well as its position in other people's minds, which leads to higher job satisfaction. This phenomenon remains to be further explored theoretically. Our study empirically supports the positive relationship between the physical environment of a workspace and individual creativity and innovation performance.

3. Our empirical results indicate that while there is a positive relationship between individual behavior and creativity, individual behavior does not have a significant impact on the organization's innovation performance. However, our data also supports a positive relationship between individual behavior and team behavior, showing that individual behavior

may affect organizational innovation performance through enhancing team conduct. This addresses the question of to what extent individual behavior affects the creativity and organizational innovation performance.

4. Our study shows that team behaviors can improve innovation outputs. Thus, team behaviors can also be viewed as a mediator between both physical and non-physical environments and innovation performance.

5. Our empirical data does not support a positive relationship between individual creativity and organizational innovation performance, showing an uncertain impact of creativity on innovation. In Chapter 5, we analyzed the reasons behind this unexpected result. This novel outcome may provide new thinking about the process of transforming creativity into innovation performance.

7.2 Recommendations

This study provides theoretical references and practical guidance for enterprise innovation management. There are many factors influencing employee work efficiency. They can be divided into four categories: personal factors (i.e., intelligence, knowledge and skills, psychological factors), social environment factors (interpersonal relationships), management factors (organizational culture and organization structure), and environmental factors (i.e., indoor environment quality such as thermal environment, light environment, acoustic environment, and air quality). Our study shows that, in addition to work pressure and job satisfaction, the physical environment also has a significant impact on employee creativity and innovation performance. Therefore, improving the quality of the environment is undoubtedly one of the most important ways to improve work efficiency.

For a long time, in the pursuit of efficiency, managers have ignored the importance of the quality of the environment. They follow building regulations and standards, which stipulate the minimum parameters of the indoor environment, to design and operate buildings, rather than creating a healthy, comfortable, and efficient working environment. There are a number of principles that may be useful to improve workspace design:

(1) Humanization. The design of office spaces should meet people's needs.

(2) Ecology. With the destruction of the environment, the shortage of resources and the deterioration of the living environment, people pay more and more attention to the environment. "Green" topics and low carbon emissions become the focus of people's attention. Respecting (and returning to) nature has become a trend.

(3) Intellectualization. The development of science and technology provides a possibility for intellectualization. In the future, workspaces will realize the integration of computer technology, communication technology, control technology, and automation of office equipment, providing users of office spaces with an efficient, comfortable, and safe office environment.

(4) Customization. Considering the different needs of the users and the rapid development of society, the offices of the future will not conform to standard designs and should be adaptable to customers' preferences. Forms of offices such as the hotel office (employees have no fixed position in the office, they can choose locations to work at will), video office (through the computer), and the mobile office (carrying out tasks anytime and anywhere) will allow to meet the requirements of dynamic functions more flexibly.

(5) Localization. The stylized and stereotyped international style will become a thing of the past, and designs will become replete with an artistic atmosphere that reflects the regional culture and a humanistic care. The expression of unique cultures and ideologies accepted by the people will become a trend.

According to these principles, our practical recommendations for Chinese workspaces are as follows. First, to create a feeling of home. A number of studies have shown that creativity and innovation often flourish in a relaxed and comfortable state of mind. People's feelings of home are familiar and pleasant, and they seldom feel uncomfortable or bored. Several scholars think that the office should be completely different from the home. That is to say that work and life are separate and opposite concepts. However, they may share some principles, with different details. In the future, work and life may become unified. Living in work and working in life are not contradictory. Therefore, there should be entertainment rooms, fitness rooms, lounges, dining areas, and other functional areas in the office. The emergence of these areas implies that work and life are inseparable. In the construction of the overall atmosphere of the office space, we can add more elements of life and family to break people's impression of the office as a place of uniformity, lack of personalization, and coldness.

Second, to emphasize the personalization of the workspace. Personalization can play a role on employees' job satisfaction. A personalized office can make employees engage by working with a sense of pride and belonging, and enhance the company's attractiveness, especially for knowledgeable candidates. Thus, the overall personalization of the office space is conducive to improving the work conditions in the office.

