Discrete Dynamics in Nature and Society

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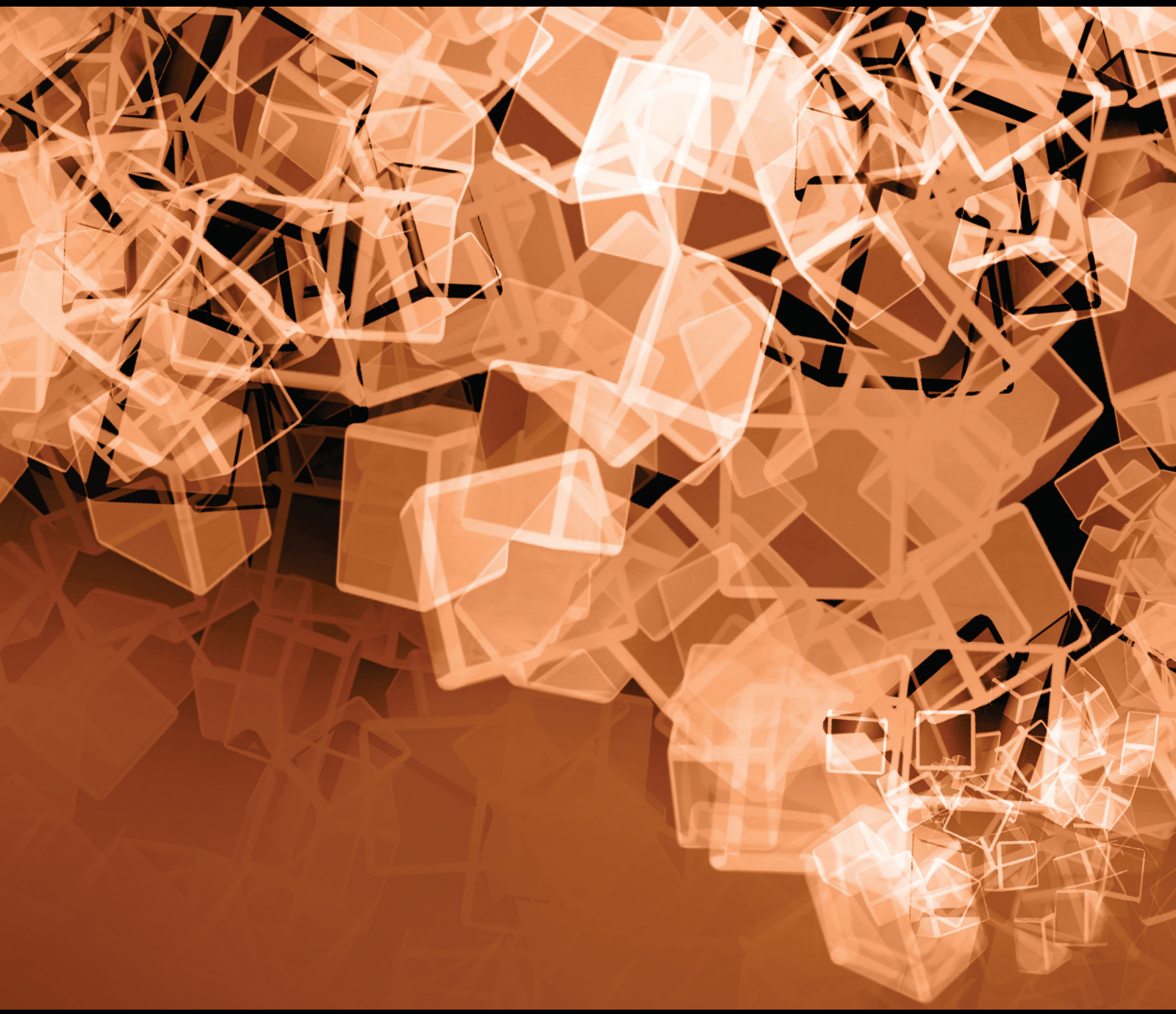

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https://doi.org/10.1155/2022/7453565

Research Article

Analyzing Impact of Intellectual Capital on Business Performance Using Structural Models Based on Customer Knowledge Management

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Received 22 December 2021; Revised 24 June 2022; Accepted 28 June 2022; Published 11 October 2022

Academic Editor: Jiafu Su

In the modern era, intellectual capital encompasses all resources within an organization that enhance the value and competence of the organization. Consequently, this indicates that managing intellectual capital effectively will enhance the value and performance of an organization. This study aims to investigate the effects of intellectual capital on business performance through the use of customer knowledge management in the Bank Mellat branches of Iran. In this study, all managers and employees working for Bank Mellat in Tehran are included. Based on Morgan's table, the sample size was 220 people. Sampling was done by the simple random method. We used a descriptive correlation method to conduct this study and a questionnaire was used to collect data. The questionnaires were scored using a Likert scale. It was confirmed by a consensus of experts that the research instrument was valid, and the reliability of the research was 0.894%. Structural equation modeling was used to analyze the data. According to the results, the dimensions of intellectual capital (human, structural, and relational) have a significant impact on business performance. However, relational capital has been more influential on business performance than other factors.

1. Introduction

As knowledge-based societies continue to progress, the role and importance of intellectual capital returns is becoming increasingly important for companies' sustainable and continuous profitability [1]. The ability to manage and control intellectual capital requires that companies identify, measure, and report intellectual capital. On the other hand, companies have resources critical to strong financial performance and competitive advantage. The first type of these sources includes tangible assets such as property, machinery, and physical technologies that can be easily traded in open markets. The second type includes intangible, valuable, scarce, non-substituted, and strategic assets that create a competitive advantage and superior financial performance [2].

In contrast, the rapid technological advancements of the last decade have had a significant effect on all aspects of human life and activity. It has led to a move towards a knowledge-based economy and a shift in the paradigm of industrial economics [3]. In today's knowledge-based economy, intellectual capital is a critical factor in the superiority and improvement of corporate performance. Intellectual capital includes all the organization's resources that increase the organization's value and the competence organization. Thus, it shows that the management of

intellectual capital effectively and efficiently will improve the value and financial performance of the organization (Ahmad Khan et al., 2012, [4]. Therefore, it can be concluded that the increasing success and productivity of the company or organization depends on attention to knowledge and intellectual capital. By recognizing the nature, model, and methods of measuring and valuing intellectual capital, the possibility of planning and optimization and continuous control and monitoring will be provided in companies and organizations [5]. However, in the last decade, with the advent of private banks in the Iranian banking system, the competition for monetary resources in the country's financial markets has intensified. However, the country's banks have faced many problems attracting and retaining customers. The attractiveness of their financial and monetary services to gain market share has diminished. Do many banks face how to get more customer satisfaction and better benefits? Is there a suitable solution to improve customer knowledge management performance? One of the reasons for the decrease in customers' willingness to invest in these banks is the negative relationship with their customers. Adverse conditions in the banking system are due to having only one technological view of customer relationship management [6]. Therefore, to achieve comprehensive development, intellectual capital seeks to be given more attention in organizations, intellectual assets, knowledge, experience, and organizational learning [7, 8].

On the other hand, the effective development of innovative capabilities has been recognized in recent years as a way to create a sustainable competitive advantage and thus improve the organization's performance. Given the fierce competition in global markets and the explosion of technology in recent years, technological capital based on innovation and differentiation is necessary for any company. Therefore, to achieve success in the market and maintain the competitive advantage of the business, the need to take advantage of new opportunities and develop new market strategies or new services and markets becomes apparent [9]. Organizational literature shows that improving business performance requires a corporate structure, information systems, and management style that becomes a specific strategy [10]. Business performance is a model in decisions and activities that is the main feature. It is the organization's relationship with its environment and is a determining factor in achieving goals. It is also a way to improve sales volume, market share, cash flow, return on investment, dividends, and market value of companies by relying on strategic planning. With this case, researchers show that intellectual capital has more direct effects on the realization of the value of an organization and has increasingly become an essential factor in business. An organization with solid intellectual capital can create favorable conditions for the use and exploitation of human capital and allow human capital to use the potential of self-reliance. Therefore, it increases the organization's potential in attracting customers and presenting new products [2]. Thus, although the discussion of intellectual capital has a long history in the world, unfortunately, in our country, in science and organizational policy, this section has not been addressed. Looking at the activities of organizations and service companies, we find that these institutions have not paid much attention to the processes of intellectual capital. In this regard, by examining the performance of Bank Mellat, we can see a volatile and controversial trend in this sector over the past few years [11].

The absence of required solutions to develop intellectual capital in Iran's specialized technical and service industries is a matter that merits special consideration, since this bank should focus on expanding and enhancing intellectual capital. In recent years, the successful creation of intellectual capital has been recognized as a means of creating a sustained competitive advantage and enhancing the performance of these organizations and businesses. Obviously, determining the function that intellectual capital can play takes a great deal of theoretical and experimental research, yet there have been surprisingly few studies conducted in this area. Therefore, we have endeavored to assess the effect of each capital component on Bank Mellat's commercial performance. In this study, it will be determined whether intellectual capital characteristics have a favorable influence on corporate performance via customer knowledge management.

2. Background of Theoretical Research

John Galbraith was the first to use intellectual capital. But in the mid-1980s, the shift from the industrial age to the information age began, creating a deep gap between the book value and the market value of companies. In the late 1980s, the first attempts were made to produce financial statements of accounts that measured intellectual capital. Also, books on the subject such as knowledge asset management were written by Amidon. In the early 1990s, intelligent capital management was first legitimized in the organization by allocating an official position, and Mr. Edinson was introduced as the director of the intellectual capital of Scandinavia. Fortune published articles in this field. But in the mid-1990s, Scandinavia published its first report on intellectual capital, and a conference on intellectual capital was held in 1996. Experts in intellectual capital agree that intellectual capital consists of three elements: human capital, structural capital, and relational capital. This section further explains these elements [12].

Human Capital. The researchers argue that employees generate intellectual capital through competence, attitude, and intellectual agility. The essential elements of the organization's human capital are the set of skills of the workforce and the depth and breadth of their experience. Human resources can be the soul and thought of the sources of intellectual capital. This capital leaves the company by the employees at the end of the business day, but the structural and relational money remains unchanged even after leaving the organization. Human capital includes

(i) Skills and competencies of the workforce.

(ii) Their knowledge in the important and necessary fields for the organization's success.

(iii) Talents and their ethics and behavior.

According to Brooking, human resources include skills, expertise, problem-solving abilities, and leadership styles. An organization with a high employee turnover rate may have lost this critical component of intellectual capital. Relationship capital refers to all the relationships that exist between an organization and any other individual or organization. There is a wide range of individuals and organizations that can be involved. These include customers, intermediaries, employees, suppliers, legal authorities, communities, creditors, and investors, among others. These relationships can be divided into two general categories.

(i) The first group includes relationships formalized through contracts and commitments with customers and suppliers or significant partners.

(ii) The second group mainly includes informal relationships.

Customer capital is considered a bridge and organizer of intellectual capital operations and is a determining factor in converting intellectual capital to market value. This capital includes the strength and loyalty of customer relationships [10].

Structural Capital. Bass and his colleagues believe that structural capital includes all non-human reserves of knowledge in the organization, including databases, organizational charts, process execution instructions, strategies, executive plans, and generally anything of higher value to the organization. Structural capital covers a wide range of essential elements.

Rossi et al. [13] looked at the influence of company characteristics on economic decisions made by small and medium businesses, with an emphasis on agro-food microbusinesses. In comparison to huge corporations, access to financing is critical for company start-up, progress, and expansion. Small businesses have quite different demands and face significant financial issues. Rossi et al. [14] investigated the impact that business ethics in general and corporate social responsibility in particular can have on the voluntary disclosure of innovation for the world's most ethically engaged enterprises. Festa et al. [15] studied India's top five pharmaceutical businesses to see if their financial structures are solid and if they are in danger of going bankrupt, underlining the importance of intellectual capital in financial stability. The financial structure of the selected firms appears to be steady based on the findings. Limijaya et al. [16] looked at how corporate governance might help to control the link between intellectual capital and business performance. Furthermore, Caputo et al. [17] investigated the function and contribution of voluntary corporate transparency and intellectual capital in improving the "quality" of company-market connections. A conceptual method was taken to discover prospective breakthroughs in the management of voluntary corporate disclosure and intellectual capital, based on the conceptual framework provided by signaling theory and legitimacy theory. Bhasin and Shaikh [18] described the manner of IC disclosures used by Indian and Australian IT companies. The study's findings indicated that IC disclosure by enterprises in these nations is modest, largely provided in narrative form, and that IC disclosure does not receive any favor from the firms' supervisors. An investment or business may lose money if it is exposed to financial risk. There are several common and distinctive financial concerns, including operational risk, credit risk, and liquidity risk [19]. Stakeholders may suffer financial losses as a result of this type of risk. The cost of starting a business from scratch is high. A business may, at some point in its development, require outside funding [20]. There is still a pressing need to address credit discrimination in the financial system and in the transformation of the digital business environment. There is a correlation between consumer behavior during the epidemic and customer-company identification and social responsibility involvement, according to [21, 22].

2.1. Business Performance. Business performance is a multidimensional concept that has administrative indicators such as financial index, marketing, and product suitability; it also has good growth and profit and can be measured by objective or subjective indicators. "Organizational performance is achieving organizational and social goals or going beyond it and fulfilling the responsibilities assigned to individuals." In other words, the analysis of different methods of payment performance refers to the process and activities within the organization that are directly involved with employees. The scope refers to the organization's boundaries that improve employees' organizational processes to create and share knowledge [23]. Furthermore, persistence of the sustainability assessment completed by an external agency is required to support the sustainability strategy and the sustainability committee, therefore legitimizing an organization within its institutional environment [24]. Zhang et al. [25] investigated the correlation between the working-from-home environment and the performance of small businesses during the pandemic. They developed a theoretical framework centered on maximizing corporate profits. The study indicated that working from home might be a "creative destruction" force that accelerates the adoption of technologically ready working from home and has long-lasting effects on industrial structure and people's work lives.

2.2. Customer Knowledge Management. At first glance, customer knowledge management may seem like just another name for customer relationship management or knowledge management. But customer knowledge managers, in some respects, need a different approach from the usual way of managing customer relationships or knowledge management. As a characteristic of customer relationship management, customer relationship managers focus primarily on customer knowledge [26]. In other words, intelligent organizations have found that their customers are more aware of the employee who seeks knowledge through direct interaction with the customer and inquiring about customer knowledge from sales representatives. Knowledge managers also focus on transforming employees from knowledge collectors to knowledge shareholders, usually

accomplished by intranet-based knowledge sharing maps [3]. It is essential for companies to know what their customer knows, what their customer thinks about that company and competing companies, and what will make them more competitive. Today, it is no longer the good and the bad separated, but the good and the good. It is also crucial for all organizations and companies not to lose even one customer because if we lose him, he will undoubtedly be a competitor to embrace him. In this regard, the flow of knowledge processes customer relationship management is divided into the following three categories [27].

(i) Knowledge for the customer: in customer relationship management processes, we need to meet the knowledge needs of customers, for example, knowledge of products, markets, and suppliers.

(ii) Knowledge about the customer: this knowledge is collected to understand the customer's motivations.

(iii) Customer knowledge: it is the customer's knowledge of products, suppliers, and markets. To interact with the customer, this knowledge can be gathered to stabilize continuous improvement. For example, improving services or developing new products are among these improvements [28].

This is while customer knowledge is divided into the following two parts by Zhu et al. Customer knowledge, which includes learning about potential customers and customer groups and its top people, the corporate brand, are a set of values that represent the organization and the positive image of the company brand not only increases competitiveness; Rather, it encourages customers to repurchase [29]. An organization's brand should convey its fundamental values, capabilities, values, and skills which constitute the organization's competitive advantage and cannot easily be duplicated or imitated [30]. Furthermore, innovation quality mediates the connection between customer knowledge management and business performance. In addition, the outcome indicates the moderating influence of competitive intensity on the link between customer knowledge management and innovation quality [31]. Literature findings indicated that among the components of knowledge for the customer, knowledge from the customer, and knowledge about the customer, the components of knowledge for the customer and knowledge about the customer had the greatest and least significant impact on creating value in electronic retail business environments, respectively [32].

2.3. Background of Experimental Research. Heidari et al. [6], in examining the relationship between cultural intelligence with social capital and intellectual capital, found no significant relationship between cultural intelligence with social capital and intellectual capital and their dimensions. However, a significant relationship was observed between social and intellectual capital ($r = 0.75$) and its dimensions. Hamdi [33], in his master's thesis entitled the study of multiple relationships between cultural capital, organizational intelligence, and organizational innovation among faculty members of Urmia University, found a positive and significant relationship between cultural capital, organizational intelligence, and organizational intelligence innovation. Dehghan Jazani (2013), in his master's thesis entitled study of the relationship between organizational culture and intellectual capital in the Ministry of Foreign Affairs of the Islamic Republic of Iran, found the following. (1) There is a significant relationship between the nature of involvement and intellectual capital in the Ministry of Foreign Affairs. (2) There is a significant relationship between adaptability and intellectual capital in the Ministry of Foreign Affairs of the Islamic Republic of Iran. (3) There is a significant relationship between mission and intellectual capital in the Ministry of Foreign Affairs of the Islamic Republic of Iran. (4) Between adaptability and capital, there is a significant relationship in the Ministry of Foreign Affairs of the Islamic Republic of Iran. (5) There is a significant relationship between organizational culture and intellectual capital in the Ministry of Foreign Affairs of the Islamic Republic of Iran. Amrizah and Rashidah [2] found in their research that there is a significant relationship between the components of intellectual capital (human capital, structural capital, and communication capital) with organizational performance. According to the theoretical foundations, the central hypothesis of the study has been formulated as follows:

(i) Human capital has a positive effect on the financial performance of Tejarat Bank.

(ii) Structural capital has a positive impact on the financial performance of Tejarat Bank.

(iii) Communication money has a positive effect on the financial performance of Tejarat Bank.

(iv) Customer knowledge management modulates the impact of intellectual capital on business performance.

3. Research Methodology

The present study was conducted because of the nature of the subject and the expertise of the authors. These findings will assist managers and marketers in improving the performance of the relevant organizations, as well as describe the method of data collection that will be used by Mellat Bank executives in making future decisions. The research population includes all managers and employees with 550 employees. The appropriate statistical sample for the study was calculated based on the sampling formula of a limited population and based on the Morgan table at an error level of 0.05% of 220 people. The research questionnaire was measured through a five-point Likert scale (strongly disagree = 1, disagree = 2, have no opinion = 3, agree = 4, and strongly agree = 5). The reliability of the questionnaires was examined using Cronbach's alpha coefficient in order to test the research hypothesis. The correlation coefficient was greater than 0.7 for all variables of the conceptual model of the study; Figure 1 illustrates the appropriate internal validity and compatibility of research structures (Table 1).

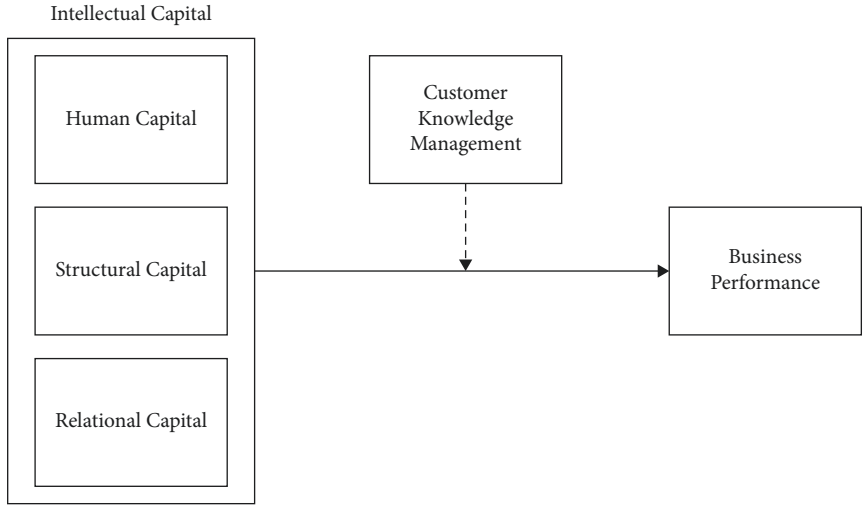

Figure 1: Conceptual model of research.

Table 1: Cronbach's alpha variables.

Variable	Cronbach's alpha
Human capital	%777
Structural capital	%812
Relational capital	%852
Business performance	%782
Customer knowledge management	%802

3.1. Examination of Research Hypotheses. To test the hypothesis, first the distribution of research data is examined. In order to determine whether to use parametric or nonparametric tests, we examine the normality of the data using the Kolmogorov–Smirnov test. The results of the Kolmogorov–Smirnov test are shown in Table 2.

$$\begin{cases} H_0, & \text{The distribution of the variable is normal,} \\ H_1, & \text{Variable distribution is not normal.} \end{cases} \quad (1)$$

According to the test results, the null hypothesis, the normality of the variables is confirmed.

3.2. Data Analysis Method. Structural equation modeling has been used to test the research hypotheses and fit the conceptual model in this research. There are different approaches to structural equation modeling. This means that structural equation modeling can be done based on various statistical methods appropriate to the research sample's variables and characteristics. One of the statistical methods in this field is the partial least squares method. Software that uses structural equation modeling based on this statistical method is compatible with conditions such as the alignment of independent variables, the normality of the data, and the small size of the sample. In the present study, SmartPLS software has been used, a widely used and helpful software in structural equation modeling based on the partial least squares method.

As a result, we track the response rate since it directly affects the quality of the data. If the rate of unit non-response is large, the final survey estimates are more likely to be biased. If the characteristics of non-responding units differ from the characteristics of responding units, estimates may be biased.

4. Research Findings

To test the conceptual model and the research hypotheses, structural equation modeling based on the least squares method has been used. SmartPLS software was used for this purpose. After testing the conceptual research model, the software output is shown in Figures 2 and 3.

Figure 3 shows the obvious and hidden variables and the path coefficients and factor loads. The numbers you see between the hidden variables of the model (variables shown in an oval shape) and the explicit variables (the variables in a rectangle that are hidden under the components of the variable) represent the factor loads. The relationships defined between the latent variables are the same as the research hypotheses, and the numbers shown on these relationships are path coefficients. Table 3 shows the results of the causal analysis of the structural equation model to test the research hypotheses.

4.1. Quality Test of the Measurement Model. The model's ability to predict observable variables through their corresponding hidden variables is measured by this index. Positive values of the CV Com index indicate that the reflective measurement model is of good quality. The appropriate value for this index is as follows (see Tables 4 and 5).

According to the five quality test results, the measurement model shows that all variables have been correctly predicted by the pertinent questions.

4.2. Structural Model Quality Test. Cohen (2009) introduced this criterion to determine the intensity of the relationship between the latent variables of the model. This index measures the model's ability to predict observable variables through the values of their corresponding latent variables.

Table 2: The result of Kolmogorov statistics.

Variable	Probability level error (s)	Kolmogorov statistics	Sig.	Test result
Human capital	0.05	1.263	0.418	The distribution of the variable is normal
Structural capital	0.05	1.472	1.012	The distribution of the variable is normal
Relational capital	0.05	0.379	1.023	The distribution of the variable is normal
Business performance	0.05	1.147	1.015	The distribution of the variable is normal
Customer knowledge management	0.05	1.028	1.12	The distribution of the variable is normal

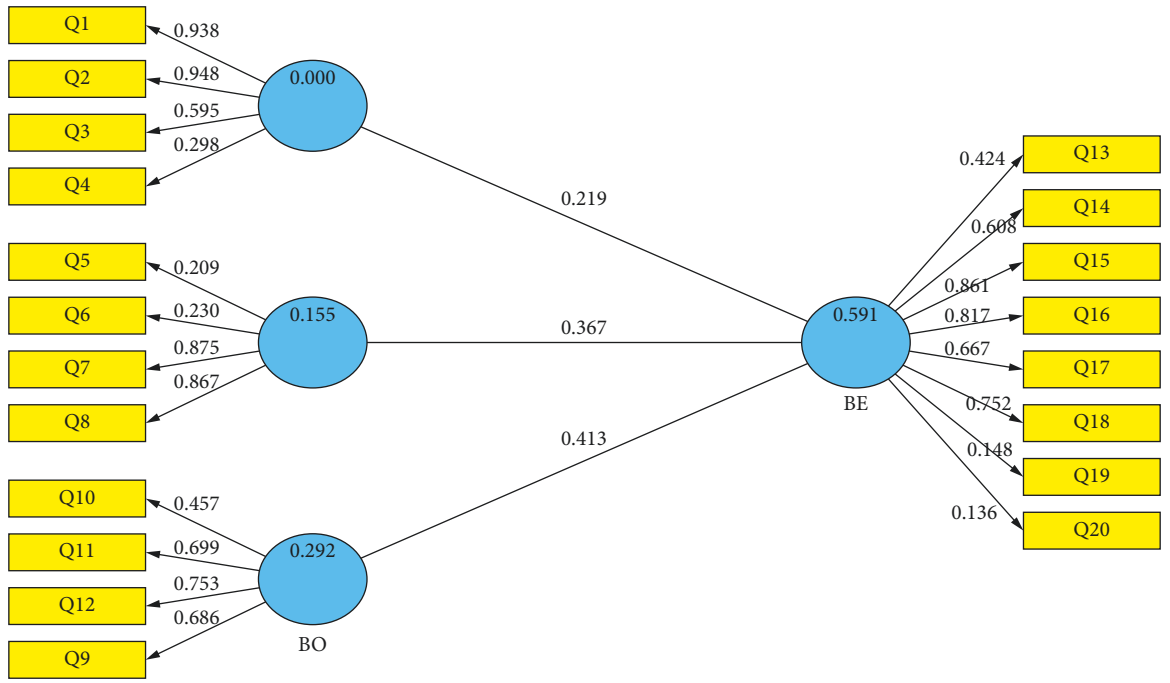

Figure 2: General model of standard research.

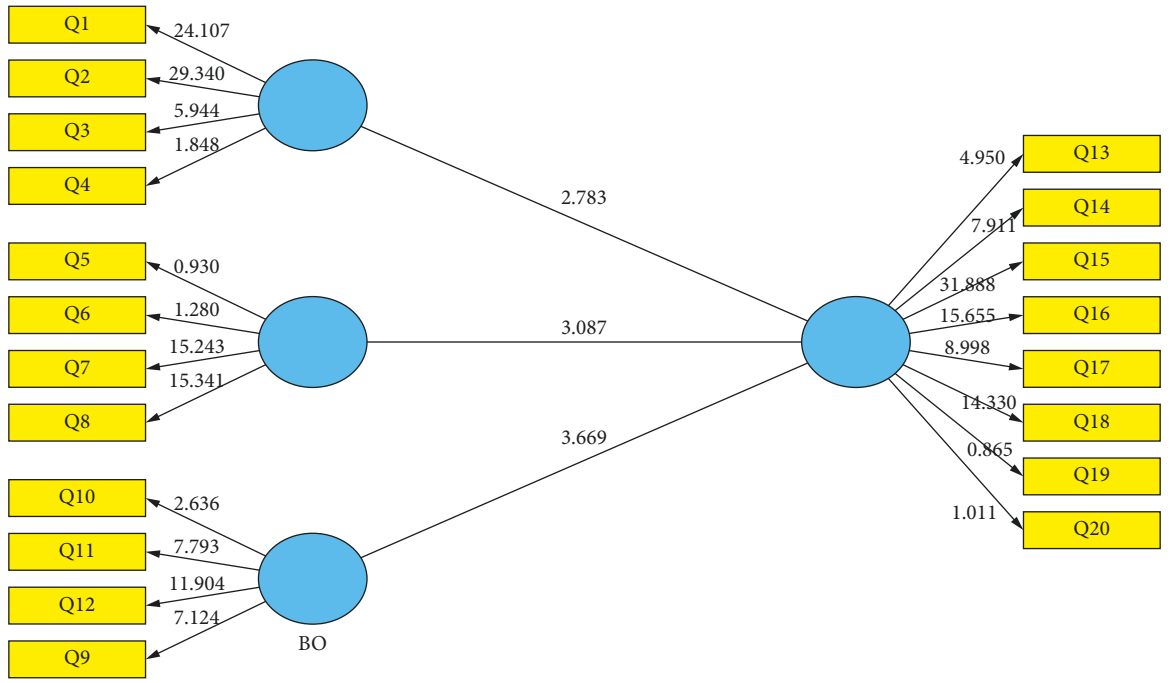

Figure 3: General model of research in a meaningful state.

Table 3: Conclusion of research hypotheses.

Hypothesis title	Test statistics	Beta coefficient	Result
The impact of human capital on business performance	2.873	0.219	H0 reject
The impact of structural capital on business performance	3.087	0.367	H0 reject
The impact of relationship capital on business performance	3.369	0.413	H0 reject

Table 4: A quality test of the measurement model.

Variables	Quality index
Human capital	0.342
Structural capital	0.349
Relational capital	0.465
Business performance	0.356

Table 5: Appropriate index of CV Com [6].

Strong	Medium	Poor
0.35	0.15	0.02

The positive values of the CV Red index indicate the appropriate quality of the structural model. According to Cohen, the appropriate weight for this index is as follows (see Tables 6 and 7).

Therefore, according to Table 7, the structural model quality test results show that the relevant questions correctly predict all variables.

4.3. PLS General Model Test (GOF). This model fit index has been proposed to evaluate the fit of models of internal equations and external measurements of data simultaneously. This index is the square of the product of the average values of the shared values and the average of the coefficients of determination. According to China (1998), this index should be at least 0.2, but ideally higher than 0.3, so Tables 8 and 9 state that the endogenous (dependent) variable has achieved the ideal value.

$$\text{GOF} = \sqrt{(\text{communality}) \times (\text{R square})}. \quad (2)$$

Therefore, the calculated value (GOF) is 1.41, indicating the model's good fit for the data. Hypothesis 4: customer knowledge management as a moderating variable has a moderating effect on the relationship between intellectual capital and business performance.

According to Table 10, since the total beta value in all variables is more than 0.3, the mediator hypothesis has been confirmed and can be inferred as follows. Hypothesis 4: the research indicates that the variable of customer knowledge management has an adjusting effect on the relationship between intellectual capital and business performance. Given that the value of the total impact obtained for this relation was more significant than 0.6, this correlation is desirable, and this hypothesis is confirmed.

5. Discussion

All the factors influencing knowledge management, especially in service-financial companies, should be considered in light of the knowledge management framework in order to effectively utilize intellectual capital. Also, design and implement an IT performance evaluation system to evaluate employee participation to apply knowledge and use knowledge assets. This issue can be considered one of the job requirements of people in foster care. It is also suggested that the motivational system of the developer encourages them to learn more about organizational learning, and help their colleagues apply what they have learned in the workplace. By examining successful organizations using intellectual capital, new strategies for acquiring knowledge should be taught to managers and employees. Customer knowledge is to design new systems and methods for acquiring customer knowledge, and senior managers have effective communication and partnership with organizations that have been successful in this field. Strengthening employee commitment to the organization and improving take place by supporting group activities, positive thinking, and trusting employees. It is suggested that Bank Mellat show their continuous support and responsibility to initiate and maintain efforts to implement customer knowledge management.

Developing a competency framework for employees and managers, which includes knowledge and skills,

Table 6: Structural model test.

Research variable	CV Red
Human capital	0.357
Structural capital	0.342
Relational capital	0.356
Business performance	0.349

Table 7: Appropriate index of CV Red (Cohen, 2009).

Strong	Medium	Poor
0.67	0.33	0.19

Table 8: The variance described for the dependent variables.

The dependent variable	R^2
Business performance	0.97

Table 9: Average of common values.

Research variable	Communality
Human capital	0.361
Structural capital	0.448
Relational capital	0.390
Business performance	0.514

Table 10: Test of mediating hypotheses.

Hypothesis	Standard beta value					Result
The relationship between intellectual capital and business performance	$\beta 3$	$\beta 2$		0.82		Approved
The role of customer knowledge management concerning intellectual capital and business performance	Customer knowledge management and intellectual capital	Customer knowledge management and business performance	Total effect	Indirect effect	Direct effect	
	0.42	0.68	0.87	0.42	0.59	

abilities, and a plan for their development. Continual assessment of employee competency levels and succession planning at various organizational levels. Evaluate business performance continuously and analyze the results of employee performance measurement, comparing the results of these measurements. Hold meetings, public hearings, and discussions on the use of new information technology and other knowledge-related topics for all employees in organizations and companies. Create a customer knowledge electronic database in the bank so that people can share their tacit knowledge without the need for face-to-face encounters with tools such as e-mail, chat groups, chat rooms, and audio and video conferencing. Carry out strategic planning to identify opportunities and threats to the external environment and internal strengths and weaknesses when drafting contracts and agreements. Use advanced structures such as team and project structures in different parts of the organization. Identify those key processes that are most valuable to the client (customer), document these processes, and identify and apply the experiences of domestic and foreign competitors. The following suggestions are made based on the findings of this study and its limitations. Due to the importance and the unique position of intellectual capital in various fields, research such as this study should be expanded and conducted at various levels. Investigate the obstacles and problems in implementing customer knowledge management following the performance characteristics of the organization. Other researchers are suggested to increase the generalizability of the results of this research by researching other organizations, other statistical communities, and different levels of education by comparing their results with each other.

Limitations are considered an integral part of the research. These constraints provide the conditions for future research. This study was no exception to this rule. One of the problems of the present study is the limitation of access to resources related to intellectual capital and its components in libraries, universities, and other organizations in the country. Due to time constraints, the questionnaire was distributed only in Tehran, which should have been included in other cities for more accuracy.

6. Conclusion

The three dimensions of intellectual capital have been studied using structural equations, namely, human capital, structural capital, and communication capital, through structural equations, showing the positive effect and the relationship between these dimensions and business performance. According to numerous studies, it is accepted that organizations with high levels of knowledge management and intellectual capital development are likely to be more successful than their competitors. Therefore, the issues of organizational knowledge and intellectual capital are considered the central part of the discussions of organizations and service companies. According to customer knowledge management, successful managers are deemed to be able to produce and develop more money in this regard. Our findings show that corporate executives need to recognize the key role of developing customer knowledge management in current employees and, in doing so, consider developing human capital, structural capital, and communication capital to deliver what it has promised. According to the research results, the following are suggested.

To effectively utilize intellectual capital in organizations, especially service-financial companies, all knowledge management influencing factors must be considered within the framework. New strategies for acquiring knowledge should be taught to managers and employees by analyzing successful organizations that utilize intellectual capital. It is recommended that Bank Mellat demonstrate ongoing support and responsibility for initiating and sustaining efforts to implement customer knowledge management.

Design a competency framework for employees and managers, which includes knowledge and skills, and plan their development based on their competencies. Using tools such as e-mail, chat groups, chat rooms, and audio and video conferencing, people can share tacit knowledge without the need for face-to-face interactions by utilizing a customer knowledge electronic database in the bank. When drafting contracts and agreements, conduct strategic planning to identify opportunities and threats in the external environment as well as internal strengths and weaknesses. Other researchers are encouraged to broaden the applicability of this study's findings by investigating additional organizations, statistical communities, and educational levels.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Hindawi
Discrete Dynamics in Nature and Society
Volume 2022, Article ID 1126772, 14 pages
https://doi.org/10.1155/2022/1126772

Research Article

The Impact of Cognitive Heterogeneity on the Behavioral Integration of the R&D Team: The Perspective of Conflict Management

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Received 6 February 2022; Revised 25 June 2022; Accepted 15 September 2022; Published 22 September 2022

Academic Editor: Jiafu Su

The impact of team heterogeneity on team effectiveness has received extensive attention. The paper aims to explore the mechanism of the effect of cognitive heterogeneity on behavioral integration in R&D teams. Based on the IPO theory, this study proposed six hypotheses about how cognitive heterogeneity directly and indirectly (via team conflict and conflict management) affect behavioral integration in R&D teams. Using data collected from 383 R&D teams in 326 high-tech enterprises in China, we investigated whether the dimensions of team conflict mediate the relationship between cognitive heterogeneity and behavioral integration and whether the dimensions of conflict management regulate the impact of cognitive heterogeneity on behavioral integration. The results show the following: (1) cognitive heterogeneity has a significant negative impact on the behavioral integration of *R&D* teams. Task conflict and relationship conflict fully mediate the relationship between cognitive heterogeneity and behavioral integration. (2) Cooperative conflict management positively moderates the impact of cognitive heterogeneity on task conflict and the impact of task conflict on team behavioral integration. (3) Avoidance conflict management reversely adjusts the positive impact of cognitive heterogeneity on task conflict and relationship conflict and the negative impact of relationship conflict on team behavioral integration. The research results can provide theoretical guidance to improve the process management of cognitive heterogeneity R&D teams.

1. Introduction

The arrival of the fourth industrial revolution has increased the complexity and changeability of manufacturing technology systems. As a result, enterprise technological innovation increasingly relies on teamwork. In recent decades, there has been increasing significant interest in the key factors affecting team collaboration and team effectiveness, and significant attention has been paid to how heterogeneity affects team collaboration and team effectiveness. For example, the cognitive heterogeneity of research and development (R&D) teams is a key element affecting team performance. In recent years, there has been increased research on the impact of cognitive heterogeneity on team innovation performance. However, research specific to R&D in this area has not yet reached clear and consistent conclusions. Because the essence of R&D work is knowledge generation, the demands on R&D team for member heterogeneity are increasing as the complexity of the technology system grows. Furthermore, the operation efficiency of R&D team is heavily dependent on team members' interaction behavior. The R&D team performance will be directly affected by the decision participation and benign interaction of team members. Although team heterogeneity is common in many types of teams, the performance of an R&D team is strongly dependent on the team's heterogeneity and behavior integration, and the boundary of the R&D team is well-defined. We can

effectively and precisely grasp the scope of the members, and it is easy to control the error when collecting data. Therefore, this study is very important and valuable to consider the R&D team.

The mechanisms by which heterogeneity influences team behavioral integration is a vital scientific problem that deserves attention. Given the important impact of behavioral integration on organizations, significant research has been conducted on the antecedent elements of this integration at the team level. Chen and Zhang noted that the emotional intelligence of senior leaders and the team is an antecedent variable for the behavioral integration of senior leadership teams [1]. Cheng et al. [2] posited that the team structure can be improved through resources and rules, promoting team-level behavioral integration. Some scholars have explained the differences in team behavioral integration from the perspective of team heterogeneity. He and Wang [3] noted that differences in the behavioral integration of a university leadership team could be explained from the perspective of team identity. Furthermore, Yao and Sun [4] found a significant negative correlation between team heterogeneity and team behavioral integration. Some studies have shown that conflict among team members directly impacts behavioral integration [5], and that cognitive heterogeneity of the team is one of the main causes of team conflict [6].

In previous studies, the relationship between team heterogeneity and team behavior integration is mostly studied from the organizational and leadership levels, however, the perspective of conflict and conflict management have received little attention. Previous studies have explored the mechanisms involved in the formation of heterogeneous team behavioral integration. However, further research is needed to explore the different mechanisms by which team heterogeneity affects such integration. Existing studies have shown that diverse thoughts across cognitively heterogeneous members help them propose multiple solutions, thereby improving innovation performance of the R&D team. Heterogeneity can provide structural advantages to these types of teams [7, 8]. However, cognitive heterogeneity may simultaneously lead to conflicts and contradictions among members, undermining cooperation, and leading to disadvantages in the innovation process [9]. Gaining a deeper appreciation of the perspective of conflict and conflict management can provide the researchers with valuable insight for team behavioral integration of heterogeneous team. From an IPO (input-process-output) perspective, the impact of R&D team heterogeneity (input) on team innovation performance (output) is mainly affected by team process [10]. When heterogeneous team members experience good interaction and cooperation, the team can simultaneously maximize structural and process advantages. Methods for realizing the behavioral integration of the cognitively heterogeneous innovation team play a key role in improving R&D innovation performance. It allows the cognitively heterogeneous R&D team to gain both structural and process advantages.

This study examines the mediating effect of conflict on the team behavioral integration of the heterogeneous team and the moderating effect of conflict management on the whole process. The new research perspective can inject new thinking into a commonplace question. There remains a lack of effective theoretical guidance on how to improve the level of heterogeneous innovation through team behavioral integration. To address this topic, this study focuses on conflict management. From an IPO (input-process-output) perspective, the impact of R&D team heterogeneity (input) on team innovation performance (output) is mainly affected by the team process [10]. When heterogeneous team members experience good interaction and cooperation, the team can simultaneously maximize structural and process advantages, discussing the impact of team cognitive heterogeneity on team conflict and team behavioral integration from the perspective of team process. This paper proposes that team conflict plays a mediating role between team heterogeneity and behavioral integration. The paper then analyzes the regulatory role of conflict management between cognitive heterogeneity and team conflict, verifies the research hypothesis through empirical analysis, and discusses the research results. Based on the IPO theory, this study proposed six hypotheses about how cognitive heterogeneity directly and indirectly (via team conflict and conflict management) affected behavioral integration in R&D teams. Using data collected from 383 R&D teams in 326 hightech enterprises in China, we investigated whether the dimensions of team conflict mediate the relationship between cognitive heterogeneity and behavioral integration and whether the dimensions of conflict management regulate the impact of cognitive heterogeneity on behavioral integration. The study reveals the mechanism of cognitive heterogeneity affecting team behavioral integration from the perspective of conflict and proposes related countermeasures to improve the level of heterogeneous R&D team behavioral integration. The study also extends and further develops team process theory, helps improve the behavioral integration fragments of heterogeneous innovation teams, and provides theoretical guidance for improving the management of R&D teams. In terms of practical implications, firstly, team task conflict and team behavioral integration are essential factors affecting team creativity in R&D heterogeneous teams, while relationship conflict is the opposite. It means that when dealing with team-level conflicts, we can encourage team members to express different opinions, and there can be arguments based on no harm and no interpersonal conflicts. On this basis, it is more conducive to the creativity of the R&D team. Secondly, on the way of enterprise development and enterprise management, team innovation needs to be paid attention to and cultivated, because innovation is a key factor for the survival and success of enterprises [11]. Managers need to use the internal advantages of enterprises to create more value. The behavioral integration in the team is also a key process to promote innovation. Hence, it is necessary to study the relationship between the antecedents of team behavioral integration and team behavioral integration. This study also provides some practical guidance for the development of heterogeneous R&D teams.

2. Theoretical Framework and Hypotheses

2.1. Cognitive Heterogeneity of R&D Team and Team Behavioral Integration. Heterogeneity occurs at the statistical population level and at the individual cognitive level [12]. Cognitive heterogeneity refers to individual differences in cognitive variables, including values, attitudes, and beliefs. At the organizational level, team cognitive heterogeneity reflects differences in views and in behavioral preferences among team members on the same topic. Cognitive models determine how individuals view, raise, and solve problems [13]. The cognitive heterogeneity of an R&D team generally reflects the degree of differences in team members' beliefs and preferences about innovation. Cognitive diversity teams outperform homogeneous groups in terms of innovation prerequisites, as well as the ability to absorb and integrate new knowledge and develop new ideas [14, 15]. According to the high-level echelon theory, team heterogeneity may affect team outcomes [16]. Previous studies have indicated that team heterogeneity was positively related to team outcomes. Specifically, Huang et al. studied that heterogeneity (e.g., discipline heterogeneity, cognitive heterogeneity, and organizational heterogeneity) induced by interdisciplinary team cooperation has a significantly positive impact on team innovation performance [17]. A cognitively heterogeneous R&D team means that the personnel bring different views and understandings with respect to the associated work. The resulting collision of different views can provide diversified solutions for problem solving, improving team creativity [15]. However, some researchers came to different results, such as the findings that teams with high heterogeneity may have more disputes and cooperation costs [18]. While the team's cognitive heterogeneity can bring diverse information, it can also blur information and increase frustration, negatively impacting communication and interactions between team members. It can damage team cohesion and a shared understanding of requirements [19].

