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Article

The Effect of Knowledge Sharing on Ambidextrous Innovation: Triadic Intellectual Capital as a Mediator

Zhenyang Zhang [1], Xinyuan Wang [1,2,*] and Dongphil Chun [1,*]

[1] Graduate School of Management of Technology, Pukyong National University, Busan 48547, Korea; zyzhang@pukyong.ac.kr
[2] School of Economics and Management, Hulunbuir University, Hulunbuir 021000, China
* Correspondence: wangxinyuan@pukyong.ac.kr (X.W.); performance@pknu.ac.kr (D.C.); Tel.: +82-051-629-5647 (D.C.)

Abstract: There is no doubt that the primary reason that firms encourage knowledge sharing is to drive innovation. As nutrients for innovation, what role do the different elements of intellectual capital play in this relationship? When we consider the ambidexterity of enterprise innovation—exploratory and exploitative—how do the different elements of intellectual capital affect the relationship between them? This study adopts a triadic perspective to divide intellectual capital into human, structural and relational capital. We analyzed 349 questionnaires from high-tech enterprises and found that knowledge sharing had a significantly positive effect on all three elements of intellectual capital, and human capital and structural capital had a positive effect on ambidextrous innovation. Relational capital had a positive effect on exploitative innovation but no significant effect on exploratory innovation. Unexpectedly, there was no direct effect of knowledge sharing on ambidextrous innovation, and the elements of intellectual capital play full mediations among them. This may suggest that firms should pay more attention to the role of relational capital when they adopt exploitative innovation. At the same time, we remind managers that innovation may be promoted only when knowledge sharing increases intellectual capital. Therefore, the misuse of management tools should be avoided, and ineffective management practices should be reduced. In addition, we explored the relationship between knowledge sharing and the open innovation paradigm and made some suggestions for future research.

Keywords: knowledge sharing; triadic intellectual capital; ambidextrous innovation; exploratory innovation; exploitative innovation; open innovation

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1. Introduction

For many high-tech enterprises, knowledge-based technical resources are the core competitive advantage on which they rely for survival. Whether to adapt to an increasingly complex market environment or become bigger and stronger based on an existing market position, enterprises are inseparable from the absorption, transformation, and application of knowledge [1]. Making full use of knowledge reserves and technical resources and insisting on innovation-driven high-quality development has become the key to success for such enterprises [2]. Among these, knowledge sharing is one means by which individuals can apply their knowledge to innovation to enhance their status within the organization. Likewise, it is an important way for enterprises to acquire creative capabilities, reduce production costs, promote a broader open innovation strategy, and achieve revenue growth [3,4]. Knowledge sharing can help enterprises become learning organizations with an efficient resource flow, promote diffusion of knowledge throughout the enterprise, and generate intellectual capital through the integrated operation of business and value processes [5], thereby providing the impetus for enterprises to innovate at different levels.

The ambidexterity characteristics of innovation have been widely discussed. Depending on the source of novelty, enterprise innovation can be subdivided into exploratory

innovation (applying new knowledge, skills, and resources to produce breakthrough results) and exploitative innovation (using existing knowledge, skills, and resources to improve the status quo) [6]. Different types of innovation have different effects on the development of the firm. Overdoing exploratory innovation may put firms in a resource dilemma, while totally exploitative innovation may lead to rapid obsolescence in the face of frequent technological changes [7]. Therefore, to reconcile the conflict between limited enterprise resources and unlimited market ambition, decision-makers need to strike a balance between exploratory and exploitative innovation [8]. Again, since the required knowledge, skills, and resources for exploratory and exploitative innovation may differ significantly, it is necessary to explore the specific mechanisms that drive ambidextrous innovation.

Studies on the antecedent influences of enterprise innovation in the literature have mainly focused on the knowledge or resource level. Most of the literature suggests that knowledge sharing helps to promote enterprise innovation [9,10], but there are many possibilities for further research on this relationship. On the one hand, most scholars have studied the impact of knowledge sharing on innovative performance and capability while ignoring its impact on different types of innovation. Due to the ambidexterity characteristics of innovation, different types of activities may have different requirements for knowledge sharing, and these deserve further discussion. On the other hand, existing studies consider the direct impact of knowledge sharing on enterprise innovation, but do not explore the specific mechanism through which knowledge sharing affects ambidextrous innovation, thereby failing to open the black box of the sharing mechanism.

At the same time, intellectual capital is the product of the integration of various resources after knowledge sharing and should be regarded as a critical motivation for ambidextrous innovation [5]. Although there have been some studies on the relationship between knowledge sharing and intellectual capital, and the relationship between intellectual capital and enterprise innovation, few scholars have integrated them to study the relationship among all three simultaneously. In addition, few scholars have studied which of the three elements of intellectual capital is a better match for the two types of ambidextrous innovation. As Bogers [4] argued, in the age of open innovation it is important for both academics and managers to better understand the relationship between knowledge sharing and other relevant factors. For these reasons, we developed a conceptual framework of "knowledge sharing–triadic intellectual capital–ambidextrous innovation". This study attempts to clarify the mechanism of action between knowledge sharing and ambidextrous innovation to provide effective management strategies for entrepreneurs to try out different types of innovation.

The rest of this paper is organized as follows: Section 2 reviews and discusses the relevant literature and theoretical foundations. Section 3 states the relationships among variables and research hypotheses. Section 4 describes the sample data and research design. Section 5 presents the empirical results of the data analysis. Section 6 concludes the paper and provides some recommendations.

2. Theoretical Basis and Literature Review

2.1. Knowledge Sharing

A power-based view of knowledge holds that the heterogeneity of knowledge gives its possessor the power to dominate it. The knowledge owner has the power to decide whether to monopolize the knowledge within certain limits or to transfer it to others. For the long-term development of firms, especially in open innovation projects, managers need to break individual control over knowledge to promote knowledge sharing so that more employees have access to this knowledge [11]. To date, there are various definitions of knowledge sharing among scholars. For example, some have taken an outcome-based view: one party provides specific knowledge or skills to another to help solve a practical problem at work or in another setting [3,12]. Other scholars consider a process-based perspective and point out that knowledge sharing is the transfer of knowledge to others through communication and connection, which is usually accompanied by contribution,

acceptance, learning, and transformation of knowledge [13,14]. Therefore, drawing on both outcome-based and process-based perspectives, this study understands knowledge sharing as a series of behaviors centered on knowledge transfer and absorption generated through interactive exchanges among different subjects within a firm to solve problems and facilitate effective work [15].