Third, to pay more attention to shaping a culture in the workspace. Our survey and interviews not only support the significant impact of physical environment but also highlight

the non-physical environment's role on creativity and innovation. People's thoughts and cultural atmosphere are inseparable. An excellent office design should pay great attention to shaping culture. Corporate engineering is an enterprise identification system that aims to standardize and unify the design of the office system, management system, advertisement, and other aspects, reflecting the corporate image through special fonts, colors, and patterns. The design and application of the enterprise identification system can reflect the enterprise's characteristics, promote it, and improve its competitiveness. In the design of office spaces, the corporate culture can be reflected to show a measure of care and the corporate spirit. For example, Walnut's space in Chengdu integrates some elements of old Chengdu in its simple and pleasant atmosphere. This is consistent with the local culture and simultaneously expresses the company's style.

With the development of science and technology, the demand for diverse skills has increased – along with competition – and employees' expectations are also shifting. As such, managers need to consider the redesign of the working environment. Due to different cultural backgrounds and needs, even in the same company, there will be opposite requirements for the workspace. Enterprises can increase employee motivation from the perspectives of cultivating creativity, improving organizational incentive policies, emphasizing individual needs, and improving organizational identity, so as to stimulate employees' creative potential, promote innovative behaviors, and achieve an enhancement in individual innovation performance, so as to improve organizational innovation performance.

Therefore, the matter of how to build a favorable office space has become a practical question challenging managers. With the development of construction technology and the influence of people-oriented ideas, individuals' requirements for office spaces have become more stringent. One not only requires one's own office for safety, economy and convenience, but also requires it to be beautiful, comfortable, personalized, and intelligent, with an atmosphere that is at once human and artistic. The physical, psychological, social, economic, and natural environment, should be taken into account, along with the human, historical, and artistic aspects of the office.

The physical environment should not only be spacious, bright, and fresh, but also offer small spaces that are private and from which one can observe the outside world and in which one does not feel claustrophobic (Ding, 2015). Alenear (1997) proposed not only the physical factors that are conducive to innovation, but also the environmental factors that hinder it. He believes that a physical environment that stimulates creativity includes sufficient light, furniture, spacious areas, and air circulation, while interior design that hinders innovation has noise, high

temperatures, dim lights, crowded spaces, and a lack of rest areas and conference rooms. Some studies have proposed that crowded office spaces are helpful for communication between members. Therefore, it is necessary to encourage employees to be involved in the design of the office spaces, given that they are the actual users of the spaces and know their needs best.

This study also provides a number of suggestions specifically for Chinese makerspaces. As low-cost, convenient, and comprehensive entrepreneurial service communities, makerspaces have become a popular place for entrepreneurs that can provide a good space for working, networking, socializing and resource-sharing. Most makerspaces in China pay more attention to public spaces with various types of rooms such as cafes, brainstorming rooms, and areas for chatting. While they provide good communication channels for employees, it is still necessary to balance public and private spaces in the office. In the office, personal space is very important. It enables privacy, provides comfort, and allows one to control communication by adjusting distance to others. In independent offices, personal space is clear and private. In open office spaces, personal space is mainly achieved by partitions or furniture enclosures. The height of partitions and furniture plays a decisive role in personal space. Long and wide furniture will strengthen privacy in personal spaces, for which reason this type of furniture should be considered when choosing furniture in an early stage.

To summarize, the workspace is a combination of a tangible physical space and an intangible non-physical environment, including geographical location, office space layout, office and entertainment facilities, indoor ecological environment, green plants, and office culture. When designing offices, knowledge-intensive companies should try their best to meet the innovation needs of knowledge workers, to facilitate interpersonal interaction and cooperation, and to promote the expression of individual personalities. Workspace should: (1) optimize cluster areas to enable rich social networks to emerge; (2) create a public space for knowledge innovation such as training, communication, and other venues; (3) be convenient for interpersonal interaction and information sharing; (4) respect independent office spaces; (5) be clear and transparent, giving people a sense of progress and enhancing mutual trust and interpersonal communication; and (6) have intelligent facilities. Public spaces, work areas, and activity rooms all belong to the functional layout of the office.

7.3 Limitations and future research

This study explores the extent to which the workspace environment affects creativity and innovation in an organization. Our findings highlight the increasing importance of workspace

environment – physical and non-physical – on creativity and innovation. While both qualitative and quantitative approaches are employed to research the proposed theoretical framework, there are still some limitations in this study, and these may guide future research directions.

First, the sample used in this study is limited to only two makerspaces: a large chain (i.e., Ucommune), and a local medium-sized makerspace (i.e., Walnut). In the future, it would be necessary to expand the sample to other makerspaces or workspaces to examine the relationship between workspace environment and organizational performance. Second, the framework proposed in this study also needs to be examined, especially on the relationship between individual creativity and organizational innovation. Third, since our focus was on the impact of the workspace, rather than on the relation between employees' behaviors and innovation, we did not consider team creativity in our proposed theoretical framework, as it is a comparatively new concept that needs to be explored in future studies. It is expected that additional novel outcomes could be found in further extensive empirical studies.