The concept of team behavioral integration has often appeared in organizational studies through the analyses of enterprise senior management teams. Liu et al. [20] and Qu [21] extended the concept of senior management team behavioral integration to R&D teams. In this context, behavioral integration is an aggregation concept with three dimensions: team cooperation, information exchange, and joint decision-making [22]. A core value of behavioral integration is "sharing" [4]. Yao and Sun [23] proposed that the internal mechanisms of behavioral integration include the dual processes of "harmony with difference" and "harmony through difference." When team members have different opinions or opinions on an issue, members' identification with the team is key to understanding team behavioral integration [3]. The disparities in professional knowledge and skills, thinking mode, global outlook, and judgment of good and wrong are all examples of cognitive heterogeneity in this research. Differences in professional knowledge and skills are particularly important in the decision-making of problem-solving service team. Furthermore, cognitive heterogeneity can aid team members in completing complicated tasks and has a significant impact on team process and outcomes. Previous research has indicated that differences in professional knowledge and skills might positively or negatively affect team performance [24], implying that the impact of heterogeneous teams on team process results is largely dependent on the team's environment [25].

Williams and O'Reilly [26] found that significant differences in the values and communication patterns of organization members can damage team identity. It can adversely affect communication and cooperation within the team. Therefore, an increase in the cognitive heterogeneity of the R&D team may be associated with a reduction in the members' sense of team identity. It further inhibits the communication and interaction between members, reducing the level of behavioral integration. According to Hambrick et al. [27], while heterogeneity may provide a broader range of cognitive resources for the management team, it may also cause team members to be divided, making the information exchange within the team to be problematic. Therefore, integrating ideas and opinions within the team and reducing negative conflicts are critical. The cognitive heterogeneity of R&D team is likely to have a negative impact on team process under the poor team's environment. This background leads to the following hypothesis:

> Hypothesis 1: R&D team cognitive heterogeneity negatively impacts team behavioral integration.

2.2. The Mediating Effect of R&D Team Conflict. Team cognitive heterogeneity reflects differences in team members' understanding of the world and modes of thought, including differences in subjective and nontask problems, such as personality, norms, or values. Previous studies have found that cognitive diversity improves team effectiveness, and it is thought to provide more extensive available knowledge for team development [28, 29]. Cognitive diversity can also help deepen the understanding of problems and enhance the ability to solve problems when addressing challenges [29]. During R&D teamwork, team members interact frequently to make decisions, solve problems, and find new innovation points. This frequent interaction can lead to conflicts and contradictions if there are significant differences in values and ways of thinking among team members [30].

Conflict begins when one considers that one's interests are, or are about to be, compromised, where another's actions are considered contrary to one's actions [31]. Because conflict is unavoidable in the organization and has a significant impact on team outcomes (e.g., team process or team creativity), this paper focuses on team conflict to investigate how team conflict affects team process. From the perspectives of organizational behavior and interdisciplinary research [32], conflict can be divided into two aspects, such as the within-person difference and the difference between individuals in the team [33]. This study adopted the concept of between-personal conflict, and it divided team conflict into task conflict and relationship conflict, according to Jehn and Mannix [34]. The task conflict in heterogeneous teams can also be identified as a cognitive conflict, which refers to

conflicts among team members about work contents or plans that result in a succession of frictions. Relational conflict is defined as the friction or antagonism among team members in interpersonal relationship, and sometimes, this type of conflict can also be taken as an emotional conflict [35]. These two conflicts might lead to different behaviors and different outcomes in the team [35, 36]. Cognitive heterogeneity leads to differences in the understanding and views of R&D team members with respect to tasks. Cognitively heterogeneous team members may propose different solutions and paths for the same task [34], leading to task conflicts. As the cognitive heterogeneity of the R&D team increases, the views proposed within the team are more diverse, leading to more pronounced task conflicts. In addition, from a social identity perspective, in a cognitively heterogeneous R&D team, the presence of similar and different opinions held can lead to the classification of team members into different types or small subgroups. Once classified or formed, the needs for self-esteem or self-interest may cause different team members to naturally identify with other members of the same type or subgroup, while depreciating or excluding other groups. It can aggravate conflicts and deteriorate interpersonal relationships among members of different groups, generating relational conflicts [37]. Improving behavioral integration despite this cognitive heterogeneity can help better manage the seriousness of relationship conflict. Thus, we propose the following:

Hypothesis 2a: R&D team cognitive heterogeneity has a positive impact on task conflict.

Hypothesis 2b: R&D team cognitive heterogeneity has a positive impact on relationship conflict.

R&D team behavioral integration is the result of team process [23]. Conflict is an important aspect of that process. Team behavioral integration is a dialectical process, where "difference" and "same" interact [3]. The team members' attitudes towars differences of opinion determine the direction of team process development. If team members objectively face differences of opinion and communicate and exchange information on a case-by-case basis, mutual communication may be smoother and team members' participation in decision-making may be improved. It may improve team cooperation and behavioral integration. In contrast, if team members are estranged by differences of opinion, or form fragmented small groups, it may reduce information communication flow, reduce members' participation in decision-making, damage team cooperation, and generate behavioral unconformity.

Task conflict can result in a heated debate, caused by team members' differences about the content of work tasks and ideas about completing tasks. It involves rational behavior about objective topics [38]. During task conflict, team member goals may be consistent, with the conflict mainly focusing on the path and method to achieve the goals. As task conflict arises from diverse viewpoints of team members, team members will actively exchange knowledge to better complete the task. Consequently, task conflict has the potential to broaden the knowledge scope of team members [36, 39]. Therefore, task conflict can help improve the level of information communication and decision-making participation among team members, supporting improved team behavioral integration.

In contrast, relationship conflict refers to interpersonal contradictions among team members, including mutual exclusion and personal attacks. They can be accompanied by anger, frustration, annoyance, and other negative emotions. They reflect the emotional behavior of specific subjects [38]. When there is a relationship conflict, information may be less effectively transmitted between team members because of emotional behavior and expression, making it is difficult to ensure the rational implementation of decision made and making the team prone to division. When team members experience the identity as a team member, they are more loyal and cooperative to prevent relationship conflict and then reduce team performance [40]. Team relationship conflicts are common in new risk teams [41, 42], and relationship conflict has also been shown to be deleterious to team effectiveness in team management research [40]. Vanaelst et al. [43] stated that interpersonal emotional conflict is the common reason for team members to leave the organization. Interpersonal emotional conflict has an impact on team stability. Lee et al. [44] suggested that team members may feel strongly different from other team members in terms of social distance when experiencing a relationship dispute, and their perception of collective identity as a group or team may weaken. This way of emphasizing social identity demonstrates that relational conflict weakens team members' engagement in the cooperation process, and negative emotions and conflict perceptions often impair individual cognition and attention, reducing team members' ability to accomplish tasks. When team members' attention is consumed, they are more likely to simplify or reduce the resources for information exchange and processing, limiting team members' scope of information processing of [45–47] and reducing team behavioral integration. Based on these, the hypotheses proposed are as follows:

Hypothesis 3a: R&D team task conflict positively impacts team behavioral integration.

Hypothesis 3b: R&D team relationship conflict negatively impacts team behavioral integration.

Cognitive heterogeneity does not have a direct linear impact on team behavioral integration. Rather, it can indirectly affect team behavioral integration through task and relationship conflict. Specifically, cognitive heterogeneity can lead to R&D team members having different views and understandings of R&D work [8]. Team members propose different solutions and paths for the same task, and there may be intense debate about the solution paths and methods, resulting in task conflict. However, despite this, because of the consistent goals of team members, task conflict may increase information sharing, joint decision-making, and team cooperation, improving the level of team behavioral integration. In addition, cognitive heterogeneity also means that R&D team members have significant differences in

beliefs, views, values, and other cognitive aspects [26]. These cognitive differences may lead to a sense of team member alienation. R&D team internalization may lead to multiple small groups with different views and values. If different groups are mutually exclusive, it can lead to relationship conflicts and emotional behavior and expression. It can negatively impact information sharing, joint decision-making, and cooperative behavior within the team, thus reducing the team behavioral integration level. It leads to the following hypotheses:

Hypothesis 4a: team task conflict plays a mediating role between team cognitive heterogeneity and team behavioral integration.

Hypothesis 4b: team relationship conflict plays a mediating role between team cognitive heterogeneity and team behavioral integration.

2.3. The Moderating Effect of R&D Team Conflict Management. Conflict management refers to a team's holistic understanding of the factors that trigger conflict, conflict cycle, conflict behavior, and conflict management system. The goals of conflict management are not to eliminate conflict but to try to control abnormal factors in the conflict and seek appropriate management methods to maximize the constructive function of conflict [48]. There are many styles of conflict management. Tjosvold et al. [49] divided conflict management into three types: cooperative, competitive, and avoidant. Cooperative conflict management refers to meeting the interests of all parties by promoting cooperation and achieving mutual benefit and win-win results guided by common goals [49]. Competitive conflict management occurs when each party maximizes their own interests, without considering the interests of other parties. Avoidant conflict management means that team members are aware of the presence of conflict, and they avoid and suppress differences to reduce team member friction and ease the tension.

According to the literature on team conflict management, good interaction can help team members to recognize and discuss conflicts publicly rather than avoid or deal with them via competition, which can lead to more effective conflict management [50, 51]. Some scholars believe that positive management strategies, such as problem-solving, cooperation, and collaboration, appear to slow down the destructiveness of some conflicts and enlarge the benefits of some conflicts on team effectiveness, and the effects of passive management tactics, such as adaptation, avoidance, or other aggressive behaviors, including competition and confrontation, appear to be ineffective [52]. The cooperative approach for conflict management can be used to promote common goals and resolve shared interests in team conflicts. However, the stakeholders' goals are negatively connected, which is a core premise in team conflict management. Thus, those who adopt the competitive approach will achieve their own goals at the expense of others' goals under the conflict situation [53]. Besides, avoidance is an attempt and conveys the intention that issues should not be dealt with and discussed openly [54]. Therefore, how to deal with and manage conflicts may exert the destructive or construction impact [55], representing that the conflict management style has a significant impact on R&D team stability [56]. Appropriate conflict management not only help resolve the short-term conflicts in R&D teams but also has a favorable impact on the team's long-term development [57]. Thus, it is necessary to identify alternative ways to manage and control conflicts rather than eliminate conflicts [48]. The way a team handles conflicts is more important than the conflict itself [18]. According to Tjosvold et al., [49] conflict management is fundamental for team development. In other words, the right conflict management strategy can help teams resolve negative conflicts and achieve positive outcomes [58].

In cognitively heterogeneous R&D teams, cooperative conflict management can promote the cooperation of all parties through a common goal orientation, and it can effectively promote a constructive debate. It can improve the level of task conflict and reduce relationship conflict. When competitive conflict management is adopted, the conflicts between the parties may intensify, promoting constructive debate. However, when the competition is excessive, the conflicts between the members may intensify further, transforming task conflict into relationship conflict. Finally, avoidant conflict management may inhibit the expression of team members' opinions, simultaneously reducing both the benefits and downsides of task conflict and relationship conflict. Based on this, the following hypothesis is proposed, which is based on the premise that H2a is valid.

Hypothesis 5a: the more team members tend to adopt cooperative conflict management, the more significant the positive effect of team cognitive heterogeneity is on task conflict.

Hypothesis 5b: the more team members tend to adopt competitive conflict management, the less significant the positive effect of team cognitive heterogeneity is on task conflict.

Hypothesis 5c: the more team members tend to adopt avoidance conflict management, the less significant the positive effect of team cognitive heterogeneity is on task conflict.

Based on this, the following hypothesis is proposed, which is based on the premise that H2b is valid.

Hypothesis 6a: the more team members tend to adopt cooperative conflict management, the less significant the positive effect of team cognitive heterogeneity is on relationship conflict.

Hypothesis 6b: the more team members tend to adopt competitive conflict management, the more significant the positive effect of team cognitive heterogeneity is on relationship conflict.

Hypothesis 6c: the more team members tend to adopt avoidant conflict management, the less significant the positive effect of team cognitive heterogeneity is on relationship conflict.

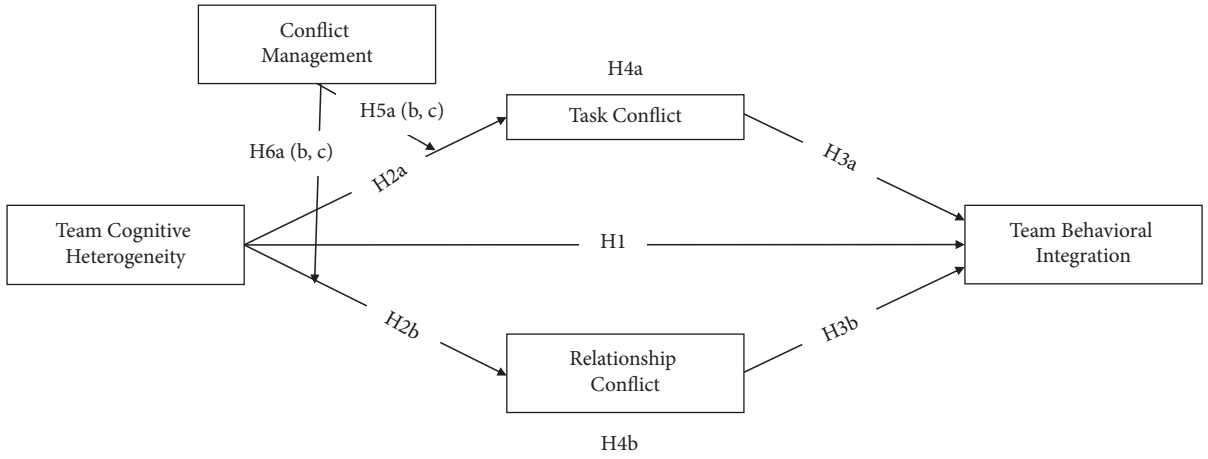


Figure 1: Conceptual model.

Taken together, Figure 1 depicts the study's conceptual model.

3. Research Methods

3.1. Sample and Data Collection. This study used a "sampling of convenience" method to select hightech enterprises with specialized R&D departments that were willing to participate in the survey. MBA and MEM trainees were used to help obtain R&D team cooperation. To participate, teams need to have at least 5 people and be established for at least 6 months. R&D team leaders or technical leads familiar with the team's operation were invited to complete the questionnaire. Using this approach, questionnaires were distributed to 433 R&D teams in 326 companies between September and December 2020. A total of 401 questionnaires were recovered at a recovery rate of 92.61%. After removing incorrect attitudes, gaps, omissions, and clear data irregularities and inconsistencies, a total of 383 valid surveys were obtained for a final response efficiency of 95.51%. This study was team focused, and hence, the individual characteristics of team members were not investigated.

The following data provide basic statistical information about the R&D teams. The number of R&D personnel in each team was as follows: 35.25% had 5 to 10 members, 40.73% had 10 to 15 members, 17.02% had 15 to 20 members, 5.53% had 20 to 25 members, and 1.47% had 25 to 30 members. Team formation time was as follows: 17.33% had been together for 6 months to 1 year, 32.12% had been together for 1 to 2 years, 25.51% had been together for 2 to 3 years, 16.40% had been together for 3 to 5 years, and 8.64% had been together more than 5 years. The nature of the enterprises was as follows: 47.56% were state-owned enterprises, 29.18% were private enterprises, and 23.26% were foreign-funded or Sino foreign joint ventures.

3.2. Measures

Dependent variable. Behavioral integration was assessed in three dimensions: teamwork, information exchange, and joint decision-making. These were measured using 12 survey items adapted from Hambrick [22], and Li and Hambrick [59], using a 5-point Likert scoring method.

Independent variable. Cognitive heterogeneity was assessed using a four-item measurement scale based on Van der Vegt and Janssen [60]. Using a 7-point Likert scale, items measured the extent to which R&D team members differ in their ways of thinking, knowledge and skills, ways of seeing the world, and perceptions of right and wrong, as perceived by the team lead or technical expert.

Mediator. Two dimensions of team conflict were assessed, namely task conflict and relationship conflict. These were assessed using 3 measurement items, adapted from a scale designed by Jehn and Mannix [34], using a Likert 5-point scoring method.

Moderator. Conflict management was measured using a scale with three dimensions: cooperative conflict management, competitive conflict management, and avoidance conflict management. They were assessed using 12 items developed by Tjosvold et al. [49], measured using a Likert 5-point scoring method.

Control variables. Based on previous studies, the control variables were as follows: *a*) size of R&D team: to control the impact of R&D team size effect on team behavioral integration, the number of members in the R&D teams was controlled between 5 and 30 because previous studies linked team size with team process and results. *b*) Team establishment time, also known as team tenure: only teams that had been together for more than 6 months were included in the study to avoid the impact of too short an establishment time on team behavioral integration [61, 62].

4. Research Results and Analysis

4.1. Variable Reliability and Validity Test. Cronbach's α values were used to assess the internal consistency of the items included in the multi-item scale. A Cronbach's

$\alpha > 0.70$ for all scales indicated that the data had credibility. KMO and Bartlett's sphericity tests were conducted for each variable. The KMO for cognitive heterogeneity = 0.701, KMO for task conflict = 0.706, KMO for relationship conflict = 0.704, KMO for cooperative conflict management = 0.764, KMO for competitive conflict management = 0.702, KMO for conflict avoidance management = 0.701, and KMO for team behavioral integration = 0.892. High KMO scores indicated that sampling was adequate and significant. Bartlett's spherical test of chi-square significance was also satisfied ($p < 0.001$), indicating that the sample was suitable for factor analysis.

A confirmatory factor analysis was conducted to test the discrimination of each variable. Table 1 shows the results. The one-factor model had the lowest degree of fit ($\chi 2/df = 4.756$, CFI = 0.49, IFI = 0.496, RMSEA = 0.138), and the seven-factor model had the highest degree of fit ($\chi 2/df = 1.658$, CFI = 0.918, IFI = 0.92, RMSEA = 0.058). It indicated that there was a good level of discriminant validity among the variables.

4.2. Descriptive Statistics and Correlation Analysis of Variables. Table 2 presents the means, standard deviations, and correlations between study variables. Several associations between study variables are noteworthy. Firstly, there were significant positive correlations between R&D team cognitive heterogeneity, relationship conflict, task conflict, and competition conflict management. Secondly, cognitive heterogeneity was negatively correlated with cooperative conflict management and team behavioral integration. Thirdly, task conflict was significantly and positively associated with relationship conflict, and there was a significant negative correlation between team behavioral integration and relationship conflict. Team behavioral integration was significantly and positively associated with relationship conflict, cooperation conflict management, and avoidance conflict management. There was no significant correlation between team behavioral integration and competition conflict management. Finally, there were significant correlations between the seven principal variables, indicating the need to test the mediation effect. The following sections examine the significance of these associations.

4.3. Direct Effect of Cognitive Heterogeneity on Behavioral Integration. A two-factor structure model was used to verify the main study effect, including an investigation of the overall effect of team cognitive heterogeneity on team behavioral integration. The standardized path coefficient showed that the cognitive heterogeneity of the R&D team had a significant negative impact on team behavioral integration ($b = -0.103$, $p < 0.05$), as shown in Figure 2. It verified hypothesis H1.

4.4. Mediation Analysis. To verify the mediating role of team conflict on R&D team cognitive heterogeneity and team behavioral integration, the mediating effect verification method embedded within the structural equation model was needed to demonstrate that the variables were significantly correlated. Table 2 shows a significant correlation between R&D team cognitive heterogeneity, team conflict, and team behavioral integration. The correlation indicates that there is a relationship between variables, however, it does not explain the causal relationship between variables and the size of the impact. Therefore, based on a correlation analysis of each factor, this study further analyzed the influence of the R&D team's cognitive heterogeneity on team behavioral integration using a structural equation model and tested the mediating effect of team conflict. AMOS23.0 was used to test multiple nested models. The results are shown in Table 3.

Table 3 shows that M1 is a direct effect model: the path is from team cognitive heterogeneity to relationship conflict, and from team cognitive heterogeneity to team behavioral integration. M2 is a partial mediation model. The path is from team cognitive heterogeneity to relationship conflict, and from relationship conflict to team behavioral integration. There is also an increase in the path from team cognitive heterogeneity to team behavioral integration. M3 is a complete mediation model. The path is from team cognitive heterogeneity to relationship conflict, and from relationship conflict to team behavioral integration. The matching index obtained from the analysis shows that the complete mediation model provides a good match. In contrast, the matching index of the direct impact model M1 and the partial mediation model M2 is relatively poor. The principle of model reduction indicates that the complete mediation model M3 is the best matching model. Similarly, M6 is the best matching model when compared with M4 and M5. The path coefficients of M3 and M6 are shown in Figure 3.

Figure 3 shows that team cognitive heterogeneity had a significant positive effect on task conflict and relationship conflict ($\beta = 0.417$, $p < 0.01$; $\beta = 0.432$, and $p < 0.01$). Task conflict had a significant positive effect on team behavioral integration ($\beta = 0.393$, $p < 0.01$), and relational conflict had a significant negative effect on team behavioral integration ($\beta = -0.406$, $p < 0.01$). The results verified hypotheses H2a, H2b, H3a, H3b, H4a, and H4b. In summary, task conflict and relationship conflict played a fully mediating role between R&D team cognitive heterogeneity and team behavioral integration.

4.5. Moderating Effect Test of Conflict Management. A hierarchical regression analysis was applied to test the moderating effect of conflict management between R&D team cognitive heterogeneity and team conflict. As indicated in Table 4, M7 is the benchmark model that only considers the impact of team cognitive heterogeneity on task conflict. M10 is the benchmark model that only considers the impact of team cognitive heterogeneity on relationship conflict. Based on M7 and M10, M8 and M11 add cooperative conflict management, competitive conflict management, and avoidance conflict management. Compared with the benchmark model, the ΔR^2 of M8 and M11 significantly increased, indicating that an increase in the three variables of cooperative conflict management, competitive conflict management, and avoidance conflict management improved the explanatory power of cognitive heterogeneity on team conflict.

Table 1: Confirmatory factor analysis.

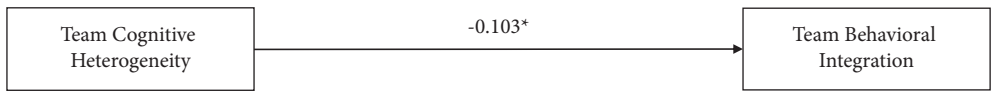
Model	$\chi 2/df$	Gfi	IFI	CFI	RMSEA
Seven-factor model: TCD, RC, TC, COCM, CMCM, ACM, BI	1.658	0.902	0.920	0.918	0.058
Six-factor model: TCD, RC + TC, COCM, CMCM, ACM, BI	1.970	0.867	0.879	0.876	0.070
Five-factor model: TCD, RC, TC, COCM + CMCM + ACM, BI	2.688	0.772	0.784	0.78	0.093
Four-factor model: TCD, RC + TC, COCM + CMCM + ACM, BI	3.759	0.632	0.640	0.634	0.118
Three-factor model: TCD + RC + TC, COCM + CMCM + ACM, BI	4.110	0.570	0.588	0.582	0.126
Two-factor model: TCD + RC + TC + COCM + CMCM + ACM, BI	4.141	0.562	0.581	0.575	0.126
One-factor model: TCD + RC + TC + COCM + CMCM + ACM + BI	4.756	0.478	0.496	0.490	0.138

Note. TCD represents team cognitive heterogeneity, RC represents relationship conflict, TC represents task conflict, COCM represents cooperative new conflict management, CMCM represents competitive conflict management, ACM represents avoidance conflict management, and BI represents behavioral integration.

Table 2: Descriptive statistics and correlation coefficient of variables.

Variable	Mean	S.D.	1	2	3	4	5	6	7
1. Cognitive heterogeneity	3.043	0.723	1						
2. Relationship conflict	3.127	0.719	0.512**	1					
3. Task conflict	3.214	0.683	0.483**	0.675**	1				
4. Cooperative conflict management	3.574	0.612	−0.185*	−0.319**	−0.201*	1			
5. Competition conflict management	3.112	0.568	0.374**	0.398**	0.425**	−0.117	1		
6. Avoidance conflict management	3.434	0.534	0.021	-0.084	-0.030	0.197**	0.241**	1	
7. Team behavioral integration	3.581	0.513	−0.162*	−0.374**	0.213**	0.532**	0.013	0.419**	1

Note. $N = 198$; S.D. = standard deviation. $^{*}p < 0.05$; $^{**}p < 0.01$.



Note. * $p < 0.05$.

Figure 2: Direct effect of cognitive heterogeneity on behavioral integration.

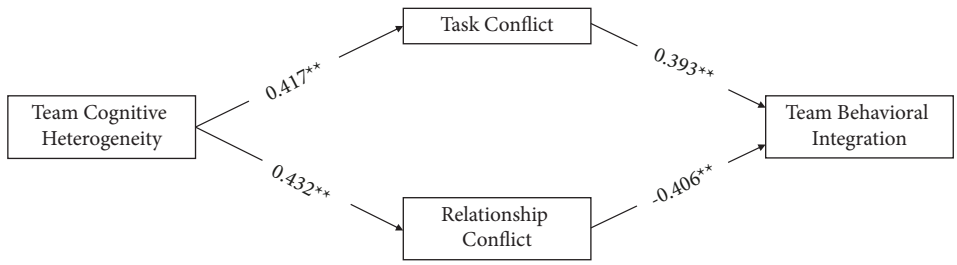
M9 and M12 added the product terms of cooperative conflict management, competitive conflict management, avoidance conflict management, and cognitive heterogeneity, based on M8 and M11, respectively. M9 and M12 tested the moderating effects of cooperative conflict management, competitive conflict management, and avoidance conflict management. All variables in M9 explained at least 53.3% of the change in task conflict, an increase of 10.4% over M8. The regression coefficient of interaction between cooperative conflict management and cognitive heterogeneity was 0.195, with a p-value < 0.1. The regression coefficient of interaction between avoidance conflict management and cognitive heterogeneity was −0.107, with a p-value < 0.05. Therefore, cooperative conflict management positively moderated the impact of cognitive heterogeneity on task conflict, verifying H5a. The moderating effect of competitive conflict management on cognitive heterogeneity and task conflict was not significant, and H5b was not supported. Avoidance conflict management had an inverse regulatory impact on the relationship between cognitive heterogeneity and task conflict, supporting hypothesis H5c.

All variables in M12 explained at least 51.2% of the change in relational conflict, which was 9.2% higher compared to M11 in explaining the change of relational conflict. The regression coefficient of the interaction between cooperative conflict management and cognitive heterogeneity was -0.093, at a p-value > 0.1. The regression coefficient of interaction between competitive conflict management and cognitive heterogeneity was 0.162, which was also at a p-value > 0.1. The regression coefficient of the interaction between avoidance conflict management and cognitive heterogeneity was −0.186 at a p-value < 0.01. Therefore, the moderating effect of cooperative conflict management on cognitive heterogeneity and relationship conflict was not found to be statistically significant, and hypothesis H6a was not verified. The moderating effect of competitive conflict management on cognitive heterogeneity and relationship conflict was not statistically significant, failing to support hypothesis H6b. Avoidance conflict management negatively moderated the impact of cognitive heterogeneity on relational conflict, verifying hypothesis H6c.

To demonstrate the moderating effect of cooperative conflict management and avoidance conflict management, cooperative conflict management and avoidance conflict management were grouped into subgroups at high and low levels. It was done to describe the impact of cognitive heterogeneity on task conflict and relationship conflict under different conflict management levels, as shown in Figure 4(a) and 4(b). Figure 4 shows that when the cooperative conflict management level was high, the positive impact of cognitive heterogeneity on task conflict was stronger compared to low cooperative conflict. When avoidance conflict management

Table 3: Comparison of matching indices between structural equation models with mediating effect.

Models	$\chi 2$/df	Gfi	IFI	CFI	RMSEA
M1 (Direct effect model): TCD⟶RC; TCD⟶BI	3.545	0.712	0.810	0.782	0.092
M2 (Partial mediation model): TCD⟶RC⟶BI; TCD⟶BI	2.413	0.810	0.899	0.854	0.078
M3 (Complete mediation model): TCD⟶RC⟶BI	1.957	0.917	0.931	0.922	0.061
M4 (Direct effect model): TCD⟶TC; TCD⟶BI	4.031	0.691	0.723	0.711	0.109
M5 (Partial mediation model): TCD⟶TC⟶BI; TCD⟶BI	3.031	0.827	0.863	0.843	0.097
M6 (Complete mediation model): TCD⟶TC⟶BI	2.154	0.901	0.496	0.49	0.083



Note. ** p< 0.10.

Figure 3: Influence path of team cognitive heterogeneity on team behavioral integration.

Table 4: The moderating effect of conflict management between cognitive heterogeneity and team conflict.

Variables	TC			RC		
	M7	M8	M9	M10	M11	M12
TCD	0.408∗∗	0.387∗∗	0.372∗∗	0.427∗∗	0.411∗∗	0.397∗∗
COCM		0.247∗∗	0.218∗∗		−0.139	−0.104
CMCM		−0.073	-0.064		0.267	0.241
ACM		−0.104∗	−.091∗		−0.112∗∗	−0.109∗∗
COCM∗TCD			0.195∗∗			-0.093
CMCM∗TCD			−0.083			0.162
ACM∗ TCD			−0.107∗			−0.186∗∗
R^2	0.403	0.429	0.533	0.398	0.420	0.512
ΔR^2		0.026	0.104		0.022	0.092
F	5.163∗∗	7.544∗∗	9.316∗∗	4.476∗∗	6.732∗∗	9.841∗∗

Note. ∗∗∗ $p < 0.001$; ∗∗ $p < 0.01$; ∗ $p < 0.05$.

level was high, the positive impact of cognitive heterogeneity on relational conflict was weaker compared to the level of avoidance conflict management. The results of hypotheses testing were finally summarized in Table 5.

5. Discussions

5.1. Findings. Based on previous research, this paper established a conceptual model of the impact of the cognitive heterogeneity of R&D teams on team behavioral integration. The study proposed a series of research hypotheses on the mediating role of team conflict and the moderating role of conflict management. The results of the empirical study show that some of the hypotheses were verified, with the following main findings.

(1) The cognitive heterogeneity of R&D teams has a significant negative impact on team behavioral integration. The empirical findings suggest that cognitive heterogeneity brings diverse solutions to R&D teams but adversely affects the quality of communication and cooperation among team members. It helps explain the difficulties R&D teams may have in gaining both structural and process advantages in the innovation process [9].

(2) Task conflict and relationship conflict fully mediate the effect of cognitive heterogeneity in R&D teams on team behavioral integration. Cognitive heterogeneity in R&D teams can stimulate team members to engage in high-quality arguments about solutions to R&D tasks, positively affecting team behavioral integration. However, it can also divide the team into multiple subgroups and create antagonistic conflicts among members, negatively affecting behavioral integration.

(3) Cooperative conflict management positively moderates the effect of cognitive heterogeneity on task conflict. Avoidant conflict management inversely moderates the effect of cognitive heterogeneity on task conflict and relational conflict. Cooperative conflict management facilitates task conflict by

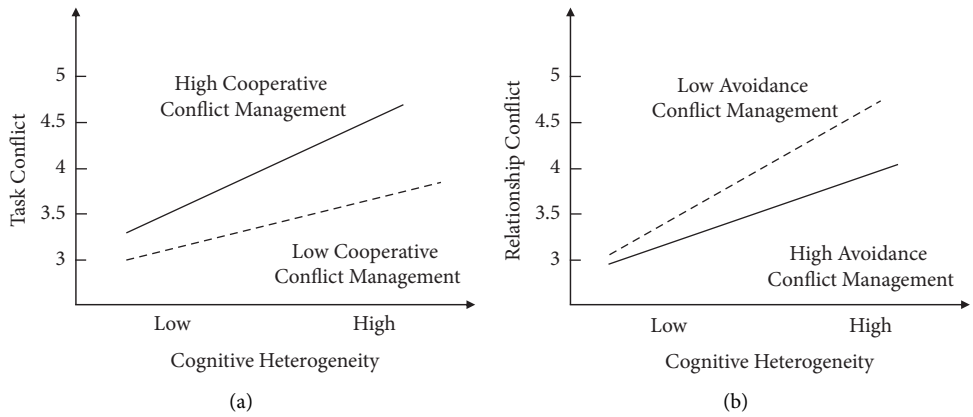


Figure 4: Moderating effect of conflict management on cognitive heterogeneity and team conflict. (a) Moderation of cooperative conflict management. (b) Moderation of avoidance conflict management.

Table 5: Verification results of moderating effect hypothesis.

Hypothesis	The contents of the hypothesis	Verified results
H5a	The more the team members tend to adopt cooperative conflict management, the more significant the positive effect of cognitive heterogeneity on task conflict.	Support
H5b	The more the team members tend to adopt competitive conflict management, the less significant the positive effect of cognitive heterogeneity on task conflict.	Nonsupport
H5c	The more the team members tend to adopt avoidance conflict management, the less significant the positive effect of cognitive heterogeneity on task conflict.	Support
H6a	The more the team members tend to adopt cooperative conflict management, the less significant the positive effect of cognitive heterogeneity on relational conflict.	Nonsupport
H6b	The more the team members tend to adopt competitive conflict management, the more significant the positive effect of cognitive heterogeneity on relationship conflict.	Nonsupport
H6c	The more the team members tend to adopt avoidance conflict management, the less significant the positive effect of cognitive heterogeneity on relationship conflict.	Support

guiding benign arguments among team members through common goals. In contrast, avoidant conflict leads to an inhibitory and evasive approach to addressing disputes among team members, simultaneously reducing task conflict and relational conflict.

(4) According to the testing results of the moderation effect hypothesis, H5b, H6a, and H6b are not supported. The data were collected in China, a country with a strong collectivism culture that contrasts with the culture that the conflict management theories assume [63, 64]. According to the examination result of H5a, in the high collectivism cultural setting, the radical competition management approach for task conflict is not significant in R&D teams with cognitive diversity. Based on the findings of H6a and H6b, when relationship conflict emerges as a result of the cognitive diversity in teams, the inability to take a construction and aggressive approach to addressing the problems suggests that the relationship conflict has hindered the team from engaging the process of good interaction and development. Conflict avoidance management reduces relational conflict caused by the team's cognitive heterogeneity, implying that in some situations, focusing on facilitating information exchange or decision-making will not be sufficient. A proper reduction in team relationship conflict will provide a constant source of motivation for the team's subsequent healthy development.

5.2. Theoretical Implications. Firstly, this study contributes to the conflict management literature from the perspectives of cognitive heterogeneity and focusing on R&D team context. This study identifies the effect of cognitive heterogeneity on task and relationship conflict management. The prior research on conflict management has focused on the personal, emotional, behavioral, and contextual factors to affect conflict management [65, 66]. The existing conflict management literature has also focused on the contexts of work teams [67], top management teams (TMTs) [68], project teams [65], etc. The cognitive heterogeneity is critical to conflict management in R&D team. However, it is ignored in the past. This study investigated and found the positive relationship between cognitive heterogeneity and team conflict management in the R&D team context and found

the moderating effects of different conflict management approaches, including cooperative and avoidance strategies.

Secondly, on the basis of the IPO model, this study identifies the impacts of cognitive heterogeneity and conflict management on behavioral integration, contributing to behavioral integration literature. In the past, scholars mainly investigated the mechanisms for behavioral integration from TMTs' perspective [69, 70] and based on the upper echelons theory [71]. However, less research focused on the effects of team heterogeneity and conflict management. Thus, this study found that task conflict played the positive mediation role between cognitive heterogeneity and behavioral integration, as well as that relationship conflict exerted the negative mediation role in this relationship.

5.3. Management Implications. Based on the results of the empirical study and the main findings, the following insights are presented for those managing heterogeneous R&D teams.

(1) Cognitive heterogeneity does not necessarily lead to improved innovation performance in R&D teams. While cognitive heterogeneity brings structural advantages, it may also bring process disadvantages. It highlights the need to strengthen the process management of cognitively heterogeneous R&D teams, which, in turn, should help improve the behavioral integration of these teams.

(2) Cognitive heterogeneity can trigger both task and relationship conflict among R&D team members. Both types of conflicts coexist [72]. Team task conflict positively affects team behavioral integration, while relationship conflict negatively affects team behavioral integration. To improve behavioral integration in R&D teams, the focus should be on enhancing task conflict among team members and decreasing relationship conflict using appropriate conflict management strategies.

(3) Cooperative conflict management promotes task conflict in teams and helps improve the level of behavioral integration in R&D teams. Therefore, when managing these heterogeneous teams, encouraging cooperative conflict management can help maximize constructive conflict and improve process efficiencies [49]. Avoidance conflict management can reduce the level of relational conflict in R&D teams and inhibit the negative effects of relational conflict on team behavioral integration. When there are small groups within R&D teams and there is serious intergroup antagonism, avoidance conflict management is not necessarily a less effective management tool. However, while avoidance conflict can reduce the level of relational conflict in teams, it can also inhibit productive task conflict, reducing constructive conflict.

5.4. Limitation and Future Research. This study makes significant contributions to the field of team management. However, there remain some limitations that deserve attention in future research. Firstly, this research focuses on R&D teams in high-tech enterprises in China. Future research should investigate teams in high-tech enterprises in other countries. Secondly, there are many types of team heterogeneity. This paper focuses on the impact of cognitive heterogeneity on the behavioral integration of R&D teams. Future studies should consider both knowledge heterogeneity and other antecedents affecting team effectiveness. Thirdly, a questionnaire survey was used as a data source for data collection. This method has some limitations, limiting the availability of some factors in data collection. Future studies could use case analysis or interviews to improve the research. Fourth, the object of this study includes R&D teams of hightech enterprises, limiting the universality of the research results. Future research should explore more meaningful representative teams and compare the results with this study to assess the universality of the conclusions.

6. Conclusions

The perspective of the effect and mechanism of team heterogeneity on behavioral integration in the R&D team context is less prevalent. This study investigated and tested the underlying mechanism of cognitive heterogeneity and behavioral integration through the data of 383 R&D teams collected from hightech enterprises in China. The results indicated that cognitive heterogeneity could increase the behavioral integration via task conflict and decrease the behavioral integration via relationship conflict. Furthermore, cooperative conflict management approach could facilitate the relationship between cognitive heterogeneity and task conflict. Avoidance conflict management approach would weaken the positive effects of cognitive heterogeneity on task and relationship conflicts. These findings provide insights into heterogeneity cognitive improvement, conflict management, and the integration of team members' behaviors for R&D teams.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

This study was funded by National Natural Science Foundation of China (Grant nos. 72162026, 72161021, and 71942006), Technical Research and Development Plan Project of China Academy of Railway Sciences Group Limited Company (Grant no. 2051YF7301), and Research Project of the Construction and Operation Mechanism of the National Sichuan-Tibet Railway Technology Innovation Centre (Grant no. 2020JDR0396).

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Hindawi
Discrete Dynamics in Nature and Society
Volume 2022, Article ID 4358132, 9 pages
https://doi.org/10.1155/2022/4358132

Research Article

Knowledge Sharing Motivation, Behavior, and Creativity of Knowledge Workers in Virtual Organizations

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Received 18 March 2022; Revised 11 May 2022; Accepted 17 June 2022; Published 8 August 2022

Academic Editor: Anibal Coronel

Focusing on the basic research subject of "seeking effective ways to enhance knowledge workers' creativity," this paper has surveyed a total of 208 employees from 11 Chinese high-tech enterprises. Based on review and analysis of relevant literature, this paper has constructed a moderating effect model including mediating factors relying on the social cognitive theory and tested the model by hierarchical multiple regression. The results show that there is a significant positive correlation between knowledge sharing motivation and creativity of members in a virtual organization. Knowledge sharing behavior plays a partial mediating role between knowledge sharing motivation and creativity, and self-efficacy moderates the complete mediating effect of knowledge sharing behavior on the relationship between knowledge sharing motivation and creativity. These conclusions enrich the theory of the relationship between knowledge sharing motivation and creativity, and enable enterprises to understand the importance of employees' knowledge sharing motivation and the ways to stimulate employees' creativity by activating their knowledge sharing behavior.

1. Introduction

Since its proposal in the 1990s [1], virtual organization has rapidly become a hot issue in the field of management research [2]. In terms of creativity, it is found in literature review that most of the existing literature analyzes employee creativity from two perspectives of personality traits and social interaction [3]. In recent years, studies have gradually shifted to explore the factors affecting the employee creativity and intrinsic mechanism [4], and have been increasingly related to psychology. Factors such as motivation and behavior are increasingly regarded as important factors affecting creativity [5]. As the research continues, scholars have realized that motivation and creativity are not simply of a direct effect, they can also be affected by a number of complex factors [6]. However, no systematic theoretical analysis and empirical research is available on the intrinsic influencing mechanism of knowledge workers' motivation and behavior on employee creativity, and there is a scarcely contextual study on how this relationship works. Therefore, it is of vital importance to study and clarify the intrinsic correlation and influencing mechanism between the motivation and creativity of knowledge workers.

Knowledge sharing is the process of providing or receiving task information and knowledge, helping or working with others to solve problems, and developing new ideas or implementing policies and procedures [7]. With the rapid development of the Internet, enterprises can set up virtual organizations for cooperation and communication more efficiently. It has been agreed that knowledge sharing plays a key role in enterprise development (access to knowledge resources and value) in today's era [8]. Huang et al. [9] believed that virtual organizations could share knowledge more freely and efficiently than traditional organizations. Pi et al. [10] held that employees would be more positive in knowledge sharing when they felt a positive atmosphere in the virtual organization. Choi [11] proved that in an organization, the more active the members were, the more they

could acquire knowledge from knowledge sharing. Moghavvemi et al. [12] argued that trust, reciprocity, and outcome expectancy were the main motivations for knowledge sharing among members of virtual organizations. Tha'er et al. [13] found that reciprocity and organizational identity were the main motivations for knowledge sharing, while trust exhibited no significant correlation with knowledge sharing motivation. Liao [14] pointed out that cognitive and social expected benefits were important factors influencing knowledge sharing intention in virtual organizations. Ma et al. [15] insisted that altruism was the primary motivation for knowledge sharing. Only Sun [16] and a few other scholars found that self-efficacy had a moderating effect on knowledge sharing motivation in virtual organizations.