Usually, scholars divide knowledge sharing into tacit and explicit knowledge sharing [16,17]. Tacit knowledge refers to professional knowledge and skills that are difficult to express, not easily manifested and usually owned by individuals. It is usually applied only in specific contexts and requires close interaction among subjects for successful sharing. Explicit knowledge can be encoded as text or pictures and can be shared in electronic or paper form [18]. According to Haas and Hansen [19], different types of knowledge have different benefits when shared. For example, tacit knowledge sharing improves the quality of work and demonstrates one's ability to do the job, but does not save time; explicit knowledge sharing saves time, but does not increase the quality of work or make one's strengths perceived by others. Knowledge sharing is a two-way interaction in that the act of assisting others to solve problems also allows the knowledge sharer to acquire new knowledge or skills from feedback and interactive discussions [20,21]. According to one view, knowledge sharing, especially when colleagues help each other, is a form of open innovation that can create value for an enterprise while reducing the uncertainty and complexity caused by the use of external resources [22]. Thus, encouraging knowledge sharing is an important way to maintain an organization's creativity and competitiveness [16,23].

2.2. Intellectual Capital

It is generally believed that John Kenneth Galbraith introduced the concept of intellectual capital, which he considered to be the sum of a firm's stock of intellectual assets and the motivation for value creation [24,25]. He also tried to use it to explain the difference between a firm's market value and the book value [26]. Later, Stewart [27] refined the definition of intellectual capital to include any knowledge or capability that could give a firm a competitive advantage or make a firm's actual value exceed its book value. Therefore, in this study, intellectual capital refers to the sum of intellectual resources such as experience, skills, talents, relationships, and institutions that can give a competitive advantage or create market value for a firm.

In academic circles, there are different views on the structure of intellectual capital: dualism, triadism, or pluralism. Among these, the mainstream view is that intellectual capital comprises human, structural, and relational capital [28–30], which is also adopted in this study. Human capital refers to all knowledge and skills possessed by employees, such as their innovative capabilities, knowledge reserves, and know-how. Structural capital refers to all kinds of knowledge and capabilities within the firm, such as management capabilities, operational processes, business norms, and even infrastructure. Relational capital reflects the resources that could be obtained through internal or external relationships. For example, the firm's employee relations, customer relations, government interaction [31]. The intellectual resources in these three dimensions intermingle within the firm to realize the continuous growth of intellectual capital thereby promoting innovation [29]. Some scholars do not mince words when they claim that the foundation of the popular open innovation paradigm lies in traditional intellectual capital theory. They view human and structural capital as the source of a firm's absorptive capacity and repeatedly emphasize the importance of relational capital [32].

Much of the early literature thought more about customer relationships and referred to relational capital as customer capital, but this is increasingly less used [33]. Other scholars have used the expression "social capital". For example, Ali et al. [34] adopt a multidimensional perspective, dividing intellectual capital into four dimensions and juxtaposing social capital with relational capital. The concept of social capital they use focuses on the relationship among employees or between a firm and its employees and could be referred to as "internal relational capital". This division makes sense, but considering that the

theory of social capital, promoted by prominent sociologists such as Pierre Bourdieu, has connotations no less important than intellectual capital [35], we try to avoid using the term "social capital" as a subset of intellectual capital.

2.3. Ambidextrous Innovation

The concept of ambidextrous innovation derives from ambidextrous learning. March and Levinthal [36,37] introduced the terms "exploratory learning" and "exploitative learning" in their study of organizational learning. Whereas exploratory learning focuses on finding new knowledge and perspectives, exploitative learning focuses on refining and consolidating existing knowledge. Regardless of the firm's size or stage of development, each learning strategy is essential for gaining a competitive advantage [33]. However, studies also show that the ambidexterity characteristics of organizational learning have a more significant impact on innovation [38]. Following the classification of ambidextrous learning, scholars in the field of innovation management have started to classify innovation by borrowing the exploratory/exploitative dichotomy, and the concept of ambidextrous innovation emerged [39,40]. Ambidextrous innovation refers to a firm's simultaneous realization of both exploratory and exploitative innovation [41]. The former refers to disrupting existing knowledge and technology; discovering new designs, methods and processes; creating new products or services; or developing new markets. The latter improves and upgrades designs, methods, and processes based on existing knowledge and technologies to further reduce costs and improve product or service quality [42].

Many scholars consider exploratory and exploitative innovations to be in competition, and a balance should be found between them [7,8]. Others suggest that the two may be complementary [43]. This difference has led to disagreement about how to measure ambidextrous innovation. Scholars who adopt the complementary view tend to add or multiply the scores of the two types of innovations [44,45], while those who adopt the balanced view often subtract the two scores and then take the absolute value [46]. Interestingly, many scholars use both the product and the absolute value after subtraction to support the complementary view [47]. Of course, many studies treat exploratory and exploitative innovation directly as separate dimensions [39,48].

Ambidextrous innovation may not be a static concept. Some scholars argue that ambidexterity should be studied from an incremental and radical perspective [49], while others look at the openness of innovation, in which exploration is inbound open innovation and exploitation as outbound [50]. There is also a view that ambidexterity may no longer be able to explain new business practices fully under the open innovation paradigm and that there is a need to move to the concept of multidexterity [51]. Given these divergences, as well as our greater focus on the finiteness and scarcity of firm resources, we remain conservative in using the traditional ambidexterity concept of exploratory and exploitative innovation as the object of study, and prefer to measure them separately as distinct dimensions. This also helps us clarify which form of innovation is best suited to which intellectual capital element to promote innovation.

3. Hypotheses

3.1. Knowledge Sharing and Intellectual Capital

The knowledge base theory argues that the main reason for the existence of the firm as an organizational form is that it is more effective than a market for sharing and transferring knowledge. To enhance its overall strength and competitiveness, a firm must focus on integrating knowledge resources and applying them to the production and development of products or services [52]. The source of a firm's competitive advantage is the integrated knowledge, not the knowledge itself. The way to solve the problem of knowledge heterogeneity within the firm is to transform individual knowledge into collective knowledge, which emphasizes the importance of knowledge integration [53]. In other words, unintegrated knowledge can hardly form intellectual capital in the true sense. Moreover, the efficiency of knowledge integration would be affected by the degree

of knowledge sharing [52]. The results of existing empirical studies show that knowledge sharing significantly and positively affects human, structural, and relational capital. The flow and exchange of knowledge within a firm not only increases the depth of intellectual capital, but active knowledge sharing among individuals deepens an understanding of their own knowledge and skills and enhances the application ability of others. Through repeated sharing and practice, the optimized knowledge is rooted in the organization and the trust among different people will be strengthened [30,54].