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Annex: Questionnaire Survey for Workspace Environment

Dear Sir / Madam,

We hope you are well. We are from the School of Management and Economics, University of Electronic Science and Technology. Please fill in the below questionnaire for us. Your responses will be treated in the utmost confidence. Thank you for your support and cooperation.

For the following questions, please select the appropriate option according to the actual situation of your team or enterprise. Tick "√" in the box "□" or change the color of the option (example: "Undergraduate" or "Undergraduate").

Basic Information
01 Gender: □ Male □ Female
02 Age：□ 20-30 □31-40 □41-50 □51 or above
03 Education：□ High school or below □ Junior School □ Undergraduate □ Master □ Ph.D.
04 Your work：_____
05 Firm's Age ： □ less than 1 year or _____Years
06 Property of firm： □ Private □State-owned □Wholly foreign owned □Joint venture
07 Main Businesses: _____
08 Number of employees：□ 10 or fewer □11-20 □21-30 □31-40 □30-40 □41 or more
09 Office location before entering Ucommune : □ Commercial office building □ Enterprise □ Park, incubator, or other makerspace □ Other _____
10 Part of enterprise in Ucommune：□ Whole enterprise □ 2 departments or more □ 1 department □ Branch □ Others

Important Note: 1 represents "Completely Disagree"; 2 represents "Disagree"; 3 represents "Hard to Say"; 4 represents "Agree"; 5 represents "Completely Agree".

Physical Environment		C.Dis.	Dis.	H.T.S	Agree	C.A.
01	The lighting design is good.	1	2	3	4	5
02	The temperature and humidity are comfortable.	1	2	3	4	5
03	The indoor layout provides convenience for communication.	1	2	3	4	5
04	I like the office equipment and furniture.	1	2	3	4	5
05	The interior design of the working space meets my needs for privacy in the working environment.	1	2	3	4	5
06	The interior design of the communal spaces meets my need for a shared working environment.	1	2	3	4	5
07	I like the interior design.	1	2	3	4	5
08	The overall spatial layout of the multi-creation space is good.	1	2	3	4	5
09	The color palette of the interior design adds to a pleasant atmosphere.	1	2	3	4	5
Non-physical Environment						
01	I like the cultural atmosphere of the makerspace.	1	2	3	4	5
02	Creating an open atmosphere in public spaces makes me feel relaxed.	1	2	3	4	5
03	I like all kinds of activities held by the makerspace.	1	2	3	4	5
04	I often communicate with members of other companies (teams) in the makerspace.	1	2	3	4	5

	Individual and Team Behaviors	C.Dis.	Dis.	H.T.S	Agree	C.A.
01	After work, I would like to take my family and friends to visit the makerspace.	1	2	3	4	5
02	I like the working environment of the makerspace.	1	2	3	4	5
03	I like the cultural atmosphere of the makerspace.	1	2	3	4	5
04	I like to work in the makerspace.	1	2	3	4	5
05	It's easy for me to exchange ideas with and get advice from my colleagues or friends in the communal spaces.	1	2	3	4	5
06	I can get help from other companies or friends in the makerspace.	1	2	3	4	5
07	In the makerspace, I can coordinate and maintain good interpersonal relationships.	1	2	3	4	5
08	Our team often holds discussions in the makerspace.	1	2	3	4	5
09	Members of our team often encourage each other.	1	2	3	4	5
10	Members of our team help each other to solve problems at work.	1	2	3	4	5
	Creativity	C.Dis.	Dis.	H.T.S	Agree	C.A.
01	I often come up with new ideas in my work.	1	2	3	4	5
02	I often have new ideas to solve problems.	1	2	3	4	5
03	I can come up with novel ideas about technology, management models or products (services).	1	2	3	4	5
	Innovation Performance					
04	Our company continuously improves its existing products or services.	1	2	3	4	5
05	Our company is constantly exploring new managerial methods.	1	2	3	4	5
06	Our company has applied for new practical patents.	1	2	3	4	5
07	Our company has applied for design patents.	1	2	3	4	5
08	Our company launches new products (services).	1	2	3	4	5
09	Our company is developing new technologies.	1	2	3	4	5
10	Our company has applied for invention patents.	1	2	3	4	5