The abovementioned analysis shows that despite many academic studies on knowledge sharing behavior in virtual organizations, there is no unified understanding of the motivations for knowledge sharing. The existing literature does not give a clear answer on how knowledge sharing motivation affects employee creativity, and the moderating effect of knowledge sharing motivation remains to be tested by empirical research. Allowing for the oversight of previous studies, this paper examines the influence of knowledge sharing motivation in virtual organizations on employee creativity with the help of a questionnaire, in an effort to make up the deficiencies in existing research.

2. Literature Review and Hypothesis Development

2.1. Knowledge Sharing Motivation and Employee Creativity in Virtual Organizations. Knowledge sharing is a unique and valuable resource that helps companies gain an edge over competition [17]. However, the flow of knowledge within an organization is not easy and knowledge sharing is usually not spontaneous [18]. Motivation is the action tendency of an individual to take a particular behavior, or rather, some degree of expression of whether or not to take this behavior guided by the decision process of the behavior choice. Therefore, motivation is the necessary process of any behavioral expression and is the decision before behavior emergence. Knowledge sharing motivation is manifested by employees' strong desire for knowledge sharing behavior [19]. In virtual organizations where information is exchanged more frequently, the cognitive ability and knowledge sharing behavior have enabled employees with strong knowledge sharing motivation to show passion and challenge for their work. As a result, these employees are more inclined to use innovative thinking to find a variety of solutions, ultimately exhibiting high creativity. Studies show that knowledge sharing motivation is the antecedent variable of knowledge sharing behavior, which determines the enthusiasm and level of employees' knowledge sharing behavior by using their expertise and creative thinking [20]. Employees with strong motivations for knowledge sharing tend to invest more time in trying to solve problems, plus have higher persistence [21]. Employees' perception of self-determined behavior is beneficial to increase their willingness to act creatively, and such input is closely related to employee creativity. Employees with strong knowledge sharing motivation tend to be curious and enthusiastic about their work, and they are more likely to explore innovative solutions spontaneously and proactively. These behaviors indicate that employees with stronger motivations for knowledge sharing can exhibit higher levels of creativity [22]. To sum up, this paper proposes the following.

Hypothesis 1. nowledge sharing motivation of virtual organization members has a positive influence on their creativity.

2.2. Mediating Effect of Knowledge Sharing Behavior. Knowledge sharing behavior is an important part of knowledge reorganization and innovation in knowledge sharing. Complex innovative behavior is mainly designed to meet the increasing needs of customers and serves as the product of the combination of knowledge resources and customers' ever-changing needs, with high dependence on knowledge resources and risks [23]. From the perspective of knowledge sharing motivation in virtual organizations, the innovation of complex knowledge products must depend heavily on the rapid exchange and transformation of knowledge between organizations using network information technology, so as to improve and update the knowledge resources of organizations. Therefore, knowledge sharing motivation encourages knowledge sharing behavior, which is also the key to innovation [24]. The social cognitive theory holds that behavior can be best explained by the ongoing interaction between cognitive and environmental factors. In practice, with a view to achieving job objectives, strong knowledge sharing motivation plays a critical role in enhancing employees' competence, and acquiring the knowledge and skills required to achieve employee creativity [25]. In virtual organizations, employees with strong knowledge sharing motivation realize that each individual cannot exhaust all knowledge and skills in the process of work alone, and knowledge sharing among members becomes necessary. Hence, they often seek to creatively complete tasks through knowledge sharing in different ways, and the core of this process is the motivation that determines the behavior. Effective knowledge sharing behavior will bring all kinds of expectations and beneficial results to individual employees. On the contrary, in order to minimize work barriers, employees' will, driven by the creativity vision, finds ways to enrich their working ability through knowledge sharing behavior, and keep pushing themselves and making them realize self-fulfillment in the process of knowledge sharing behavior. This process reveals the reason why employees with strong knowledge sharing motivation are more active in knowledge sharing. Therefore, employees with strong knowledge sharing motivation can deal with difficulties in work calmly and confidently through knowledge sharing behavior. To sum up, this paper proposes the following.

Hypothesis 2. Knowledge sharing motivation of virtual organization members has a positive influence on their knowledge sharing behavior.

One of the key factors for an organization to realize creative activities is the knowledge sharing behavior among employees. This psychological process and behavior practice are also important factors in organizational knowledge management and innovation, and employees' knowledge sharing behavior affects their creativity to a large extent [26]. Knowledge sharing among employees often produces better results and achievements than individuals and is more conducive to facing challenges, thus enhancing employee creativity [27]. Kessler and Chakrabarti [28] pointed out that knowledge sharing behavior helped to reduce the R&D cost of products and increase the speed of product innovation. Based on the research of a large multidivision electronics enterprise, Hansen [29] pointed out that the higher the knowledge sharing level of the project team, the faster the completion of the new product development. In addition, with the dissemination and sharing of explicit knowledge such as reports and technical documents among key stakeholders, new knowledge can be created, thus improving the system and function of products, and improving the quality of product innovation. Based on the case study of biotechnology and the medical engineering industry, Johnson and Lorenz [30] proposed that appropriate knowledge sharing could substantially shorten the innovation process and thus accelerate the speed of innovation in complex product R&D. Meanwhile, in the R&D of complex products, key stakeholders can share their experiences and lessons by means of in-depth face-to-face interaction and communication, so as to promote the generation of new knowledge, solutions, and ideas. Moreover, these new knowledge and solutions are not easily imitated by competitors, avoiding the rigidity of innovation capability, which is conducive to improving the innovation quality in the R&D of complex products [31]. To sum up, this paper proposes the following.

Hypothesis 3. Knowledge sharing behavior among virtual organization members has a positive influence on their creativity.

According to the literature review, there is a flood of literature on knowledge sharing motivation as an antecedent variable of creativity. However, the theoretical research and empirical test of knowledge sharing behavior as the mediating variable between them are still lacking. Employees with strong knowledge sharing motivation will take diversified paths to share knowledge. At work, they often accumulate experiences, knowledge, and skills through knowledge sharing to solve difficult problems and complete some challenging and complex tasks, thus enhancing their creativity. From another perspective, employees with strong knowledge sharing motivation can get access to social networks and knowledge resources, and enhance personal expression, in addition to higher creativity. These benefits will encourage employees to adopt more diversified, effective, and sustainable knowledge sharing behaviors. This process is conducive to inspiring new ideas related to the task at work, which in turn promotes the creativity of employees [32]. Based on the findings available, we propose that knowledge sharing behavior plays a mediating role in the influence of knowledge sharing motivation on employee creativity, and employees' knowledge sharing motivation has an effect on creativity through their knowledge sharing behavior. Hence, this paper proposes the following.

Hypothesis 4. nowledge sharing behavior mediates the influencing mechanism of employees' knowledge sharing motivation on creativity.

2.3. Moderating Effect of Self-Efficacy. Employees' knowledge sharing motivation does not simply have a direct effect on employee creativity; instead, its influencing and effectiveness mechanisms are situation-specific, namely, employees' knowledge sharing motivation features contingency in its influencing mechanism on creativity. Self-efficacy is the basis of human initiative. It involves the belief whether an individual can achieve results at work, including overcoming difficulties and challenges creatively, and completing tasks with confidence [33]. Self-efficacy reflects the direction of individual behavior and exerts a certain influence on individual behavior. However, the origin and final effect of individual behavior are common problems faced by scholars and managers, and this problem is most easily ignored in management practice. The cognition and research of efficacy have been extended to the micro level of organizational behavior and human resources. Subject to the research situation, most of the research on self-efficacy (if any) is limited to education. Self-efficacy is related to knowledge sharing behavior; employees' confidence in self-competence has a positive impact on their knowledge sharing behavior. Social psychologists tell us that knowledge sharing behavior can promote self-worth and reciprocal relationships among employees. Employees with high self-efficacy tend to be more efficient and diversified in knowledge sharing activities, and they are more confident, which keeps them more active in knowledge sharing [34]. Further analysis shows that employees with high self-efficacy are more active in knowledge sharing activities, and their knowledge sharing frequency and level are higher than those with low self-efficacy. Accordingly, we propose the following.

Hypothesis 5. Self-efficacy plays a moderating role in the influence of employees' knowledge sharing motivation on knowledge sharing behavior.

Based on the abovementioned information, this paper assumes that knowledge sharing behavior plays a mediating role in the mechanism of employees' knowledge sharing motivation and creativity, and the strength of this role depends on the specific situation of employees' perception of self-efficacy. It is found in literature review that self-efficacy is an important factor to mobilize individual creativity and will significantly affect an individual's creativity [35, 36]. Employees with higher self-efficacy are more active in knowledge sharing and show more positive attitudes and behaviors when encountering difficulties, thus presenting

higher creativity. From another point of view, employees with high self-efficacy are featured by a greater influence of knowledge sharing motivation on their knowledge sharing behavior, i.e., employees' knowledge sharing behavior plays a more conductive role in the influencing mechanism of knowledge sharing motivation on their creativity. On the contrary, employees with low self-efficacy are less active in knowledge sharing than those with high self-efficacy. Therefore, for employees with low self-efficacy, knowledge sharing motivation has a relatively weak influence on their knowledge sharing behavior. Accordingly, this paper proposes the following.

Hypothesis 6. Self-efficacy positively moderates the mediating effect of knowledge sharing behavior on the influencing mechanism between knowledge sharing motivation and creativity.

3. Questionnaire Design and Research Samples

3.1. Questionnaire Design. The questionnaire in this study is designed by collating the literature on knowledge sharing and innovation among members of virtual organizations [37, 38]. The questionnaire design has been based on the interview opinions of four scholars in the field of virtual organization and innovation management, and three operation executives from virtual organizations to modify the content and wording of the questionnaire.

The virtual organization is a dynamic alliance that shares core capabilities of enterprises through a network IT platform, characterized by innovative modularization and platform virtualization. Therefore, the samples in this study are mainly taken from industry enterprises with the popularization of network IT and convenient online connections such as e-commerce, information electronics, energy conservation and environmental protection, education, and cultural and creative products. Meanwhile, allowing for the essential attributes of innovation in virtual organizations, the sample selection has to meet the following conditions: (1) in the past three years, enterprises have had clear partners in product R&D, manufacturing, sales or service, and other value chain links, and worked with partners for innovation through online network technologies; (2) enterprises have access to outsourcing services in product or project R&D, manufacturing, marketing, and other innovative links; (3) enterprises feature a good environment for knowledge sharing.

The respondents of the questionnaire are mainly targeted at virtual organizations based on the R&D, publicity and development, and organization departments of enterprises that are most likely to share knowledge frequently, so as to ensure the filling level and quality of the questionnaire, and the accuracy and completeness of the questionnaire items. In this study, the questionnaires are mainly distributed in two ways: (i) paper questionnaires are distributed to the selected enterprises and collected on the spot; (ii) electronic questionnaires by Wenjuanxing, e-mail, and OA among others. Finally, 67 paper and 175 electronic questionnaires (totaling 242) were distributed, and 230 were collected. Excluding 18 questionnaires with incomplete basic information or unqualified sample selection, and 4 with incomplete item answers or too short filling time, 208 valid questionnaires were finally obtained, with a valid questionnaire recovery of 85.95%. In terms of sample distribution, 52.17% were males. In the age distribution, those under 35 accounted for 59.62%, those aged 35–55 for 15.38%, and those over 55 for 7.69%. In terms of education, those with a bachelor's degree or below accounted for 63.94%, and those with a master's degree or above accounted for 31.26%. The structural characteristics of samples are shown in Table 1.

3.2. Measure of Variables

(1) Knowledge sharing motivation: in this study, the measuring items for knowledge sharing motivation of members in virtual organizations is mainly referred to the mature and valid index items developed by Tierney et al. [39] and combined with the actual survey; four items were used for measurement, as shown in Table 2.

(2) Self-efficacy: in this study, self-efficacy was mainly measured by referring to the research results of Schwarzer et al. [37] and adapting into four items based on the actual situation, as shown in Table 3.

(3) Knowledge sharing behavior: in this study, the knowledge sharing behavior was mainly measured by referring to the research results of Yi and Reychav [40, 41] and using four items, as shown in Table 4.

(4) Creativity: in this study, the creativity of members in virtual organizations was mainly measured by referring to the scale developed by Kessler et al. and Zhou et al. [28, 42], and adapting into four items based on the actual situation, as shown in Table 5.

(5) Control variables: since this research is based on the creativity of virtual organization members, four control variables are selected in this paper, including age, education, industry, and number of employees, in order to ensure the validity and integrity of variable relation study. (1) Age: to some extent, the age of employees reflects their innovation potential, knowledge and experience accumulation, and management level. For the convenience of quantitative analysis, "1" is defined as under 18, "2" as 18–25, "3" as 25–35, "4" as 35–55, and "5" as over 55. (2) Education: the level of education is an important organizational characteristic that affects the knowledge activities and innovation ability of organization members. In this paper, "1" stands for junior college diploma, "2" for bachelor's degree, "3" for master's degree, "4" for doctor's degree, and "5" for others. (3) Industry: the knowledge structure and scale of the industry is one of the important factors affecting the creativity of members. This study included industry in the measuring range, with "1" representing e-commerce, "2" information electronics, "3" energy conservation and environmental protection, "4" education, and "5" cultural and creative products. (4)

Table 1: Descriptive statistics of the samples.

Item		Samples (Nr.)	Percentage
Age distribution	<18	8	3.85
	18–25	26	12.50
	25–35	90	43.27
	35–55	68	32.69
	>55	16	7.69
	Total	208	100.00
Education	Junior college	27	12.98
	Undergraduate	106	50.96
	Postgraduate	43	20.68
	PhD	22	10.58
	Others	10	4.80
	Total	208	100.00

Table 2: Measuring items for knowledge sharing motivation.

Independent variable	Measuring items	Source of items
Knowledge sharing motivation	I like to help others by sharing my knowledge I believe knowledge sharing benefits both sides I believe others will respect me for sharing knowledge I believe knowledge sharing will strengthen my connections with others	Tierney, Farmer, and Graen

Table 3: Measuring items for self-efficacy.

Moderator variable	Measuring items	Source of items
Self-efficacy	I am confident in my knowledge sharing contents I am confident that I can express my views clearly in knowledge sharing I am confident that I can adhere to my ideal and achieve my goal I can solve most of the problems encountered in knowledge sharing if I put in the effort	Schwarzer, Bäßler, Kwiatek, Schröder, and Zhang

Table 4: Measuring items for knowledge sharing behavior.

Mediating variable	Measuring items	Source of items
Knowledge sharing behavior	I often share knowledge within the organization I take a positive attitude towards knowledge sharing within the organization I will keep an eye on and participate in the follow-up matters in knowledge sharing I often get involved in multiple types of knowledge sharing rather than a specific one	Reychav and Weisberg; Yi

Table 5: Measuring items for creativity.

Dependent variable	Measuring items	Source of items
Creativity	I am good at using new methods to improve work efficiency I am good at making plans and goals for new methods I am good at taking the right opportunity to demonstrate creativity at work I am good at setting new goals on my past achievements	Scott, Bruce Zhou, and George

Enterprise scale: the enterprise scale is related to the scale and structure of knowledge village, and also demonstrates the ability that enterprises can provide different financial and human resources to deal with an uncertain environment and carry out product innovation. Therefore, this paper takes the number of employees as an important reference index of the enterprise scale, with "1" representing less than 100 employees, "2" representing 100–500 employees, "3" representing 501–1,000 employees, "4" representing 1,001–5,000 employees, and "5" representing more than 5,000 employees. The conceptual model is shown in Figure 1.

4. Result Analysis

4.1. Correlation Coefficient. There is a strong positive correlation between knowledge sharing motivation of virtual organization members and knowledge sharing behavior

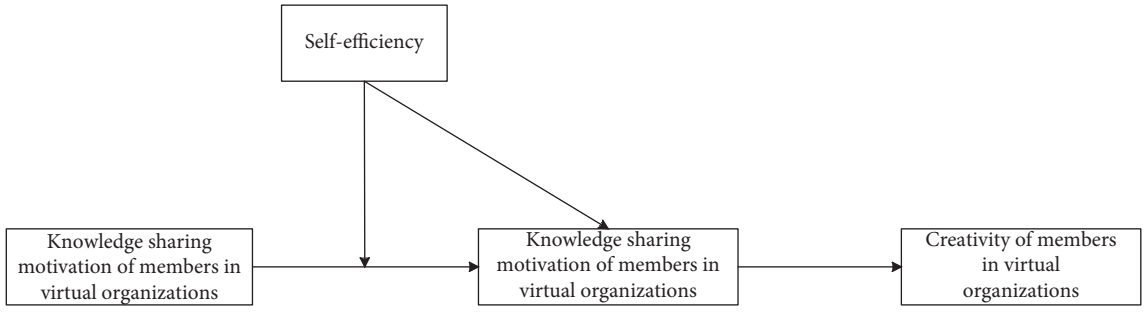

Figure 1: Conceptual model.

($r = 0.532$, $p < 0.01$) and employee creativity ($r = 0.527$, $p < 0.01$), and the knowledge sharing behavior is correlated with employee creativity ($r = 0.561$, $p < 0.01$). Then, the common method variance (CMV) test, and reliability and validity analysis are performed to test the hypothesis more accurately.

4.2. CMV Test. The questionnaire survey of this study is completed independently by each employee. To avoid the common method variance, this study uses Harman's single factor test in SPSS 19.0 to make exploratory factor analysis to all items of the questionnaire and derives the first principal component by orthogonal rotation using the maximum variance method, with a total variance of 19.36, free from any CMV.

4.3. Reliability and Validity Analysis. In this study, the Internal Consistency Index is used to test the reliability. Cronbach's α of knowledge sharing motivation, knowledge sharing behavior, employee creativity, and self-efficacy are 0.871, 0.898, 0.850, and 0.883, respectively, with reliable reliability. The main fitting indexes of the confirmatory factor analysis results for the 4-factor model are as follows: $\chi^2/df = 1.120$, GFI = 0.943, TLI = 0.994, CFI = 0.995, and Rmsea = 0.024.

4.4. Hypothesis Testing

4.4.1. Mediating Effect of Knowledge Sharing Behavior. Through four steps, this study examines whether knowledge sharing behavior plays a mediating role between knowledge sharing motivation and creativity of members in virtual organizations. Model 2 in Table 6 shows that there is a significant positive effect between knowledge sharing motivation and behavior of members in virtual organizations ($\beta = 0.517$, $p < 0.01$). Subject to the control variables (age, gender, and education), knowledge sharing motivation of virtual organization members can explain 26.0% variation of knowledge sharing behavior. Thus, hypothesis H2 is supported. According to the results of regression analysis of Model 4, the knowledge sharing motivation of members in virtual organizations has a significant positive effect on their creativity ($\beta = 0.528$, $p < 0.01$), so H1 is tenable. The regression results of Model 5 show that knowledge sharing behavior influences the employee creativity positively ($\beta = 0.555$, $p < 0.01$), and hypothesis H3 is tested. On the basis of Model 4, the addition of knowledge sharing behavior into Model 6 has significantly affected the employee creativity ($\beta = 0.381$, $p < 0.01$), and the influence of knowledge sharing motivation is decreased from 0.528 ($p < 0.01$) to ($\beta = 0.332$, $p < 0.01$). This indicates that knowledge sharing behavior plays a partial mediating role between knowledge sharing motivation and employee creativity; therefore, hypothesis H4 is tested.

4.4.2. Moderating Effect Test. This study proposes in hypothesis H5 that the self-efficacy of virtual organization members has a positive moderating effect on the relationship between knowledge sharing motivation and behavior of members. In this study, Model 7 of the SPSS 19.0 process test was used for analysis. As shown in Table 7, the R^2 value of Model 3 increased with respect to Model 1, and the interaction term of knowledge sharing motivation and self-efficacy had a significant positive effect on knowledge sharing behavior ($\beta = 0.125$, $p < 0.01$). This indicates that the self-efficacy of virtual organization members has a positive moderating effect on the relationship between knowledge sharing motivation and behavior of members. Thus, hypothesis H5 is tenable. The global hypothesis model was further tested in this study, with the results shown in Table 8; high and low standard deviations were used to illustrate the coefficient changes of the moderator variables. In case of low self-efficacy, the moderated mediating effect was 0.162, and the confidence interval did not contain 0, indicating that the mediating effect was valid; in case of median self-efficacy, the moderated mediating effect was 0.204, and the confidence interval did not contain 0, indicating that the mediating effect was valid; in case of high self-efficacy, the moderated mediating effect was 0.244, and the confidence interval did not contain 0, indicating that the mediating effect was valid. Therefore, it is proved that self-efficacy (moderator variable) has a significant positive moderating effect on the relationship between knowledge sharing motivation (independent variable) and knowledge sharing behavior (mediating variable), and even a positive moderated mediating effect. Thus, H6 is tenable.

Table 6: Regression analysis on the mediating effect of knowledge sharing behavior.

Variable	Knowledge sharing behavior		Employee creativity			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Age	0.193**	0.122*	0.1 59*	0.086	0.052	0.040
Gender	−0.035	0.005	0.072	0.113	0.092	0.111*
Education	0.049	0.073	0.065	0.089	0.037	0.061
Knowledge sharing motivation		0.517**		0.528**		0.332**
Knowledge sharing behavior					0.555**	0.381**
F	3.066*	21.906**	2.188	21.886**	24.407**	27.205**
R^2	0.043	0.303	0.031	0.302	0.326	0.404
ΔR^2	0.043	0.260	0.031	0.271	0.295	0.373

The symbol * indicates P<0.05; the symbol ** indicates P<0.01.

Table 7: Moderating effect of self-efficacy.

Variable	Knowledge sharing behavior		
	Model 1	Model 2	Model 3
Age	0.086	0.085	0.118*
Gender	0.113	0.113	0.023
Education	0.089	0.089	0.115
Knowledge sharing motivation	0.528**	0.528**	0.557**
Self-efficacy		0.006	−0.023
Knowledge sharing motivation * self-efficacy			0.125**
F	21.886**	17.425**	16.083
R^2	0.302	0.302	0.325
ΔR^2	0.302	0.000	0.023

The symbol * indicates P<0.05; the symbol ** indicates P<0.01.

Table 8: Moderated mediating effect.

Mediating path	Self-efficacy	Effect	SE	LLCI
Knowledge sharing motivation > knowledge sharing behavior > employee creativity	M-SD	0.162	0.046	0.081
	M	0.204	0.051	0.112
	M + SD	0.244	0.065	0.127

5. Conclusions

5.1. Main Conclusions. This paper explores the disparate impact of knowledge sharing motivation of members in virtual organizations on their creativity. Self-efficacy plays a positive moderating role in the relationship between knowledge sharing motivations and knowledge sharing behaviors, and self-efficacy positively moderates the mediating role of knowledge sharing behaviors in the relationship between knowledge sharing motivations and creativity. The results show that (1) knowledge sharing motivation of members in virtual organizations has a positive influence on their creativity. Knowledge sharing motivation is the direct antecedent of knowledge sharing behavior. Regardless of the age, education, enterprise scale, and industry, knowledge sharing motivation always has a significant positive correlation with knowledge sharing behavior. This indicates that the stronger the knowledge sharing motivation is, the more likely it is to be transformed into knowledge sharing behavior. The existing studies and analyses on the antecedents of employee creativity are mostly done from the perspectives of personality traits and social interaction. This study summarizes the variable of knowledge sharing motivation to provide a new research perspective for employee creativity, and serves as a supplement to previous studies. (2) Knowledge sharing behavior plays a mediating role in the relationship between knowledge sharing motivation and creativity. This paper has applied knowledge sharing behavior to influence the knowledge sharing motivation of organizational members on creativity and verified the mediating effect of knowledge sharing behavior in the influence process of knowledge sharing motivation and creativity. This provides a new theoretical perspective to explain the influencing mechanism of knowledge sharing motivation. (3) The empirical analysis results show that self-efficacy positively moderates the relationship between knowledge analysis motivation and behavior of virtual organization members, and also positively moderates the mediating effect of knowledge sharing behavior on knowledge sharing motivation and creativity. Employees with strong self-efficacy have stronger motivation to engage in more active knowledge sharing activities. According to research findings, compared with those with weak self-efficacy, employees with strong self-efficacy are better at transforming knowledge

sharing motivation into creativity through knowledge sharing behavior besides stronger knowledge sharing motivation and more active knowledge sharing behavior.

This paper provides new ideas on how to effectively improve the creativity of virtual organization members. (1) The results of this study are helpful to promote organizations to pay full attention to the knowledge sharing motivation and to carry out targeted long-term follow-up observation. The needs of members within an organization are diverse and constantly changing, so the motivations for members to share knowledge are varied, either for financial returns, personal growth, or both. As employees become more knowledgeable, their demand levels of knowledge sharing motivation are also rising, mainly manifesting in the following two aspects: first, whether the value of knowledge sharing matches the return; second, whether their knowledge can be demonstrated and recognized at work through knowledge sharing. The members in virtual organizations and their needs and knowledge sharing motivations may be different from those of ordinary employees; thus, business managers should pay close attention. Therefore, the design of the corporate knowledge sharing incentive mechanism should be targeted to meet the needs of employees at different levels as far as possible, so that employees' knowledge sharing behavior is activated by stimulating their knowledge sharing motivation more scientifically in an effort to effectively facilitate their creativity. (2) The results of this study encourage virtual organizations to focus on their members' knowledge sharing behavior. In the era of a knowledge economy with fierce competition, organizations can consider giving appropriate incentives to keep employees more active in knowledge sharing, in order to enhance the environmental adaptability of knowledge sharing behavior in organizations and stimulate the creativity of members. In addition, the identification and construction of situations conducive to the knowledge sharing behavior among employees is also the focus that organizations and organizational managers have to pay attention to. (3) The findings also point out the important moderating effect of self-efficacy in the mechanism of this model. Organizations are required to examine the changes in self-efficacy of members and pay reasonable attention to their knowledge sharing motivation based on the degree of self-efficacy, so as to achieve a good control over employees' knowledge sharing behavior. It can be reasonably inferred from the findings that employees' self-efficacy directly affects their knowledge sharing ability. Their knowledge sharing ability is mainly subject to individual and organizational factors. Individual factors mainly refer to the employees' communication skills, while organizational factors mainly include enterprise hardware facilities such as information system and organizational culture. Business managers are expected to pay more attention to employee training in terms of communication skills and team spirit, constantly improving the enterprise network information system, and strive to create a learning organization culture that encourages knowledge sharing. Therefore, how to shape an organizational climate for knowledge sharing, overcoming the employee barriers to knowledge sharing, and comprehensively improving the self-efficacy of employees in knowledge sharing activities are important steps to promote comprehensive knowledge management of enterprises.

5.2. Future Research. From the perspective of process philosophy, any study is the continuation of previous studies and also the basis for follow-up studies, which has promoted the gradual perfection of the theory. Despite some progress, this study is still suffering from many limitations to be supplemented by future research, subject to the research time, funds, and the author's ability.

First, all variables are measured by self-answering, which mainly depends on the subjective attitudes and perceptions of the respondents. Although management advice has been taken into account in the questionnaire design, there is no management feedback or actual consideration of these variables in collecting the questionnaire. Therefore, there may be some errors in data sources. A variety of parallel research methods may be tried to further improve the reliability and validity.

Second, this study introduces self-efficacy as a moderator variable, but fails to refine it due to the limited space, so the concept is somewhat abstract, e.g., employees' self-perceived knowledge sharing ability and level. This variable can be further refined in subsequent studies.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Hindawi
Discrete Dynamics in Nature and Society
Volume 2022, Article ID 4891288, 7 pages
https://doi.org/10.1155/2022/4891288

Research Article

Entropy Weight TOPSIS Evaluation of Corporate Internal Control Quality Based on Fuzzy Matter-Element Model

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Received 8 April 2022; Revised 25 May 2022; Accepted 31 May 2022; Published 15 June 2022

Academic Editor: Jiafu Su

One of the core objectives of domestic and foreign regulation policies is to strengthen internal control and improve corporate risk management ability. To evaluate corporate internal control quality (CICQ), this paper constructs a composite fuzzy matter-element model based on the fuzzy matter-element theory and the data on 781 listed enterprises in China. By the entropy weight method, five evaluation indices of internal control were weighed and compared with the positive and negative ideal indices. Next, the internal control of the listed enterprises was measured by TOPSIS. The results show that the indices of laws and regulations (LR), financial statements (FS), assets safety (AS), operation (OP), and strategy (ST) are of different weights in terms of CICQ evaluation. The LR, OP, and ST indices are more important than the FS indices. Among the secondary indices, the most important indices, namely, major litigation and arbitration cases, turnover of total assets, and Tobin's Q account for 66% of total weights. In addition, the CICQ varies with industries: the top-10 enterprises in terms of CICQ mostly belong to industries with strict requirements on work safety. The research findings lay a methodological and practical basis for the CICQ evaluation of Chinese enterprises.

1. Introduction

Since the enactment of Sarbanes–Oxley (SOX) Act in 2002, corporate internal control quality (CICQ) has raised worldwide concern among practitioners and researchers [1, 2]. The Chinese government released the *Basic Standard for Corporate Internal Control* in 2008 and issued the *Supporting Guidelines for Corporate Internal Control* two years later. In addition to dividing internal control into five interrelated elements: internal environment, risk assessment, control activities, information and communication, and internal supervision, the above-mentioned documents also require enterprises to formulate specific internal control evaluation methods and carry out internal control evaluation work in an orderly manner. The corporate internal control is no easy task, for the internal structure of an enterprise involves a dazzlingly array of operational and management factors [3, 4]. The fat finger trading incident that broke out at Everbright Securities in 2013 aroused heated discussions quickly. China Securities Regulatory Commission (CSRC) punished Everbright Securities for insider trading, including the confiscation of all their illegal income, and a fine of more than 5 times the illegal income. The fat finger trading incident not only brought huge economic losses and serious negative impacts to Everbright Securities, it also reflected the serious problems existing in the internal control quality of Chinese companies. After the 2013 Everbright fat finger trading incident, many Chinese scholars turned their attention to CICQ.

Precise evaluation is the premise to CICQ improvement. How to evaluate CICQ precisely, the existing research has achieved certain results. For example, Han and Wang [5] evaluated CICQ comprehensively through analytic hierarchy process (AHP). Li and Dai [6] established evaluation systems for corporate internal control environment, using the Delphi method. However, neither AHP nor the Delphi method is objective and scientific enough to derive a standard judgement matrix. To overcome the defect, some researchers introduced fuzzy comprehensive evaluation (FCE) to the CICQ analysis. For instance, Zhu et al. [7] combined FCE with a backpropagation (BP) neural network to evaluate the design of corporate control activities,

operational risks, and safety level. Yang [8] employed FCE to evaluate the internal control of a construction material producer. However, when FCE finally determines the results, the principle of maximum membership degree is usually adopted. The principle overemphasizes the extreme value and fails to make full use of the vector obtained by FCE, resulting in the loss of data information. There may even be unfair evaluation results. This motivates researchers to evaluate CICQ by the fuzzy matter-element model. With explicit concept and simple operation, the fuzzy matter-element model greatly promotes the evaluation of CICQ [9].

To sum up, the evaluation system of CICQ has been gradually perfected, and insights have been provided for CICQ improvement. Nevertheless, the existing studies face several disadvantages: the approach is too subjective, the indices are not diverse, and the index attributes/positions are often not considered. To address these disadvantages, this paper resorts to three cutting-edge technologies: fuzzy matter-element model, which solves the incompatibility of multiple indices; TOPSIS, which easily compares objects both horizontally and vertically; entropy weight method, which assigns an objective and real weight to each index according to the original data. Based on the fuzzy matter-element model, this paper constructs an entropy-weight TOPSIS evaluation system for CICQ and systematically analyzes the CICQ of 781 listed enterprises in China. The research results shed new lights on CICQ evaluation.

2. Materials and Methods

2.1. Design Principles of Evaluation System. The CICQ evaluation indices must be comprehensive, systematic, objective, applicable, and valid [10]. According to the comprehensive and systematic principle, the CICQ evaluation system should cover the contents of business activities, as well as all design factors of internal control, such as to reflect internal control comprehensively and systematically. According to the objective and applicable principle, the evaluation system should take account of the actual situation and operating condition of each enterprise. According to the principle of validity, the evaluation system should manifest the relationship between internal control and corporate management and pinpoint the weak links of internal control.

2.2. Index Selection. Following the above design principles, the provisions of Chinese regulations, and the ideas of Hwang et al. [11], this paper establishes an evaluation system for CICQ from the perspectives of laws and regulations (LRs), financial statements (FSs), assets safety (AS), operation (OP), and strategy (ST).

2.2.1. Laws and Regulations. The LR, essential to the survival of an enterprise, is the fundamental indicator of internal control. The sustainable development of an enterprise hinges on the observation of the laws, regulations, and policies of the host country, as well as the criteria of the market and the industry. Any violation of the LR will be penalized. Hence, two secondary indices were designed for LR: penalty for LR violation and major litigation and arbitration cases.

2.2.2. Financial Statements. The FS, another fundamental indicator of internal control, provides an effective channel for stakeholders to understand the business condition of an enterprise. In this paper, FS is measured by audit opinion of FS.

2.2.3. Assets Safety. The AS, a basic indicator of internal control, reflects the asset risks of an enterprise, and the executives' demand for the enterprise. This paper chooses asset-liability ratio, assets impairment loss ratio, and non-business expenditure to measure AS.

2.2.4. Operation. The OP, the core indicator of internal control, manifests the goal of production and business activities. Hence, this indicator was measured by operating profit margin, net return on equity, and turnover of total assets.

2.2.5. Strategy. The ST, a prospective indicator of internal control, reveals the overall operation and development direction of an enterprise. Here, ST was measured by Tobin's Q, growth rate of total assets, and rate of net return on total assets.

Through the above analysis, an CICQ evaluation system was established, involving 12 secondary indices and 5 primary indices. The details of the system are listed in Table 1.

2.3. Sampling and Data Sources. To measure CICQ in China comprehensively, this paper selects the CICQ data on 1,700 A-share listed enterprises in 2018, after fully considering data availability and sample representativeness. The enterprises receiving special treatment (ST) or with incomplete data were removed from the sample set. To evade the influence generated by the extreme values of samples on the results, double-sided 1% Winsorization processing was performed for all continuous variables. The remaining data involve 781 listed enterprises. The original data were acquired from China Stock Market & Accounting Research Database (CSMAR) and the 2018 financial statements of these enterprises.

2.4. Features of Fuzzy Matter-Element Model and Entropy-Weight TOPSIS Method. The CICQ system is a complex internal management system of enterprises. The various indices involved in the CICQ evaluation are very likely to be incompatible with each other. The fuzzy matter-element model can make systematic evaluation with multiple indices and solve complex incompatible problems.

As an objective weighting approach, the entropy weight method is widely adopted in management science to weigh different indices based on their variability. This method treats entropy as a measure of information uncertainty, which is negatively correlated with the information size of

Table 1: CICQ evaluation system.

Index	Primary index	Secondary index	Code	Definition
CICQ	LR	Penalty for LR violation	X1	1, if an enterprise is penalized for violating LR; 0, otherwise
		Major litigation and arbitration cases	X2	1, if an enterprise has major litigation and arbitration cases; 0, otherwise
	FS	Audit opinion of FS	X3	1, if an enterprise faces standard unqualified opinion; 0, otherwise
	AS	Asset-liability ratio	X4	Ratio of total liabilities to total assets
		Assets impairment loss ratio	X5	Ratio of the asset impairment loss to operating income
		Nonbusiness expenditure	X6	Various nonoperating expenses
	OP	Operating profit margin	X7	Ratio of operating profit to operating income
		Net return on equity	X8	Ratio of net profit to net assets
		Turnover of total assets	X9	Ratio of the sales revenue to average asset balance
	ST	Tobin's Q	X10	Ratio of market value to replacement value
		Growth rate of total assets	X11	Ratio of growth of total assets to total assets
		Rate of net return on total assets	X12	Ratio of net profit to average total assets

the sample. Highly uncertain information contributes little to the comprehensive evaluation. The inverse is also true.

Proposed by Hwang and Yoon [12], the TOPSIS is a multiobjective decision method capable of multi-index evaluation. The main ideas of TOPSIS are as follows: firstly, the positive and negative ideal solutions are constructed. Then, the closeness of each object to the two solutions is computed. After that, the multiple objects are ranked in descending order of the closeness. TOPSIS can produce very reasonable results on a small sample size.

Entropy-weight TOPSIS combines the merits of both entropy weight method and TOPSIS. This composite approach can overcome the disadvantages of traditional evaluation methods and effectively quantify multiple objects.

2.5. Flow of Entropy-Weight TOPSIS Method Based on Fuzzy Matter-Element Model. Firstly, a composite fuzzy matter-element model is constructed. Secondly, the evaluation indices are weighed by the entropy weight method and used to set up a weighted normalization matrix. Finally, TOPSIS was applied to sort the samples by CICQ. The flow of our approach is summarized as follows.

Step 1. Establish a composite fuzzy matter-element model.

A is the fuzzy matter element, C is the thing, M is the characteristic of the thing, X is the magnitude, and then the fuzzy matter element $A = (\mathrm{C}, \mathrm{M}, \mathrm{X})$.

$$A_{mn} = \begin{bmatrix} & C_1 & C_2 & \cdots & C_n \\ M_1 & x_{11} & x_{12} & \cdots & x_{1n} \\ M_2 & x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ M_m & x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}, \quad (1)$$

where M is the first to m-th enterprises; C is the first to n-th CICQ indices; x_{mn} is the original data of the n-th index of the m-th enterprise.

Step 2. Normalize the composite fuzzy matter-element model to obtain a normalized matrix R.

The different dimensions and units hinder the comparison between indices. Hence, all indices are normalized. The indices positively correlated with CICQ (positive indices) and those negatively correlated with CICQ (negative indies) are normalized by different formulas.

Positive indices

$$x_{mn}^* = \frac{x_{mn} - \min(x_{mn})}{\max(x_{mn}) - \min(x_{mn})}. \quad (2)$$

Negative indices

$$x_{mn}^* = \frac{\max(x_{mn}) - x_{mn}}{\max(x_{mn}) - \min(x_{mn})}. \quad (3)$$

Then, the normalized data are summarized to obtain the normalized fuzzy matter-element matrix R.

$$R = \begin{bmatrix} x_{11}^* & x_{12}^* & \cdots & x_{1n}^* \\ x_{21}^* & x_{22}^* & \cdots & x_{2n}^* \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1}^* & x_{m2}^* & \cdots & x_{mn}^* \end{bmatrix}, \quad (4)$$

where R is the normalized evaluation matrix; x_{ij} and x_{mn}^* are the initial and normalized values of the n-th index of the m-th enterprise, respectively.

Step 3. Determine the entropy value of each index.

Firstly, the weight f_{mn} of x_{mn} is calculated by the following equation:

$$f_{mn} = \frac{x_{mn}}{\sum_{m=1}^{i} x_{mn}}. \quad (5)$$

Then, the entropy e_n of n indices is calculated by the following equation:

$$e_n = -\frac{1}{\ln n}\left(\sum_{n=1}^{j} f_{mn} \ln f_{mn}\right). \quad (6)$$

Step 4. Weigh each index.

The weight w_n of each index is calculated by the following equation:

$$w_n = \frac{1 - e_n}{n - \sum_{n=1}^{j} e_n}. \tag{7}$$

Step 5. Establish the optimal fuzzy membership matrix.

In matrix R, the data on characteristic C can be divided into two types: the-bigger-the-better index, and the-smaller-the-better index. For the first type, CICQ increases with the numerical value of indices; for the second type, CICQ decreases with the numerical value of indices. The optimal fuzzy membership T of the-bigger-the-better index and the-smaller-the-better index can be, respectively, calculated by the following equation:

$$\theta(x_{mn}) = \frac{x_{mn} - \min(x_{mn})}{\max(x_{mn}) - \min(x_{mn})},$$
$$\theta(x_{mn}) = \frac{\max(x_{mn}) - x_{mn}}{\max(x_{mn}) - \min(x_{mn})}, \tag{8}$$

where $\theta(x_{mn})$ is the optimal fuzzy membership of the n-th eigenvalue of the m-th object; $\max(x_{mn})$ and $\min(x_{mn})$ are the maximum and minimum eigenvalues of the characteristic index, respectively.

Step 6. Establish the weighted optimal fuzzy matter-element membership matrix, and positive and negative ideal solutions.

The weight w_n is multiplied with R to obtain the weighted optimal membership matrix Y.

$$Y = Wn \times R. \tag{9}$$

Furthermore, the positive and negative ideal solutions (Y^+ and Y^-) in Y are determined. Specifically, Y^+ is the maximum of the n-th index of the m-th enterprise in the evaluation data. It is the most preferred scheme and thus called the positive ideal solution. Y^- is the minimum of the n-th index of the m-th enterprise in the evaluation data. It is the least preferred scheme and thus called the negative ideal solution. The two solutions can be, respectively, calculated by the following equation:

$$Y^+ = \{\max_{1\le m\le i} y_{mn} | m = 1, 2, \ldots, i\} = \{y_1^+, y_2^+, \ldots, y_i^+\},$$
$$Y^- = \{\min_{1\le m\le i} y_{mn} | m = 1, 2, \ldots, i\} = \{y_1^-, y_2^-, \ldots, y_i^-\}. \tag{10}$$

Step 7. Calculate the Euclidean distance.

Out of the various distance metrics, this paper chooses the Euclidean distance [10]. The distance S_n^+ between the m-th index and y_m^+, and that S_n^- between that index and y_m^- can be, respectively, calculated by the following equation:

$$S_n^+ = \sqrt{\sum_{m=1}^{i} (y_m^+ - y_{mn})^2},$$
$$S_n^- = \sqrt{\sum_{m=1}^{i} (y_m^- - y_{mn})^2}, \tag{11}$$

where y_{mn} is the normalized weighted value of the n-th index of the m-th enterprise; y_m^+ and $y_m^- y_i^-$ are the values of the most and least preferred schemes in the m-th index.

Step 8. Compute the closeness between each object and the ideal solutions.

Let $Z_m \in [0, 1]$ be the closeness of the m-th CICQ to the optimal quality. The greater the closeness, the nearer the CICQ is to the optimal quality. The CICQ reaches the maximum at $Z_m = 1$ and reaches the minimum at $Z_m = 0$. Here, the closeness represents the level of CICQ. The Z_m value can be calculated by the following equation:

$$Z_m = \frac{S_n^+}{S_n^+ + S_n^-}. \tag{12}$$

3. Results and Discussion

3.1. Index Weighting. Based on the proposed CICQ evaluation system, the weights of primary and secondary indices were determined by the entropy weight method and fuzzy matter-element model. The results in Table 2 show that LR (0.359871), OP (0.2510953), and ST (0.2163799) had relatively high weights among the five primary indices. Among them, LR accounts for 35.98% of total weights, indicating that this fundamental index directly manifests CICQ. OP accounts for 25.1% of total weights, suggesting that this core index mirrors the realization of business goals of enterprises. ST accounts for 21.64% of total weights, which implies that the index reflects the development direction of the enterprises and the sustainability of CICQ. The weights of these three primary indices are basically in line with the actual situation of enterprises and consistent with the conclusions of relevant studies.