In addition, Oliveira et al. [55] argued that knowledge sharing not only improves all elements of intellectual capital and facilitates the formation of human capital, but it also reduces the loss of knowledge associated with changes in human resources [56]. By exporting their experiences and skills, knowledge sharers can deepen their re-understanding of acquired knowledge, while knowledge receivers use this new knowledge to improve their own work methods. It greatly facilitates collaboration and complementarity among employees, improves the firm's overall capabilities, and accelerates the accumulation of human capital. Knowledge sharing also provides the ground for the growth of structural capital [30]. Firms can compile high-quality individual knowledge in the form of workbooks and repositories that are shared throughout the firm to increase the spread of knowledge. Firms can also ensure the growth of structural capital by improving policies, systems, and processes to strengthen its infrastructure. Meanwhile, knowledge sharing likewise leads to an increase in relational capital [57]. With frequent communication and interaction, mutual trust and appreciation will grow significantly because of knowledge sharing and exchanges to assist each other in overcoming key problems, which helps build relational capital. Accordingly, we propose the following research hypothesis:

Hypothesis 1 (H1a). *Knowledge sharing has a significantly positive effect on human capital.*

Hypothesis 1 (H1b). *Knowledge sharing has a significantly positive effect on structural capital.*

Hypothesis 1 (H1c). *Knowledge sharing has a significantly positive effect on relational capital.*

3.2. Intellectual Capital and Ambidextrous Innovation

The relationship between intellectual capital and innovation has been extensively studied, but the complexity of intellectual capital and enterprise innovation leaves ample research space for other scholars. In particular, a common line of research is to subdivide these concepts to investigate the relationship among the subdivisions. For example, Chen et al. [58] argued that closed innovation strategies have been replaced by open innovation strategies. Previous theories of intellectual capital focused on the firm's internal aspects, and were not suitable for open innovation. Thus, they reconstructed the traditional model of intellectual capital, distinguished between external and internal intellectual capital and researched their relationship to innovation. Similarly, Zhou et al. [59] classified open innovation as inbound- and outbound-oriented and investigated the mediating role of intellectual capital in the strategic flexibility of two-way open innovation. They argued that both inbound and outbound open innovation require human, structural, and relational capital to provide the underlying resources for the integration of innovative ideas and the commercialization of technology. It follows that while there seems to be a consensus that intellectual capital could influence innovation, many details still need to be examined.

3.2.1. Human Capital and Ambidextrous Innovation

Human capital is so crucial for explaining organizational and innovation theories that it often transcends intellectual capital to combine with concepts from other domains to form new frameworks. Abouzeedan and Hedner [60] incorporate human capital with open, financial, and systems capital to construct a new innovation capital model to explain the open innovation paradigm. Most existing studies focus on how firm executives influence enterprise innovation, but often ignore the role of employees. For example,

Liu et al. [61] found that human capital on the board of directors of high-tech firms has a significant impact on ambidextrous innovation and concluded that directors with higher levels of education and overseas study help firms to grow. However, the success of a firm's innovation strategy is also highly dependent on intelligent employees, who are not only the providers of innovative ideas, but also concrete executors and implementers of them [62]. For example, Zhang et al. [63] examined the inverted U-shaped relationship between open innovation and profitability and the moderating role of human capital, which positively moderates the inverted U-shaped relationship in technology-oriented firms but has a negative effect in production-oriented firms.

In some earlier studies, Hayton [64] showed that human capital diversity contributed to the innovation of high-tech new ventures in the United States, and the study by Bogers et al. [65] further found that employee diversity contributed to a firm's open innovation strategy. In particular, employee diversity in knowledge and educational background was positively associated with openness at the firm level, and work experience diversity was not directly related to it. Kang and Snell [66] argued that different types of employees promote different forms of enterprise innovation. Specialist employees usually have more in-depth knowledge in a particular field and are less willing and capable of exploring knowledge outside their field. Thus, they are more likely to focus on exploitative innovation. Although generalist employees are hardly an authority in a particular field, they master more knowledge in different fields and have an unusual perspective. They are good at generating new ideas and solutions through ambidextrous learning and are more inclined to promote exploratory innovation within the firm. Based on the above reasons, we propose the following research hypothesis:

Hypothesis 2 (H2a). *Human capital has a significantly positive effect on exploratory innovation.*

Hypothesis 2 (H2b). *Human capital has a significantly positive effect on exploitative innovation.*

3.2.2. Structural Capital and Ambidextrous Innovation

The development of a firm is a process of constant adaptation to changes in the environment and adjustments to its organizational structure, strategy and behavior, and structural capital plays a vital role [67]. For example, Jayabalan et al. [68] showed that intellectual capital, including structural capital, contributes to frugal open innovation to help organizations with low profitability, such as private colleges and universities, out of financial distress. As stated by Wu et al. [69], the structural capital of a firm contains all encoded knowledge that is not related to human resources and anything that has a higher actual use value than material value for the firm. At the same time, their findings suggest that structural capital can significantly and positively affect the firm's innovation capability. Both for large and small firms, structural capital largely explains the effectiveness of new idea generation [70]. The reuse of encoded knowledge helps strengthen the firm's existing knowledge base. A dexterous organizational structure, standardized business processes, a rich knowledge base, and an excellent corporate culture also provide strong support for the firm's innovation strategy [71]. Firms that implement open innovation strategy, to consolidate structural capital, need to use more effective ways to manage knowledge and pay particular attention to the inflow and outflow and whether the knowledge is easy to decode [72].

The empirical study by Barrena-Martínez et al. [32] showed that structural capital has a significantly positive linear effect on a firm's collaboration with external subjects to develop product innovations. They describe it as successful open innovation and suggest that this may be because structural capital components such as organizational processes and intellectual property rights help develop the firm's ability to absorb and exploit external knowledge. Thus, stronger structural capital is conducive to exploitative innovation based on the existing knowledge base. Meanwhile, although exploratory innovation is riskier and more uncertain than exploitative innovation, robust structural capital not only

provides a supply of knowledge, but also provides institutional protection and cultural incentives. As a prerequisite for innovative performance, firms engage in exploratory learning intending to explore new advanced technologies or opportunities and stimulate the creativity of their employees. Faced with the trend toward openness to innovation and the resulting differences in mental and coding schemes, firms have elevated their willingness to undertake exploratory learning to understand new external knowledge accurately [73]. It could motivate employees to break through path dependence and use more cutting-edge knowledge to obtain breakthrough results, ultimately promoting exploratory innovation. Based on this, the following research hypothesis is proposed.

Hypothesis 2 (H2c). *Structural capital has a significantly positive effect on exploratory innovation.*

Hypothesis 2 (H2d). *Structural capital has a significantly positive effect on exploitative innovation.*

3.2.3. Relational Capital and Ambidextrous Innovation

As mentioned earlier, relational capital refers to the knowledge and capabilities embedded in a firm's internal and external social relationships. As a core component of relational capital, trust and commitment directly influence the ability to collaborate among partners, and this ability significantly affects innovation [74]. Internally, relational capital enhances cooperation and interaction among employees, the exchange of ideas about each other's work, and opportunities for new ideas to be generated and implemented. Externally, relational capital emphasizes the importance of working closely with upstream and downstream partners to establish common goals. This provides an opportunity for firms to integrate the knowledge accumulated internally with the knowledge held by external participants to improve their innovation capabilities [75]. Especially in the context of open innovation, good external relational capital plays a key role in the success of start-ups or early stages of the product life cycle [33]. For example, Bharati and Chaudhury (2019) [76] showed that the more relational capital an organization has, the more big-data innovation it has. They argued that many work tasks would be simplified if relationships with business partners were well used to gather technical information.

Relational capital not only helps firms absorb useful knowledge from outside, but it also facilitates the transformation of internal knowledge into product and process innovation and accelerates the speed of innovation [77]. Meanwhile, the role of relational capital and innovation may not be unidirectional but rather reciprocal. Lenart-Gansiniec [78] believes relational capital and innovation are interdependent because an increasingly open innovation environment widens mutual communication channels and builds exchange platforms for previously unfamiliar innovation subjects, making it possible for organizations to harvest new ones external relationships in their innovation activities. The results of the empirical study by Michelino et al. [79] also indicates that collaborative development with other firms might increase all elements of intellectual capital. For this study, we specifically argue that, on the one hand, the knowledge bases firms are usually heterogeneous internally and externally, and reliable relationships will influence technical assimilation and help firms acquire new knowledge and ideas [76], which is conducive to exploratory innovation. On the other hand, trust-based communication may deepen the understanding of existing knowledge, which in turn improves the practical methods and processes and promotes exploitative innovation. Based on this, we propose the following research hypothesis.

Hypothesis 2 (H2e). *Relational capital has a significantly positive effect on exploratory innovation.*

Hypothesis 2 (H2f). *Relational capital has a significantly positive effect on exploitative innovation.*

3.3. Knowledge Sharing and Ambidextrous Innovation

Knowledge sharing and knowledge creation are inextricably linked from the perspective of knowledge management. Knowledge sharing creates chances for organizations and

individuals to incorporate different perspectives. Singh et al. [80] emphasize the critical role of top management in focusing on internal knowledge sharing to support open innovation. They argue that firms could effectively manage knowledge only when employees are willing to share what they know, thereby sustaining innovation at the individual, team, and firm levels; seizing changing and fleeting market opportunities; and meeting customer needs quickly and with minimal cost. Knowledge sharing is important not only among employees, but also among entrepreneurs and managers. For example, Setini et al. [35] examined open innovation communities consisting of women entrepreneurs in Bali. They concluded that the knowledge sharing brought about by such communities is a self-improvement process. The information exchange motivates the women and the resulting information is ultimately used to create various innovations to meet market needs, thereby positively influencing performance.

Wang and Wang [15] showed empirically that knowledge sharing has a significantly positive effect on innovation performance and can lead to better knowledge management. Yeşil et al. [10] point out that the process of driving innovation in firms is highly dependent on the knowledge and experience of individuals, and that knowledge sharing can precisely integrate fragmented knowledge to form a strong innovation capability, which translates into innovation performance. Chiang and Hung [9] also pointed out that knowledge sharing is a valuable input for innovation because knowledge flow within an organization can facilitate performance. Both exploratory and exploitative innovations are unlikely to leave the core resources, which are based on tacit and explicit knowledge. Scuotto et al. [81] argue that innovation evokes an open process that combines these two forms of knowledge, forming a virtuous circle that establishes a link between the exploitation and exploration of knowledge and the exploitation and exploration of technology. The mutual exchange, learning, and understanding generated by this form of knowledge sharing accelerate the diffusion and application of new knowledge within the firm, as well as the development and commercialization of new products, and knowledge sharing is bound to become a proper part of ambidextrous innovation. Therefore, we propose the following research hypothesis:

Hypothesis 3 (H3a). *Knowledge sharing has a significantly positive effect on exploratory innovation.*

Hypothesis 3 (H3b). *Knowledge sharing has a significantly positive effect on exploitative innovation.*

3.4. Triadic Intellectual Capital as a Mediator

Management scholars have widely recognized the positive effect of knowledge sharing on intellectual capital [55]. Many studies have also shown that different elements of intellectual capital bring different effects to enterprise innovation or performance, and such effects are sometimes even negative [31,82]. Other studies have argued that intellectual capital could mediate the positive impact of knowledge sharing on performance. Firms should not only pay attention to the guidance of knowledge sharing, but also understand how it affects the firm through different elements of intellectual capital. Some scholars have advocated that decision-makers should establish appropriate mechanisms to ensure that intellectual capital can be properly planned to achieve the desired effects of decisions [30]. Scholars have done many studies on proximate topics. For example. Lo et al. [83] verified the mediating role of triadic intellectual capital in open strategies on innovation performance by using a sample of listed service firms. However, the literature still lacks a discussion of how knowledge sharing affects firm innovation through different elements of intellectual capital. This is especially true for ambidextrous innovation, an outcome variable that is controversial for seeking either balance or complementarity.

We argue that there is a mediating role for intellectual capital between knowledge sharing and ambidextrous innovation. At the human level, whether for exploratory or exploitative innovation, knowledge sharing provides employees with an original knowledge base that can effectively enhance their innovative skills and thinking and drive the forma-

tion of innovative activities at all levels. At the organizational structure level, knowledge sharing not only helps firms acquire new knowledge and ideas, but also promotes improved organizational structure, shapes the atmosphere of innovation for everyone, and drives the progress of the knowledge management system. At the internal or external relationship level, knowledge sharing deepens the intimate relationship between employees and cooperative enterprises through frequent interaction and communication. Moreover, the collision of knowledge in multiple fields triggers new thinking and increases the probability of sparking innovation from both sides, ultimately promoting ambidextrous innovation generation. Based on the above reasons, we propose the following research hypothesis:

Hypothesis 4 (H4a). *Human capital mediates the effect of knowledge sharing on exploratory innovation.*

Hypothesis 4 (H4b). *Human capital mediates the effect of knowledge sharing on exploitative innovation.*

Hypothesis 4 (H4c). *Structural capital mediates the effect of knowledge sharing on exploratory innovation.*

Hypothesis 4 (H4d). *Structural capital mediates the effect of knowledge sharing on exploitative innovation.*

Hypothesis 4 (H4e). *Relational capital mediates the effect of knowledge sharing on exploratory innovation.*

Hypothesis 4 (H4f). *Relational capital mediates the effect of knowledge sharing on exploitative innovation.*

In Figure 1 we constructed a conceptual framework of knowledge sharing, triadic intellectual capital, and ambidextrous innovation.