In addition, the AS, accounting for 16.08% of total weights, has an important impact on CICQ. This index reflects the asset management quality in enterprise internal control. The growing asset risks can obviously suppress the overall operational safety. The FS accounts for 1.18% of total weight. The five primary indices interact and complement each other. Each of them not only affects the corporate internal control but also work with other primary indices to enhance the CICQ.

When it comes to secondary indices, the top three indices were major litigation and arbitration cases (X2) (0.2999216), turnover of total assets (X9) (0.2122838), and Tobin's Q (X10) (0.1518735). Together, the three secondary indices account for 66% of total weights and correspond to LR, OP, and ST, respectively. Considering the weight distribution, enterprises should enhance CICQ by observing

Table 2: Weights of CICQ evaluation indices.

Primary index	Secondary index	Nature	Entropy value	Weight	
LR	X1	Positive	0.9952843	0.0598953	0.359817
	X2	Positive	0.9763863	0.2999216	
FS	X3	Positive	0.9990674	0.011845	0.011845
AS	X4	Negative	0.9913721	0.1095845	0.1608628
	X5	Negative	0.9991669	0.010581	
	X6	Positive	0.9967958	0.0406973	
OP	X7	Positive	0.9976097	0.0303596	0.2510953
	X8	Positive	0.9993346	0.0084519	
	X9	Positive	0.9832863	0.2122838	
ST	X10	Positive	0.9880426	0.1518735	0.2163799
	X11	Positive	0.9971212	0.0365638	
	X12	Positive	0.9978	0.0279426	

Table 3: Top-10 enterprises in terms of CICQ.

Enterprise	Industry	S_j^+	S_j^-	Z_i
PetroChina	Oil and gas extraction	0.053538	0.046886	0.466877
Sichuan Tianyi	Chemical raw materials and chemical products manufacturing	0.061604	0.037512	0.378465
Hengrui Medicine	Pharmaceutical manufacturing	0.063343	0.033469	0.345708
Zhangzhou Pien Tze Huang	Pharmaceutical manufacturing	0.063929	0.030489	0.322911
Grinm Advanced Materials	Nonferrous metal smelting and rolling processing	0.0662	0.025111	0.275001
Kweichow Moutai	Liquor, beverage, and refined tea manufacturing	0.064633	0.02352	0.266809
Hundsun Technologies	Software and information technology service	0.064672	0.022155	0.255167
Chongqing Brewery	Liquor, beverage, and refined tea manufacturing	0.064414	0.02146	0.249898
M&G	Cultural, educational, industrial, sports, and entertainment products manufacturing	0.065066	0.020979	0.243815
Haili Biology	Pharmaceutical manufacturing	0.065626	0.020181	0.235189

laws and regulations, meeting the regulatory requirements on information supply and disclosure, improving the effectiveness of business activities, and formulating appropriate development strategies.

3.2. TOPSIS-Based CICQ Evaluation. After computing the weights of CICQ indices for Chinese listed enterprises, the authors quantized the CICQ of 781 samples and sorted their quality levels through TOPSIS. Firstly, the CICQ evaluation matrix was established by formula (9). Secondly, the maximums and minimums of all indices for the 781 samples were solved and taken as positive and negative ideal solutions. Thirdly, the distances (S_n^+ and s_j^-) from every sample to the positive and negative ideal solutions were estimated by the formula of Euclidean distance. Fourthly, the closeness (Z_m) of each sample to the optimal CICQ was computed and used to evaluate the CICQ of that sample. For the lack of space, only the top-10 enterprises in terms of CICQ are displayed (Table 3).

As shown in Table 3, the top-10 A-share listed enterprises in terms of CICQ are PetroChina, Sichuan Tianyi, Hengrui Medicine, Zhangzhou Pien Tze Huang, Grinm Advanced Materials, Kweichow Moutai, Hundsun Technologies, Chongqing Brewery, Morning Glory, and Haili Biology. These high-CICQ enterprises belong to industries with the strictest requirements on work safety, namely, mining, chemical engineering, medicine, etc.

In addition, two top-10 enterprises were found in the burgeoning industries of information technology and education, namely, Hundsun Technologies and M&G. This means enterprises in China's emerging industries can enhance their overall competitiveness by increasing CICQ.

PetroChina stands out clearly from the top-ranking enterprises. The CICQ gap from the 5th to the 10th enterprises is not very large. It can be seen that PetroChina has achieved world-class CICQ, and Chinese enterprises with high CICQ develop collaboratively.

Our ranking differs from the China Top 500 ranking. In the latter ranking, the top-10 Chinese enterprises in terms of CICQ include Sinopec, CNPC, CSCEC, Ping'an Insurance, SAIC Motor, China Mobile, ICBC, China Railway, CRCC, and China Life Insurance. The difference can be interpreted in two aspects: firstly, the two rankings focus on different attributes. Our ranking mainly considers the construction of CICQ, while the other ranking highlights the comprehensive strength. Secondly, some listed enterprises with high comprehensive strength still have a large space to improve CICQ.

3.3. TOPSIS-Based Industry Analysis of CICQ. The 781 samples were further divided into 14 industries. Those belong to the accommodation and catering industry and those

Table 4: Index weights and rankings of various industries.

Industry	Sample size	Mean	Standard deviation	Ranking
Real estate	11	0.118326	0.155665	1
Manufacturing	466	0.094434	0.028061	2
Agriculture, forestry, animal husbandry, and fishery	7	0.091194	0.024031	3
Wholesale and retail	49	0.089743	0.034077	4
Transportation, warehousing, and postal service	41	0.086753	0.048317	5
Water conservancy, environment, and public facilities management	10	0.084431	0.00718	6
Mining	30	0.080756	0.041164	7
Information transmission, software, and information technology service	83	0.077015	0.019875	8
Culture, sports, and entertainment	11	0.075936	0.014403	9
Resident services, repairs, and other services	8	0.073355	0.01713	10
Electricity, heat, gas, and water production and supply	36	0.069791	0.01339	11
Construction	24	0.068326	0.013761	12
Miscellaneous	4	0.06714	0.012981	13

with missing or abnormal data were eliminated. Then, the remaining 13 industries was processed by TOPSIS to obtain their distributions and rankings (Table 4).

As shown in Table 4, the different industries varied in terms of CICQ. The leading industries include real estate, manufacturing, agriculture, forestry, animal husbandry, and fishery, wholesale and retail, as well as transportation, warehousing, and postal service. Specifically, real estate had the highest CICQ, but the standard deviation was far greater than that of any other industry. Despite the high overall CICQ in the industry, real estate enterprises differ significantly in the construction of internal control. This reveals the great gap between these enterprises in CICQ management.

Resident services, repairs, and other services, electricity, heat, gas, and water production and supply, construction, and miscellaneous occupied the bottom positions in the ranking, a sign of the poor CICQ of these industries. However, the small standard deviations show that these industries are highly stable and not competitive. The smallest standard deviation was achieved by electricity, heat, gas, and water production and supply, indicating that the industry is highly monopolized.

4. Conclusions

Based on the fuzzy matter-element model, this paper sorts out the CICQ data on 781 A-share listed enterprises in China and establishes a CICQ evaluation system by the entropy-weight TOPSIS method, giving full consideration of Chinese policies on internal control, and the features of China's capital market and listed enterprises. The evaluation system makes full use of the information in the original data and determines weights objectively, providing an effective way to evaluate multiattribute factors comprehensively. The results show that CICQ evaluation is significantly affected by LR, OP, and ST. Specifically, major litigation and arbitration cases, turnover of total assets, and Tobin's Q account for 66% of total weights. The top-10 enterprises in terms of CICQ mostly belong to industries with strict requirements on work safety. Emerging industries also began to pay attention to the construction of CICQ. In view of industries, real estate achieved the highest overall CICQ, but had a high CICQ difference among its enterprises. The research results provide theoretical insights into reasonable measurement of the validity of internal control modes.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This study was supported by Provincial Science and Technology Plan Project: "Research on the development path and Countermeasures of Northern Anhui driven by scientific and technological innovation" (Grant No. 202106f01050017) and Scientific Research Project of Provincial Department of Education: "Study on Rural Entrepreneurship effect of public financial expenditure in Anhui Province" (Grant No. SK2019A0132).

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Hindawi
Discrete Dynamics in Nature and Society
Volume 2022, Article ID 9755719, 13 pages
https://doi.org/10.1155/2022/9755719

Research Article

The Internet-Based Business Model and Corporate Risk-Taking: An Empirical Study from the Information Empowerment Perspective

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Received 22 April 2022; Revised 23 May 2022; Accepted 26 May 2022; Published 15 June 2022

Academic Editor: Jiafu Su

Reasonable risk-taking acts as a solid foreground for sustaining corporate growth. Having companies trading on Chinese stock exchanges between 2010 and 2019 sampled, this paper explored how an Internet-based business model would affect corporate risk-taking from the perspective of information empowerment. Through the mediation effect model and quantitative text analysis, the following findings were obtained here. First, a network-powered business model could significantly enhance the risk tolerance of companies. Second, mechanism testing showed that such a novel model would help reduce the asymmetry of corporate information and thus enhance corporate risk-taking capacity. Third, an analysis on heterogeneity revealed that businesses that enjoy a freer market and fewer financing constraints could better feel the positive impact of an Internet-based business model on corporate risk-taking. Fourth, an examination of economic consequences showed that risk-taking under Internet-based business models allowed enterprises to create sustainable value. Overall, the present work confirmed the positive impact of an Internet-based business model on corporate risk-taking from the information empowerment angle, and it is expected to provide a theoretical basis for enterprises to optimize their investment decision-making strategies and increase their risk-taking willingness and capacity.

1. Introduction

Higher potential returns on investment usually go hand in hand with increased risks. The risk capacity of businesses showcases their investment and risk preferences [1] and has a pivotal impact on corporate sustainability and macroeconomic growth. On a micro level, a willingness to take risks will push enterprises to seek higher returns on investment, improve business performance, and strengthen their competitiveness [2, 3]. On a macro level, enhanced risk willingness and capacity are fundamental to technological upgrade, capital accumulation, and steady economic growth [4]. However, it was reported that emerging-world firms tend to refrain from risk-taking, and this has led to low levels of risk tolerance in the emerging-world business community [5].

There is an interplay of various factors influencing corporate risk-taking. From a macro perspective, these factors involve the macroeconomic cycle [6–8], systems, and policies [4]. For enterprises, risk-taking willingness and capacity are closely linked to corporate features [9], the shareholding structure [10], board characteristics [11], and incentives [12]. Also, it is perceived, from the angle of executive individuals, that management's demographic features [13], personal experiences [14], and psychological characteristics [2] have a considerable impact on the risk-taking behavior of a business. However, the level of corporate risk-taking not only depends on the influence of the above factors but also is subject to the constraints of information acquisition and application [15]. Businesses taking risk is essentially a decision made by them based on how much information they have in their hands, thus

making it heavily rely on information [16]. With insufficient information, a company will run into the information asymmetry conundrum when making decisions.

Over these years, the world has been shaped by a great technological revolution, in which the next-generation information technologies, represented by the Internet, have thrived and come to drive socioeconomic transformation. Theoretically, the Internet can reduce information asymmetry and enhance businesses' ability to gain and apply information as it is capable of pooling and allocating resources [17]. In practice, a growing number of enterprises expect to improve competitiveness through the Internet-based business model amid China's stepped-up effort to implement the "Internet Plus" initiative and enhance national strength by the Internet means. Then, can the network-based business model help enterprises effectively minimize information asymmetry in a way that lifts up the level of corporate risk-taking? Taking into account an array of the above-mentioned factors, we sampled companies listed on Chinese stock exchanges between 2010 and 2019 and examined the impact of an Internet-based business model on corporate risk-taking from the perspective of information empowerment. The study showed that when carrying out an Internet-based business model, companies could considerably level up their risk tolerance, and the same held true for the scenarios free of endogenous issues. The mechanism test showed that such a model encourages businesses to take risks by reducing information asymmetry. A further study revealed that companies with a freer market and fewer financing constraints could better feel the positive impact of the model. Research also found that risk-taking under a network-based business model would contribute to consistent value creation for enterprises.

The major contributions of the present work are as follows. Firstly, this study provides new evidence for companies to effectively improve the level of risk-taking in investment decisions. The existing literature mainly discusses the influencing factors of corporate risk-taking from manager characteristics, corporate governance mechanism, and policy system. Different from the previous literature, this paper demonstrates that the implementation of an Internet-based business model help enterprises to improve their investment decision-making from the perspective of the empowerment of next-generation information technology. This conclusion guides enterprises to effectively promote risk-taking relying on Internet technology. Secondly, the research on the implementation effect of the Internet-based business model was expanded from the angle of risk-taking. The previous studies on that effect mostly focus on the innovation performance and operating performance of enterprises. Our research proves that the implementation of an Internet-based business model enhances the risk-taking level of enterprises in investment decision-making and exists as an antecedent of the improvement of innovation performance and operating performance. This conclusion facilitates the understanding of the empowering effect of the Internet-based business model on corporate operation and innovation activities. Thirdly, it served as a testimony to the capability of the Internet Plus initiative to generate value. Prior research efforts explored corporate value brought by an Internet-based business model from the asset specificity perspective [18]. Given that, our study found, in an empirical way, that the network-based business model could multiply the value of businesses by enhancing their risk tolerance. On top of that, it acted as a refreshing addition to research on how such a model makes an impact on corporate value from the risk-taking angle while justifying the benefits of the adoption by enterprises of the model.

2. Theoretical Analysis and Research Hypotheses

At present, there has been no consensus with regard to the definition of the Internet-based business model in the academic circle. Many, according to the available literature, believe that such a model is a business operation system transcending time and space upon the integration, upgrade, restructuring, and overhaul of current industries, organizations, and business channels. Designed to match the needs of resources via the Internet, it creates, delivers, and obtains value by using data, information, and platforms [19–21]. Many present online business models involve various new elements built on the Internet, such as artificial intelligence, big data, and the models of B2B and B2C. Compared with conventional business models, the Internet-based one features connection across industries, resource aggregation, and interaction across platforms [22]. Therefore, we based our research on the characteristics and attributes of the Internet-driven business model and focused on reducing information asymmetry for companies when making risk management decisions. The aim was to explore how a network-powered business model can enhance companies' willingness to take a risk by furnishing them with more information and getting them better informed and oriented.

(1) On information collection, an Internet-based business model brings together more sources of information and keeps businesses better informed. First, prior to a business venture, a company needs to gather all sorts of information related to the investment in a timely manner. This, on the one hand, calls for the enhanced capability of information acquisition; on the other hand, it drives up the cost of harvesting information that is likely to be uncomprehensive, inaccurate, and belated, thus taking a toll on the decision-making behavior of the company [23]. An internet-based commercial mode, however, allows enterprises to leverage its built-in searching technology to expand the sources of information retrieval and reach deeper and further resources in a way that timely delivers more and better information to companies [24]. Second, the Internet enables businesses to remove unnecessary links from the information collection process and streamline information retrieval procedures [25]. This ensures the efficient match between demands and supplies and helps companies quickly access needed information.

Third, the ultralow marginal cost of the Internet can offset the cost of time and materials in gathering information [26]. Thus, when it comes to information acquisition, a network-driven business mode empowers businesses to enlarge the information search range, facilitate the demand-supply match, and lower the data search cost. In doing so, companies would be better informed and more willing to take risks.

(2) On information integration, an Internet-based business model helps pool information and allows companies to increase their capability to merge data. The ability to absorb and integrate information resources is crucial to the decisions made by companies since external information is not necessarily involved in the process of risk management decision-making [27]. Organizational learning theory points out that corporate learning is a process in which decision-makers continuously learn and absorb external information resources. Under an Internet-driven business model, big data analysis enables enterprises to gather and select a variety of data resources and identify the interconnectedness among them, and the data-absorbing capability can strengthen through mapping knowledge domains and digital portraits. From the perspective of dynamic capability, growing in a complicated external environment requires businesses to develop the ability to absorb, merge, disintegrate, and reconstruct information resources [28]. On the Internet platform, companies can manage fragmented information in an intensive fashion. This facilitates the coordination of internal and external information, tackles the conflict between the demand for diversified information and supply of fragmented data, and leads the management of corporate information resources to new heights. On the front of data merging overall, enterprises can be more effective in absorbing information and see it managed intensively through the adoption of an Internet-based business model. That is how the ability to integrate information resources can be strengthened in a way that keeps businesses better informed and motivated to take risks.

(3) On information application, an Internet-based business model gives data a pivotal role in the decision-making of enterprises and allows them the enhanced capability to use information. Poor-quality data gets businesses disoriented in making investment decisions and prevents them from taking risks [23]. In a web-powered commercial mode, a company can simulate and improve different plans by making use of the Internet-assisted decision-making system, with a view to understanding the distribution of returns and risks across varied investment proposals. This deters enterprises from ineffective input in decision-making and navigates their way to an accurate and science-based decision through massive data, thus ensuring a better quality of information application. Moreover, the big data-based prediction technique gives corporate decision-makers more forward-looking information to motivate them to polish up the present investment plan or develop a new one and to increase their capability of dynamic adjustment. For instance, the technique allows businesses to spot and learn the data about peers in a given area and enhance their ability of risk prediction and dynamic adjustment by identifying the rules within, drawing on novel experiences, and following new trends. In applying information, therefore, an Internet-driven business model helps enhance the quality of data application and the ability of risk prediction and dynamic adjustment. This is how enterprises can always stay oriented in the decision-making process.

Overall, an Internet-based business model offers support in data acquisition, integration, and application for enterprises carrying out investment projects. This can free businesses making risk management decisions from any constraints brought by information asymmetry and encourage them to be more open to risk-taking. Founded on the above-mentioned analysis, we put forth the following hypotheses.

Hypothesis 1. The adoption of an Internet-based business model leads to a higher level of corporate risk-taking. And the more engaged a company is to such a model, the more willing it is to take risks.

Hypothesis 2. The adoption of an Internet-based business model reduces the constraints imposed by information asymmetry and thus enhances corporate risk capacity.

3. Research Design

3.1. Data Sources. The samples used for research were selected from the companies trading on Chinese stock markets between 2010 and 2019 that met the following conditions. First, given that the intrinsic relationship between listed Internet firms and the net-based commercial mode could affect the results of the empirical study, the paper excluded companies in or related to such sectors closed linked to the Internet as computer manufacturing and software maintenance. Second, financial companies and those with anomalies in financial statements were removed. Third, businesses missing data were excluded. With that, the final sampling pool contained a total of 10,036 corporate values for analysis. We then trimmed the pool by removing 1% of the lowest and highest values of a continuous variable. The data about the adoption of an Internet-based business model were provided through the combination of buzz words in listed firms' annual reports and manual selection, whereas information about listed companies was sourced from the CSMAR database.

3.2. Definition of Variables

(1) Explained variable: corporate risk-taking. Following the way John et al. [4] and Boubakri et al. [1] used, we

employed fluctuating return-on-assets (ROA) to measure the level of a company's risk tolerance. ROA, in this paper, indicated a ratio of a company's earnings before interest and taxes (EBIT) against its total assets, and *A_ROA* was calculated by relating *ROA* to an annual average on an industrial basis, which is shown in equation (1). With every three years (from *t-2* to *t*) as an observation session, the study measured the standard deviation (see equation (2)) and range (see equation (3)) of the adjusted value of *A_ROA* and computed the explained variables *RISK*1 and *RISK*2 by multiplying the value by 100. The greater the fluctuation of *ROA* (the larger the standard deviation), the higher the risk tolerance of a company.

$$A\_ROA_{\mathrm{it}} = \frac{EBIT_{\mathrm{it}}}{ASSET_{\mathrm{it}}} - \frac{1}{M}\sum_{k=1}^{M}\frac{EBIT_{\mathrm{it}}}{ASSET_{\mathrm{it}}}, \tag{1}$$

$$RISK1_{it} = \sqrt{\frac{1}{T-1}\sum_{t=1}^{T}\left(A\_ROA_{\mathrm{it}} - \frac{1}{T}\sum_{t=1}^{T}A\_ROA_{it}\right)^{2}} \cdot |T = 3, \tag{2}$$

$$RISK2_{\mathrm{it}} = Max\left(A\_ROA_{\mathrm{it}}\right) - \mathrm{Min}\left(A\_ROA_{\mathrm{it}}\right). \tag{3}$$

(2) Core explanatory variable: the Internet-based business model. Inspired by Yang and Bi [18], as well as Li et al. [21], we measured the relative level of the introduction of a network-powered commercial mode by companies. The executive suite would reveal how their company has implemented and promoted the Internet Plus initiative in the annual report. Given that, we, on the basis of the textual information contained in the samples' annual reports, defined the texts and made an etymological analysis. Built on such guiding documents as the *Industrial Internet Development Action Plan (2018-2020)*, the paper gathered basic etymology on the Internet-based business model, including 20 keywords such as the Internet, Internet-based business model, "Internet Plus," big data, blockchain, the Internet of Things, artificial intelligence, e-commerce, and O2O. Then, we used the programming language of R to count the number of sentences containing the aforementioned keywords in the board report section of the annual report of listed companies. A manual review was conducted to remove expressions that put negative characters, such as "not" (meaning "nothing" or "negative"), before a keyword, and sentences containing keywords in the sections irrelevant to business development, including those introducing the companies' shareholders, executives, suppliers, and customers, and all tables and obscure descriptions were also deleted. Upon the removal, we counted the number of keywords mentioned and measured how penetrating the Internet-based business model is in the business community by employing the logarithm to the sum of the number of keywords counted and 1, expressed by *INT*1, and meantime, the dummy variable, indicated by *INT*2, was also created to show whether an enterprise has adopted a network-driven business model. If the enterprise implements the model (the information disclosed in the annual report of the listed enterprise contains keywords about the model), $INT2 = 1$; otherwise, $INT2 = 0$.

(3) Mediator variable: the extent of information asymmetry (*ASY*). The *ASY* was measured in reference to Amihud [29]. Liquidity ratio (*LR*), illiquidity ratio (*ILL*), and return reversal (*GAM*) were selected for PCA. The top-ranking components were extracted as the variable of the degree of information asymmetry of enterprises:

$$\begin{aligned} LR_{\mathrm{it}} &= \frac{1}{D_{\mathrm{it}}}\sum_{k=1}^{D_{\mathrm{it}}}\sqrt{\frac{V_{\mathrm{it}}(k)}{\left|r_{\mathrm{it}}(k)\right|}}, \\ ILL_{\mathrm{it}} &= \frac{1}{D_{\mathrm{it}}}\sum_{k=1}^{D_{\mathrm{it}}}\sqrt{\frac{\left|r_{\mathrm{it}}(k)\right|}{V_{\mathrm{it}}(k)}}, \end{aligned} \tag{4}$$

where $r_{it}(k)$ is the stock yield of enterprise i on the kth trading day in year t; $V_{it}(k)$ is the daily turnover; D_{it} is the number of trading days in the current year. $GAM_{it} = \mid \gamma_{it} \mid$, where coefficient γ_{it} is estimated by $r^{e}_{\mathrm{it}}(k) = \theta_{\mathrm{it}} + \varphi_{\mathrm{it}} r_{\mathrm{it}}\ (k-1) + \gamma_{\mathrm{it}} V_{\mathrm{it}}(k-1)\mathrm{sign}[r^{e}_{\mathrm{it}}(k-1)] + \varepsilon_{\mathrm{it}}(k)$. Among them, $r^{e}_{\mathrm{it}}(k) = r_{\mathrm{it}}(k) - r_{mt}(k)$ is the excess return, and $r_{mt}(k)$ is the stock market return weighted by the current market value. When other conditions remain unchanged, the higher the company's information asymmetry, the lower its stock liquidity, and the greater the *LR*, *ILL*, and *GAM*. In this study, the top-ranking components of the three original indices are extracted to represent the *ASY* of the company. Our descriptive statistics show that the minimum and maximum of *ASY* were −2.030 and 1.004, respectively. A greater *ASY* value indicated larger degrees of information asymmetry.

(4) Control variables. We took a common approach to further keep variables related to a company and its locality constant. Those concerning a company included *Age* (the logarithm to years a company spends on a Chinese stock market plus 1), *State* (1 for state-owned enterprises, and 0 for those otherwise), *Growth (the increase of business revenue), Cash (net cash flow divided by total assets), ROA (net profit divided by total assets), Lev* (asset-liability ratio), *Size* (the natural logarithm of business revenue), *RD* (expenditure on research and development divided by business income), *Dual (to indicate whether a single individual assumes two posts), First* (the first majority shareholder of a company), *Bdsize* (the size of a board), and *Indep* (the number of independent directors). Control variables regarding a company's locality involved *Market*

(the Marketization Index for Chinese provinces, put forth by Chinese economist Fan Gang) and GDP (the per capita GDP of Chinese provinces).

3.3. Modeling. To test Hypothesis 1, we built the following baseline model to examine the impact that an Internet-based model has on corporate risk-taking.

$$RISK_{\mathrm{it+1}} = \beta_0 + \beta_1 INT_{\mathrm{it}} + \beta_2 X_{\mathrm{it}} + \alpha_Y + \alpha_R + \alpha_I + \varepsilon_{\mathrm{it}}. \quad (5)$$

Given that there is a time lag between the adoption of a net-driven commercial mode and the effect of corporate risk-taking, the paper made time-lag-based adjustments to dependent variables. In (5), $RISK_{it+1}$ indicates the level of risk-taking for the i company in the year of $t+1$, including *RISK*1 and *RISK*2; INT_{it} is the extent to which an Internet-based business model is carried out, including *INT*1; X_{it} refers to a range of control variables implying a company's performance and locality in this paper. Moreover, the study further kept such variables as time-fixed effect (α_Y), industry-fixed effect (α_I), and provincial-level fixed effect (α_R) constant. ε_{it} denotes a random error.

To verify Hypothesis 2, we adopted the method Baron and Kenny [30] used and on the basis of (5), improved the mediation effect model, which is shown in (6) and (7).

$$ASY_{\mathrm{it}} = \lambda_0 + \lambda_1 INT_{\mathrm{it}} + \lambda_2 X_{\mathrm{it}} + \alpha_Y + \alpha_R + \alpha_I + \varepsilon_{\mathrm{it}}, \quad (6)$$

$$RISK_{\mathrm{it+1}} = \mu_0 + \mu_1 INT_{\mathrm{it}} + \mu_2 ASY_{\mathrm{it}} + \mu_3 X_{\mathrm{it}} + \alpha_Y + \alpha_R + \alpha_I + \varepsilon_{\mathrm{it}}. \quad (7)$$

In equations (5)–(7), β_1 refers to the overall effect of corporate risk-taking presented by the Internet-based business model; μ_1 suggests the direct effect of risk-taking brought by the network-driven commercial mode; $\lambda_{1\times}\mu_2$ is the effect imposed by the Internet-based business model through mediator variable *ASY*.

4. Results Analysis

4.1. Descriptive Statistics Analysis. Table 1 lists the descriptive statistics of the main variables. Among others, the mean and standard deviation of *INT*1 stood at 1.021 and 1.252, respectively, suggesting the difference in the extent to which an Internet-based business model is carried out by listed companies in China. The median of *RISK*1 registered 0.163, lower than its mean (0.234), which means the risk-taking level of most listed enterprises remains low. The mean and standard deviation of *ASY* were -0.140 and 0.600, respectively, signaling that a majority of companies trading on China's stock exchanges are subject to the constraints of information failure to varying degrees. Table 2 shows the correlation analysis of major variables. It can be found that the correlation coefficient between *INT*1 and *RISK*1 and between *INT*1 and *RISK*2 stand at 0.047 and 0.044, respectively, both lower than 0.6, a threshold; and the variance inflation factor (VIF) average for the proposed model is 1.60, indicating that the model was free from major multicollinearity concerns.

4.2. Baseline Regression. The regression results that relate an Internet-based business model to corporate risk-taking are shown in Table 3. Among others, Column (1) shows the regression results relating *INT*1 to *RISK*1 through the method of Ordinary Least Squares (OLS); Column (2) involves the control variables of a company's performance, as well as dummy variables based on the year, industry and region; Column (3) introduces control variables based on regions; Column (4) interprets the regression results with the dummy variable of *INT*2 involved; Column (5) displays the estimates with *RISK*2 involved. According to the findings from Columns (1) to (3), the regression coefficients of *INT*1 are all positive at the significance level of 1%; the coefficient of *INT*2 in Column (4) stands at 0.003 at the significance level of 1%; the coefficient of *INT*1 in Column (5) registers 0.012 at the significance level of 5%. All these five columns reveal that when adopting an Internet-based business model, companies will see a surge in risk capacity, and the more committed to such a model they are, the higher level of risk tolerance they will enjoy and the conclusion justified Hypothesis 1.

4.3. The Mechanism of Action Testing. To prove the mechanism of action for a network-based commercial mode to affect corporate risk-taking, we ramped up efforts to test how the model makes an impact on companies' risk tolerance. The aforesaid theoretical analysis found that the Internet-driven business model could allow enterprises to be free from constraints imposed by information asymmetry when making investment decisions, thus encouraging them to be more willing to take a risk. That means the reduction of information failure is crucial to enhancing a company's risk tolerance under a web-powered business model.

Columns (1) to (3) in Table 4 display the estimates from the mediation effect model involving the dependent variable *RISK*1. The coefficient of *INT*1 in Column (1) is 0.007 and positive at the significance level of 1%, and that in Column (2) is -0.026 at the significance level of 1%, suggesting that the Internet-based business model can effectively reduce the information imbalance between companies and the outside world. The coefficient of *INT*1 in Column (3) stands at 0.006 and is positive at the significance level of 5%, and that of *ASY* is -0.044 at the significance level of 1%, meaning the mediation effect was created to a certain extent when information asymmetry weighed in on the relationship between an Internet-based commercial mode and corporate risk-taking. And the effect, according to a further calculation, accounted for 15.1% of the overall effect. That suggested Hypothesis 2 was valid. Beyond that, the regression analysis about the mediation effect with the dependent variable *RISK2* involved was also conducted in this paper, and the statement that the mediation effect was, to a certain extent, created still held water, according to the results, shown in columns (4) to (6) in Table 4. In addition, we adopted the Bootstrap method for the robustness test. Bootstrap sampling was carried out 1,000 times. When the dependent variable was *RISK*1, the product between coefficients fell in the interval [0.001, 0.002] at the significance level of 95%; when the dependent variable was *RISK*2, the product

Table 1: Descriptive statistics of variables.

Variables	Sample size	Mean	Standard deviation	Median	Maximum	Minimum
RISK1	10036	0.234	0.232	0.163	1.455	0.016
RISK2	10036	0.444	0.434	0.310	2.747	0.029
INT1	10036	1.021	1.252	0.693	4.644	0.000
ASY	10036	−0.140	0.600	−0.067	1.004	−2.030
RD	10036	0.033	0.037	0.0290	0.193	0.000
Age	10036	2.227	0.623	2.303	3.219	0.693
State	10036	0.422	0.494	0.000	1.000	0.000
Growth	10036	0.341	0.915	0.141	10.23	−0.725
Dual	10036	0.757	0.429	1.000	1.000	0.000
Indep	10036	0.373	0.056	0.333	0.800	0.125
Bdsize	10036	2.267	0.178	2.303	2.944	1.386
Cash	10036	0.173	0.113	0.144	0.593	0.015
Roa	10036	0.042	0.048	0.036	0.193	−0.225
Lev	10036	0.435	0.197	0.433	0.902	0.059
Size	10036	22.38	1.297	22.16	26.09	19.70
First	10036	3.498	1.487	3.329	7.496	0.872
Market	10036	8.373	1.890	8.580	11.03	2.940
GDP	10036	6.777	2.755	6.417	14.02	1.312

Table 2: Statistical analysis on correlation among major variables.

	RISK1	RISK2	INT1	RD	Age	State	Roa	Lev	Size
RISK1	1								
RISK2	0.998***	1							
INT1	0.047***	0.044***	1						
RD	−0.022**	−0.024***	0.215***	1					
Age	0.061***	0.060***	−0.048***	−0.321***	1				
State	−0.058***	−0.058***	−0.185***	−0.224***	0.482***	1			
Roa	−0.258***	−0.255***	0.012	0.038***	−0.102***	−0.088***	1		
Lev	−0.054***	−0.056***	−0.114***	−0.319***	0.346***	0.322***	−0.344***	1	
Size	−0.137***	−0.137***	0.006	−0.295***	0.391***	0.370***	0.001	0.534***	1

Note. *, **, and *** suggest significance at the levels of 10%, 5%, and 1%, respectively.

between coefficients fell in the interval [0.002, 0.004] at the significance level of 95%. Neither interval contains zero, which further demonstrates the robustness of the mediation effect.

4.4. Endogeneity. To reduce endogeneity brought by reverse causality, omitted variables, and sample selection bias, we employed four methods as follows.

(1) Fixed-effect model. The statistical model could be undermined by the omission of variables, particularly the individual features that do not change over time, thus leading to unreliable conclusions. By using a fixed-effect model, we reined in the individual effect of businesses, and this was based on the fixed effects of region, industry, and time. The estimated coefficients of *INT*1 are 0.005 and 0.010, respectively, in Columns (1) and (2) in Table 5, both being positive at the significance level of 10%.

(2) Heckman two-stage model. To address sample selection bias that could take a toll on the model, we employed the Heckman two-step model, on top of drawing on the research by He et al. [31]. A Probit regression model, adopted at Stage 1, involved *INT_Dummy*, a dummy variable to indicate whether an Internet-based business model is implemented. Meanwhile, *INT_Other*, as an exogenous instrumental variable to show the proportion of other peers carrying out a network-based commercial model in the same year, was also included at Stage 1 to calculate the inverse Mills ratio (*Lambda*), which would be fitted at Stage 2. Results from Column (3) in Table 5 find that *Lambda* is positive at the significance level of 1%, and the estimated coefficient of *INT*1 is 0.009 and positive at the significance level of 5%.

(3) Difference-in-differences (DID) model. In 2017, the Chinese government proposed a blueprint to develop China into a network powerhouse. By adopting a strategy of integrating the Internet, big data, and artificial intelligence with the real economy, the initiative also made it clear for the country to accomplish three main tasks in network development. Guided by government policies, an increasing number of enterprises have since laid a greater emphasis on the application of the Internet. The phenomenon, as Li et al. [21] put it, was a quasiexperiment, which was tested on a DID model. To

Table 3: The Internet-based business model and corporate risk-taking.

Variables	(1) RISK1	(2) RISK1	(3) RISK1	(4) RISK1	(5) RISK2
INT1	0.014***	0.007***	0.007***		0.012**
	(6.59)	(2.77)	(2.70)		(2.53)
INT2				0.003***	
				(2.90)	
RD		0.093	0.094	0.091	0.156
		(1.01)	(1.01)	(0.98)	(0.90)
Age		0.043***	0.043***	0.043***	0.081***
		(9.02)	(9.13)	(9.14)	(9.06)
State		−0.034***	−0.035***	−0.035***	−0.065***
		(−5.69)	(−5.74)	(−5.73)	(−5.75)
Growth		0.004	0.004	0.004	0.007
		(1.10)	(1.10)	(1.10)	(1.09)
Dual		−0.002	−0.002	−0.002	−0.005
		(−0.40)	(−0.40)	(−0.38)	(−0.46)
Indep		−0.011	−0.008	−0.009	−0.019
		(−0.23)	(−0.17)	(−0.19)	(−0.22)
Bdsize		−0.038**	−0.037**	−0.037**	−0.066**
		(−2.42)	(−2.37)	(−2.37)	(−2.26)
Cash		−0.053**	−0.050**	−0.051**	−0.095**
		(−2.37)	(−2.25)	(−2.27)	(−2.25)
Roa		−0.846***	−0.848***	−0.848***	−1.567***
		(−9.06)	(−9.09)	(−9.09)	(−8.98)
Lev		−0.115***	−0.115***	−0.116***	−0.221***
		(−5.72)	(−5.74)	(−5.75)	(−5.85)
Size		−0.013***	−0.013***	−0.013***	−0.024***
		(−4.78)	(−4.83)	(−4.82)	(−4.74)
First		−0.002	−0.002	−0.002	−0.004
		(−1.19)	(−1.19)	(−1.16)	(−1.31)
Market			0.023***	0.023***	0.043***
			(3.12)	(3.07)	(3.11)
GDP			−0.002	−0.002	−0.003
			(−0.36)	(−0.36)	(−0.40)
Constant	0.220***	0.622***	0.439***	0.441***	0.823***
	(76.02)	(10.45)	(5.15)	(5.18)	(5.15)
Year/ Ind/ Region	NO	Yes	Yes	Yes	Yes
N	10036	10036	10036	10036	10036
R^2	0.006	0.094	0.095	0.095	0.095

Note. The figure within brackets is the t value upon the calculation of robust standard errors. *, **, and *** suggest significance at the levels of 10%, 5%, and 1%, respectively (the same below).

be specific, we viewed samples that failed to adopt an Internet-based business model during research time as a reference group and those that did not implement such a model between 2010 and 2016 but did so from 2017 through 2019 as the experimental group. As Column (4) in Table 5 shows, the estimated coefficient of *Treat*×*Post* is 0.041 at the significance level of 1%, and *Post* is absorbed by the time-fixed effect. Results from the DID model's parallel trend test show that the coefficients of $Treat \times Year2015$ and $Treat \times Year2016$ are insignificant before the implementation of the initiative in 2017, but those of $Treat \times Year2017$ and $Treat \times Year2018$ are positive at the significance level of 5% at least in 2017 and the following year. That signaled analysis results passed the parallel trend test.

(4) Placebo test. There could be other random factors we cannot observe or measure currently, despite the best possible efforts made to keep critical variables affecting corporate risk-taking under control. Given that, we employed a placebo test, which was inspired by Liu and Lu [32]. The approach was designed to convert the impact of an Internet-based business model on a company's risk capacity into a stochastic process and have it iterated 500 times. This ensured that core explanatory variables exerted no real effects, meaning the estimated coefficient β should be 0 and the mean of β could be computed. Results showed that the mean of the stochastically processed β was 0.000141, nearing 0, and the average of t was 0.054. The β and t values randomly distributed 500 times are displayed in Figures 1 and 2. It can be found that all these values linger around 0, suggesting unobserved factors could barely make an impact on regression results. That, therefore, consolidated the robustness of our conclusions.

4.5. Robustness Test. To make our conclusions more reliable, we took the following steps to test robustness.

(1) Replace the core explanatory variable. To overcome the impact of differences in the length of annual reports, we, by following the method proposed by Li et al. [21], multiplied *INT*3 (meaning the total of Internet terms divided by the word count of annual reports) by 100. As Column (1) in Table 6 notes, the coefficient of *INT*3 is 0.003 at the significance level of 1%.

(2) Swap the explained variable. Inspired by the research of Boubakri et al. [1], the paper used *RISK*2 to indicate the level of risk tolerance, and *INT*3 remained a core explanatory variable. Column (2) in Table 6 shows that the estimated coefficient is 0.005 at the significance level of 1%.

(3) Change the estimation time period. By adopting the research time period suggested by Yang and Bi [18], we removed data on companies trading on Chinese stock exchanges between 2010 and 2012 and made a regression analysis on data from 2013 through 2019. The conclusions, upon the analysis, stayed robust, as results from Column (3) in Table 6 found.

(4) Remove corporate samples that fail to carry out an Internet-based business model. Nearly half of the sample pool we built was not committed to a network-driven commercial mode. And to overcome the impact presented by these samples, we acknowledged the approach proposed by Li et al. [21] by merely estimating the samples whose *INT*1 was greater than 0. The estimated coefficient is 0.009 at the significance level of 5%, as is shown in Column (4) in Table 6.

Table 4: Mechanism of action testing.

Variables	(1) RISK1	(2) ASY	(3) RISK1	(4) RISK2	(5) ASY	(6) RISK2
INT1	0.007***	−0.026***	0.006**	0.012**	−0.026***	0.010**
	(2.70)	(−6.60)	(2.24)	(2.53)	(−6.60)	(2.08)
ASY			−0.044***			−0.082***
			(−6.60)			(−6.61)
Constant	0.439***	6.964***	0.747***	0.823***	6.964***	1.397***
	(5.15)	(45.70)	(7.63)	(5.15)	(45.70)	(7.62)
Year/Ind/Region	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
N	10036	10036	10036	10036	10036	10036
R^2	0.095	0.631	0.100	0.095	0.631	0.099

Table 5: Endogeneity reduction.

Variables	(1) RISK1	(2) RISK2	(3) RISK1	(4) RISK1	(5) RISK1
INT1	0.005*	0.010*	0.009**		
	(1.87)	(1.85)	(2.37)		
Treat × Post				0.041***	
				(3.32)	
Treat				−0.009*	
				(−1.68)	
Post					
Lambda			0.095***		
			(2.95)		
Treat × Year2015					−0.014
					(−1.22)
Treat × Year2016					−0.011
					(−0.88)
Treat × Year2017					0.042***
					(3.13)
Treat × Year2018					0.007**
					(2.34)
Constant	1.007***	1.890***	0.282**	0.441***	0.433***
	(5.34)	(5.33)	(1.97)	(5.20)	(5.10)
Firm	Yes	Yes	NO	NO	NO
Year/Ind/Region	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
N	10036	10036	10036	10036	10036
R^2	0.397	0.397	0.401	0.095	0.095

5. Further Analysis

5.1. Moderation Effect Analysis. The preceding paragraphs suggested that an Internet-based business model allows enterprises to ease the constraints imposed by information failure as they make investment decisions and thus enhances their risk tolerance. The information empowerment effect created by such a model, however, could be affected by an interplay of internal and external elements, with the external market environment and the restrictions on corporate financing being typical ones.

(1) Market-based moderation. The market environment is crucial for a company's investment decisions [33]. A freer market tends to boast a more mature combination of market systems, factors of production, and intermediaries and also results in improved Internet infrastructure and network-based platforms. That means a region whose development is driven more by market forces will see a significant enhancement in the accessibility, penetration, and efficiency of Internet services and thus create synergy between the market environment and information technology. With market-oriented institutions and Internet technology, businesses can largely reduce information asymmetry when making investment decisions. That helps level up their willingness and capacity to take risks in a way that justifies the role the Internet has in facilitating corporate risk-taking. Inspired by Hou et al. [33], we employed the Fan Gang-proposed Marketization Index to indicate the level of marketization on a provincial level and had it fitted through average growth in indices between

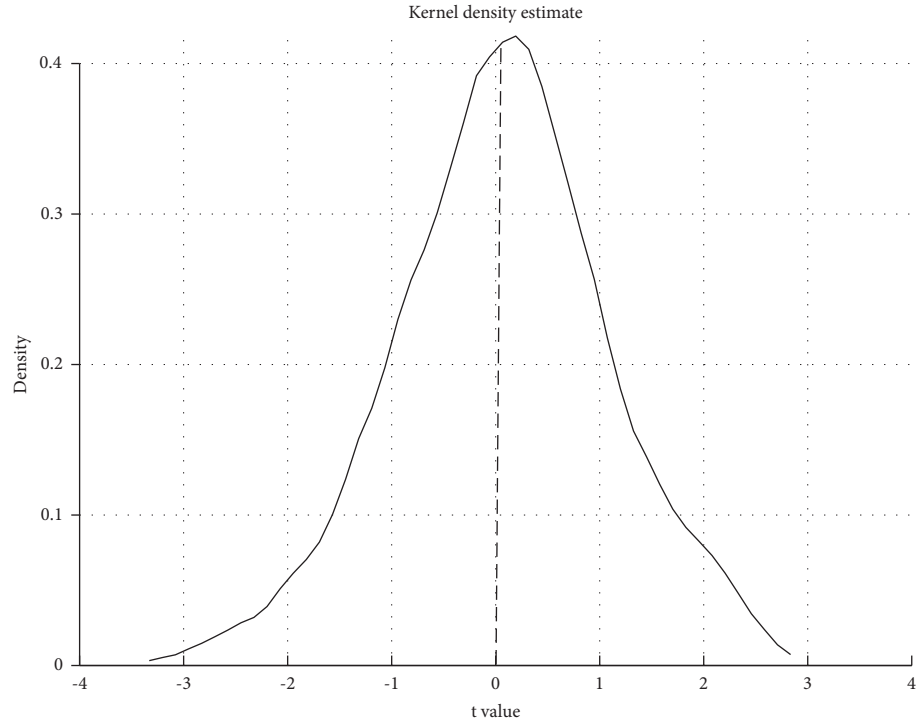

Figure 1: Distribution of the stochastically processed β.