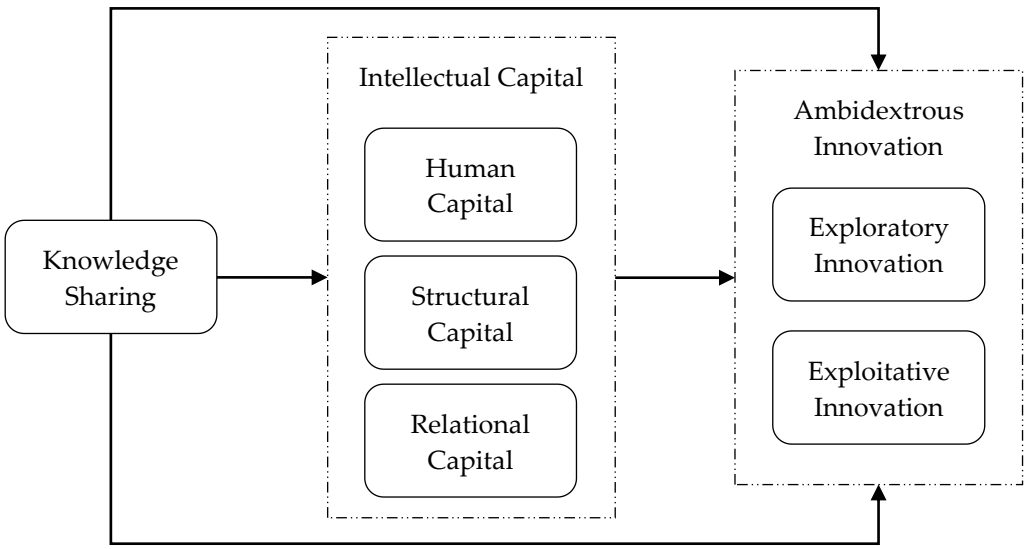

Figure 1. Conceptual framework.

4. Methods

4.1. Participants and Procedure

In this study, high-tech industries (e.g., computer, communication, and biomedical), which are more knowledge-intensive, were taken as samples. There were two major reasons. First, compared with other industries, high-tech industries have a greater demand

for knowledge, and it is very common to share knowledge through various forms within enterprises. Second, high-tech industries are undergoing rapid change, so they must rely on innovation to continuously develop or upgrade their technology to survive and grow. We used a questionnaire, which is more commonly used in the study of intellectual capital, to conduct a survey of high-tech enterprises in Jiangsu Province, which has one of the more developed economies in China. The respondents comprised senior managers, middle managers, and general technical staff. Considering the practical difficulties of collecting the questionnaire face-to-face under the current social and public health conditions, the survey was distributed mainly through the researchers' social network, and respondents were invited through online channels such as e-mail and SNS apps. The statistical software we used was SPSS and AMOS 28.0. The survey lasted from 15 March to 15 May 2021; 600 questionnaires were distributed, and 459 responses were received. After eliminating obviously invalid responses, a total of 349 valid samples passed screening for a valid response rate of 58.17%. Among these, the sample distribution characteristics are shown in Table 1.

Table 1. The distribution characteristics of the sample.

Statistical Characteristics	Type	Frequency	Percentage
Gender	Male	230	65.90
	Female	119	34.10
Position	Senior Management	17	4.87
	Middle Managers	75	21.49
	General technical staff	257	73.64
Industry	High-tech Manufacturing	169	48.42
	High-tech Services	153	43.84
	Others	27	7.74
Number of employees	1–50	46	13.18
	51–200	46	13.18
	201–500	72	20.63
	501–1000	74	21.20
	>1000	111	31.81
Work experience (year)	<1	48	13.75
	1–5	122	34.96
	5–10	103	29.51
	>10	76	21.78
Registered capital (CNY)	<10 Million	39	11.17
	10–50 Million	58	16.62
	50–100 Million	90	25.79
	>100 Million	162	46.42
Firm age (year)	<3	15	4.30
	3–5	29	8.31
	5–10	74	21.20
	10–15	79	22.64
	>15	152	43.55

4.2. Measures

To ensure the reliability and validity of each construct, all items of the questionnaire were selected from existing established scales. At the same time, some items were appropriately modified according to the characteristics of the sample and purpose of the study. The whole questionnaire was measured using a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The complete questionnaire scale translated from Chinese is shown in Appendix A.

4.2.1. Knowledge Sharing

We adopted a seven-point scale to measure knowledge sharing, such as "employees frequently communicate with each other about their work" and "employees regularly participate in job-related training", which mainly refers to the studies of Zhang et al. [84] and Wang and Wang [15].

4.2.2. Intellectual Capital

Although existing studies disagree about dualism, triadism and pluralism, most studies using the questionnaire method tend to divide intellectual capital into human, structural, and relational capital according to triadism. This study also adopted this classification, and the practical scale used refers to the studies of Bontis [85], Hsu and Fang [26], and Wang et al. [30]. Human capital consisted of 5 items, such as "Employees generally have good professional knowledge"; structural capital consisted of 5 items, such as "Our company has efficient decision-making mechanisms"; and relational capital consisted of 4 items, such as "Our company maintains good relationships with suppliers".

4.2.3. Ambidextrous Innovation

For ambidextrous innovation, according to previous studies, we divided it into two dimensions: exploratory and exploitative innovation, which were measured separately. The practical scale refers to the research of Cao et al. [46] and Ma et al. [86]. Exploratory innovation consisted of 4 items, such as "Our company is introducing a new generation of products or services", and exploitative innovation also consisted of 4 items, such as "Our company is improving the quality of existing products or services".

4.3. Common Method Bias

Since all items in each questionnaire were filled out by a single respondent, a spurious common variance may result from the homogeneity of the data and the use of the same measurement tool, thus requiring a test for common method bias (CMB). To this end, this study used Harman's single factor test to conduct an unrotated exploratory factor analysis (EFA) of all question items to determine whether a single factor explained more than 40% of the variance in a reasonable way [87,88]. During the test, six factors with characteristic roots greater than 1 were extracted, and the total explanation of variance was 70.80%. Among these, the first factor explained 35.74% of the variance, which met the empirical criteria and indicated that the study had no serious CMB problem.

5. Results

5.1. Measurement Model

5.1.1. Reliability

Before evaluating the structural model, the reliability of the questionnaire was tested. We use the more commonly used Cronbach's alpha for the test: knowledge sharing, 0.866; human, structural, and relational capital, 0.837, 0.902, and 0.872, respectively; and exploratory and exploitative innovation, 0.869 and 0.868, respectively. All of these values are greater than the critical value of 0.700, indicating that the internal consistency of the latent variables was satisfactory, and the questionnaire had good reliability. The specific data are shown in Table 2.