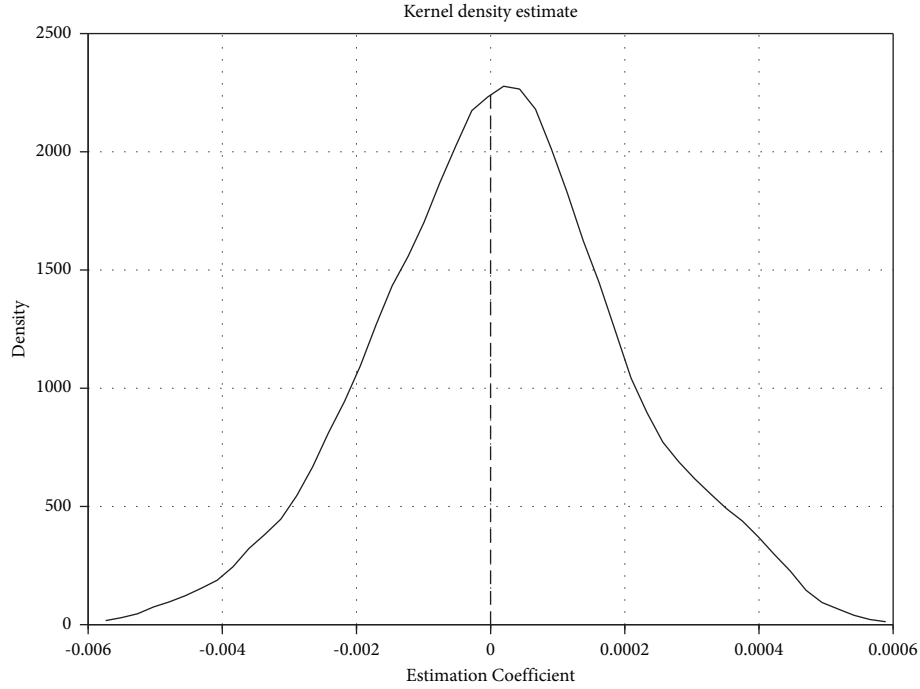

Figure 2: Distribution of the stochastically processed t.

2010 and 2019. Results from regression analysis, shown in Columns (1) and (2) in Table 7, find that the coefficients of $INT1 \times Market$ are positive at the significance level of 1%, meaning in an enabling market environment, the enhancement of a company's risk capacity can be driven more by an Internet-based business model. Therefore, a blend of increased marketization and the web-powered commercial mode is of significance to inspire enterprises to take risk.

Table 6: Robustness test.

Variables	(1) RISK1	(2) RISK2	(3) RISK1	(4) RISK1
INT3	0.003***	0.005***		
	(2.90)	(2.74)		
INT1			0.005**	0.009**
			(2.06)	(2.37)
Constant	0.441***	0.827***	0.393***	0.343***
	(5.18)	(5.18)	(3.36)	(2.65)
Year/Ind/Region	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
N	10036	10036	7693	5372
R^2	0.095	0.095	0.114	0.113

Table 7: Moderation effect testing.

Variables	(1) RISK1	(2) RISK2	(3) RISK1	(4) RISK2
INT1	−0.025**	−0.046**	0.065***	0.124***
	(−2.44)	(−2.41)	(2.63)	(2.71)
INT1 × Market	0.004***	0.007***		
	(3.05)	(2.97)		
Market	0.018**	0.033**		
	(2.35)	(2.36)		
SA			0.020	0.039
			(1.16)	(1.18)
INT1 × SA			−0.017**	−0.032**
			(−2.35)	(−2.44)
Constant	0.509***	0.951***	0.333***	0.620***
	(5.80)	(5.78)	(2.82)	(2.80)
Year/Ind/Region	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
N	10036	10036	10036	10036
R^2	0.096	0.096	0.075	0.075

(2) Moderation of internal financing constraints. The relationship between an Internet-based business model and corporate risk-taking could concern the financing constraints of a company. Previous studies found that financial embarrassment exerts a great impact on a firm's willingness to take the risk [6]. In reality, a lack of resources would hold back firms from carrying out ambitious investment plans, despite a host of business opportunities for them. Therefore, when companies grapple with many financing constraints, their desire for higher risk capacity cannot be effectively driven by a network-based commercial mode. By adopting the method proposed by Hadlock and Pierce [34], we used the value of the index *SA* to indicate the extent to which a company is financially constrained. The greater the value, the more financially embarrassed the company is. Regression results, displayed in Columns (3) and (4) in Table 7, show that *the coefficients of INT*1×*SA* are negative at the significance level of 5%, signaling that when more financing constraints are imposed on a company, the role of an Internet-based business model in facilitating corporate risk-taking would be undermined to a large extent.

5.2. Extensibility Analysis. The preceding part of the paper demonstrated how the adoption of an Internet-based business model can encourage a company to take a risk. But will a company see its ability to create value enhance as its risk tolerance increases? To explore the issue, we examined the economic consequences presented by corporate risk-taking under an Internet-based business model and see whether risk capacity could contribute to the enhancement of corporate value. Inspired by Ferris et al. [35], we employed *TobinQ* to indicate corporate value and created the explained variable values with one or two time lags, given that the impact of an Internet-based business model on corporate value could be delayed. This is how we could fully observe the dynamic impact of risk tolerance on a company's value in a web-driven commercial mode.

Results from Columns (1) and (2) in Table 8 reveal that the coefficients of $RISK1 \times INT1$ are both positive. The coefficients of $RISK2 \times INT1$, as shown in Columns (3) and (4), are positive at the significance level of 5%. That means under an Internet-based business model, risk tolerance plays an important role in facilitating corporate value. At the same time, despite delayed effects, such facilitation helps sustain the generation of business value. Additionally, the study demonstrated a significant mediation effect among the Internet-driven commercial mode,

Table 8: Testing of consequences presented by corporate risk-taking under an Internet-based business model.

Variables	(1) $TobinQ_{it+1}$	(2) $TobinQ_{it+2}$	(3) $TobinQ_{it+1}$	(4) $TobinQ_{it+2}$
RISK1	0.258***	0.099		
	(4.37)	(1.46)		
RISK2			0.138***	0.053
			(4.39)	(1.49)
RISK1 × INT1	0.085**	0.088*		
	(2.46)	(1.95)		
RISK2 × INT1			0.047**	0.048**
			(2.56)	(2.00)
INT1	0.005	−0.002	0.004	−0.003
	(0.37)	(−0.16)	(0.28)	(−0.21)
Constant	9.839***	9.976***	9.838***	9.974***
	(26.53)	(22.98)	(26.53)	(22.97)
Year/Ind/Region	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
N	10036	8200	10036	8200
R^2	0.410	0.385	0.410	0.386

corporate risk-taking, and business value by introducing a mediation effect model, proving that under such a model, risk capacity can maximize corporate value on a continuous basis.

For example, the Chinese company Xiaomi makes smartphones its core business. In recent years, Xiaomi has actively built a product ecosystem based on the Internet-based business model. With the support of the Internet platform, Xiaomi has established supply chain partnerships with more than 400 companies and successfully incubated nearly 300 ecological chain companies. The Internet-based "investment + incubation" model significantly expands the investment scale, improves the level of risk-taking in investment decisions, and increases the value and brand influence of Xiaomi. The company ranked the 222nd among the largest listed companies in the world, according to the 2021 ranking by Forbes. Its ranking continued to improve in the past years.

6. Conclusions and Implications

Leveraging the data about companies trading on China's stock exchanges between 2010 and 2019, we identified the interconnectedness between an Internet-based business model and corporate risk-taking from the perspectives of information acquisition, integration, and application through a series of empirical analyses and tests. The study noted that the introduction of a network-driven commercial mode allows businesses to be more willing to take a risk. Such a model can effectively reduce information asymmetry, thus enhancing corporate risk-taking, the mechanism of action analysis found. The enhancement of risk capacity, as was indicated by the moderation effect study, will be more noticeable when there is a freer market and the company itself is less financially constrained. And the analysis of economic consequences showed that under an Internet-based business model, a company's risk tolerance can sustain the increase of its business value. The findings contributed to the following implications for policy.

Ramped-up efforts should be made by governments to see the Internet Plus initiative materialize. As the study showed, the Internet-based business model motivates enterprises to take risks in a way that creates greater value. Although the initiative has been of national and strategic significance since it was first proposed by the Chinese government in 2015, the willingness and capacity to capitalize on the Internet remain to be improved. Given that, the government should advance the implementation of the Internet Plus initiative, encourage businesses to go digital in a way that suits their realities, and develop action plans and supporting policies that facilitate digitalization on the part of enterprises.

Priority should be given to carrying out the Internet Plus initiative as businesses make risk management decisions. The mechanism analysis found that an Internet-based business model helps enhance corporate risk-taking by allowing enterprises to reduce information asymmetry as they gather, absorb, and apply data. That means the adoption of such a novel model should not be treated as an option to go with the stream, nor a strategic behavior to garner public attention. Instead, enterprises need to develop "Internet thinking," or Internet-oriented ideology, and follow the rules and patterns in the Internet business world. In so doing, they should blend the attributes of the Internet-based business model with their decision-making so as to create and deliver business value.

Sound internal and external environments serve as the solid groundwork and vital catalyst for the Internet-driven commercial mode. That means, on the one hand, the functions of government should be further transformed and the building of market-oriented regions advanced. This is how the external environment can be shaped to promote the business model. On the other hand, financing constraints should be high on the agenda for enterprises, and when implementing such a model, companies should overcome the obstacle posed by capital shortage and ensure the model is given full play by shaping enabling internal and external environments.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The research was funded by the National Social Science Fund of China Project (21AJY020).

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Hindawi
Discrete Dynamics in Nature and Society
Volume 2022, Article ID 1519717, 11 pages
https://doi.org/10.1155/2022/1519717

Research Article

Dual-Channel Effect of Job Insecurity on Knowledge Workers' Innovative Behavior

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Received 12 March 2022; Revised 11 April 2022; Accepted 25 April 2022; Published 17 May 2022

Academic Editor: Jiafu Su

Job insecurity reflects the desire and expectation of organizational managers for employees' exhibition of innovative behavior. Ubiquitous and inevitable, it has gradually become a concern psychological problem for job survival and stability. As a key driver of innovation, employee innovation depends heavily on knowledge workers, who are best able to spot problems and identify and capture opportunities. Based upon the transactional theory of stress and coping (TTSC), this paper discusses the influencing mechanism of knowledge workers' job insecurity and innovative behavior in enterprises, emphatically analyzes the mediating effects of two coping strategies, i.e., proactive work behavior and working withdrawal behavior, and verifies the moderating effect of organizational climate for innovation. With the data from 665 questionnaires of enterprise knowledge workers, this paper shows that job insecurity can influence knowledge workers' innovative behavior either positively through proactive work behavior or negatively through working withdrawal behavior, thus forming a dual-channel effect model of influencing their innovative behavior, and that organizational climate for innovation has a moderating effect on the relationship between job insecurity and proactive work behavior/working withdrawal behavior. The organizational innovation climate played a moderating role between job insecurity and proactive work behavior and work withdrawal behavior and detected the value of the boundary where the organizational innovation climate played a mediating role.

1. Introduction

With the launch of "Made in China 2025" and Germany's "Industry 4.0" strategy, intelligentization has promoted a new round of technological and industrial revolution. Every business and even individuals are faced with "uncertainty, complexity, and ambiguity." With a view to taking the lead in market competition, enterprises have to adopt reform measures and competitive mechanisms such as "competition for posts," "lowliest place elimination series," "layoff mechanism," and "996 work schedule." Heightened uncertainty in the employment environment leads to the increased employment risks for employees. As employment tensions rise, so does concern among employees about the future loss of work itself or important features, making more and more employees feel insecure at work, and then have a sense of insecurity about the viability of the job [1]. Meanwhile, the outbreak of COVID-19 has swept over 200 countries and regions, affecting more than 7 billion people. The world has faced a grave crisis and severe test, which has once again increased the uncertainty in the working environment of enterprises and aggravated the job insecurity of employees. Job insecurity has gradually become one of the important stressors in today's work [2] and a common psychological problem in the workplace.

Technological changes, market changes, and the on-and-off pandemic have exposed the enterprises to many uncertainties and problems. Enterprises have also realized that only by developing innovative products or services and constantly maintaining innovative vitality can they survive in the complex market competition [3]. Innovation is mainly driven by employees in an enterprise [4], where knowledge workers are best able to find problems and identify and capture opportunities [5]. Therefore, having a group of

proactive and innovative workers has become the key to improve the innovation capability of enterprises. So far, the research on individual innovation has basically focused on effective interaction [6, 7], positive atmosphere [8], proactive leadership [9, 10] and other supportive and stable factors. However, little attention is paid to negative factors that are not conducive to innovation [11]. Research suggests that it is of equal importance to identify and eliminate negative factors in the workplace that discourage innovation [12]. Studies have found that job insecurity will have a negative impact on employees' job satisfaction [13], physical and mental health [14], risk tolerance [15], and civic behavior [16], among others. Meanwhile, some scholars analyze that job insecurity has a certain negative impact on innovative behavior [17]. Job insecurity is understood as a hindrance situation, and it is proposed to eliminate employees' perceived insecurity at work [18]. Other studies, however, have not found such relationship [19]. This also implies that the relationship between job insecurity and employee innovative behavior is uncertain. Existing studies on the impact of job insecurity on employee innovative behavior are to be improved. There is still no consensus on the relationship between the two and ways to influence the latter [20, 21]. More theories are required to explore and explain the relationship between them from more perspectives [22].

To sum up, this paper contributes to the following two: first, based on the TTSC, proactive work behavior and working withdrawal behavior are introduced as positive and negative coping styles, respectively, in an effort to explain the dual-channel effect of job insecurity on knowledge workers' innovative behaviors. Second, this paper argues that the high or low organizational climate for innovation affects the coping styles of knowledge workers in case of perceived job insecurity and thus constructs a two-path moderated mediation model. With this model, the influencing mechanism and boundary conditions of job insecurity on knowledge workers' innovative behaviors are analyzed systematically to help business managers better understand the effects of job insecurity requirements and take advantage of job insecurity to enhance the innovative behavior of enterprises.

2. Literature Review and Hypotheses Development

TTSC is a subjective appraisal of stress from the perspective of interaction. It expounds the subjective process and important role of cognitive appraisal and coping response [23] and is often applied to study the individual differences in response to stress [24]. There is no difference between positive and negative. The difference between challenge and hindrance stress is the product of subjective cognitive appraisal. Different cognitive appraisals prompt individuals to adopt different coping styles and strategies [25]. In an environment of uncertainty, employees tend to adopt the negative coping style when they have appraised the current situation as damage or threat; when the situation is appraised as a challenge, employees are more willing to adopt the positive coping style [25]. It is essentially a process in which individuals adjust to the management objectives set by the organization. Different coping strategies are bound to produce different behavioral outcomes, so it is an important strategy to cope with stress [26]. In conclusion, when the employees feel insecure in the workplace, the cognitive appraisal of stress will influence the employees to adopt different coping strategies and thus have different effects on innovative behavior.

2.1. Impact of Job Insecurity on Employee Innovative Behavior: The Mediating Effect of Proactive Work Behavior. The stress of job insecurity is a peculiar phenomenon in business [27]. Job insecurity is pervasive and inevitable [28]. Research shows that organizational environment is an important situational factor to stimulate the proactive work behavior [29]. People tend to be slack in a comfortable environment, while job insecurity from the outside can moderate such slack, and thus the stress from job insecurity is not always negative. According to the TTSC, the duality of stress implies that challenge stressors will stimulate individuals to take positive coping strategies while hindrance stressors are consuming internal resources [25]. Job insecurity may also be a positive stimulus, which plays a positive role in stimulating and maintaining employees' enthusiasm and effort [30]. Meantime, individuals are more willing to adopt the positive coping style, put in more efforts, and perform better when they believe the availability of greater external benefits in dealing with job insecurity [31], thereby facilitating more proactive behaviors.

Proactive work behavior is a behavior committed to improving the internal working environment of an organization, characterized by spontaneity, foresight, and change [32]. Proactive work behavior is generally positive for the organization [7]. In addition, by exhibiting proactive work behavior, employees can usually have access to more opportunities for career advancement [33]. Parker [34] has proposed that proactive work behavior is committed to changing and improving the working environment within an organization, such as improving workflow [35], offering constructive suggestions [36], putting forward new ideas, and actively implementing them [37]. Therefore, proactive work behavior is a positive work behavior, which is beneficial to improve employees' work performance and promote their innovative behavior.

To sum up, based on the TTSC, this paper holds that employees will make a positive appraisal of themselves when they identify job insecurity as a challenge stressor. This appraisal will motivate employees to engage in more proactive work behaviors, thus improving their innovative behavior. Based on the above analysis, the following hypotheses are proposed.

Hypothesis 1. (H1+): job insecurity positively influences proactive work behavior.

Hypothesis 2. (H3+): proactive work behavior positively influences employee innovative behavior.

Hypothesis 3. (H5+): proactive work behavior has a mediating effect on the relationship between job insecurity and employees' innovative behavior.

2.2. Impact of Job Insecurity on Employee Innovative Behavior: The Mediating Effect of Working Withdrawal Behavior. While perceiving a threat to the ongoing safety of job, employees will rely more on routine solutions and reduce the sharing of knowledge and other resources in order to avoid risks and failures and achieve the purpose of self-protection, thus producing working withdrawal behavior to some extent [38]. In this situation, employees will have greater psychological stress in the face of work pressure [39]. For example, the threat of losing one's job can trigger frustration, anger, and pain, inducing emotional exhaustion [40]. In the context of stress response, working withdrawal behavior is the counterproductive work behavior of employees to instinctively protect themselves and deliberately avoid group or specific situational tasks [41]. The working withdrawal behavior is manifested by being late, leaving early, absenteeism, gossiping during working hours, and turnover intention [42]. Withdrawal can help individuals avoid further pain as a way of distancing themselves from harm [43].

While exhibiting working withdrawal behavior, employees are less committed to their jobs (such as resources and energy), so that it is difficult for them to perfect work tasks, thus reducing the innovative behavior [44]. In addition, job insecurity often causes employees to violate and resist organizational management, thus undermining the employee innovative behavior [45]. Wei and Si [46] note that news of layoffs trigger emotional exhaustion among employees, which in turn weakens the employee innovative behavior. Job insecurity is the factor to trigger working withdrawal behavior [46]. Working withdrawal behavior will have a negative impact on employees' innovation [47].

In conclusion, based on the TTSC, this paper finds that when employees identify job insecurity as a hindrance stressor, such negative cognitive appraisal will prime their motivation to protect themselves, so that employees may avoid the threat by holding back, ultimately not conducive to the innovative behavior. Based on the above analysis, the following hypotheses are proposed:

Hypothesis 4. (H2+): job insecurity positively influences working withdrawal behavior.

Hypothesis 5. (H4-): working withdrawal behavior negatively influences employee innovative behavior.

Hypothesis 6. (H6+): working withdrawal behavior has a mediating effect on the relationship between job insecurity and employee innovative behavior.

2.3. Moderating Effect of Organizational Climate for Innovation. An important factor for an organization to achieve innovation is to encourage and support innovation [48]. From a subjective perspective, this paper interprets organizational climate for innovation as employees' perception of recognition, support, and encouragement of innovation in the working environment [49], including colleague relations, leadership support, resource support, and organizational support. O'Driscoll and Randall [50] believe that organizational support perceivers are more likely to care about and contribute to the development of the organization. Having highly perceived the organizational climate for innovation, employees tend to meet organizational expectations through proactive behaviors [51]. In this case, perception tends to be more of a challenge for employees, which clarifies their direction of efforts. Otherwise, employees may think that the organization is demanding and be more likely to think of the perception as a hindrance and respond to the organization through working withdrawal behavior. Besides, organizations with a strong climate for innovation will attach great importance to learning and provide necessary material resources for employees [52]. Organizations with a strong climate for innovation will offer employees a relaxed and positive working environment and give them psychological resources to minimize their psychological cost and risk perception [48]. At the same time, the efficiency of the team's knowledge sharing can be improved [53]. Employees tend to have positive feelings when they perceive the work environment as positive and believe that stress on the job enhances potential earnings and will be more motivated to work [54]. This positive perception will raise employees' willingness to work proactively, and they will prefer positive actions to gain more resources and get rid of job threats. In the meantime, employees with job insecurity will also be threatened with the loss of resources. Sufficient resources allow employees to deal with job insecurity proactively [55] and serve as a prerequisite for proactive work behavior. With sufficient resources, employees can take the initiative to improve their competitiveness and meet the organization's expectations, thus improving employment relations and gaining continuing benefits from employment.

While perceiving a high organizational climate for innovation, employees are more willing to work hard to turn stress into motivation, overcome difficulties and challenges at work through proactive behaviors, and achieve changes. Similarly, while perceiving a low organizational climate for innovation, employees are reluctant to engage in proactive work behavior and often adopt working withdrawal behavior to cope with job insecurity. In conclusion, this paper suggests that the higher perceived level of organizational climate for innovation has a positive moderating effect on the relationship between job insecurity and proactive work behavior, and the lower perceived level of organizational climate for innovation negatively moderates the relationship between job insecurity and working withdrawal behavior. Further, it puts forward the following hypotheses:

Hypothesis 7. (H7a): organizational climate for innovation positively moderates the impact of job insecurity on proactive work behavior, i.e., the higher the perceived level of organizational climate for innovation, the stronger the impact of job insecurity on proactive work behavior.

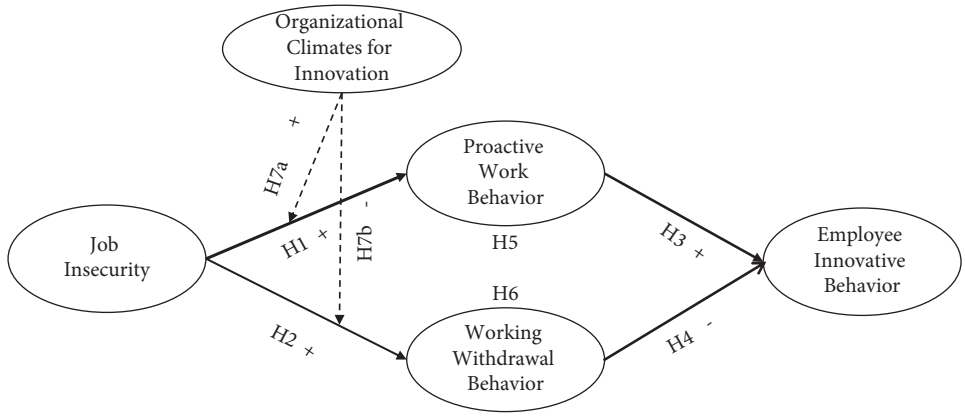

Figure 1: Theoretical model.

Table 1: Basic sample description.

Items	Categories	*N*	%	Items	Categories	*N*	%
Gender	Male	338	50.83	Marriage	Single	248	37.29
	Female	327	49.17		Married	344	51.73
	—	—	—		Divorced	73	10.98
Age	20–28	152	22.86	Education	Junior college	120	18.05
	29–35	263	39.55		Undergraduate	232	34.89
	36–45	177	26.62		Postgraduate	271	40.75
	>45	73	10.98		PhD	42	6.32

Hypothesis 8. (H7b): organizational climate for innovation negatively moderates the impact of job insecurity on working withdrawal behavior, i.e., the higher the perceived level of organizational climate for innovation, the weaker the impact of job insecurity on working withdrawal behavior.

The theoretical model is shown in Figure 1.

3. Research Design

3.1. Samples and Data Collection. The research samples are mainly from production and service enterprises in Zhejiang, Jiangsu, and Jiangxi provinces. All respondents are promised in this paper that the questionnaire will only be used for scientific research only, without any disclosure of personal information. Besides, there are questions whether the enterprise has implemented the "lowliest place elimination series," "competition for posts," "layoff mechanism," "996 work schedule," and other incentive measures. If not, jump to the end, thereby ensuring the authenticity of the sampling situation and respondents. A total of 201 predictive questionnaires were handed out, of which 159 were valid, with an effective recovery of 79.1%. A total of 684 formal questionnaires were handed out, of which 665 were valid, with an effective recovery of 97.22%.

The official samples were 50.83% male and 49.17% female. In terms of age, 263 employees (39.55%) are aged 29–35, 177 (26.62%) aged 36–45, 152 (22.86%) aged 20–28, and 73 (10.98%) aged over 45. Education: 271 with master's degree, accounting for 40.75%; 232 with bachelor's degree, 34.89%; 120 with junior college diploma, 18.05%; and 42 with doctor's degree, 6.32%. Marriage: 248 single, accounting for 37.29%; 344 married, 51.73%; and 73 divorced, 10.98%, as shown in Table 1.

3.2. Variable Measurement. In order to ensure the reliability and validity of study samples, mature scales at home and abroad were used. The 5-point Likert scale was used for the measurement items, with 1~5 ranging from "very inconsistent" to "very consistent," and conversely otherwise. The 7-item scale developed by Hellgren et al. [56] was employed for job insecurity. In this paper, the Cronbach's α was 0.921. Innovative behavior adopted the 12-item scale in the study by Huang [57], divided into two dimensions: the generation and execution of innovation ideas. In this paper, the Cronbach's α was 0.936. The 7-item scale developed by Frese [58] was employed for proactive work behavior. In this paper, the Cronbach's α was 0.961. The 7-item scale developed by Lehman and Simpson [42] was used for reference for working withdrawal behavior, divided into psychological and physical withdrawal behaviors. In this paper, the Cronbach's α was 0.926. The organizational climate for innovation adopted the 20-item scale perfected by Yuandong and Jisheng [59], divided into colleague support, supervisor support, and organizational support. In this paper, the Cronbach's α was 0.932. Four demographic variables (gender, age, marriage, and education) were used as control variables.

3.3. Model Building. In order to test the relationship between job insecurity, proactive work behavior, working withdrawal behavior, organizational climate for innovation and

knowledge workers' innovative behavior, this paper has built the following empirical model:

$$
\begin{aligned}
&(1)\ \mathrm{PWB} = a_0 + a_1\mathrm{SEX} + a_2\mathrm{AGE} + a_3\mathrm{EDU} + a_4\mathrm{MRG} + a_5\mathrm{JbI} + \mu_1,\\
&(2)\ \mathrm{PWB} = b_0 + b_1\mathrm{SEX} + b_2\mathrm{AGE} + b_3\mathrm{EDU} + b_4\mathrm{MRG} + b_5\mathrm{JbI} + b_6\mathrm{OCI} + \mu_2,\\
&(3)\ \mathrm{PWB} = c_0 + c_1\mathrm{SEX} + c_2\mathrm{AGE} + c_3\mathrm{EDU} + c_4\mathrm{MRG} + c_5\mathrm{JbI} + c_6\mathrm{OCI} + c_7\mathrm{JbI}\times\mathrm{OCI} + \mu_3,\\
&(4)\ \mathrm{WWB} = d_0 + d_1\mathrm{SEX} + d_2\mathrm{AGE} + d_3\mathrm{EDU} + d_4\mathrm{MRG} + d_5\mathrm{JbI} + \mu_4,\\
&(5)\ \mathrm{WWB} = e_0 + e_1\mathrm{SEX} + e_2\mathrm{AGE} + e_3\mathrm{EDU} + e_4\mathrm{MRG} + e_5\mathrm{JbI} + e_6\mathrm{OCI} + \mu_5,\\
&(6)\ \mathrm{WWB} = f_0 + f_1\mathrm{SEX} + f_2\mathrm{AGE} + f_3\mathrm{EDU} + f_4\mathrm{MRG} + f_5\mathrm{JbI} + f_6\mathrm{OCI} + f_7\mathrm{JbI}\times\mathrm{OCI} + \mu_6,\\
&(7)\ \mathrm{EIB} = g_0 + g_1\mathrm{SEX} + g_1\mathrm{AGE} + g_2\mathrm{EDU} + g_3\mathrm{MRG} + g_4\mathrm{JbI} + \mu_7,\\
&(8)\ \mathrm{EIB} = h_0 + h_1\mathrm{SEX} + h_2\mathrm{AGE} + h_3\mathrm{EDU} + h_4\mathrm{MRG} + h_5\mathrm{JbI} + h_6\mathrm{PWB} + h_7\mathrm{WWB} + \mu_8,\\
&(9)\ \mathrm{EIB} = i_0 + i_1\mathrm{SEX} + i_2\mathrm{AGE} + i_3\mathrm{EDU} + i_4\mathrm{MRG} + i_5\mathrm{JbI} + i_6\mathrm{PWB} + i_7\mathrm{WWB} + i_8\mathrm{OCI} + \mu_9,\\
&(10)\ \mathrm{EIB} = j_0 + j_1\mathrm{SEX} + j_2\mathrm{AGE} + j_3\mathrm{EDU} + j_4\mathrm{MRG} + j_5\mathrm{JbI} + j_6\mathrm{PWB} + j_7\mathrm{WWB} + j_8\mathrm{OCI} + j_9\mathrm{JbI}\times\mathrm{OCI} + j_{10}\mathrm{JbI}\times\mathrm{OCI} + \mu_{10},
\end{aligned}
\tag{1}
$$

where SEX = gender, AGE = age, EDU = education, and MRG = marriage, all of which are control variables. JiB denotes job insecurity, an independent variable, PWB proactive work behavior, WWB working withdrawal behavior, OCI organizational climate for innovation, and EIB employee innovative behavior.

4. Results Analysis

4.1. Common Method Bias Test. CMB test is designed to ensure the scientific nature of research and avoid the influence of single sample source on the increase or decrease of interdimensional correlation. Based on the suggestions of Podsakoff et al. [60] and the experience of Anmin and Lei [61], Harman's single-factor test was employed to make factor analysis on all the 45 items. The unrotated principal component factor analysis was used to extract 10 principal component factors with eigenvalues greater than 1. The cumulative explanatory explained variance was 84.395%, and the explained variance of factor 1 was 25.698%, less than the standard 50%. Therefore, there's no serious common method variance in the data in this paper, and the findings are reliable.

4.2. Confirmatory Factor Analysis. First, CFA was used in this paper to test the discriminant validity of variables, with the results as shown in Table 2. Compared with alternative 4-factor, 3-factor, 2-factor, and single-factor models, the fitting indexes ($\chi^2 = 327.211$, CFI = 0.965, TLI = 0.958, RMSEA = 0.059, SRMR = 0.071) of the 5-factor model (job insecurity, proactive work behavior, working withdrawal behavior, organizational climate for innovation, and employee innovative behavior) were better than those of other models. Arguably, the 5-factor model in this paper features good structural validity among variables. Second, as advised by Fornell and Larcker [62], when the square root of dimension AVE is greater than the correlation coefficient between AVE and other dimensions, the discriminant validity is available among dimensions. In this paper, the square root of each dimension AVE is greater than the correlation coefficients between other dimensions, so there is good discriminant validity among the dimensions (Table 3).

4.3. Description and Analysis. The mean, standard deviation (SD), and correlation coefficient of each variable are shown in Table 3. Job insecurity had significant positive correlation with proactive work behavior ($\beta = 0.480$, $p < 0.01$), and with working withdrawal behavior ($\beta = 0.173$, $p < 0.01$), which primarily tested Hypotheses 1 and 2. There was a significant positive correlation between proactive work behavior and employee innovative behavior ($\beta = 0.387$, $p < 0.01$) and a significant negative correlation between working withdrawal behavior and employee innovative behavior ($\beta = -0.105$, $p < 0.01$), which primarily tested Hypotheses 3 and 4. organizational climate for innovation had significant positive correlation with proactive work behavior ($\beta = 0.366$, $p < 0.01$) and significant negative correlation with working withdrawal behavior ($\beta = -0.097$, $p < 0.05$), which provided preliminary support for hypothesis testing.

4.4. Hypothesis Testing. This paper uses regression analysis to test the hypothesis. As shown in Table 4, after controlling the demographic variables such as gender and age, job insecurity has a significant positive effect on proactive work behavior in Model 2 ($\beta = 0.475$, $p < 0.01$), so Hypothesis 1 is supported. In Model 4, job insecurity has a significant positive effect on working withdrawal behavior ($\beta = 0.195$, $p < 0.01$), so Hypothesis 2 is supported. In Model 8, working withdrawal behavior has a significant negative effect on employee innovative behavior ($\beta = -0.139$, $p < 0.01$), and proactive work behavior has a significant positive effect on employee innovative behavior ($\beta = 0.191$, $p < 0.01$), so

Table 2: Confirmatory factor analysis.

Model	χ^2	df	χ^2 (df)	CFI	TLI	RMSEA	SRMR
Single-factor model	1218.986	104	11.721	0.83	0.804	0.127	0.105
2-factor model	988.762	103	9.6	0.865	0.843	0.114	0.096
3-factor model	678.976	101	6.723	0.912	0.896	0.093	0.08
4-factor model	520.159	100	5.202	0.936	0.923	0.08	0.075
5-factor model	327.211	99	3.305	0.965	0.958	0.059	0.071

Note. $N = 665$, single-factor model: job insecurity + proactive work behavior + working withdrawal behavior + organizational climate for innovation + employee innovative behavior; 2-factor model: job insecurity + proactive work behavior + working withdrawal behavior + organizational climate for innovation, and employee innovative behavior; 3-factor model: job insecurity + proactive work behavior + working withdrawal behavior, organizational climate for innovation, and employee innovative behavior; 4-factor model: job insecurity, proactive work behavior + working withdrawal behavior, organizational climate for innovation, and employee innovative behavior; 5-factor model: job insecurity, proactive work behavior, working withdrawal behavior, organizational climate for innovation, and employee innovative behavior.

Table 3: Mean, SD, and correlation coefficient matrix.

Variable	Mean	SD	JiB	PWB	WWB	EIB	OCI
JiB	3.095	1.148	0.772				
PWB	3.385	1.172	0.480**	0.881			
WWB	3.218	1.087	0.173**	−0.085*	0.804		
EIB	2.712	1.06	0.410**	0.387**	−0.105**	0.789	
OCI	3.244	1.046	0.348**	0.366**	−0.097*	−0.053	0.687

Note. $N = 665$, * $p < 0.05$, ** $p < 0.01$; the diagonal number is the square root of AVE; JiB denotes job insecurity, an independent variable, PWB proactive work behavior, WWB working withdrawal behavior, OCI organizational climate for innovation, and EIB employee innovative behavior.

Table 4: Hierarchical regression modeling ($N = 665$).

Variable	PWB			WWB			EIB			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
SEX	0.039	0.032	0.017	0.009	0.014	0.033	−0.291**	−0.297**	−0.291**	−0.258**
AGE	0.084	0.093*	0.098*	−0.009	−0.016	−0.022	0.047	0.03	0.012	−0.003
EDU	0.101	0.093	0.114*	−0.063	−0.058	−0.085	0.089	0.061	0.062	0.008
MRG	−0.033	−0.074	−0.083	−0.091	−0.061	−0.05	−0.096	−0.102	−0.051	−0.032
JiB	0.475**	0.401**	0.384**	0.195**	0.247**	0.268**	0.333**	0.270**	0.337**	0.371**
WWB								−0.139**	−0.176**	−0.225**
PWB								0.191**	0.259**	0.299**
OCI		0.257**	0.225**		−0.181**	−0.139**			−0.323**	−0.270**
JiB*OCI			0.118**			−0.155**				−0.264**
R^2	0.242	0.287	0.303	0.036	0.062	0.093	0.192	0.256	0.337	0.427
F value	41.973**	44.182**	40.710**	4.912**	7.273**	9.590**	31.385**	32.253**	41.738**	54.170**
$\triangle R^2$	0.171	0.046	0.015	0.033	0.026	0.031	0.103	0.063	0.082	0.089

Note. SEX = gender, AGE = age, EDU = education, and MRG = marriage, all of which are control variables. JiB denotes job insecurity, an independent variable, PWB proactive work behavior, WWB working withdrawal behavior, OCI organizational climate for innovation, EIB employee innovative behavior, and JiB*OCI is the interaction term of job insecurity and organizational climate for innovation. *indicates $p < 0.05$ and **indicates $p < 0.01$.

Hypotheses 3 and 4 are supported. Compared with Model 7, it can be found in Model 8 that the regression coefficient of job insecurity has changed from 0.333 to 0.27 ($p < 0.01$), indicating that proactive work behavior and working withdrawal behavior have partial mediating effects on the relationship between job insecurity and employee innovative behavior; thus, Hypotheses 5 and 6 are tenable. In Model 3, the interaction term of organizational climate for innovation and job insecurity has a significant positive effect on proactive work behavior ($\beta = 0.118$, $p < 0.01$), indicating that the higher the perceived organizational climate for innovation, the stronger the positive effect of job insecurity on proactive work behavior. Therefore, Hypothesis 7 is supported. In Model 6, the interaction term of organizational climate for innovation and job insecurity has a significant negative effect on working withdrawal behavior ($\beta = -0.155$, $p < 0.01$), indicating that the higher the perceived organizational climate for innovation, the weaker the positive effect of job insecurity on working withdrawal behavior. Therefore, Hypothesis 8 is supported.

By following the suggestions of Hayes [63], the process plug-in in SPSS was adopted to further clarify the mediating effect of proactive work behavior and working withdrawal behavior. The results are as shown in Table 5. Bootstrap method was used for 5,000 repeated samples with 95% CI. The lower limit, upper limit, and two-tailed significance tests

Table 5: Analysis on the mediating effect of proactive work behavior and working withdrawal behavior ($N = 665$).

Types	Paths	β	SE	p	Bootstrap (95% CI)	
					LLCI	ULCI
Direct effect	JiB -> EIB	0.263	0.039	0.000	0.187	0.339
Indirect effect	JiB -> WWB -> EIB	−0.115	0.036	0.001	−0.184	−0.045
	JiB - > PWB -> EIB	0.173	0.038	0.000	0.099	0.247

Table 6: Test results of moderating effect ($N = 665$).

Y	Interaction item	R2-change	p value	LLCI	ULCI
PWB	JiB*OCI	0.019	0	0.064	0.181
WWB	JiB*OCI	0.035	0	−0.22	−0.096

Note. PWB denotes proactive work behavior, WWB working withdrawal behavior, JiB*OCI is the interaction term of job insecurity and organizational climate for innovation; R^2-change is the change in R; LLCI is the lower limit of 95% CI, and ULCI is the upper limit of 95% CI.

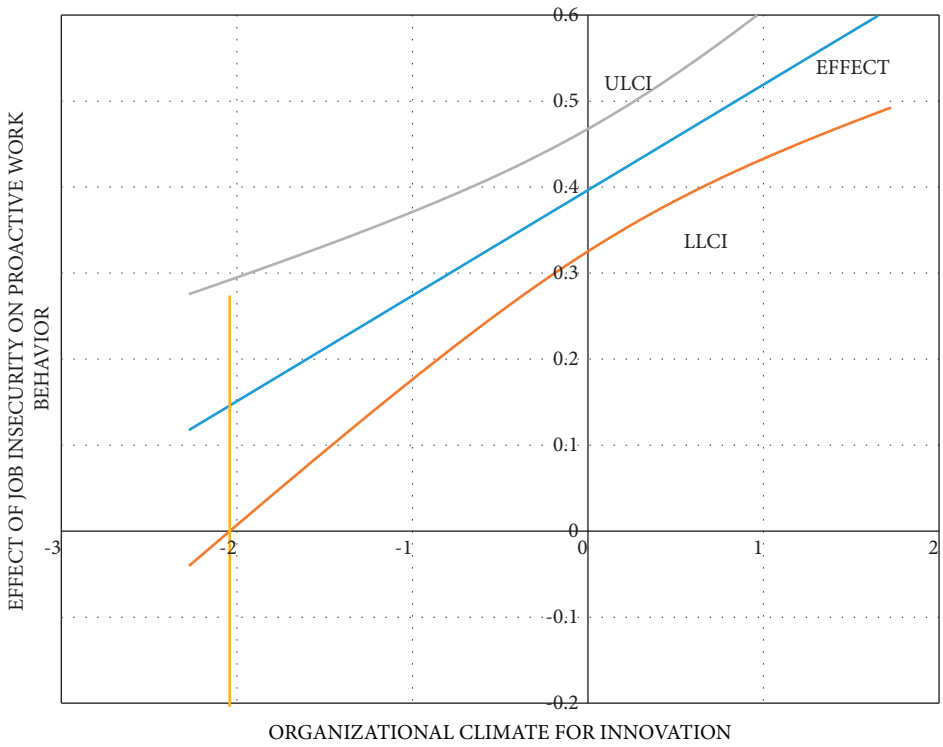

Figure 2: Effect of organizational climate for innovation on job insecurity and proactive work behavior.

of the total effect, direct effect, and indirect effect were estimated. The results show that job insecurity has a significant indirect effect on employee innovative behavior through proactive work behavior (indirect effect = 0.173, 95% CI = [0.099, 0.247]), excluding 0; job insecurity has a significant indirect effect on employee innovative behavior through working withdrawal behavior (indirect effect = −0.115, 95% CI = [−0.184, −0.045]), excluding 0. Thus, Hypotheses 5 and 6 are tested again.

To test the moderating effect, the data should be first centralized. Hayes [64] verified that the correlation between interaction terms and independent and moderating variables could be reduced after data centralization, thus improving the validity of model estimation. In this paper, process plug-in was used for 5,000 repeated samples with 95% CI to test the moderated mediating effect of organizational climate for innovation. Seen from Table 6, in the influence of the interaction term of job insecurity and organizational climate for innovation on proactive work behavior and working withdrawal behavior, the confidence interval does not contain 0, indicating that proactive job behavior and working withdrawal behavior are influenced by the moderating variable (organizational climate for innovation) in the relationship between job insecurity and

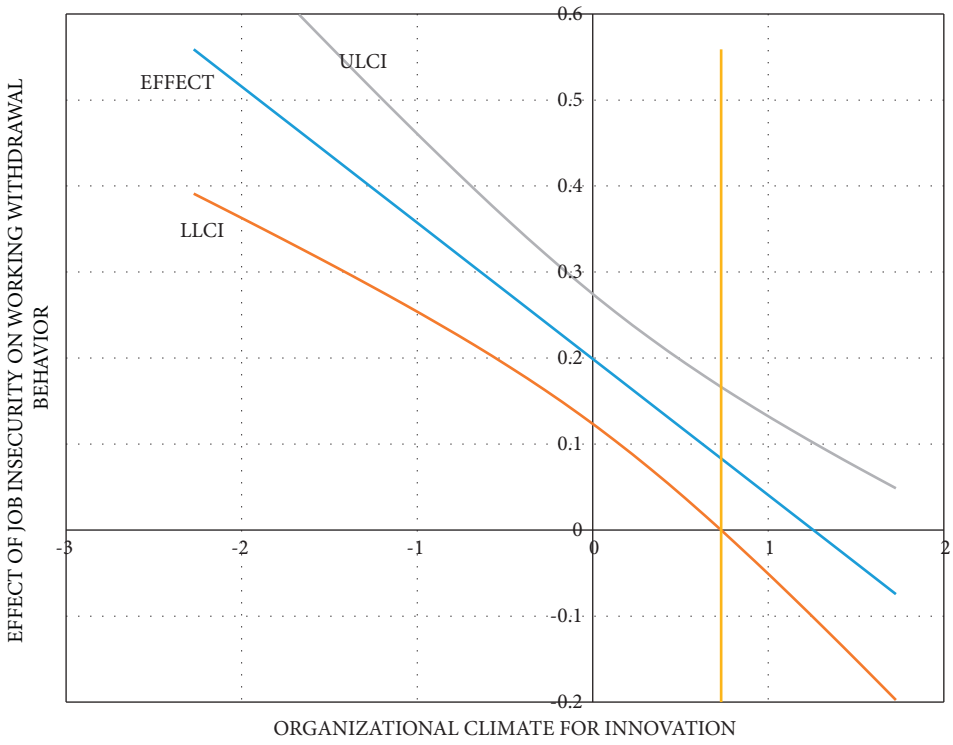

Figure 3: Effect of organizational climate for innovation on job insecurity and working withdrawal behavior.

employee innovative behavior. Therefore, there are moderated mediating effects. Hypotheses 5 and 6 are tested.

With a view to further quantifying the moderating effect, Spiller and Fitzsimons [65] have proposed to use Jonson-Neyman technique to test the moderating interval, so as to determine the moderating level of the moderator variable to the independent and dependent variables. It can be seen from Figure 2 that when the standardized value of knowledge workers to organizational climate for innovation is greater than −2.0407, the moderating effect is significantly positive, but no moderating effect when the value is less than −2.0407. Hence, the higher the knowledge workers' perception of organizational climate for innovation, the stronger the effect on proactive work behavior. Similarly, it can be seen from Figure 3 that when the standardized value of knowledge workers to organizational climate for innovation is less than 0.7315, the moderating effect is significantly negative, but no moderating effect when the value is greater than 0.7315. Therefore, the lower the knowledge workers' perception of organizational climate for innovation, the stronger the effect on working withdrawal behavior, that is, the higher the perception of organizational climate for innovation, the weaker the effect on working withdrawal behavior. Hypotheses 7 and 8 are thus tested.

5. Conclusions

5.1. Conclusions and Management Implications

(1) Based on the TTSC, this paper has, following the thinking of "employee cognitive appraisal—selection of coping strategy—innovative behavior" under the perception of job insecurity, expounded the process mechanism of different coping strategies and innovative behaviors arising from differences in individual perceptions of job insecurity and broadened the single perspective that job insecurity has a negative impact and is advocated to be eliminated in the previous research. From the perspective of integration, this paper reveals the internal mechanism of job insecurity and knowledge workers' innovative behavior, i.e., the dual-path mediating effect of proactive work behavior and working withdrawal behavior. Path 1 shows that job insecurity positively influences employees' proactive work behavior and thus improving their innovative behavior, which verifies that job insecurity positively influences the employee innovative behavior [33, 34]. Path 2 shows that job insecurity triggers employees' work withdrawal behavior, thus inhibiting their innovative behavior. which supports the study of employees' negative coping style in the face of job stress [18, 66]. This paper proposes a dual-path effect of job insecurity on employees' innovative behavior from an integrated perspective, explaining why job insecurity enhances or inhibits employees' innovative behavior and providing a new explanation mechanism for the previous two viewpoints. It helps scholars and business management practitioners to understand the function of job insecurity from a balanced and dialectical perspective.

(2) This paper clarifies the moderating mechanism of organizational innovation climate in the relationship

between job insecurity and employee innovative behavior. The results show that high organizational innovation climate enhances the positive relationship between job insecurity and proactive work behavior and stimulates more proactive work behaviors; a high organizational innovation climate enhances the negative relationship between job insecurity and working withdrawal behavior and reduces employees' working withdrawal behavior. The above results verify that the perception of organizational innovation climate as a boundary condition can effectively explain the dual-path effect of job insecurity and answer the question of when job insecurity in companies requires stimulating proactive work behaviors and enhancing employees' innovative behaviors and when it triggers job withdrawal behaviors and reduces employees' innovative behaviors. The results of the study illustrate the important value of organizational innovation climate. The organization should show care and positive feedback to employees, in an effort to improve their perception of organizational innovation climate.

5.2. Future Research. Job insecurity is objective, from an individual perspective only; the empirical study in this paper shows that job insecurity has, as a stressor, influenced the employee innovative behavior through the dual path of proactive work behavior and working withdrawal behavior. We are expected to focus on how job insecurity influences employees physiologically and physically, and how job insecurity is distinguished as challenge and hindrance stressors. Then, the cross-sectional data in the questionnaire survey has certain limitations in analyzing the relationship between job insecurity and employee innovative behavior, whose correlation can be proved, while the analysis of causality has to be further verified by supplementing time series data.

With the TTSC, this paper reveals the effects of job insecurity, the difference of which lies in different behavioral strategies based upon employees' cognitive appraisal. In addition, the impact of job insecurity on individuals is subject to a number of conditions [67]. The future research can focus further on the factors that cause differential effects of job insecurity from multiple perspectives (such as age), so as to help business managers and researchers better understand the effects of job insecurity requirements, take advantage of job insecurity, and make it the driving force to enhance enterprise innovative behavior.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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Hindawi
Discrete Dynamics in Nature and Society
Volume 2022, Article ID 6756548, 12 pages
https://doi.org/10.1155/2022/6756548

Research Article

Relationship between External Environment, Internal Conditions, and Digital Transformation from the Perspective of Synergetics

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Received 22 December 2021; Revised 9 February 2022; Accepted 13 April 2022; Published 5 May 2022

Academic Editor: Jiafu Su

As the digital technologies develop, traditional pharmaceutical enterprises have also begun the exploration of digital transformation (DT). Previous studies mainly focused on the technology application, strategy, performance, and leadership of digital in manufacturing enterprises and small- and medium-sized enterprises (SMEs), and more qualitative methods were used. However, few researchers systematically investigated the impact mechanism of pharmaceutical enterprises' DT. The purpose of this study is to analyze the influencing factors of Chinese pharmaceutical enterprises' DT by constructing the structural equation model (SEM) based on synergetics. This study shows that the influencing factors of pharmaceutical enterprises' DT include the external environment (customer needs, market competition, government policy, and digital technology) and internal conditions (digital strategy, leadership, and organization capability). The theoretical innovation of this study is to explore the synergistic effect of external environment and internal conditions on DT and put forward that the internal conditions play mediating role in the external environment and DT. Customer needs and digital strategies have great impacts on pharmaceutical enterprises' DT. Therefore, this study finds the main influencing factors, which are helpful in promoting pharmaceutical enterprises' DT.

1. Introduction

Digital transformation is a way of applying digital technology to improve enterprise performance or influence [1]. Information and communication technologies (ICTs) are increasingly important for businesses, consumers, and governments. The development of digital economy can not only promote economic growth, but also improve the quality of economic growth [2]. The development of digital economy has been widely valued by countries around the world, and DT of the global economy is also being promoted continuously. In 2015, China government formulated "Made in China 2025." The proportion of industrial digitization in China's digital economy increased from 49.1% in 2005 to 80.2% in 2019 [3]. DT has completely changed the business mode of many industries. However, the adoption of digital services in the pharmaceutical industry is relatively slow. Nowadays, pharmaceutical enterprises are forced to use and implement DT in order to avoid retreating from competitors in a competitive environment and respond to customer needs. Pharmaceutical enterprises actively participate in DT to achieve the goal of "Medical Internet +," transform traditional pharmaceutical enterprises through network thinking, create a new medical industry chain model, and realize the integration of traditional manufacturing and Internet [4]. According to the literature, there are not many studies related to the DT of pharmaceutical enterprises. The pharmaceutical business mainly has been influenced by digital technology, trust, leadership, cost, and regulatory policies [5]. DT of pharmaceutical enterprises is driven by internal factors and external factors. The impact of external and internal factors on DT is studied, and the relationship between external and internal factors is not studied. Otherwise, previous studies have not proposed a complete model of influencing factors of pharmaceutical enterprises' DT and lack empirical evidence on whether internal conditions play the mediating role between external environment and DT. Therefore, it is significant for pharmaceutical

enterprises to find the key influencing factors and paths affecting DT.

Taking Chinese pharmaceutical enterprises as the research object, the purpose of this study is to explore the influence mechanism of pharmaceutical enterprises' DT and analyze the relationship between external environment, internal conditions, and DT, thus establishing the influencing factor model of Chinese pharmaceutical enterprises' DT. This study will use quantitative analysis method to empirically test and modify the theoretical model through structural equation model (SEM) and regression analysis and then demonstrate the impact of external environment and internal conditions on pharmaceutical enterprises' DT, as well as the relationship between the influencing factors. The main contributions of this study are as follows: based on the synergy theory, it constructs the influencing factor model of pharmaceutical enterprises' DT, reveals the mediating role of internal conditions between external environment and DT, and expounds that customer needs and digital strategy are the main influence of pharmaceutical enterprises' DT, which provides a certain theoretical support and practical basis for pharmaceutical enterprises' DT. It can help pharmaceutical enterprises accurately identify the key influencing factors and influencing paths to implement DT projects.

2. Literature Review and Research Hypotheses

2.1. The External Environment Factors of DT. According to the literature research of scholars in recent years, it is found that the external environment factors of enterprise DT are as follows.

2.1.1. Customer Needs. Customer needs refers to a broad and in-depth understanding of the actual needs of customers, so as to help enterprises make correct decisions. For pharmaceutical enterprises, the government, commercial companies, hospitals, pharmacies, and patients are their customers. With rapidly changing digital technologies and increasingly demanding customer needs in mature markets, digital technologies are becoming increasingly important to help companies upgrade their manufacturing activities and develop new product and service solutions [6]. Many companies see DT as a major challenge. In addition, the industry is heavily affected by DT, as DT and customer expectations drive shifts in the need to adjust strategies, processes, and IT. Therefore, the upgrading of customer demand, diversification of customer behavior, and improvement of customer satisfaction are the driving factors for the DT of enterprises.

2.1.2. Government Policy. Government policies have a direct and indirect impact on the DT of enterprises, and targeted measures should be taken to use ICTs as a tool for environmentally sustainable industries [7]. The strategy of DT has been studied by many governments, multilateral organizations, and industry bodies to develop relevant policies of DT [8]. Policy incentives are designed to promote the cost-effective adoption of digital technologies. Government policy formulation promotes the DT of pharmaceutical enterprises. Besides, grading treatment and" Internet + medical" can help pharmaceutical enterprises expand new sales channels [9].

2.1.3. Digital Technology. The application of digital technology becomes the major benefit for managers at all levels of the enterprise to coordinate all resources. More and more enterprises are being influenced by the development of digital technology and the huge amount of data that systems collect every day to transform their business structure [10]. Modern enterprise marketing is influenced and changed by digital technology and digital tools, which can establish relationships with customers and create more value for enterprises. Regarding big data, the Internet of Things and blockchain are the technical support for the DT of China's industries [11].

2.1.4. Market Competition. Today's market competition is very fierce, and the product cost is closely related to the enterprise benefit. The quality of cost control will directly affect the economic benefits of enterprises and their core competitiveness. The intensive application of advanced technologies leads to the DT that must be experienced by enterprises operating in a constantly changing environment. This increases the competitive pressure among enterprises, whose market share also depends on the speed of DT. DT is the way to improve product competitiveness. In the "Made in China 2025" strategy and "Manufacturing + Internet," traditional manufacturing enterprises use the Internet to promote transformation and upgrading and seek new profit growth [12].

2.2. The Internal Conditions Factors of DT. According to the literature research of scholars in recent years, it is found that the internal conditions factors of enterprise DT are as follows.

2.2.1. Digital Strategy. DT is driven by enterprise strategy. Digital strategy formulation and implementation have become a priority for many enterprises. More and more companies are pursuing digital strategies to create value and access digital resources. Corporate strategic transformation is the main reason why digitalization, AI, and organizational change are at the top of most companies' agendas [13]. The DT under Industry 4.0 is complex and resource-intensive, and making strategic digital guidelines is crucial to the success of SMEs in Industry 4.0 transformation [14].

2.2.2. Organization Capability. Organizations need more agile IT capabilities through DT to explore the application of IT in the digital business environment. Organizations' operations, products, and services are being transformed by digital technology. The way to improve organizational efficiency and effectiveness is through DT of organizations

[15]. Organization development (OD) can make important systematic and conceptual contributions to the successful introduction of agile working methods and mindsets in a company. Dynamic capability has a significant impact on the performance of enterprises. Therefore, manufacturers must strive to improve their dynamic capability to cope with the uncertainty of the environment.

2.2.3. Leadership. Most industries and enterprises can benefit from DT. DT requires strong leadership to drive change. Leadership plays the vital role in DT and can facilitate the more advanced stages of DT. CEOs from most industries are studying the opportunities that digitization brings to businesses. Supportive leadership and investment in R&D are key roles in determining a company's digitalization [16]. In a word, leaders' awareness of DT is very important, which influences the formulation and implementation of DT strategies and plays a driving role in the process of enterprise DT.

2.3. Hypotheses Development

2.3.1. The Relationship between External Environment and DT. External factors can affect DT of SMEs. Tarutė et al. [17] pointed out that the upgrading of consumer demand affects the DT of enterprises, especially the upgrading of consumer behavior and consumer expectations. The consumer centric development trend will also affect the digital transformation of enterprises [18]. The development of digital technology, the improvement of information infrastructure, and technical capacity all promote the DT of enterprises. Market competition (e.g., competition pressure, cost cutting, productivity improvements, and changing competitive landscape) leads to the DT of enterprises. Ebert and Duarte [8] pointed that government policy had a positive impact on enterprises' DT. Based on the above analysis, we propose the following hypothesis.

(i) hypothesis 1: External environment has a positive impact on DT.

(ii) hypothesis 1a: Consumer needs have a positive impact on DT.

(iii) hypothesis 1b: Market competition has a positive impact on DT.

(iv) hypothesis 1c: Government policy has a positive impact on DT.

(v) hypothesis 1d: Digital technology has a positive impact on DT.

2.3.2. The Relationship between External Environment and Internal Conditions. External environment had a positive influence on the change of the internal conditions of enterprises. Tarutė et al. [17] proposed consumer behavior and expectations can drive companies to adopt digital strategies to meet consumer needs. The pressure of market competition needs cost-cutting, and productivity improvements can force enterprises to adopt digital strategy to gain competitive advantage. Ifenthaler and Egloffstein [19] proposed digital technology can promote the change of enterprise organization and make the organization more agile. Burchardt and Maisch [20] pointed out that digital technology can transform the traditional enterprise culture into an innovative enterprise culture. Government policies can incentivize companies to adopt digital strategies [7]. The application of digital technology can help enterprises improve dynamic capabilities. Based on the above analysis, we propose the following hypothesis in Table 1.

2.3.3. The Relationship between Internal Conditions and DT. The internal conditions of the enterprise mainly include digital strategy, organization capability, leadership, and dynamic ability. Kane et al. [21] considered that digital strategy plays an important role in the DT of enterprises. Agile organization and learning organization can provide support for the DT of enterprises [22]. Digital transformative leader can support the organization and digital change. Nasiri et al. [23] pointed out that the dynamic ability of the organization capability (integration ability, learning ability, knowledge management ability, and technological innovation ability) is the guarantee to promote DT. Based on the above analysis, we propose the following hypothesis.

(i) hypothesis 3: Internal conditions have a positive influence on DT.

(ii) hypothesis 3a: Digital strategy has a positive impact on DT.

(iii) hypothesis 3b: Organization capability has a positive impact on DT.

(iv) hypothesis 3c: Leadership has a positive impact on DT.

2.3.4. The Mediating Role of Internal Conditions. Internal conditions have a mediating effect in the external environment on DT, and internal conditions mainly involve digital strategy, organizational ability, and leadership. The formulation of digital strategy is to formulate the strategic direction of digital guiding principles at the company level and a single business level [24]. Using the power of digital technology can help cultivate the ability of organizational learning and innovation [25] and then help promote the digital transformation of enterprises [26]. Based on the above analysis, we propose the following hypothesis.

(i) hypothesis 4: Internal conditions play a mediating role in the relationship between external environment and DT.

3. Study Design and Methods

3.1. Research Model. Synergetics is concerned with the collaboration of various parts of a system [27]. Synergy refers to the overall effect or collective effect produced by the interaction between systems in a complex open system. Enterprise resource integration is one of the key factors that affect performance of enterprises [28]. The synergetic

Table 1: Subhypotheses of H2.

Num	Hypothesis content
H2	External environment has a significant impact on internal conditions
H2a1	Customer needs have a significant impact on digital strategy
H2a2	Customer needs have a significant impact on organization capability
H2a3	Customer needs have a significant impact on leadership
H2b1	Market competition has a significant impact on digital strategy
H2b2	Market competition has a significant impact on organization capability
H2b3	Market competition has a significant impact on leadership
H2c1	Government policy has a significant impact on digital strategy
H2c2	Government policy has a significant impact on organization capability
H2c3	Government policy has a significant impact on leadership
H2d1	Digital technology has a significant impact on digital strategy
H2d2	Digital technology has a significant impact on organizational ability
H2d3	Digital technology has a significant impact on leadership

method in management provides a new way for effective management and the formation of enterprise development strategy [29]. However, external environment will directly change the internal conditions and indirectly affect the DT of enterprises. Therefore, external environment and internal conditions will jointly affect the DT of enterprises based on Synergetics. Therefore, in order to understand the mechanism affecting the DT of pharmaceutical enterprises, this study puts forward the influencing factor model of pharmaceutical enterprises' DT. The research model of pharmaceutical enterprises' DT is shown in Figure 1.

3.2. Research Samples and Procedures. The research objects are pharmaceutical enterprises of China. The superiority of quantitative analysis is empirical, explicit, and objective. This study adopts quantitative analysis, collects the relevant information of the influencing factors of Chinese pharmaceutical enterprises' DT by means of questionnaire, and uses SPSS and Amos tools to process and analyze the data. In order to ensure that the samples are representative and generalizable, this study uses the purposive sampling method of nonprobability sampling to collect sample data [30]. In order to investigate the impact of external environment and internal conditions on enterprises' DT, the online-questionnaires were mainly sent to the first-line, middle, senior managers, ordinary staff of pharmaceutical enterprises in China through member of China Pharmaceutical Enterprise Management Association (CPEMA), and MBA and EMBA alumni groups of Yunnan University. From January 10 to March 8, 2022, 400 questionnaires of this study were distributed, and 290 questionnaires were recovered, and the questionnaire recovery rate was 72.5%; 246 valid questionnaires were obtained, and the effective questionnaire rate was 84.82%. The statistics of respondents are shown in Table 2.

The respondents in the questionnaire have different positions. Among the ownership types, private enterprises account for a larger proportion than state-owned enterprises, which is in line with China's national conditions. The distribution of sample objects is normal and has good external validity.

3.3. Measurement of Variables. This study uses the Likert scales with five subjective measures. The questionnaire used in this study is based on the measures developed in previous studies. Relevant questions are selected and modified. It selects and modifies relevant questions to adapt to the background of pharmaceutical enterprises research. The independent variable is external environment, which includes four variables: customer needs, market competition, government policy, and digital technology. Cronbach's α coefficient is 0.883.

(a) Customer needs: customer needs dimensions are measured by the scale developed by [17], which consists of 5 questions. For example, "Do you think the upgrading of customer consumption behavior has an important impact on the DT of enterprises?" Cronbach's α coefficient is 0.801.

(b) Market competition: market competition dimensions are measured by the scale developed by [18], which consists of 4 questions. For example, "Do you think the impact of market competition pressure from the same industry on the DT of enterprises is important?" Cronbach's α coefficient is 0.808.

(c) Government policy: government policy dimensions are measured by the scale developed by [31], which consists of 4 questions. For example, "Do you think the government's formulation of financial subsidies and tax relief policies have an important impact on the DT of enterprises?" Cronbach's α coefficient is 0.833.

(d) Digital technology: digital technology dimensions are measured by the scale developed by [32], which consists of 4 questions. For example, "Do you think the development of new generation information technology (5G, cloud computing, big data, artificial intelligence, Internet of Things, and blockchain) has an important impact on the DT of enterprises?" Cronbach's α coefficient is 0.817.

The mediating variable is internal conditions, which include three variables: digital strategy, organization capability, and leadership. Cronbach's α coefficient is 0.855.

(a) Digital strategy: digital strategy dimensions are measured by the scale developed by [32], which consists of 3 questions. For example, "Do you think the development of digital strategy has an important impact on the DT of enterprises?" Cronbach's α coefficient is 0.823.

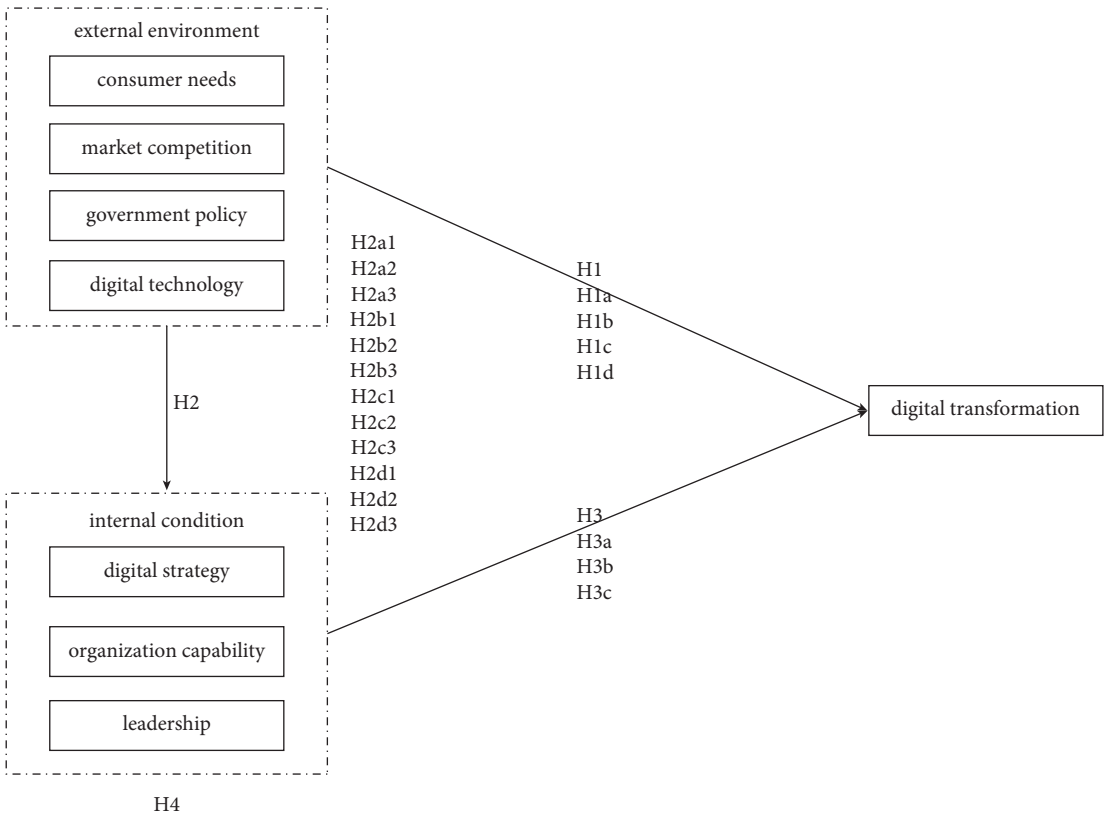

Figure 1: The research model of pharmaceutical enterprises' DT.

Table 2: Demographic statistics.

Item	Category ($N = 246$)	Frequency	Percentage (%)
Position	Ordinary staff	73	29.67
	First-line managers	89	36.18
	Middle manager	31	12.60
	Senior manager	53	21.54
Age	Within 3 years	46	18.70
	Within 3–5 years	65	26.42
	Within 5–10 years	47	19.11
	More than 10 years	88	35.77
Size of employees	Less than 100	46	18.70
	100–300	68	27.64
	300–2000	71	28.86
	More than 2000	61	24.80
Ownership type	State-owned enterprise	83	33.74
	Private enterprise	163	66.26
Situation of digital transformation	No, and there is no intention and plan for DT	24	9.76
	No, but there is a willingness and plan for DT	51	20.73
	Yes, the DT project is in the early stage of construction	91	36.99
	Yes, the DT project has achieved certain results	80	32.52

(b) Organization capability: organization capability dimensions are measured by the scale developed by [33], which consists of six questions. For example, "Do you think the impact of organizational agility on the DT of enterprises is important?" Cronbach's α coefficient is 0.786.

(c) Leadership: leadership dimensions are measured by the scale developed by [18], which consists of six questions. For example, "Do you think it is important for leaders to support the DT of enterprises?" Cronbach's α coefficient is 0.808.

The dependent variable is DT, and the DT dimensions are measured by the scale developed by [34], which consists of four questions. For example, "Do you think the DT of enterprises will lead to performance improvement?" Cronbach's α coefficient is 0.784.

In this study, SPSS 26.0 was used for reliability test, and Cronbach's coefficients for all variables α all are greater than 0.7, indicating that the reliability of the scale meets the requirements, and its internal consistency is high [35]. The questionnaire used in this study has good reliability.

4. Results Analysis

It can be seen from Table 3 that Kaiser-Meyer-Olkin (KMO) values of external environment, internal conditions, DT, and the whole scale of this study are 0.834, 0.844, 0.759, and 0.881, respectively, which are greater than 0.7, and their Sig. is less than 0.05, so the factor analysis can be carried out.

4.1. Confirmatory Factor Analysis. In this study, the second-order factor model of external environment is proposed; that is, there is another high-order dimension (external environment) in the four dimensions of customer needs, market competition, government policy, and digital technology, as shown in Figure 2. In addition, according to the data in Table 4 and 5, each index of the second-order factor model of external environment is within the recommended value range, and the fitting effect of the model is good. Therefore, this study uses the second-order external environment latent variable, which can meet the requirements.

In this study, the second-order factor model of internal conditions is proposed; that is, there is another high-order dimension (internal conditions) in the three dimensions of digital strategy, organization capability, and leadership, as shown in Figure 3. In addition, according to the data in Table 6 and 7, each index of the second-order factor model of internal conditions is within the recommended value range, and the fitting effect of the model is good. Therefore, this study uses the second-order internal conditions latent variable, which can meet the requirements.

4.2. Correlation Test. The purpose of correlation test is to preliminarily explore whether there is a certain correlation between variables and establish a regression model on the basis of verifying the correlation [36]. Pearson correlation was used to analyze the relationship between the variables in this study. The correlation analysis results are shown in Table 8. According to the results of correlation analysis, $P < 0.01$, there is a significant correlation between customer needs, market competition, government policy, digital technology, digital strategy, organization capability, leadership, and DT.

Table 3: Statistical table of variable validity test.

Variable	KMO	Bartlett's test		
		Approx. Chi-square	Df	Sig.
External environment	0.834	1274.34	78	0.000
Internal conditions	0.844	953.182	45	0.000
Digital transformation	0.759	265.863	6	0.000
The whole scale	0.881	2890.548	351	0.000

4.3. Regression Analysis. On the basis of correlation analysis, regression analysis was used to verify the relationship between variables. Forced entry regression analysis can verify whether all independent variables can explain dependent variables, and multicollinearity will affect the results of regression analysis [37]. This study uses the standard of VIF <5, $P < 0.05$ for screening. Based on the above hypotheses, the regression analysis is carried out. Firstly, the analysis results indicate that external environment (customer needs, market competition, government policy, and digital technology, VIF <5, $P < 0.05$) has a significant positive impact on DT, so H1a, H1b, H1c, and H1d are valid. Secondly, the analysis results indicate that internal conditions (digital strategy, organization capability, and leadership, VIF <5, $P < 0.05$) have a significant positive impact on DT, so H3a, H3b, and H3c are valid. Thirdly, the analysis results indicate that external environment (customer needs, market competition, government policy, and digital technology, VIF <5, $P < 0.05$) has a significant positive impact on digital strategy separately, so H2a1, H2b1, H2c1, and H2d1 are valid. Fourthly, the analysis results indicate that external environment (customer needs, market competition, and digital technology, VIF <5, $P < 0.05$) has a significant positive impact on organization capability separately, so H2a2, H2b2, and H2d2 are valid. But the standardized path coefficient of government policy on organization capability is 0.027 (VIF <5, $P = 0.692 > 0.05$), indicating that government policy has no significant positive impact on organization capability, so H2c2 is not tenable. Fifthly, the analysis results indicate that external environment (customer needs, market competition, and government policy, VIF <5, $P < 0.05$) has a significant positive impact on leadership separately, so H2a3, H2b3, and H2c3 are valid. But the standardized path coefficient of digital technology on leadership is 0.082 (VIF <5, $P = 0.241 > 0.05$), indicating that digital technology has no significant positive impact on leadership, so H2c3 is not tenable. To sum up, it can be deduced that H4 is tenable.

4.4. Model Verification. In this study, Amos24.0 is used to draw the model path map, and the indicators are replaced by letters, in which CN, MC, GP, and TT represent customer needs, market competition, government policy, and digital technology, respectively; DS, OC, and LS, respectively, represent digital strategy, organization capability, and leadership; EE represents the external environment; IC represents internal conditions, as shown in Figure 4.

In this study, Amos 24.0 was used to process the data from the questionnaire, and the parameter estimation and model fitting of the influencing factor model of

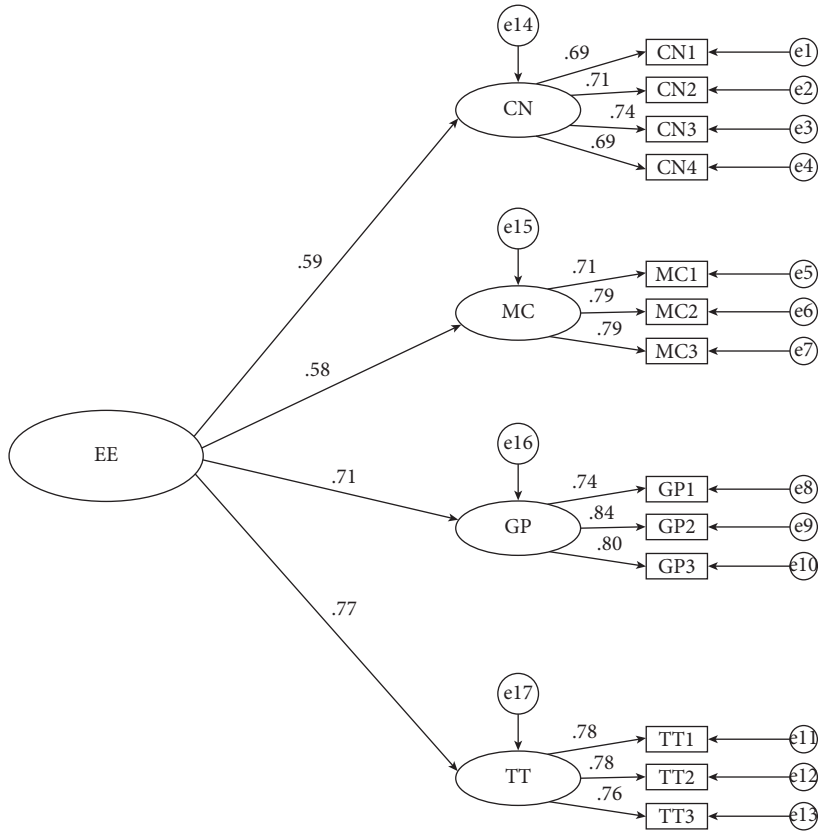

Figure 2: Second-order CFA path analysis chart of external environment scale (standardized).

Table 4: CFA fitting index of external environment scale.

Fitting index	X^2/df	RMSEA	GFI	AGFI	TLI	IFI	PNFI	PCFI
Recommended value	<3	<0.08	>0.8	>0.8	>0.9	>0.9	>0.5	>0.5
Second-order factor model	1.191	0.028	0.958	0.938	0.988	0.991	0.738	0.775

Table 5: Second-order factor convergence validity coefficient of external environment.

			Estimate	S.E.	C.R.	*P*	Standardized estimate
CN	<---	EE	1				0.595
MC	<---	EE	1.078	0.218	4.944	***	0.584
GP	<---	EE	1.351	0.253	5.35	***	0.708
TT	<---	EE	1.377	0.258	5.338	***	0.769
CN1	<---	CN	1				0.686
CN2	<---	CN	1.045	0.115	9.099	***	0.71
CN3	<---	CN	1.13	0.121	9.365	***	0.742
CN4	<---	CN	0.969	0.108	8.947	***	0.694
MC3	<---	MC	1				0.793
MC2	<---	MC	1.017	0.094	10.868	***	0.792
MC1	<---	MC	0.869	0.085	10.252	***	0.714
GP3	<---	GP	1				0.798
GP2	<---	GP	1.055	0.084	12.492	***	0.842
GP1	<---	GP	0.918	0.081	11.36	***	0.736
TT3	<---	TT	1				0.76
TT2	<---	TT	0.979	0.089	11.024	***	0.784
TT1	<---	TT	0.998	0.091	10.951	***	0.775

*** $P < 0.001$.

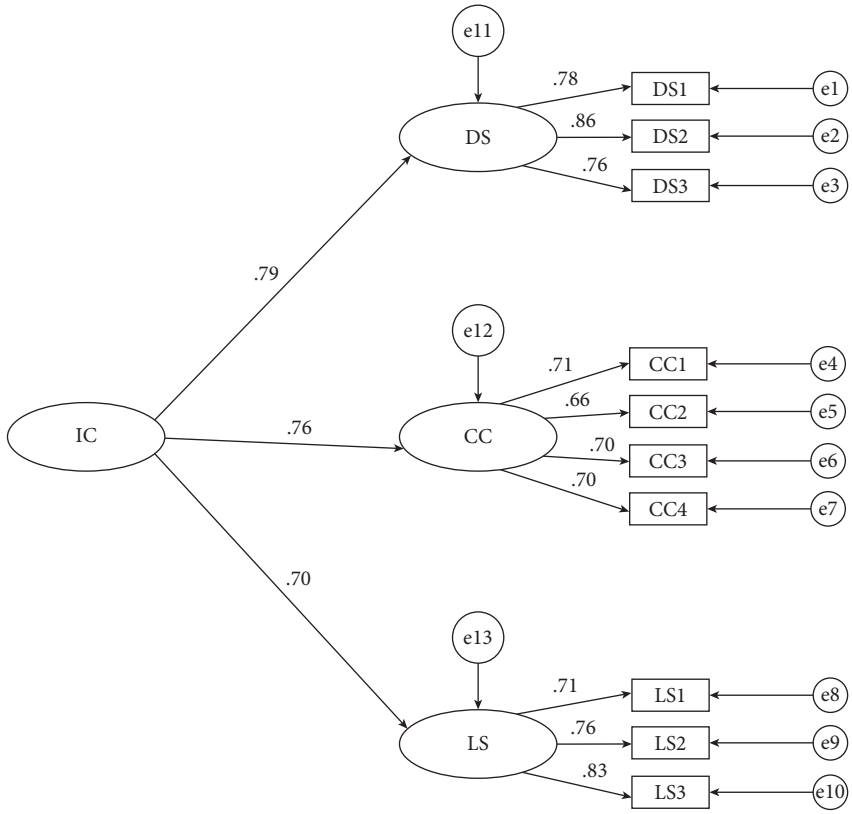

Figure 3: Second-order CFA path analysis chart of internal conditions scale (standardized).

Table 6: CFA fitting index of internal conditions scale.

Fitting index	X^2/df	RMSEA	GFI	AGFI	TLI	IFI	PNFI	PCFI
Recommended value	<3	<0.08	>0.8	>0.8	>0.9	>0.9	>0.5	>0.5
Second-order factor model	1.881	0.06	0.955	0.928	0.957	0.97	0.667	0.689

Table 7: Second-order factor convergence validity coefficient of internal conditions.

			Estimate	S.E.	C.R.	*P*	Standardized estimate
DS	<---	IC	1				0.79
OC	<---	IC	0.917	0.155	5.895	***	0.765
LS	<---	IC	0.977	0.158	6.193	***	0.703
DS3	<---	DS	1				0.758
DS2	<---	DS	1.043	0.092	11.343	***	0.801
DS1	<---	DS	1.074	0.096	11.145	***	0.778
OC3	<---	OC	1				0.703
OC4	<---	OC	0.967	0.106	9.092	***	0.697
OC2	<---	OC	0.927	0.107	8.664	***	0.656
OC1	<---	OC	0.987	0.108	9.181	***	0.707
LS3	<---	LS	1				0.831
LS2	<---	LS	0.855	0.077	11.085	***	0.755
LS1	<---	LS	0.769	0.073	10.536	***	0.708

*** $P < 0.001$.

pharmaceutical enterprises' digital transformation were carried out. It can be seen from Table 9 that the influencing factor model of pharmaceutical enterprises' DT has good fitting effect. The standardized path coefficient of external environment on internal conditions is 0.825 ($t = 5.92$, $P = *** < 0.001$), indicating that the external environment has a significant positive impact on internal conditions, so H2 is valid. The standardized path coefficient of the external environment on DT is 0.287 ($t = 2.572$, $P = 0.01 < 0.05$), indicating that the external environment has a significant positive impact on DT, so H1 is valid. The standardized path coefficient of internal conditions to DT is 0.385 ($t = 2.141$,

Table 8: Correlation coefficient of variables.

Variables	CN	MC	GP	TT	DS	OC	LS	DT
CN	1							
MC	.377**	1						
GP	.482**	.500**	1					
TT	.485**	.288**	.417**	1				
DS	.476**	.482**	.515**	.431**	1			
OC	.568**	.389**	.506**	.499**	.493**	1		
LS	.377**	.376**	.366**	.240**	.318**	.472**	1	
DT	.541**	.514**	.556**	.485**	.546**	.593**	.468**	1

**Correlation is significant at the 0.01 level (one-tailed).

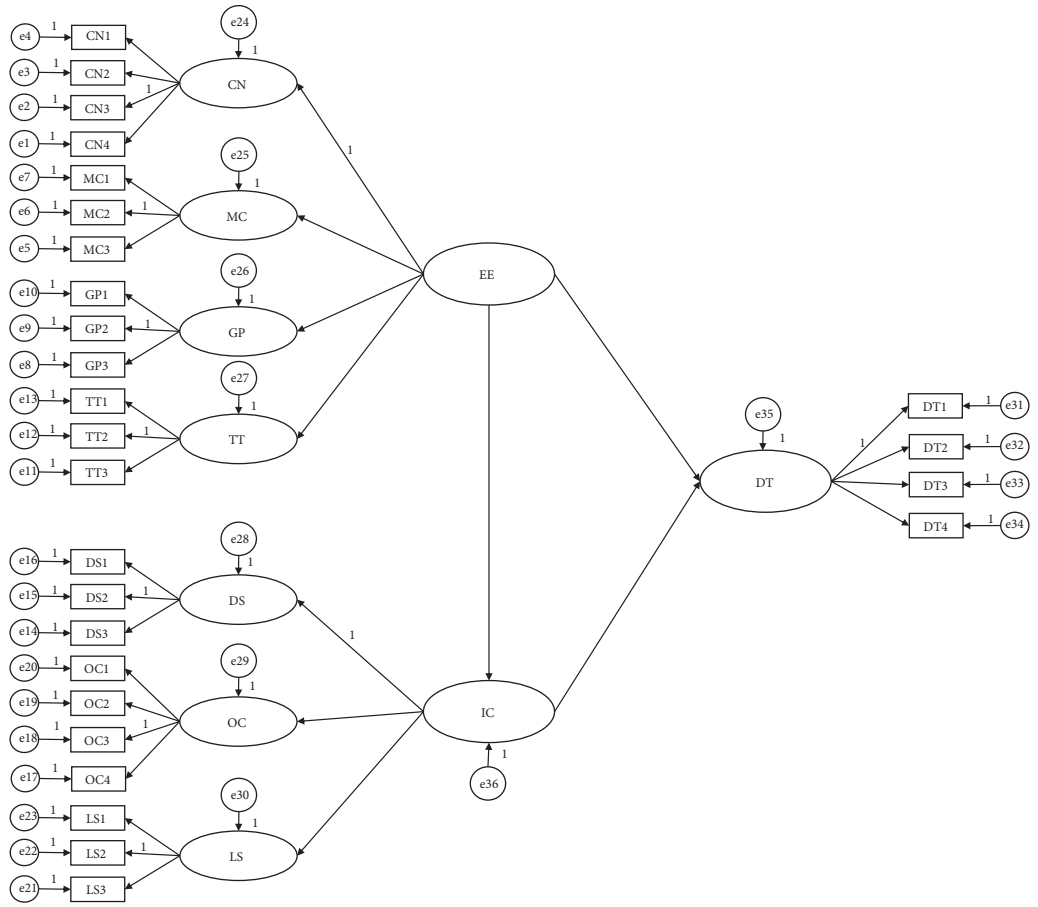

Figure 4: SEM of pharmaceutical enterprises' DT.

Table 9: Fitting indexes of influencing factor model of pharmaceutical enterprises' DT.

Fitting index	X^2/df	RMSEA	GFI	AGFI	TLI	IFI	PNFI	PCFI
Recommended value	<3	<0.08	>0.8	>0.8	>0.9	>0.9	>0.5	>0.5
Second-order factor model	1.175	0.027	0.908	0.889	0.977	0.98	0.785	0.876

$P = 0.032 < 0.05$), indicating that internal conditions have a significant positive impact on DT, so H3 is tenable.