5.1.2. Validity

We used two indicators, convergent and discriminant validity, to assess the validity of the measurement model. As can be seen from Table 2, all factor loadings in this study ranged from 0.693 to 0.905, which was greater than 0.55; the composite reliabilities (CR) of each latent variable ranged from 0.877 to 0.923, which was greater than 0.70; and the average variance extracted (AVE) ranged from 0.556 to 0.785, which was greater than 0.50. All these values were within a reasonable range, indicating that each construct has good convergent validity. As shown in Table 3, the square root of AVE for each latent variable

on the diagonal was higher than the correlation coefficient between this and other latent variables, indicating that the model had good discriminant validity [89].

Table 2. Reliability and validity test results.

Constructs	Items	Factor Loadings	CR	Cronbach's Alpha	AVE
Knowledge Sharing (KS)	KS1	0.693	0.877	0.866	0.556
	KS2	0.711			
	KS3	0.721			
	KS4	0.796			
	KS5	0.794			
	KS6	0.786			
	KS7	0.712			
Human Capital (HC)	HC1	0.811	0.890	0.837	0.671
	HC2	0.791			
	HC3	0.814			
	HC4	0.838			
	HC5	0.843			
Structural Capital (SC)	SC1	0.877	0.923	0.902	0.769
	SC2	0.881			
	SC3	0.860			
	SC4	0.899			
	SC5	0.868			
Relational Capital (RC)	RC1	0.741	0.892	0.872	0.724
	RC2	0.869			
	RC3	0.881			
	RC4	0.905			
Exploratory Innovation (EY)	EY1	0.834	0.890	0.869	0.718
	EY2	0.842			
	EY3	0.854			
	EY4	0.859			
Exploitativ Innovation (EE)	EE1	0.848	0.916	0.868	0.785
	EE2	0.883			
	EE3	0.883			
	EE4	0.890			

Table 3. Square roots of AVE and correlation coefficients.

Constructs	1	2	3	4	5	6
1. Knowledge Sharing	**0.745**					
2. Human Capital	0.456 **	**0.819**				
3. Structural Capital	0.427 **	0.450 **	**0.877**			
4. Relational Capital	0.314 **	0.476 **	0.398 *	**0.851**		
5. Exploratory Innovation	0.197	0.374 **	0.390 **	0.268	**0.847**	
6. Exploitative Innovation	0.393	0.470 **	0.460 *	0.309 **	0.244 **	**0.886**

Note: The bold diagonal elements are the square roots of each AVE. * $p < 0.05$; ** $p < 0.01$.

5.2. Structural Model

5.2.1. Model Fitness

Before testing the research hypotheses, we constructed the structural model in Amos 28.0 and tested the fit of the model. Some of the important fit indices are shown in Table 4. As can be seen, these show that the measurement model exhibited an adequate fit to the data and could proceed to hypothesis testing.

Table 4. Overall fit indices of the measurement model.

	χ^2/df	CFI	TLI	NFI	RFI	GFI	RMSEA
Scores	1.539	0.97	0.966	0.92	0.912	0.902	0.038
Criteria	<3	>0.9	>0.9	>0.9	>0.9	>0.9	<0.05

5.2.2. Path Coefficient

The results of the hypothesis tests are shown in Table 5, and the path coefficients of the structural model are shown in Figure 2. In the test of the relationship between knowledge sharing and intellectual capital, there was a significant positive effect on human capital (β = 0.557, $p < 0.001$), structural capital (β = 0.527, $p < 0.001$), and relational capital (β = 0.315, $p < 0.001$). H1a, H1b, and H1c were supported. In the test of the relationship between intellectual capital and ambidextrous innovation, there was a significant positive effect of human capital on exploratory innovation (β = 0.237, $p < 0.001$) and on exploitative innovation (β = 0.323, $p < 0.001$). H2a and H2b were supported. Structural capital on exploratory innovation (β = 0.318, $p < 0.001$) and exploitative innovation (β = 0.131, $p = 0.044$) also showed a significantly positive effect, H2c and H2d were supported. No significant effect of relational capital on exploratory innovation was detected, while there was a significant positive effect on exploitative innovation (β = 0.279, $p < 0.001$). H2e was not supported but H2f was. No significant effect of knowledge sharing on either exploratory or exploitative innovation was detected, so H3a and H3b were not supported.

Table 5. Standardized path coefficients.

		Paths		Coefficients	*t*	*p*	Remarks
H1a	KS	→	HC	0.557	11.879	***	Accept
H1b	KS	→	SC	0.527	11.388	***	Accept
H1c	KS	→	RC	0.315	5.706	***	Accept
H2a	HC	→	EY	0.237	3.406	***	Accept
H2b	HC	→	EE	0.323	4.823	***	Accept
H2c	SC	→	EY	0.318	4.040	***	Accept
H2d	SC	→	EE	0.131	2.019	0.044	Accept
H2e	RC	→	EY	0.069	1.109	0.268	Reject
H2f	RC	→	EE	0.279	4.535	***	Accept
H3a	KS	→	EY	0.125	1.706	0.089	Reject
H3b	KS	→	EE	0.077	1.452	0.147	Reject

Note: *** $p < 0.001$.

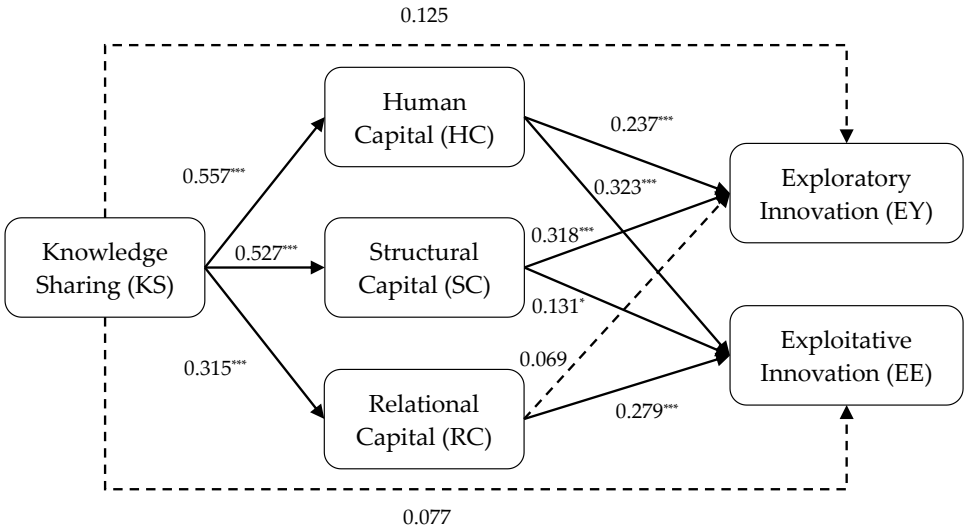

Figure 2. Research model and testing results. Note: * $p < 0.05$; *** $p < 0.001$.

5.2.3. Mediating Effects

After testing the main research hypothesis, we further used bootstrapping analysis to detect the mediating effect of intellectual capital between knowledge sharing and ambidextrous innovation. The number of samples with replacement was 5000, and the confidence interval was 95%. The test results are shown in Table 6. Among the mediating effects detected in this study, all paths except the path "knowledge sharing → relational capital → exploratory innovation" did not contain 0 at the 95% confidence interval ($p < 0.05$). It showed that both human capital and structural capital play a mediating role in the effect of knowledge sharing on exploratory and exploitative innovation. In contrast, relational capital plays a mediating role in the effect of knowledge sharing on exploitative innovation but does not play a mediating role in the effect of knowledge sharing on exploratory innovation. H4a, H4b, H4c, H4d, and H4f were supported, but H4e was not. Based on the results of the test of mediating effects, it can be further concluded that the total effect of knowledge sharing on exploratory innovation through two mediators (human capital and structural capital) was 0.5194. The total effect of knowledge sharing on exploitative innovation through three mediators (human capital, structural capital, and relational capital) was 0.6123.

Table 6. Results of the test for mediating effects.

	Paths	Effect	SE	LLCI	ULCI
H4a	KS → HC → EY	0.2511	0.043	0.1714	0.3394
H4b	KS → HC → EE	0.2747	0.054	0.1750	0.3837
H4c	KS → SC → EY	0.2683	0.042	0.1875	0.3535
H4d	KS → SC → EE	0.1612	0.034	0.0946	0.2278
H4e	KS → RC → EY	0.0517	0.033	−0.0130	0.1164
H4f	KS → RC → EE	0.1764	0.031	0.1156	0.2372

6. Conclusions and Discussion

6.1. Conclusions

Based on the 349 survey samples, we examined the impact of knowledge sharing on ambidextrous innovation (exploratory and exploitative innovation) through different elements of intellectual capital (human, structural, and relational) using structural equation modeling, and we obtained the following conclusions.

(1) Knowledge sharing has a significantly positive effect on different elements of intellectual capital, indicating that the greater the active knowledge sharing in an enterprise, the more likely it is to promote the accumulation of intellectual capital. This was consistent with the findings of some previous studies. Human and structural capital both showed significantly positive effects on ambidextrous innovation, which may indicate that as employees' personal knowledge grew and skills improved, and the organization's knowledge continued to be deposited, the processes continued to be optimized, and structures continued to improve. However, it is important to note that relational capital significantly affected exploitative, not exploratory, innovation. It may have indicated that many high-tech enterprises realized that good internal and external relationships help to redevelop and reuse existing knowledge. Thus, relational capital plays a positive role in developing exploitative innovation. However, exploratory innovation places more emphasis on disrupting existing knowledge, sometimes even trying to replace the dominant paradigm in the current market. It requires a high degree of expertise and originality, and the help that could be obtained from relational networks is more limited. Managers should be aware of the risks of over-reliance on relational capital and avoid over-searching and over-collaborating [32].

(2) Unexpectedly, there was no significantly direct effect between knowledge sharing and ambidextrous innovation. While we realized that this might be an isolated phenomenon limited by the research instrument, we still speculated that the process of

encouraging knowledge sharing as a means of strengthening internal management did not in itself significantly stimulate innovation. Only intellectual capital increased through effective knowledge sharing could truly promote innovation. It is a reminder to decision-makers that a focus on strengthening internal management without paying attention to enhancing the hard and soft power of the firm through the introduction of new talent and technology may make promoting enterprise innovation tantamount to trying to get blood from a stone. In a situation where a firm seriously lacks knowledge reserves and the employees' personal skills are seriously inadequate, no matter how much knowledge sharing is encouraged, it cannot effectively improve the firm' overall capability. At this time, it not only does not contribute to the accumulation of intellectual capital, but also may become a burden to innovation because of the excessive time spent on management activities.

(3) The three elements of intellectual capital (human, structural, and relational) mediate to a certain degree the effect of knowledge sharing on ambidextrous innovation (exploratory and exploitative). Among them, knowledge sharing will have a significantly positive impact on exploratory innovation through the mediation of human and structural capital, respectively, and a significantly positive impact on exploitative innovation through the mediation of human, structural, and relational capital. Since the effect of knowledge sharing on ambidextrous innovation is not significant, all of these mediating effects are full mediations. In addition, the mediating effect of human capital between knowledge sharing and exploratory innovation was not detected because of its non-significant effect on exploratory innovation. This again suggests that decision-makers should pay attention to the pivotal role of intellectual capital and its elements in the positive effect of knowledge sharing on other outcome variables.

6.2. Implications

The possible theoretical contributions of this study include the following. First, the driving mechanism of ambidextrous innovation is further clarified. Based on previous studies, we investigated how knowledge sharing affects ambidextrous innovation through intellectual capital, thereby enriching the research perspective of knowledge management behavior. Second, most existing studies discuss the effects of knowledge sharing on overall enterprise innovation. Knowledge sharing will produce different effects for different types of innovation activities, which may not be controversial. So, we explored the differences in the effects of knowledge sharing on exploratory and exploitative innovation in more depth. It is a supplement to the field of knowledge management behavior. Finally, regarding the three different elements of intellectual capital as mediating variables, we analyzed the differences in the indirect effects of knowledge sharing on exploratory and exploitative innovation through these different elements. This reveals which element of intellectual capital was the most prioritized and important to accumulate for these two modes of innovation.

This study may also provide some implications for specific business practices. First, the importance of intellectual capital for innovation is mentioned once again. From the human level, it is necessary to improve employee knowledge and skills, but also to recruit new talent. From the organizational level, a complete knowledge base, a flexible organizational structure, and a tolerant corporate culture may help stimulate employees' innovative energy. From the relationship level, building good internal/external relationships and upstream/downstream relationships, and strengthening interaction with stakeholders, may contribute to the long-term and stable development of firms, and is conducive to exploitative innovation. Second, the benefits of encouraging knowledge sharing are obvious. It gives employees the opportunity to interact and learn from each other, which strengthens human capital by increasing the average level of employees' knowledge and skills. New ideas generated during the interaction may help improve the organizational structure and business processes to increase structural capital. Moreover, the trust and reciprocity built by employees during the sharing and interaction process may also strengthen the relational capital. Finally, under the condition of limited resources, enterprises should match the

differentiated intellectual capital according to the type of innovation they focus on. For exploratory innovation, firms should focus on improving their knowledge base, decision-making mechanisms, operational processes, and business structures to consolidate human and structural capital. For exploitative innovation, firms could appropriately strengthen their investment in building internal–external relationships, and improve the quality of their products or services by learning from the experience of other entities.