The results are shown in Figure 5. Comparing the influence degree of several influencing factors, it is found that the external environment (path coefficient = 0.483, $t = 2.572$) has a greater positive impact on DT than the internal conditions (path coefficient = 0.385, $t = 2.141$). Therefore, the external environment is more important than the internal conditions for pharmaceutical enterprises' DT. That is, when carrying out DT, pharmaceutical enterprises should firstly pay attention to the external environment, followed by the internal conditions. In addition, for the external environment, customer needs (path coefficient = 0.238, $t = 4.104$) have a greater positive impact on DT than market

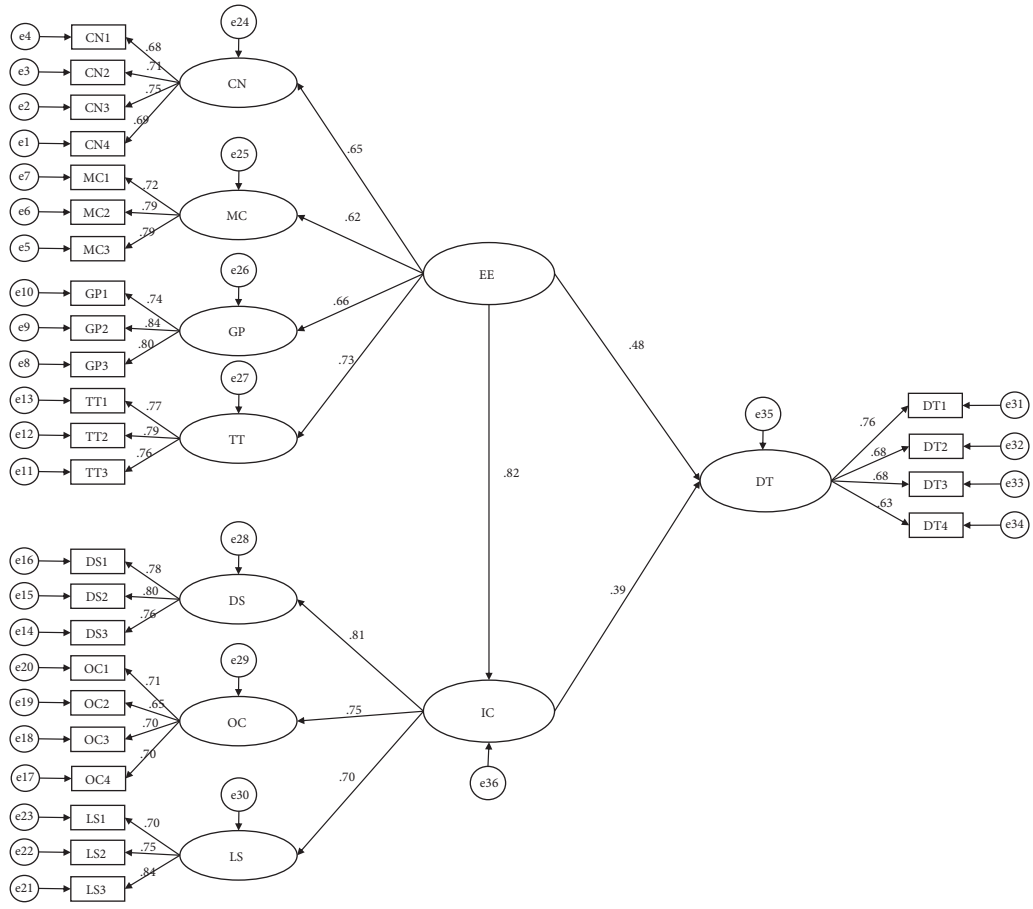

Figure 5: Influencing factor model of pharmaceutical enterprises' DT (Standardization).

competition (path coefficient = 0.229, $t = 3.931$), government policy (path coefficient = 0.125, $t = 2.043$), and digital technology (path coefficient = 0.222, $t = 3.579$). Therefore, customer needs are more important than market competition, government policy, and digital technology for pharmaceutical enterprises' DT. For internal conditions, digital strategy (path coefficient = 0.285, $t = 4.599$) has a greater positive impact on DT than organization capability (path coefficient = 0.235, $t = 3.812$) and leadership (path coefficient = 0.217, $t = 3.6$). Therefore, digital strategy is more important than organization capability and leadership for pharmaceutical enterprises' DT.

5. Conclusions

Based on the synergy theory, this study constructs the influencing factor model of Chinese pharmaceutical enterprises' DT and discusses the influencing mechanism of Chinese pharmaceutical enterprises' DT. Further research found that, firstly, external environment (customer needs, market competition, government policy, and digital technology) and internal conditions (digital strategy, organization capability, and leadership) have a positive impact on the DT of pharmaceutical enterprises. Secondly, internal conditions play a mediating role between the external environment and the DT of pharmaceutical enterprises. Thirdly, customer needs and digital strategy have the greatest impact on the digital transformation of pharmaceutical enterprises. Finally, this study provides a methodology for other industries and enterprises to carry out DT projects.

5.1. Theoretical Implication. Firstly, based on synergy theory, this study will propose a new influencing factor model of Chinese pharmaceutical enterprises' DT. It makes up for the theoretical gap in the research on the influencing factors of Chinese pharmaceutical enterprises' DT. It can make more DT researchers obtain valuable information.

Secondly, this study effectively identifies the influencing factors of digital transformation of pharmaceutical enterprises, including external environment and internal conditions. It improves the shortcomings of previous studies on the influencing factors of digital transformation of pharmaceutical enterprises.

Thirdly, this study discusses the mediating role of internal conditions in the relationship between the external environment and pharmaceutical enterprises' DT, which makes up for the shortcomings of previous studies.

5.2. Practical Implication. Firstly, this study confirms that the external environment (customer needs, market competition, government policy, and digital technology) and

internal conditions (digital strategy, organization capability, and leadership) have positive impacts on the DT of pharmaceutical enterprises. Pharmaceutical enterprises should actively explore the influencing factors, so as to effectively carry out DT projects.

Secondly, this study verifies the mediating role of internal conditions in the relationship between external environment and DT. Pharmaceutical enterprises should pay attention to the external environment and internal conditions, effectively collaborating to promote DT.

Thirdly, this study also confirms that the influence of customer needs and digital strategy on the DT of pharmaceutical enterprises is greater than that of other factors. Pharmaceutical enterprises should focus on customers, grasp customer needs, and actively respond to market competition, and the government should formulate relevant policies to guide and promote pharmaceutical enterprises' DT. Pharmaceutical enterprises can improve the digital capability by applying advanced digital technology, so as to meet customer needs. Before carrying out DT, pharmaceutical enterprises need to establish an effective digital strategy, combine with organization capability, and get the support of leaders, so as to better promote DT.

6. Future Research

This study still has the following three limitations. Firstly, this study has the limitation of small sample size. In the future, it is necessary to increase the number of samples for analysis. Secondly, this study only studies pharmaceutical enterprises of China. For enterprises in different countries and industries, whether the influencing factors of DT are the same still needs to be further studied in the future. Thirdly, this study mainly explores the impact of external environment (customer needs, market competition, government policy, and digital technology) and internal conditions (digital strategy, organization capability, and leadership) on enterprises' DT and their relationship. However, this study lacks the researches on the impact of regulatory variables on DT, such as enterprise scale. This study lacks the impact of control variables on DT, such as enterprise age, ownership type, and region. In the future, we need to further evaluate and study the results of enterprises' DT under the influence of these factors to develop effective digital transformation plans for them.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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Hindawi
Discrete Dynamics in Nature and Society
Volume 2022, Article ID 1631931, 12 pages
https://doi.org/10.1155/2022/1631931

Research Article

Evolutionary Analysis of Innovation Development in a Metropolitan Area from a Symbiosis Perspective: Empirical Research on the Shanghai Metropolitan Area

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Received 27 December 2021; Accepted 16 March 2022; Published 12 April 2022

Academic Editor: Yi Su

Promoting the innovative development of cities in the metropolitan area holds great significance for China's implementation of the "innovation-driven development" strategy. According to symbiosis theory, this paper constructed a city-based Lotka-Volterra symbiosis model and innovation-level index system. We used the Shanghai metropolitan area as a sample for empirical analysis to explore the evolution of the comprehensive development level of urban innovation under different symbiotic relationships. The research results showed that under a reciprocal relationship, the innovative development of core city and node cities was higher than the actual level; under a mutual inhibition symbiosis or parasitic symbiotic relationship, the innovative development of core city and node cities was lower than the actual level; and under an independent symbiotic relationship, the innovative development of the core city was higher than the actual level, while that of the node cities was lower than the actual level.

1. Introduction

As China's economy has shifted from a stage of rapid growth to a stage of high-quality development, the traditional factor-driven economic growth model no longer meets China's development requirements. In this context, the 18th National Congress of the Communist Party of China proposed an innovation-driven development strategy, emphasizing that science and technology innovation is strategic support for improving social productivity and comprehensive national power, and it must be placed at the core of the overall national development. As an important aspect of innovation-driven development, regional innovation is a key area that the government pays attention to. The "Outline of the National Innovation-Driven Development Strategy" clearly pointed out that the development of regional innovation in China not only relied on the construction of regional science and technology demonstration areas but also required the government to optimize the allocation of innovation resources to achieve the coordinated development of regional innovation. On this basis, given that metropolitan areas are regional resource-gathering centers, the improvement of their innovation capacity holds great significance for regional innovation development. Numerous studies have shown that the innovative development of each city in metropolitan areas not only depends on the development conditions of the city itself but is also closely related to the innovation linkage between cities [1–4]. In China, the economic, cultural, and political connections between cities in the region have formed a huge and complex metropolitan area. With development plans such as the "Development Plan for the Yangtze River Delta City Cluster," the "Outline of the Beijing-Tianjin-Hebei Coordinated Development Plan," and the "Guiding Opinions on the Cultivation and Development of Modern Metropolitan Areas," the development of China's metropolitan areas has been greatly accelerated and the innovation linkages between cities have also been strengthened. As a result, urban

innovation in the metropolitan area has set a development trend of clustering and networking, with megacities as the center [5]. In this context, the symbiotic relationships among cities in the metropolitan area encourage further innovation development and will inevitably have an impact on the level of comprehensive innovation development of the city [6]. Therefore, studying the impact of this symbiotic relationship among cities in the metropolitan area on the comprehensive innovation development level of the city holds great significance for the formulation of a reasonable development strategy to promote the development of urban innovation in metropolitan areas.

2. Related Reference Review

Integrating ecological concepts into urban innovation development and actively creating an urban innovation ecosystem has become the government's preferred strategy for promoting regional innovation development [7]. In reality, understanding how to coordinate the symbiotic relationships among cities, as well as how to enhance the overall development of the innovation ecosystem, in order to achieve the synergistic development of innovations in the metropolitan area has presented a significant challenge for the government in the process of regional innovation development. Guided by these questions, related innovation ecosystems, symbiotic relationships among subjects, and the innovative development of metropolitan areas have become popular research topics for scholars.

2.1. Innovation Ecosystem Study. The ecosphere was first studied in biology, and Jucevicius argued that the "ecosphere" is actually a complex system with a self-regulating function formed by the interaction of life subjects in an inorganic environment [8]. Pan and Yang summarized that the ecosphere is characterized by the diversity of population tribes, mutual symbiosis, and ecological self-reproduction [9]. With the deepening of research, based on the practical significance and characteristics of the ecosystem, this theory has been widely used in the study of the relationship among micro-innovative entities, including enterprises, universities, scientific research institutions, and service institutions. Ander argued that in a corporate innovation ecosystem, business can reduce operating risks and expand returns through resource sharing [10]. Wu et al. constructed a spiral innovation ecosystem by combining government, enterprises, universities, and technology business incubators. They found that the diversity and differentiation of innovation agents were important features of the innovation ecosystem [11]. Taking the development of enterprise agglomeration as a logical starting point, Xu and Ren found that the operating mechanism of the innovation ecosystem within a central city was composed primarily of a symbiosis mechanism, a benefit distribution mechanism, and an environmental matching mechanism [12]. Based on the Lotka-Volterra model, Peng et al. found that the introduction of universities can effectively facilitate the transfer of subject knowledge in the innovation ecosystem [13]. Li proposed that the integration of industry, innovation, capital, and service chains can effectively enhance the energy level of the innovation ecosystem. They argued that the essence of the integration of the four was the process of deepening the synergy among enterprises, universities, research institutions, and service institutions [14].

2.2. Study of Symbiotic Relationships. As an important condition and evolutionary guarantee for the formation of an innovation ecosystem, symbiosis offers great research value. The theory of symbiosis was first proposed by German mycologist De Berry. This theory elaborates primarily on the phenomenon that different populations interact with each other and evolve synergistically to achieve symbiosis and coprosperity. Based on the practical significance of this theory, many scholars have extended it to the field of innovation ecosystems. According to the theory of symbiotic relationships, Moore argued that the best relationship among enterprises should be symbiotic evolution, rather than the traditional relationship of cooperation and competition [15]. According to Li et al., the essence of the innovation ecosystem is a community formed by the mutual influence and symbiotic evolution of innovation subjects [16]. Zahra and Nambisan speculated that the symbiotic relationship between subjects is the foundation of the innovation ecosystem, and the core enterprise optimizes the innovation development environment of satellite enterprises [17]. Long et al. constructed an innovation ecosystem consisting of government, technology alliances, and intermediary organizations and found that a reciprocal and symbiotic ecological relationship is conducive to enhancing the efficiency of knowledge transfer [18]. Gu and Xie used symbiosis theory to study the Toyota business ecosystem, and the results showed that cocreation and value sharing were the prerequisites for the existence of symbiosis [19]. Wu et al. analyzed the symbiotic relationship of subjects in the patent innovation ecosystem, and they found that the symbiotic relationship among subjects had an important impact on patent growth [20]. Hao and Ren calculated the coefficient of symbiosis between enterprise subjects and concluded that reciprocal symbiosis was the best way to develop an innovation ecosystem [21].

2.3. Study of Innovative Development of Metropolitan Areas. In recent years, against the background of the flourishing development of metropolitan areas, including the Yangtze River Delta, Beijing-Tianjin-Hebei, Guangdong, Hong Kong, and Macao, research on their innovative development has garnered increasing scholarly attention. Using the Guangdong–Hong Kong–Macao Greater Bay Area as a research object, Dong et al. concluded empirically that reducing the cost of collaborative innovation among cities can improve the innovation efficiency of cities [22]. Through cohesive subgroup analysis and knowledge complexity measurement, Xu et al. found that innovation synergy among cities is conducive to promoting regional innovation development. They proposed that a regional innovation community with a division of labor and collaboration should be developed to enhance the innovation competitiveness of cities [23]. On the basis of the perspective of an evolutionary

game, Liu and Yan found that the initial state of innovation agents, evolutionary environment, and synergistic mechanism all can influence the evolutionary path of collaborative innovation in urban clusters [24]. Based on an exponential stochastic model, Wang et al. found that knowledge elements, economic development, and research investments were important factors influencing city innovation synergy. Their results showed that the government should guide cities to develop innovation strategies based on local conditions to help build an interactive and synergistic innovation network [25]. Li and Zhang evaluated the innovation ecological synergy of three major metropolitan areas in China. They concluded that the variability of innovation coordination in urban agglomerations is determined mainly by government environmental regulation, science, and technology innovation support and the degree of market competition [26].

This body of literature has enriched the theory of innovation ecosystems, symbiotic relationships, and the innovative development of metropolitan areas. This research still has shortcomings in the following areas: first, the existing research on innovation ecosystems and symbiotic relationships has focused mainly on the research of microsubjects, including enterprises, scientific research institutions, and universities, whereas relatively few macrostudies have focused on cities. Second, in actual situations, the innovation relationship between cities is relatively complex and diverse, whereas the existing research has focused mainly on the impact of coordinated development between cities on regional innovation and has failed to consider the impact of other possible relationships on urban innovation development comprehensively. Third, the existing research on urban innovation has ignored the factors of urban heterogeneity and has failed to fully integrate the regional distribution characteristics of core cities and node cities in China's metropolitan circle in its analysis.

This study addresses the shortcomings of the research conducted to date. First, to better reflect the theoretical contribution of this study, from the perspective of a symbiotic relationship, we selected the entire city as the research object and established a symbiotic evolution model of core cities and node cities in the urban innovation ecosystem. Second, we selected the Shanghai metropolitan area as an example to conduct an empirical analysis and analyzed the evolutionary trend of the comprehensive development level of urban innovation under different symbiotic relationships through simulation. There are two main innovations and contributions of this article. The first is that it takes the entire city as the research object by analyzing the impact of symbiotic relationships on regional innovation development from a macro perspective and providing theoretical support for the government to coordinate the symbiotic relationship among cities in the process of regional innovation development. Second, we fully integrated the regional distribution characteristics of core cities and node cities in China's metropolitan area to study the urban symbiotic relationship and analyzed the evolutionary trend of the comprehensive development level of urban innovation under different symbiotic relationships to provide a reference for the innovation development of China's metropolitan areas.

3. Symbiosis Model Construction and Parameter Estimation

3.1. Theoretical Foundations. The Lotka-Volterra model in symbiosis theory was first established by the American scholar Lotka (1925) and the Italian scholar Volterra (1926). This model was first applied to the study of the interaction between different populations in ecology. In recent years, it has been widely cited in the field of innovative ecological management. Existing studies have suggested that symbiotic relationships such as reciprocal symbiosis, mutual inhibition symbiosis, independent symbiosis, and parasitic symbiosis are common among ecological agents, and the symbiotic relationship is determined by the symbiotic coefficients (u_{ij}, $i \neq j$) [27]. The details are shown in Table 1.

3.2. Model Construction. Given that the innovative development behavior of cities in a metropolitan area is consistent with the symbiotic ecological characteristics of natural populations and that this model has been applied to study the symbiotic relationships among multiple agents in various fields of economic management, such as technological innovation, urban development, and knowledge synergy, we used the Lotka-Volterra model to explore the symbiotic relationship among cities in the metropolitan area and its impact on the development of comprehensive innovation. In this study, we categorized the cities in the metropolitan area into a core city ($x1$) and node cities ($x2$, $x3$). A core city is a megacity with a huge economic scale, rich innovation resources, and obvious competitive advantages over neighboring cities. A node city is a city that is geographically close to the core city and is greatly affected by the spillover effect of the core city in terms of its economy [28]. The model assumptions are as follows.

Assumption 1. Status Constraints.

Metropolitan areas did not have any status constraints on core cities or status constraints on node cities. In the process of regional development, because node cities did not have the relatively important urban status of core cities, they were constrained relative to core cities in areas such as external policy support, resource allocation, and talent flow, which in turn affected their level of comprehensive innovation development.

Assumption 2. Symbiotic Relationship.

In the process of regional innovation development, the innovation development of cities was influenced by other cities. According to symbiotic relationship theory, we found reciprocal symbiosis, mutual inhibition symbiosis, independent symbiosis, and parasitic symbiosis between core cities and node cities. In this relationship, "⟶" is characterized as the interaction between subjects, "+" indicates that the coefficient of symbiosis between two subjects is

Table 1: Symbiotic relationships.

Symbiotic coefficients	Symbiotic relationships	Definition
$u_{ij} > 0, u_{ji} > 0$	Reciprocal symbiosis	Population i and population j reinforce each other for mutual development
$u_{ij} > 0, u_{ji} > 0$	Mutual inhibition symbiosis	Population i and population j inhibit each other and hinder each other's development
$u_{ij} = 0, u_{ji} = 0$	Independent symbiosis	Population i and population j are independent of each other and do not affect each other's development
$u_{ij} < 0, u_{ji} > 0$ *or* $u_{ij} > 0, u_{ji} < 0$	Parasitic symbiosis	Population i promotes the development of population j, while population j inhibits the development of population i

greater than 0, and "–" indicates that the coefficient of symbiosis between two subjects is less than 0.

Assumption 3. Evolutionary Patterns.

In the initial stage of comprehensive urban innovation development, its growth showed a relatively obvious upward trend. As the level gradually increased, the growth rate of comprehensive innovation development level would decrease because of the constraints of the relationship and development (R&D) capacity of urban subjects and technology costs. Thus, the growth process of comprehensive innovation development level of cities in the metropolitan area followed the logistic law [29].

Assumption 4. Evolutionary Dynamics.

We did not find any status constraints on core cities. The amount of change in its level of comprehensive innovation development at the moment is $dx_1/dt = r_1 x_1$, while the node city is affected by the status constraint, and the amount of change at the moment is $dx_i/dt = r_i x_i (1 - x_i/N_i) \quad (i = 2, 3)$.

According to these assumptions, the Lotka-Volterra model of cities (x_1, x_2, x_3) constructed in this study is as follows:

$$\begin{cases} \dfrac{dx_1}{dt} = r_1 x_1 \left(1 + u_{12}\dfrac{x_2}{N_2} + u_{13}\dfrac{x_3}{N_3}\right), \\ \dfrac{dx_2}{dt} = r_2 x_2 \left(1 - \dfrac{x_2}{N_2} + u_{21}x_1 + u_{23}\dfrac{x_3}{N_3}\right), \\ \dfrac{dx_3}{dt} = r_3 x_3 \left(1 - \dfrac{x_3}{N_3} + u_{31}x_1 + u_{32}\dfrac{x_2}{N_2}\right). \end{cases} \tag{1}$$

where N_i ($i = 1, 2, 3$) represents the highest level of comprehensive innovation development of the city under the constraints of objective conditions; u_{ij} represents the coefficient of symbiosis between cities, which indicates the degree of influence of city i on the innovative development of city j; and $r_i > 0$ ($i = 1, 2, 3$) represents the net growth rate of the comprehensive innovation development level of cities in the metropolitan area.

3.3. Estimation of Parameters. To calculate the coefficient of symbiotic effect between core cities and node cities, this study draws on the method of Wu and Wang to estimate the parameters using the gray estimation method [30].

Given that the expansion of (1) is

$$\begin{cases} dx_1/dt = r_1 x_1 + r_1 u_{12}/N_2 x_1 x_2 + r_1 u_{13}/N_3 x_1 x_3 \\ dx_2/dt = r_2 x_2 - r_2/N_2 x_2^2 + r_2 u_{21} x_2 x_1 + r_2 u_{23}/N_3 x_2 x_3 \\ dx_2/dt = r_3 x_3 - r_3/N_3 x_3^2 + r_3 u_{31} x_3 x_1 + r_3 u_{32}/N_2 x_3 x_2 \end{cases}$$

For convenience, (1) is written as follows:

$$\begin{cases} \dfrac{dx_1}{dt} = \alpha_{10}x_1 + \alpha_{11}x_1^2 + \alpha_{12}x_1x_2 + \alpha_{13}x_1x_3, \\ \dfrac{dx_2}{dt} = \alpha_{20}x_2 + \alpha_{22}x_2^2 + \alpha_{21}x_1x_2 + \alpha_{23}x_2x_3, \\ \dfrac{dx_3}{dt} = \alpha_{30}x_3 + \alpha_{33}x_3^2 + \alpha_{31}x_1x_3 + \alpha_{32}x_2x_3. \end{cases} \tag{2}$$

where α is defined as $\alpha_{10} = r_1, \alpha_{11} = 0, \alpha_{12} = r_1 u_{12}/N_2, \alpha_{13} = r_1 u_{13}/N_3 \alpha_{20} = r_2, \alpha_{22} = -r_2/N_2, \alpha_{21} = r_2 u_{21}, \alpha_{23} = r_2 u_{23}/N_3$ $\alpha_{30} = r_3, \alpha_{33} = -r_3/N_3, \alpha_{31} = r_3 u_{31}, \alpha_{32} = r_3 u_{32}/N_3$

Based on the mapping relationship between the gray derivative and the even logarithm, the system of equations in equation (2) is discretized to obtain equation (3), as follows:

$$\begin{cases} x_1(t+1) - x_1(t) = \alpha_{10}\dfrac{x_1(t) + x_1(t+1)}{2} + \alpha_{11}\dfrac{[x_1(t) + x_1(t+1)]^2}{4} + \alpha_{12}\dfrac{[x_1(t) + x_1(t+1)][x_2(t) + x_2(t+1)]}{4} + \alpha_{13}\dfrac{[x_1(t) + x_1(t+1)][x_3(t) + x_3(t+1)]}{4}, \\ x_2(t+1) - x_2(t) = \alpha_{20}\dfrac{x_2(t) + x_2(t+1)}{2} + \alpha_{22}\dfrac{[x_2(t) + x_2(t+1)]^2}{4} + \alpha_{21}\dfrac{[x_1(t) + x_1(t+1)][x_2(t) + x_2(t+1)]}{4} + \alpha_{23}\dfrac{[x_2(t) + x_2(t+1)][x_3(t) + x_3(t+1)]}{4}, \\ x_3(t+1) - x_3(t) = \alpha_{30}\dfrac{x_3(t) + x_3(t+1)}{2} + \alpha_{33}\dfrac{[x_3(t) + x_3(t+1)]^2}{4} + \alpha_{31}\dfrac{[x_1(t) + x_1(t+1)][x_3(t) + x_3(t+1)]}{4} + \alpha_{32}\dfrac{[x_2(t) + x_2(t+1)][x_3(t) + x_3(t+1)]}{4} \end{cases} \tag{3}$$

To facilitate the calculation, (3) is transformed into a matrix equation form, as shown in the following:

$$\begin{aligned} X_{1n} &= A_1\alpha_1, \\ X_{2n} &= A_2\alpha_2, \\ X_{3n} &= A_3\alpha_3. \end{aligned} \tag{4}$$

According to the law of least squares, (7) is obtained as follows:

$$\begin{aligned} \widehat{\alpha}_1 &= \left(A_1^T A_1\right)^{-1} A_1^T X_{1n}, \\ \widehat{\alpha}_2 &= \left(A_2^T A_2\right)^{-1} A_2^T X_{2n}, \\ \widehat{\alpha}_3 &= \left(A_3^T A_3\right)^{-1} A_3^T X_{3n}. \end{aligned} \tag{5}$$

Finally, the coefficients are reduced to the system of differential equations to obtain the symbiotic coefficients in the original equations:

$$\begin{aligned} u_{ij} &= \alpha_{ij} \times \frac{N_j}{r_i} \quad (i \neq j, j \neq 1), \\ u_{ij} &= \alpha_{ij} \times \frac{N_j}{r_i} \quad (i \neq j, j = 1). \end{aligned} \tag{6}$$

4. Research Object Selection and Index System Construction

4.1. Research Object Selection. The promulgation of the "Outline for the Development of Regional Integration in the Yangtze River Delta" in 2019 marks the development path of the Yangtze River Delta toward achieving regional integration and coordinated development. The outline notes that innovation drive is the key to promoting the integrated and high-quality development of the Yangtze River Delta. In the same year, to give full play to the radiation role of core cities and realize the regional agglomeration effect, the National Development and Reform Commission proposed the concept of a metropolitan area in the "Guiding Opinions on Cultivating and Developing Modern Metropolitan Areas." The purpose of the metropolitan area is to consider the megacity as the core, with neighboring node cities participating in the division of labor and cooperation to achieve common development in the areas of finance, culture, innovation, and transport. The latest "Report on the Development of China's Metropolitan Areas" released by Tsinghua University pointed out that the Yangtze River Delta Metropolitan Area is currently the most mature metropolitan area in China, and all its indicators rank first in the country.

As the most important core city in the Yangtze River Delta region, Shanghai plays a crucial role in its integration. The "Outline for the Development of Regional Integration in the Yangtze River Delta" clearly noted that the development of the Yangtze River Delta would promote a regional linkage development with Shanghai as the core. The "Shanghai City Master Plan" also proposed that Shanghai should build a Shanghai metropolitan area that includes Suzhou, Jiaxing, Wuxi, Nantong, and Ningbo, and established an efficient mechanism for cooperation among government, industry, academia, and research in the field of science and technology innovation to share science and innovation resources and form an innovation community. As important node cities adjacent to Shanghai, Suzhou, and Jiaxing are closely related to Shanghai. Suzhou has been known as the "Biluo Spring Tea under the big tree," and for many years, Suzhou has maintained the development concept of harmony but has had Shanghai as the center. In recent years, under the policy of "integrating with Shanghai and promoting integration," Jiaxing and Shanghai have cooperated deeply in terms of industrial platforms, infrastructure, and public services. Specifically, after the "Shanghai-Jiaxing G60 Science and Innovation Corridor Strategy" was proposed, the innovation linkage between the two has become more frequent.

Therefore, by considering Shanghai (core city), Suzhou (node city), and Jiaxing (node city) in the Yangtze River Delta region as the research objects, we were able to fully reflect the current symbiotic relationship and innovation-level development track of the most cutting-edge and mature metropolitan areas in China today.

4.2. Indicator System Construction and Data Processing. Comprehensive urban innovation is a development process that involves multiple fields. Most existing studies have measured and evaluated this relationship in terms of knowledge, technology, industry, and environment. In this study, based on the methods of Zhao et al. [31] and Wu and Tan Cui [32], and following the principles of comprehensiveness, scientific quality, and data availability, we constructed an index system from four dimensions: innovation subject, innovation environment, innovation input, and innovation output (as shown in Table 2). Among them, innovation subject is the human foundation of city innovation development; innovation environment provides infrastructure conditions for city innovation development; innovation input is an important guarantee for city innovation development; innovation output is an important criterion to measure the competitiveness of city innovation development and the level of result transformation.

5. Empirical Research

5.1. Calculation of the Comprehensive Innovation Development Level. At present, the weights for the index system commonly follow the hierarchical analysis method, the Delphi method, the entropy weight method, the principal component analysis method, or the factor analysis method. Considering the fuzziness of the criteria in judging the importance of indicators, we adopted the fuzzy comprehensive evaluation method to determine the weights of the index system of urban innovation development level on the basis of squaring and normalizing the original data. The calculated scores of the city's comprehensive innovation development level are shown in Table 3, and the development trend is shown in Figure 1.

Table 2: Comprehensive innovation development level indicator system.

Tier 1 indicator	Tier 2 indicators	Tier 3 indicators
Comprehensive innovation development level	Innovation subject	Number of universities
		Number of high-tech enterprises
		Number of scientific research institutions in the city
		Number of national key laboratories
		Number of national technology incubators
	Innovation environment	CPI
		GDP per capita in the region
		Park green area per capita
		Total number of libraries and museums
		Number of beds in hospitals and health centers
		Number of public books per capita
	Innovation input	Total expenditures of local government funds for science and technology
		Total expenditures of local government funds for education
		R&D investment of industrial enterprises above designated size
		Number of R&D personnel in industrial enterprises above designated size
		Number of people engaged in research activities in the university
	Innovation output	Number of patent applications
		Number of patents granted
		Number of technology market contract transactions
		Value of technology market contracts
		Number of national-level science and technology awards
		Total number of scientific and technical papers published
		High-tech industry output value

Table 3: Comprehensive innovation development levels of three cities (2008–2019).

Year	Shanghai	Suzhou	Jiaxing
2019	0.8522	0.5689	0.4252
2018	0.7985	0.5666	0.4246
2017	0.7422	0.5588	0.4238
2016	0.7025	0.5584	0.423
2015	0.6528	0.5574	0.4213
2014	0.6064	0.5497	0.4179
2013	0.5737	0.5372	0.4127
2012	0.5324	0.5057	0.3983
2011	0.5029	0.4665	0.3669
2010	0.4643	0.3915	0.325
2009	0.4254	0.2995	0.2422
2008	0.3911	0.2212	0.161

5.2. Measurement and Fitting of Coefficient of Urban Symbiosis. Using the parameter gray estimation method to perform matrix operations on the data in Table 3, the following results can be obtained:

$$\begin{aligned}\alpha_1 &= [\alpha_{10}, \alpha_{11}, \alpha_{12}, \alpha_{13}]^\tau = [0.1014, 0, -0.1655, 0.1305],\\ \alpha_2 &= [\alpha_{20}, \alpha_{22}, \alpha_{21}, \alpha_{23}]^\tau = [0.5319, -2.7433, 0.1203, 2.1858],\\ \alpha_3 &= [\alpha_{30}, \alpha_{33}, \alpha_{31}, \alpha_{32}]^\tau = [0.7859, -1.6879, 0.0335, -0.1678].\end{aligned} \quad (7)$$

Reducing the obtained coefficients to the differential (1), the net growth rates of the innovation development level and symbiotic coefficients for the three subjects are as follows:

$r_1 = 0.1014$, $r_2 = 0.5319$, $r_3 = 0.7859$; $u_{12} = -0.3164$, $u_{21} = 0.2262$, $u_{13} = 0.5990$, $u_{31} = 0.0424$, $u_{23} = 1.9131$, $u_{32} = -0.0414$. We concluded that when $u_{12} < 0$, $u_{21} > 0$, Shanghai and Suzhou are in a parasitic symbiotic relationship; when $u_{13} > 0$, $u_{31} > 0$, Shanghai and Jiaxing are in a reciprocal symbiotic relationship; when $u_{23} > 0$, $u_{32} < 0$, Suzhou and Jiaxing are in a parasitic symbiotic relationship. The symbiotic relationships among Shanghai, Suzhou, and Jiaxing in the metropolitan area are shown in Figure 2.

The coefficients derived from the gray estimation are input into Matlab for simulation to observe the evolutionary dynamics of Shanghai, Suzhou, and Jiaxing in terms of their integrated level of urban innovation development, as shown in Figure 3.

According to Figure 3, Shanghai maintained a clear growth trend throughout, whereas Suzhou and Jiaxing followed a faster growth trend in the early stages and leveled off in the later stages. In general, the evolution trend of the comprehensive development level of urban innovation obtained by simulation was consistent with the actual comprehensive development level of urban innovation shown in Figure 1. Thus, it was reasonable and feasible to use the Lotka-Volterra model to study the symbiotic relationship between core cities and node cities in a metropolitan area.

5.3. Simulation Analysis. By changing the value of the symbiosis coefficient between the core city and the node city, we could observe the evolution trend of the city's comprehensive innovation development level under different symbiotic relationships. Then, we explored the impact of the symbiotic relationships among the cities on a comprehensive urban innovation development level.

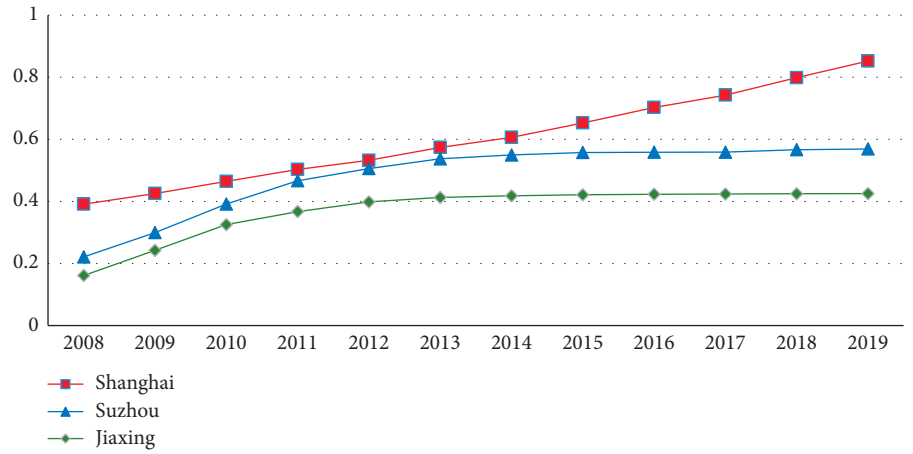

Figure 1: Time trend of comprehensive innovation development levels. *Note.* Data are from the China Science and Technology Statistical Yearbook, China Statistical Yearbook, China High and New Technology Industry Statistical Yearbook, Shanghai Statistical Yearbook, Suzhou Statistical Yearbook, Jiaxing Statistical Yearbook, China City Database, WIEGO Statistical Database, websites of Science and Technology Bureau and Statistics Bureau, and government work reports from 2008 to 2019. The descriptive statistics of all indicator data are shown in Table 4.

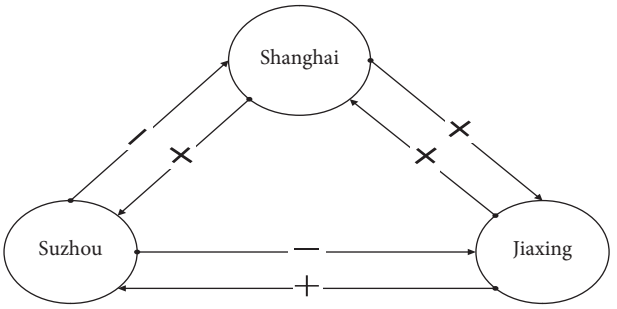

Figure 2: Symbiotic relationships among Shanghai, Suzhou, and Jiaxing.

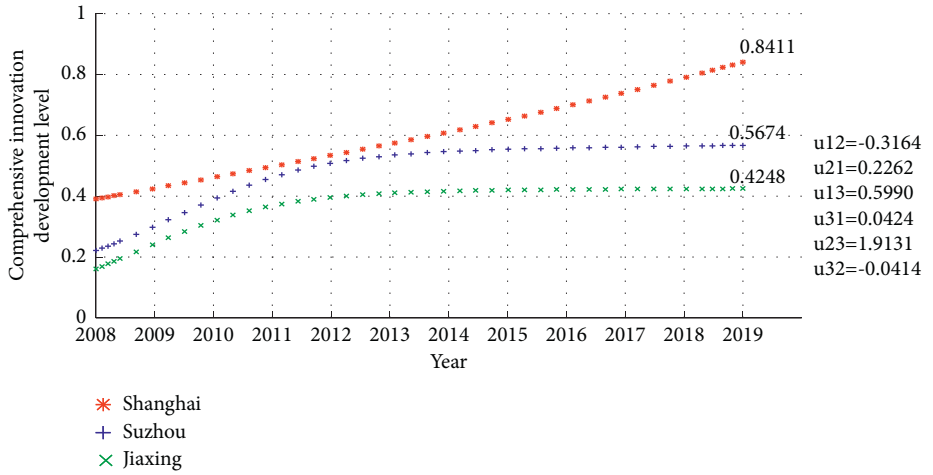

Figure 3: Evolution trend of comprehensive innovation development level in Shanghai, Suzhou, and Jiaxing.

5.3.1. Reciprocal Symbiosis between Core City and Node Cities. Holding other parameters constant, Figure 4 shows the evolution of the comprehensive innovation development level of the three cities when Shanghai was in a reciprocal symbiotic relationship with Suzhou and Jiaxing. Overall, the level of comprehensive innovation development in all three cities has increased to varying degrees by 2019 compared with the actual situation. The most pronounced rise was in Shanghai, which was in the dominant position in the metropolitan area and had a much higher rate and level of

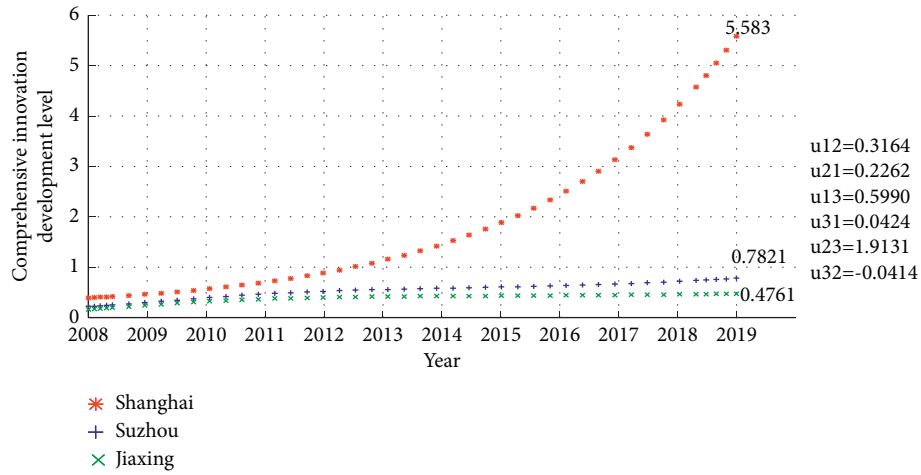

Figure 4: Evolution trend of comprehensive innovation development level under reciprocal symbiosis.

rising than the two node cities. In a metropolitan area, because of the radiation effect of the core cities on the node cities, the level of comprehensive innovation development in the node cities was enhanced, and the innovative development of the node city improved the innovation environment and agglomeration effect of the metropolitan area, which in turn promoted the core city's development. This result suggested that when node cities and core cities maintained a reciprocal symbiotic relationship, the core cities would lead the node cities to achieve a higher level of comprehensive innovation development.

5.3.2. Mutual Inhibition Symbiosis between Core City and Node Cities. Holding other parameters constant, Figure 5 shows the evolution of the comprehensive innovation development level of the three cities when Shanghai was in a mutual inhibition symbiotic relationship with Suzhou and Jiaxing. As shown in the graph, the comprehensive innovation development level of the three cities declined compared with the actual level achieved by 2019. Among these cities, the decline in Shanghai was the most evident, and its curve tended to decline slowly after a slight increase. Although Suzhou and Jiaxing have maintained relatively rapid growth, they gradually tended to follow a gradual evolutionary trend, but the final comprehensive development level of innovation was lower than the actual value. Although Suzhou and Jiaxing showed an evolutionary trend of faster growth, followed by a gradual leveling-off, their final comprehensive innovation development was lower than the actual value. In the metropolitan area, because of the relatively high net growth rate of the comprehensive innovation development level of the node cities, it followed an upward trend. Subsequently, because of the dampening effect of the core cities, the growth slowed down and eventually fell below the actual level. The core cities experienced a decline in their comprehensive innovation development because of the combined inhibiting effect of the surrounding node cities. This finding suggested that when the core city and the node city maintained a mutual inhibition symbiotic relationship, the comprehensive innovation development of all three eventually would be lower than the actual level.

5.3.3. Independent Symbiosis between Core City and Node Cities. Holding other parameters constant, Figure 6 shows the evolution of the comprehensive innovation development level of the three cities when Shanghai was in an independent symbiotic relationship with Suzhou and Jiaxing. As shown in the graph, by 2019, Shanghai's comprehensive development level of innovation improved significantly compared with the actual situation, whereas Suzhou and Jiaxing had declined to varying degrees. On the one hand, because of the lack of the radiating effect of the core cities, the innovation development of the node cities lost a favorable factor, and thus, the level decreased compared to the actual situation. On the other hand, because of the unconstrained status and inherent advantages of their own resources, the core cities achieved higher levels of innovative development than the actual situation. This finding suggested that when the core city and the node city maintained an independent symbiotic relationship, the comprehensive innovation development of the core cities eventually would be higher than the actual level, and the situation of the node city would be the opposite.

5.3.4. Parasitic Symbiosis between Core City and Node Cities. Holding other parameters constant, Figure 7 shows the evolution of the comprehensive innovation development level of the three cities when Shanghai followed a parasitic symbiotic relationship with Suzhou and Jiaxing. As shown in Figure 7, the level of Shanghai's comprehensive innovation development experienced a significant decline. Although Suzhou and Jiaxing maintained a rapid upward trend, followed by a gradual leveling-off, the level of comprehensive innovation development in the two cities was still lower than the actual value in 2019. In the metropolitan area, when node cities were parasitic on core cities, because of the relatively high net growth of comprehensive innovation development level and the innovation spillover of core cities, the

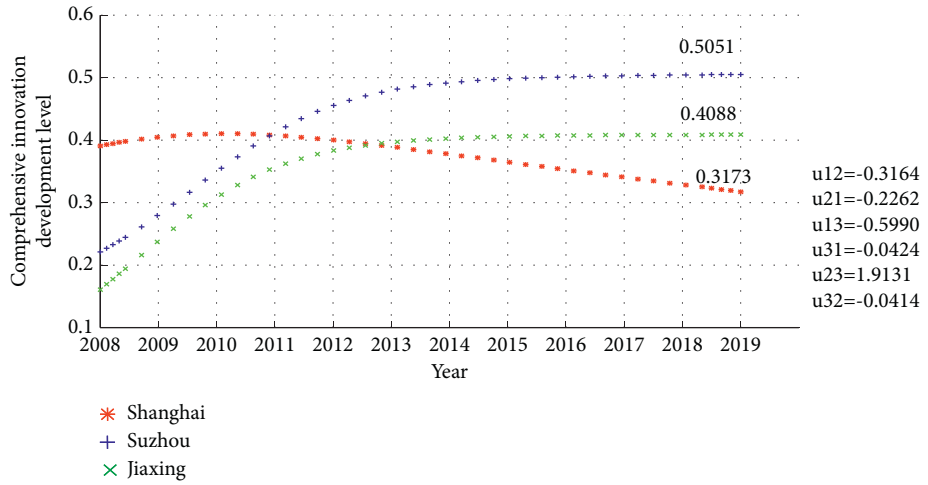

Figure 5: Evolution trend of comprehensive innovation development level under mutual inhibition symbiosis.