6.3. Discussion

For a long time, academia has tended to focus on how the management activities of a firm could drive innovation while ignoring the question of whether inappropriate management behavior could be detrimental to innovation. It seems to have become such a mindset that it has sometimes led management to turn a blind eye to employee complaints about the misuse of management tools. For this study, it seemed that it was difficult to apply knowledge sharing directly to innovation. Does this suggest that at some point, the tools used by decision-makers to strengthen internal controls (including strengthening internal knowledge management) may not be conducive to innovation? For example, in recent years, some Chinese firms have forced their employees to install mobile workplace apps to clock in and out of work, in an attempt to prompt knowledge sharing through these apps while strengthening internal controls even during non-working hours. However, it is doubtful how much energy employees have left for meaningful knowledge sharing and innovation after being overwhelmed with these management activities [90]. In the study by Hau et al. [16], organizational rewards reduced employees' knowledge sharing intentions. In the study by Hsu and Fang [26], structural capital showed a mildly negative correlation with new product development performance. All these seem to imply that we cannot ignore the negative impact on innovation from ineffective managerial behavior that deprives employees of their individual will and do not consider the state of the firm. Few studies address how a specific management tool designed to facilitate knowledge sharing would affect intellectual capital and enterprise innovation, and this study has been no exception.

It is time to shift the focus to the well-being of the individual employee. Existing research has focused too much on the organization, often ignoring individuals. Even when individuals are the subject of study, scholars prefer to examine how some attributes of top management affect performance or strategic choices. However, labor relations under the neo-liberal ideology are pure and utilitarian [91]. What determines the way employees behave is, first of all, their individual interests, and only secondly might it be collective interest combined with individual interests. After the continuation of COVID-19 restrictions and the normalization of remote work, individualism in the workplace is rapidly increasing, and the Great Resignation and severe labor shortages that have occurred in many developed countries speak volumes about this trend. Specifically with respect to the concepts relevant to this study, knowledge sharing on the surface may appear to be a behavior that tends toward collectivism, which presupposes in-group identification and cooperation [92]. However, the empirical results of many studies showed that both individual and collective orientations positively affect knowledge sharing intention [93,94]. This seems to indicate that individualism and collectivism are not entirely opposite; they could coexist under certain conditions. For example, Yun et al. [22] argued that open innovation is one such field that allows them to merge. Successful open innovation is determined by individuals, but in the process, they may develop cohesion among themselves and, as a result, their collectivism could contribute their mastery of knowledge and reduce the complexity of open innovation. This model of transforming from individual intelligence to collective intelligence is essentially a process of knowledge sharing. It integrates a large group of people with specialized skills to do something collectively to achieve synergy [95].

A strong link between knowledge sharing intention and open innovation seems to have emerged. However, as mentioned earlier, not all management behavior is effective, and not all initiatives aimed at promoting knowledge sharing are consistent with an open

innovation culture. A prerequisite is a culture of altruism within the group, which refers to the lowering of one's own comfort level to enhance the comfort level of others for the sake of the group's growth prospects, with tolerance at its core [96]. This encompasses both the tolerance of ordinary employees toward each other and entrepreneurs or managers toward their subordinates. Many firms claim to be implementing an open innovation strategy while at the same time trying to eliminate an individualist orientation through various means, which often puts a great deal of psychological stress on employees [90]. Employees who could share knowledge have usually invested considerable time or money in their abilities, and they expect to receive their due rewards, including psychological ones. This makes many people prefer to accept a sub-standard salary as long as they gain sufficient status and respect [91]. In other words, firms' attempts to eliminate individualism and enhance collectivism, while making employees psychologically more anxious, have instead strengthened their sense of self. This also explains one possible reason for the Great Resignation.

Thus, as scholars in this research area know, studying the relationship between knowledge sharing and open innovation from the perspective of individualism and collectivism is not new. Meanwhile, the psychological factors contained herein that may lead employees to change their jobs may greatly affect intellectual capital elements such as human capital. Existing studies have invariably ignored the well-being of individual employees when discussing individualism and have paid little attention to whether those lauded management tools actually contribute to innovation. We suggest that future studies categorize management tools designed to encourage knowledge sharing from a behavioral perspective, rather than limiting the categorization to using the attributes of knowledge (i.e., explicit and tacit). At the same time, more consideration should be given to the value and feelings of employees as independent individuals. Qualitative or quantitative research could both be used to explore which types of management tools are genuinely effective and which ones may be ineffective or even burdensome to employees and the business. In addition, the antecedent variables of ambidextrous open innovation [50] or "multidexterous" innovation [51] could also be discussed more.

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Appendix A

Appendix A.1. Knowledge Sharing

KS1: Employees frequently communicate with each other about their work.
KS2: Employees regularly participate in job-related training.
KS3: Employees are constantly learning new job-related knowledge from each other.
KS4: Employees regularly express their opinions in meetings.
KS5: Employees frequently share their work experience and skills with each other.
KS6: Employees frequently discuss key problem-solving issues together.
KS7: Employees often present their unique ideas and perspectives.

Appendix A.2. Human Capital

HC1: Employees generally have good professional knowledge.
HC2: Employees generally have solid work skills.
HC3: Employees generally have a strong sense of innovation.
HC4: Employees generally have strong problem-solving skills.
HC5: Employees generally have independent research skills.

Appendix A.3. Structural Capital

SC1: Our company has an efficient decision-making mechanism.
SC2: Our company has an effective information management system.
SC3: Our company has a good innovation culture.
SC4: Our company has a flexible organizational structure.
SC5: Our company has a standardized internal system.

Appendix A.4. Relational Capital

RC1: Our company maintains good relationships with our employees.
RC2: Our company maintains good relationships with our suppliers.
RC3: Our company maintains good relationships with our customers.
RC4: Our company maintains good relationships with our partners.

Appendix A.5. Exploratory Innovation

EY1: Our company is introducing a new generation of products or services.
EY2: Our company is expanding into new product ranges.
EY3: Our company is working to open new markets.
EY4: Our company is introducing industry-leading technology.

Appendix A.6. Exploitative Innovation

EE1: Our company is improving the quality of existing products or services.
EE2. Our company is increasing production or reducing material losses.
EE3. Our company is trying to reduce the cost of an existing product or service.
EE4. Our company is improving the production equipment or process.

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