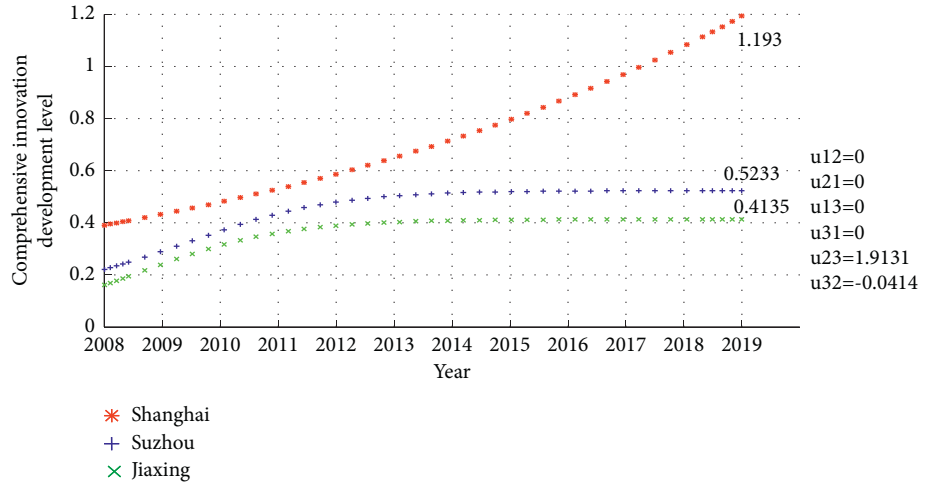

Figure 6: Evolution trend of comprehensive innovation development level under independent symbiosis.

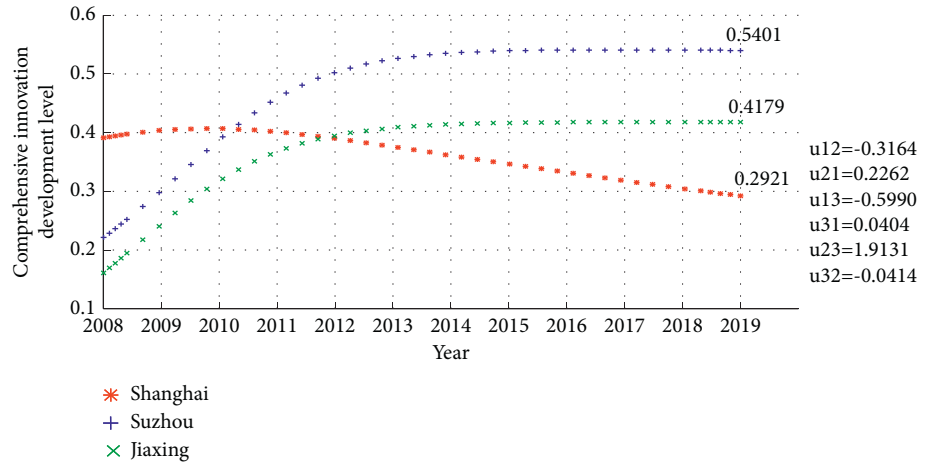

Figure 7: Evolution trend of comprehensive innovation development level under parasitic symbiosis.

Table 4: The descriptive statistics of all indicator data.

Variable	Obs	Mean	Std. Dev	Min	Max
Number of universities	36	32.19	27.67	3	97
Number of high-tech enterprises	36	3940	2723.97	682	12619
Number of scientific research institutions in the city	36	75.33	60.20	3	165
Number of national key laboratories	36	12.72	13.52	0	45
Number of national technology incubators	36	18.42	16.92	0	55
CPI	36	102.64	1.62	98.47	105.78
GDP per capita in the region	36	103028	34146.17	42626	162503
Park green area per capita	36	11.38	2.89	6.97	15
Total number of libraries and museums	36	51.33	43.62	6	128
Number of beds in hospitals and health centers	36	63351.97	43700.35	12484	146454
Number of public books per capita	36	1.67	1.11	0.49	3.43
Total expenditures of local government funds for science and technology	36	1079516	1336677	15911	4263655
Total expenditures of local government funds for education	36	2618144	3172218	88554	9956956
R&D investment of industrial enterprises above designated size	36	2364188	1641542	310289	5906504
Number of R&D personnel in industrial enterprises above designated size	36	111702.41	168922.8	20794	812459
Number of people engaged in research activities in the university	36	18672.39	18615.67	1345	69761
Number of patent applications	36	73735.97	51495.32	5536	173586
Number of patents granted	36	54175.72	76203.02	2984	461109
Number of technology market contract transactions	36	16122.33	9792.05	3708	35928
Value of technology market contracts	36	3193590	3522234	61023	14223539
Number of national-level science and technology awards	36	18.03	23.94	0	58
Total number of scientific and technical papers published	36	39139.71	27554.14	11246	97943
High-tech industry output value	36	10222.22	10079.98	1936.12	51239

innovative development of node cities followed an upward trend. Because of the continuous reduction of innovation spillovers in core cities, however, the comprehensive innovation development level of node cities ultimately was lower than the actual value. For core cities, because of the inhibiting effect of the two node cities, the level of comprehensive innovation development dropped significantly. This finding suggested that when node cities were parasitic towards core cities, the comprehensive innovation development level would be lower than the actual value.

6. Conclusion

From the perspective of symbiosis, this paper combined the development of urban innovation and ecological theory to establish a Lotka-Volterra model that considered core cities and node cities in the metropolitan circle as the research object. On the basis of the construction of an index system for the comprehensive innovation development level of cities, we conducted an empirical study with Shanghai, Suzhou, and Jiaxing as case objects and simulated different symbiotic relationships among core cities and node cities to reveal their evolutionary patterns. The results of this research are as follows:

(1) When the core city and the node city were in a reciprocal symbiotic relationship, the comprehensive innovation development of both was higher than the actual level. In this case, the core cities were in a dominant position and promoted each other with the node cities to form an efficient innovation mechanism. Therefore, in a metropolitan area, the government of the core city should give full play to its leading role in innovation, actively establish cooperation mechanisms with neighboring node cities, develop cooperation channels, and realize the sharing and effective circulation of science and innovation resources by promoting the construction of innovation platforms, such as research centers, laboratories, and information resource centers.

(2) Under the mutual inhibition symbiotic relationship, the innovation development of both core cities and node cities was lower than the actual level. The vicious competition between core cities and node cities inhibited each other, resulting in a wastage of resources and low efficiency of urban innovation development. Therefore, in a metropolitan area, core cities and node cities should break down the barriers of cooperation, avoid vicious competition, and adopt measures such as reciprocal incentives and financial investment to facilitate the transformation of the relationship between them into a reciprocal symbiosis.

(3) Under the independent symbiotic relationship, the comprehensive innovation development level of node cities declined because of the loss of innovation radiation from core cities, whereas core cities still maintained an upward trend because of their natural resources and policy advantages. This difference resulted in the development of innovation in core cities being higher than the actual level and that of node cities being lower than the actual level, forming the "Matthew effect." In a metropolitan area, on the one hand, the governments of the node cities should provide more support to the local innovation industry and prevent the massive outflow of innovation resources [33], such as talents, universities, and

capital, by setting favorable policies and creating a comfortable living environment. On the other hand, they should also proactively develop innovation cooperation with the core cities and expand the radiation effect of the core cities by improving transportation and cobuilding scientific research institutions.

(4) Under the parasitic symbiotic relationship, both core and node cities were below the actual level of innovation development. Because of the massive outflow of innovative resources, the restraining effect between cities, and the reduction of innovation spillovers, the innovative development of both was obviously hindered. Therefore, in a metropolitan area, the node city government should strive to build an innovation system with local characteristics and advantages and enhance internal innovation vitality to reduce excessive innovation dependence on core cities.

Data Availability

Data are from the China Science and Technology Statistical Yearbook, China Statistical Yearbook, China High and New Technology Industry Statistical Yearbook, Shanghai Statistical Yearbook, Suzhou Statistical Yearbook, Jiaxing Statistical Yearbook, China City Database, WIEGO Statistical Database, websites of Science and Technology Bureau and Statistics Bureau, and government work reports from 2008 to 2019.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This research work was financially supported by the National Natural Science Foundation of China (No. 71771161), the National Social Science Foundation of China (No. 19FGLB029), the Postgraduate Research Innovation, the Practice Activity of Jiangsu Province (No. KYCX21-3409), and Jiangsu Soft Science Research Program (No. BR2018049).

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Hindawi
Discrete Dynamics in Nature and Society
Volume 2022, Article ID 2100837, 6 pages
https://doi.org/10.1155/2022/2100837

Research Article

Decision Analysis for the Remanufacturing System in the Presence of Carbon Cap and Trade Policy and Low-Carbon Consumers

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Received 2 December 2021; Revised 25 December 2021; Accepted 25 February 2022; Published 26 March 2022

Academic Editor: Jiafu Su

This paper considers a remanufacturing system in which an original equipment manufacturer (OEM) and an independent remanufacturer (IR) compete with each other. The paper conducts a model analysis for the optimal decisions in the remanufacturing system, taking into account the impacts of consumers' low-carbon awareness and carbon cap and trade (CCT) policy. With the studies, it is found that the effects of CCT and consumers' low-carbon awareness can be trading off sometimes on the remanufacturing system, and in this case, excessive cultivation of consumers' low-carbon awareness will weaken the beneficial effects of CCT on the remanufacturing system due to the resulted excessive consumers' willingness to pay for the remanufactured products.

1. Introduction

With the increasing environmental problems, much attention has been paid to carbon emission reduction. A typical policy that is used to control carbon emission is the carbon cap and trade (CCT) policy. With the CCT policy, the manufacturer is allocated a number of carbon allowances and he can buy or sell some certain carbon allowances via the carbon trading market according to the actual carbon emission amount needed for his production [1]. Obviously, the CCT policy can have an essential effect on the manufacturer's competitive position and the manufacturer who has a low carbon emission will gain a competitive advantage over those who have a high carbon emission.

It is widely recognized that the remanufactured product has a good low-carbon nature, which leads to an essential environmental and economic benefit. As reported by the United Nations Environment Programme, compared with a new product, the remanufactured product can generally save the use of new materials and reduce carbon emissions by 79%–99%. Due to the low-carbon advantage associated with remanufacturing, the remanufacturing industry is encouraged to a large extent in many countries. Typically, China initiated a plan for promoting the circular economy in the next five years in July 2021 with the aim to cultivate a group of leading remanufacturing enterprises. With this plan, more enterprises will enter into the remanufacturing market and become independent remanufacturers (IRs). Inevitably, this trend will lead to increasing competition between the original equipment manufacturer (OEM) and the IR [2, 3]. In addition, it is obvious that the level of low-carbon awareness of consumers has an essential effect on the remanufacturing industry [4]. With intuition, it can be known that an increase of the level of low-carbon awareness can promote more consumers to buy remanufactured products and enhance consumers' willingness to pay for the remanufactured products [5–7]. Besides, it should be noted that the CCT policy also has a positive effect on the remanufacturing industry and can attract more enterprises to participate in the remanufacturing business. It seems that

the CCT and the level of low-carbon awareness of consumers always have a consistently positive effect on the remanufacturing system. Is this true? That is, may their effects be trading off on a remanufacturing system? This should be an interesting and important issue for the operations management of the remanufacturing system.

Motivated by the above analysis, the paper is devoted to exploring a remanufacturing system in which an original equipment manufacturer (OEM) and an independent remanufacturer (IR) compete with each other. For resolving the above issue, the paper places the research emphasis on the operations management of the remanufacturing system with simultaneous consideration of the CCT policy and the level of the low-carbon awareness of consumers. As compared to the existing literature, a fundamental contribution of this paper lies in that it develops an analytical examination of how the CCT and the level of low-carbon awareness of consumers affect the remanufacturing decisions and how the CCT and the level of low-carbon awareness of consumers affect mutually on each other.

2. Literature Review

This paper mainly is related to two literature streams; the first is how the CCT policy affects the remanufacturing system, and the second concerns the impacts of low-carbon awareness on the remanufactured system.

For the first related research stream, the core issues have been placed on the examination of the optimal operations decisions for the remanufacturing system in the presence of the CCT policy. For example, Chang et al. [8]; Chang et al. [9]; and Chai et al. [10] studied a monopolist manufacturer who produces new products in the first period and produces both new and remanufactured products simultaneously in the second stage under the CCT policy. They analyzed the impacts of carbon emission-related parameters on the manufacturer's optimal operations decisions with the assumption that the new and remanufactured products are distinguishable. Gan et al. [11] and Yang et al. [12] explored the impacts of the CCT policy on remanufacturing with a supply chain comprising manufacturers and retailers (distributors). They explored the optimal decisions of how to improve manufacturers' profit targets and carbon emission targets. The above literature assumes that the remanufacturing is only carried out by the OEM, and the research focus is placed on the exploration of the cannibalization effect of remanufactured products on the new products. As a different research line, Chai et al. [13] examined the effects of CCT policy on remanufacturing with a remanufacturing system in which an OEM and an IR compete with each other. Their studies demonstrate that the OEM will suffer a loss from the free-riding behavior of the IR with the CCT policy. Hu et al. [1] explored the tradeoff between the carbon tax and the CCT mechanism in the remanufacturing system from the perspective of the government with numerical studies. All the above studies do not consider whether there exists a conflicting effect between the consumers' low-carbon awareness and the CCT policy, which is just the fundamental difference for this paper.

For the second related research stream, the research focus has been placed on the exploration of how the level of low-carbon awareness affects remanufacturing. For example, Wu and Zhou [14] and Mitra [15] exhibited that the target consumer group for remanufactured products are usually the green consumers who only choose the remanufactured products and the functional consumers who are willing to buy remanufactured products at a low price. Agrawal et al. [16] revealed that remanufactured products produced by third-party remanufacturers can improve consumers' perceived value on the new products. Zhu et al. [17] found that remanufacturers' adoption of warranty strategy can increase consumers' perceived value on the remanufactured products. In addition, there are some empirical pieces of evidence that show that some consumers are totally unwilling to buy remanufactured products [18]. Michaud et al. [19] pointed out that remanufactured products can be considered as green products because of the environmental benefits. And, unless consumers are informed of their impacts on the environment, they tend to pay less attention to remanufactured products than the traditional products. The questionnaire survey by Wang et al. [21] showed that consumers do not exhibit enough appreciation for the green concept of remanufactured products in Asia. All these studies advocated with an empirical approach that we should promote remanufacturing by strengthening the cultivation of consumers' low-carbon awareness and changing the perceptions of consumers [20]. Actually, there exists some literature exploring the effects of the cultivation of consumers' low-carbon awareness on remanufacturing. For example, recent research by Zhou et al. [22] incorporated low-carbon awareness cultivation into the remanufacturing system. Their studies demonstrated that excessive low-carbon awareness cultivation may make manufacturers withdraw from remanufacturing.

As compared with the above studies, the fundamental differences of this paper lie in two aspects as follows: i) This paper considers the remanufacturing system in the presence of competition between the OEM and the IR. (ii) This paper explores the remanufacturing system with simultaneous consideration of the effects resulted from the CCT policy and the consumers' low-carbon awareness. Furthermore, the paper also reveals how the CCT mechanism and the consumers' low-carbon awareness affect mutually each other.

3. Model Description

Consider a remanufacturing system comprising an OEM and an IR. The OEM produces the new products and the IR competes with the OEM and produces the remanufactured products by the recycled old products [23–25]. At the beginning of the period, the OEM and the IR receive the carbon allowance assigned by the carbon regulator and then they decide to buy or sell the carbon allowance based on their production quantity and their unit carbon emission [9]. In general, the carbon allowance allocation is based on two rules including the grandfathering and the bench-marking.

The common feature of both rules is that they allocate the carbon allowance according to the production quantity of the manufacturer. Let the unit carbon emission for the new and remanufactured products be e_n and e_r and the unit carbon allowance for the new and remanufactured products be g_n and g_r, respectively. Hence, the carbon allowance that needs to buy in the carbon trading market for each unit's new and remanufactured products are, respectively, $t_n = e_n - g_n$ and $\omega t_n = e_r - g_r$. As discussed in the Introduction section, given the low-carbon nature of the remanufactured products, it is reasonable to require that $\omega < 1$; that is, the carbon quota that needs to buy for each unit remanufactured product is lower than that of the unit new product. In addition, since the remanufactured products are produced with recycled old products, the production quantity for the remanufactured products should be bounded from above by the production quantity of the new products. That is, it should be required that $q_r^{ij} \le \tau q_n^{ij}$, where τ is the recycle ratio of the used-old products. For clarity, we summarize all notations of the model in Table 1.

We divide the consumers into two types, namely, the functionality-oriented consumers (FOCs) and the newness-conscious consumers (NCCs). The FOCs choose both the new and remanufactured products and let their ratio be ϕ. The NCCs choose only the new products and let their ratio be $1 - \phi$ [26, 27]. Without loss of generality, we normalize the maximum WTP of consumers to 1 and require that the unit cost of the new product is $c_n < 1$. The FOCs with WTP being θ prefer the new product to the remanufactured product. The FOCs who treat the new and remanufactured products as the same can be expressed as $\theta - p_n^{ij} = \delta\theta - p_r^{ij}$, and so the marginal customers for the FOCs can be expressed as $\theta_{nr} = (p_n^{ij} - p_r^{ij})/(1 - \delta)$. The FOCs who have the same utility between buying the remanufactured product and buying nothing can be expressed as $\delta\theta - p_r^{ij} = 0$, and so the marginal customers for the FOCs can be expressed as $\theta_{rz} = p_r^{ij}/\delta$. Therefore, the FOCs' demand for remanufactured products is $\phi((p_n^{ij} - p_r^{ij})/(1 - \delta) - p_r^{ij}/\delta)$, and their demand for the new products is $\phi(1 - (p_n^{ij} - p_r^{ij})/(1 - \delta))$. For the NCCs, their WTP for the new products is θ and is zero for the remanufactured products. Thus, their net utility with purchasing the new products is $\theta - p_n^{ij}$ and is $-p_r^{ij}$ with buying the remanufactured products. Therefore, the NCCs' demand for the remanufactured products is 0 and is (1-ϕ) (1-p_n^{ij}) for the new products. According to the results by Zhou et al. (2021), it can be obtained that $p_n^{ij} = 1 - q_n^{ij} - \delta q_r^{ij}$ and $p_r^{ij} = \delta(1 - q_n^{ij} - q_r^{ij}) - \delta(1 - \delta)q_r^{ij}/\phi$.

4. Model Analysis

4.1. Scenario 1: Analysis of the Model without CCT. In this section, we conduct the analysis for the model that does not consider the effect of CCT. For this case, the optimization problem for the OEM can be formulated as follows:

$$\max \pi_n^{i1}\left(q_n^{i1}\right) = \left(p_n^{i1} - c_n\right)q_n^{i1}. \tag{1}$$

And, the optimization problem for the IR can be formulated as follows:

$$\begin{aligned} &\max \pi_r^{i1}\left(q_r^{i1}\right) = \left(p_r^{i1} - c_r\right)q_r^{i1}, \\ &s.t., q_r^{i1} \le \tau q_n^{i1}. \end{aligned} \tag{2}$$

The following proposition characterizes the optimal production quantities of the new and remanufactured products for the OEM and the IR in response to different cost advantages of the remanufactured product.

Proposition 1. *The optimal production quantities of the new and remanufactured products for the OEM and the IR in scenario 1 can be characterized as follows:*

(i) When $r > \delta(1 + c_n)/2c_n$, *the IR will adopt the no-remanufacturing strategy and the optimal production quantities of the new and remanufactured products for the IR and the OEM are* $q_r^{11} = 0$ *and* $q_n^{11} = (1 + c_n)/2$, *respectively.*

(ii) When $\delta(1 + c_n)/(2c_n) - ((-1 + c_n)\delta\tau(-4(1 + \phi) + \delta(4 + \phi))/(2c_n(2 + \delta\tau)\phi)) < r < \delta(1 + c_n)/(2c_n)$, *the IR will adopt the partial remanufacturing strategy, i.e.,* $0 < q_r^{21} < \tau q_n^{21}$, *and the optimal production quantities of the new and remanufactured products for the IR and the OEM are, respectively, as follows:*

$$\begin{aligned} q_r^{21} &= -\frac{(\delta + c_n(-2r + \delta))\phi}{\delta(-4(1 + \phi) + \delta(4 + \phi))}, \\ q_n^{21} &= \frac{-2(1 + \phi) + \delta(2 + \phi) + c_n(2 - 2\delta + 2\phi - r\phi)}{-4(1 + \phi) + \delta(4 + \phi)}. \end{aligned} \tag{3}$$

(iii) When $r < \delta(1 + c_n)/(2c_n) - ((-1 + c_n)\delta\tau(-4(1 + \phi) + \delta(4 + \phi))/(2c_n(2 + \delta\tau)\phi))$, *the IR will adopt the full-remanufacturing strategy, i.e.,* $q_r^{31} = \tau q_n^{31}$, *and the optimal production quantities of the new and remanufactured products for the IR and the OEM are, respectively, given by* $q_r^{31} = \tau(1 - c_n)/(2 + \delta\tau)$ *and* $q_n^{31} = (1 - c_n)/(2 + \delta\tau)$.

4.2. Scenario 2: Analysis of the Model with CCT. In this section, we will conduct the analysis for the model with CCT. For this case, the optimization problem for the OEM can be formulated as

$$\max \pi_n^{i2}\left(q_n^{i2}\right) = \left(p_n^{i2} - c_n - \mathrm{c}t_n\right)q_n^{i2}. \tag{4}$$

And, the optimization problem for the IR can be formulated as follows:

$$\begin{aligned} &\max \pi_r^{i2}\left(q_r^{i2}\right) = \left(p_r^{i2} - c_r - \mathrm{c}\omega t_n\right)q_r^{i2}, \\ &s.t., q_r^{i2} \le \tau q_n^{i2}. \end{aligned} \tag{5}$$

The following proposition characterizes the optimal production decisions for the OEM and the IR in the model with CCT.

Proposition 2. *The optimal production quantities of the new and remanufactured products for the OEM and the IR in scenario 2 can be characterized as follows:*

Table 1: Model notations.

Notations	Definitions
p_n^{ij}/p_r^{ij}	Price of the new/remanufactured product.
q_n^{ij}/q_r^{ij}	Demand for the new/remanufactured product, where $i = 1/2/3$ stands for no/partial/full remanufacturing and $j = 1, 2$ stands for the model without and with CCT, respectively.
$\phi/1-\phi$	Ratio of the functionality-oriented consumers (FOCs)/the newness-conscious consumers (NCCs).
θ'/0	The NCCs' willingness to pay (WTP) for each unit's new/remanufactured product.
$\theta/\ \delta\ \theta$	The FOCs' WTP for each unit new/remanufactured product, where $\delta \in (0, 1)$ indicates the discount factor of the FOCs' WTP for each unit remanufactured product.
π_n^{ij}/π_r^{ij}	Profit of the OEM/IR.
c_n/rc_n	Production cost per unit of the new/remanufactured product, where $r \in (0, 1)$ indicates the cost saving for the remanufactured product.
c	The unit price of the carbon trading.
g_n/g_r	Allocated carbon allowance per unit of new/remanufactured product.
e_n/e_r	Carbon emissions per unit of new/remanufactured product.
$t_n/\omega t_n$	The carbon trading volume of the OEM/IR, where $\omega < 1$ indicates the saving of the carbon emission for the remanufactured product.
τ	Collection ratio, where $\tau \in (0, 1)$.

(i) When $r > (\delta(1 + c_n) + c\,t_n(\delta - 2\omega))/(2c_n)$, the IR will adopt the no-remanufacturing strategy and the optimal production quantities of the new and remanufactured products for the IR and the OEM are given, respectively, by $q_r^{12} = 0$ and $q_n^{12} = (1 - c_n)/2$.

(ii) When $(\delta(1+c_n)+c\,t_n(\delta-2\omega))/(2c_n) - (-1+c_n)\delta\tau$ $(-\ 4\ (1+\phi)+\delta(4+\phi))/(2c_n(2+\delta\tau)\phi) < r < (\delta(1+c_n)+c\,t_n(\delta-2\omega))/(2c_n)$, the IR will adopt the partial remanufacturing strategy, i.e., $0 < q_r^{22} < \tau q_n^{22}$, and the optimal production quantities of the new and remanufactured products for the IR and the OEM are as follows:

$$q_r^{22} = -\frac{(\delta + c_n(-2r+\delta))\phi + ct_n(\delta - 2\omega)}{\delta(-4(1+\phi) + \delta(4+\phi))},$$
$$q_n^{22} = \frac{-2(1+\phi) + \delta(2+\phi) + c_n(2 - 2\delta + 2\phi - r\phi) + ct_n(2 - 2\delta + 2\phi - \phi\omega)}{-4(1+\phi) + \delta(4+\phi)}. \quad (6)$$

(iii) When $r < (\delta(1 + c_n) + c\,t_n(\delta - 2\omega))/(2c_n) - (-1+c_n)\delta\tau(-4(1+\phi)+\delta(4+\phi))/(2c_n(2+\delta\tau)\phi)$, the IR will adopt the full remanufacturing strategy, i.e., $q_r^{32} = \tau q_n^{32}$, and the optimal production quantities of the new and remanufactured products for the IR and the OEM are given, respectively, by $q_r^{32} = \tau(1 - c_n - ct_n)/(2 + \delta\tau)$ and $q_n^{32} = (1 - c_n - ct_n)/(2 + \delta\tau)$.

5. Effects of the CCT and the Low-Carbon Consumers

In this section, we conduct an analysis on the effects of the CCT based on the optimal decisions of the production quantity in response to different cost advantages of the remanufactured products. The main results are summarized in the following proposition.

5.1. Effects of CCT on the Profit of the IR

Proposition 3. *(i) When $\delta < 2rc_n/(1 + c_n)$ and $\omega < \omega_2$ or when $\delta > 2rc_n/(1 + c_n)$, $\omega_1 < \omega < \delta/2$ and $\omega < \omega_3$, the IR's profit without CCT is lower than that with CCT. (ii) When $\delta > 2rc_n/(1 + c_n)$, $\delta/2 < \omega < \omega_2$, and $\omega_3 < \omega < \omega_1$, the IR's profit without CCT is higher than that with CCT, where $\omega_1 = (\delta(1 + ct_n) + c_n(\delta - 2r))/(2ct_n) - (-1 + c_n + ct_n)t(-4(1 + \phi) + \delta(4 + \phi))/(2ct_n(-2 + \tau))$ and $\omega_2 = (\delta(1 + ct_n) + c_n(\delta - 2r))/(2ct_n)$.*

Figure 1(a) and 1(b) exhibit the results graphically in Proposition 3. The curve indicates the range in which the CCT policy will increase the IR's profit, and the thick line indicates the range in which the CCT policy will reduce the IR's profit. If $\delta < 2rc_n/(1 + c_n)$, as long as the IR enters the remanufacturing market, the CCT policy will help the IR increase profit. Actually, $\delta > 2rc_n/(1 + c_n)$ implies that the remanufacturing cost-saving factor satisfies $r < \delta(1 + c_n)/(2c_n)$, and for this case, the CCT can always increase the profit of the IR, regardless of the remanufacturing carbon cost.

If $\delta < 2rc_n/(1 + c_n)$, the CCT can increase the IR's profits for the small values of ω. Actually, $\delta < 2rc_n/(1 + c_n)$ implies that the remanufacturing cost-saving factor satisfies $r > \delta(1 + c_n)/(2c_n)$. And, when r is relatively large, the unit production cost of the remanufactured product is lower than that of the unit new product. As this is the case,

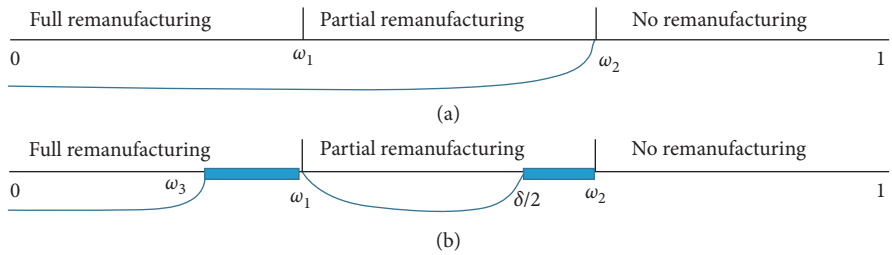

Figure 1: (a) Effects of CCT on the profit of the IR with $\delta < 2rc_n/(1+c_n)$. (b) Effects of CCT on the profit of the IR with $\delta > 2rc_n/(1+c_n)$.

the carbon cost will increase the cost of the remanufactured products with the implementation of CCT. Only when the carbon cost of the remanufactured product is lower than that of the new product, CCT can increase the IR's profit. When the carbon cost of the new products is lower than that of the remanufactured products, CCT will reduce the profit of the IR. Therefore, when δ is relatively low, an excessive increase of the discount factor of the remanufacturing products can do harm to the positive effects of CCT on the IR and the remanufacturing market. That is, the effects of CCT and consumers' low-carbon awareness can be trading off sometimes on the remanufacturing system, and in this case, an excessive cultivation of consumers' low-carbon awareness will weaken the beneficial effects of CCT on the remanufacturing system due to the resulted excessive consumers' WTP for the remanufactured products.

5.2. Sensitivity Analysis of the CCT

Proposition 4

(i) *For the case of partial remanufacturing, it is derived that* $\partial\pi_r/\partial\omega > 0$, *and if* $\omega < \min\{\delta/2, \omega_2\}$, *then* $\partial\pi_r/\partial c > 0$, $\partial\pi_r/\partial t_n > 0$; *if* $\delta > 2rc_n/(1+c_n)$ *and* $\delta/2 < \omega < \omega_2$, *then* $\partial\pi_r/\partial c > 0$ *and* $\partial\pi_r/\partial t_n < 0$

(ii) *For the case of full remanufacturing, it is derived that* $\partial\pi_r/\partial\omega < 0$, *and if* $\omega < \omega_3$, *then* $\partial\pi_r/\partial c > 0$ *and* $\partial\pi_r/\partial t_n > 0$; *if* $\omega > \omega_3$, *then* $\partial\pi_r/\partial c < 0$ *and* $\partial\pi_r/\partial t_n < 0$, *where* $\omega_3 = (-2c_n r\phi + \delta^2\tau(2 - 2c_n - ct_n + \phi) + \delta((2c_n + ct_n)\phi + (-2 + ct_n)\tau(1+\phi) + c_n\tau(2 - (-2 + r)\phi)))/((-1 + c_n + ct_n)(2 + \delta\tau)\phi)$.

The results in Proposition 4 can be exhibited by Figures 1(a) and 1(b). To be specific, when $\delta < 2rc_n/(1+c_n)$, as long as the IR enters the remanufacturing market, an increase in c and t_n will lead to an increase in profit. Actually, when δ is relatively small, it implies that r is relatively large. Therefore, the cost of the remanufactured products is relatively high and the remanufactured product has a relatively small cost advantage relative to the new product. It can be explained in a similar way for the case of $\delta > 2rc_n/(1+c_n)$. Similar to Proposition 3, if the FOCs' WTP for the remanufactured products is too high, it will do harm to the synergistic effects between the low-carbon awareness cultivation and the CCT policy.

5.3. Sensitivity Analysis of the Ratio of Consumers

Proposition 5. *For the case of partial remanufacturing, it is derived that* $\partial\pi_r/\partial\phi > 0$, *and for the case of full remanufacturing, it is derived that* $\partial\pi_r/\partial\phi > 0$.

The results in Proposition 5 show that an increase in the proportion of the FOCs will lead to an increase in the profit with the partial and full remanufacturing scenarios. Given the important role of consumers' low-carbon awareness cultivation in increasing the functional consumers, it can be seen that the cultivation of consumers' low-carbon awareness is beneficial to the profit of the IR. Even so, it should be noted that an excessive cultivation of consumers' low-carbon awareness can sometimes weaken the beneficial effects of CCT on the remanufacturing system. As a result, it is necessary to balance the effects of the CCT and the cultivation of consumers' low-carbon awareness on the remanufacturing system.

6. Conclusion

This paper examines a remanufacturing system with competition between the OEM and the IR. We have developed a model analysis for the effects of the CCT policy and the consumers' low-carbon awareness on the remanufacturing system and have examined the optimal decisions for the remanufacturing system in the presence of carbon cap and trade policy and low-carbon consumers. A particularly interesting result derived from the studies is that the CCT and the consumers' low-carbon awareness can have a trading-off effect sometimes on the remanufacturing system. Therefore, it is necessary to conduct an appropriate cultivation on the low-carbon awareness of consumers in the remanufacturing system in the presence of CCT policy. In the conclusion, it should be pointed out that there exist some limitations for this study and these limitations can inspire some topics for future research. For example, it is assumed in the model that the OEM does not engage in remanufacturing. Actually, it is common in reality that the OEM participates in the competition of remanufacturing market. Hence, it is worthwhile to extend the model to consider that the OEM produces both the new and remanufactured products at the same time. In addition, it should be noted that after-sales services associated with the remanufactured products are usually different from those associated with the new products. Hence, it is also significant to extend the model to consider the effects of after-sales services on the remanufacturing system.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Authors' Contributions

Xiaoge Meng, Shushu Xie, and Yingxue Zhao contributed to model development and analysis. Xiaoge Meng, Shushu Xie, and Menghao Xi contributed to basic writing of the paper. Shushu Xie is responsible for conducting the research.

Acknowledgments

This work was supported in part by the National Natural Science Foundation of China (71901066, 71871063, and 72174019) and the Fundamental Research Funds for the Central Universities in UIBE (CXTD11-06).

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Hindawi
Discrete Dynamics in Nature and Society
Volume 2022, Article ID 9067136, 10 pages
https://doi.org/10.1155/2022/9067136

Research Article

Organizational Climate, Innovation Orientation, and Innovative Work Behavior: The Mediating Role of Psychological Safety and Intrinsic Motivation

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Received 16 December 2021; Accepted 16 February 2022; Published 21 March 2022

Academic Editor: Yi Su

Nowadays, many high-tech SMEs have gradually focused on innovation-orientation and have adopted various measures to create an organizational climate, stimulate knowledge workers' enthusiasm for innovation, and promote individual innovation behavior, but met with little success. Based on the stimulus organism response (SOR) model, the objective of this study is to explore the mediating factors that affect knowledge workers' innovative work behavior, and construct a three-level model of the external environment, psychological factors, and individual behavior. This study selected 575 valid samples from 24 high-tech SMEs in Zhongguancun, which is a technology hub in Haidian District, Beijing, China. Through the convenience sampling method, This study analyze the data and perform structural equation modeling (SEM) using AMOS 23.0. The external environment (i.e., organizational climate, innovation orientation) and psychological factors (i.e., intrinsic motivation, psychological safety) have a significant positive impact on innovative work behavior. Psychological factors have the most significant impact on innovative work behavior. Besides, psychological factors also mediate the relationship between the external environment and innovative work behavior. The findings indicated that high-tech SMEs need to formulate scientific innovation-orientation when implementing strategies, and continue to shape a harmonious and equal organizational climate. Furthermore, high-tech SMEs should encourage knowledge workers to speak the truth, express different voices, and stimulate work enthusiasm to improve psychological safety and intrinsic motivation, thereby enhancing knowledge workers' innovative work behavior.

1. Introduction

Extensive research has focused on the concept of innovation [1], and the study on innovation is one of the most significant emerging trends in management sciences. Innovation is considered as the key to the competitive advantage of organizations [2], which has been shown to make success in today's competitive work environment. Since innovation in firms starts with new ideas generated, adopted, or modified by knowledge workers, it is imperative to understand the antecedents of individual innovative behavior.

Especially for high-tech SMEs, the living environment of enterprises has undergone significant changes. Ministry of Science and Technology will, in particular, boost the development of innovative sci-tech SMEs featuring key technologies, research personnel, high-value intellectual property rights, and high research input, according to the notice that studies on innovation issues have received much attention in recent decades [1, 3]. However, business management is not a simple matter to promote knowledge workers to carry out sustainable and long-term innovative work behaviors [3]. Knowledge workers as the core members of enterprise, most of the knowledge workers are engaged in creative work [4]. They rely on their own professional knowledge, use their minds to think creatively, and constantly form new knowledge achievements. And compared with ordinary work behavior, innovative work behavior always depend on the knowledge works, which is expressing

new ideas to achieve innovation. Most research focuses on building an organizational climate such as infrastructure construction, improving knowledge workers' working environment, increasing work remuneration, and improving living and welfare levels, or leadership relationship. However, it ignores the knowledge worker's psychological factors and the company's innovation-orientation. In the antecedents of innovative behavior, the antecedents at different levels are not explored in depth. Therefore, to stimulate knowledge workers' innovation activities, this study is based on the stimulus-organism-response (SOR) model and constructs a three-level impact mechanism model of the external environment, psychological factors, and individual behavior. The objectives of this study are as follows. First, it is to construct an innovative work behavior model from organization, knowledge worker's psychology, and behavior. Second, it is to explore the factors that influence innovative work behavior. Third, it is to inform the organizations on the existing climate and strategy to make suggestions. This study found the influence of psychological factors (i.e., psychological safety and intrinsic motivation based on the SOR theory) further stimulated innovative work behavior and played an important mediating role between the external environment (i.e., organizational climate and innovation orientation). This study chooses high-tech SMEs as samples, which can effectively help small and medium-sized enterprises to adjust their strategy and organizational climate to achieve product, service, and management innovation.

The following sections are structured as follows: Section 2 reviews the literature related to the theory of SOR, the hypotheses and conceptual models. Section 3 introduces data collection and data analysis methods. Section 4 describes the results of the data analysis and tests the hypotheses. Section 5 discusses the theoretical and managerial implications. Section 6 summarizes the central ideas, limitations with directions for future studies.

2. Literature Review

2.1. The Theory of Stimulus Organism Response (SOR). Calvo et al. [5] reposed a one-way linear research idea of individual behavior. They believed that particular behavior was directly stimulated by external environmental factors, which resulted in a "stimulus-response" (S–O) behavior research model. The S–O model oversimplifies individual behavior, ignores consciousness and psychological state, and believes there is no mediating effect between external stimuli and behavioral responses. In later research, scholars [6] proposed the SOR model, which believed that the combination of individual differences and external stimuli formed a mediating variable between the stimulus and response, and this mediating variable directly impacted individual behavior (see Figure 1). Nolan and Garavan [6] further improved the "S–O-R" model by studying the environment and individual behavior. They believed that the physical situation could affect the individual's inner psychological state and prompt the individual to produce corresponding behavioral responses.

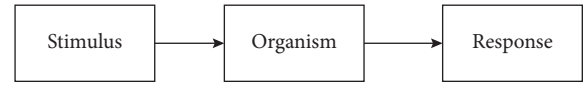

Figure 1: Stimulus organism response model.

The SOR model is often used to predict consumer behavior, and rarely used to predict innovative behavior, but innovation is also one of the critical results of organizational response [7]. Stimulus is an influencing factor of the internal and external situations of the organism, which can affect the mental state of the cognitive identification state of the organism. After a series of psychological or identification activities, the organism will adopt an internal and external behavioral response to the stimulus [8]. The internal response is reflected in the individual's attitude, and the external response is reflected in the individual's behavior [9].

The innovative behavior of knowledge workers is mainly affected by two factors, namely, organizational orientation and work climate. Strategic orientation determines the behavior direction of knowledge workers, and work situation climate also has a significant influence on knowledge workers' behavior choices [10]. Innovation orientation is an innovation-orientation developed by an organization to respond to permanent market challenges [11]. It is a strategic environmental factor that can provide knowledge workers with innovation orientation task guidance an/d has a positive impact on their innovation behavior. Organizational climate is the atmosphere of the work environment that knowledge workers can perceive. It is an environmental factor at the work team level [12]. It contains team groups' expectations and support for knowledge workers' behavior and has an important impact on knowledge workers' innovative behavior.

In terms of organism factors, knowledge workers' psychological safety and intrinsic motivation are important factors that affect individual innovative work behavior. Psychological security means to feel safe from the psychological level. Newman et al. [13] proposed an understanding of the individual's psychological safety and believed that psychological security is a feature based on the individual's psychological perception and inner state. Intrinsic motivation is a mental state in which the individual is attracted and motivated by the work itself and desires to devote themselves to work [14].

It can also be seen from the "S–O-R" model research paradigm that external environmental stimuli can affect the internal psychological state of knowledge workers and have an impact on their innovative behavior. In this study, psychological safety and intrinsic motivation mediate the relationship among innovation orientation, organizational climate, and knowledge worker's innovative work behavior. In short, the "S–O-R" research paradigm believes that the study of an individual behavior should pay attention to the stimulating effect of the external environment and the mediating development of the individual's internal consciousness. Stimuli from external environmental factors can affect the inner psychological state, which in turn encourages individuals to produce different behavioral response results.

Therefore, based on the "S–O-R" research paradigm, this study builds a model of the influence of innovation orientation and organizational climate on knowledge worker innovation behavior.

2.2. Hypothesis Development

2.2.1. Organizational Climate, Innovation-Orientation, and Innovative Work Behavior. Innovation orientation is an innovation-driven strategy launched by an organization to respond to permanent market challenges, and it is a formal control force that affects knowledge workers' innovative behavior [15, 16]. It can reduce the knowledge workers' perception of the dangers of innovation and promote the development of knowledge workers' innovative behavior activities. Wei et al. [17] found through empirical research a clear positive correlation between the innovation-oriented attitude towards change and the introduction of innovation.

Regarding the earliest research on organizational climate, Litwin (1968) believes that organizational climate is something that every member of the organization can perceive and experienced organizational environment, which can be measured by members. In such a friendly climate, colleagues will trust each other, which will make the cooperation between members stronger, so that they can share their knowledge and generate new ideas [18]. According to the fairness theory, the degree of fairness that employees feel in the organization will affect the behavior of employees, so the degree of fairness that employees feel is an important antecedent to the study of employee behavior results. Johannessen and Olsen [19] found that when employees feel supported by the organization, they actively participate in the creation because it is an climate that the organization strongly promotes. Even if employees are frustrated or fail in the innovation process, the organization does not punish them, thereby stimulating employees to innovate. Thus, the following hypothesis is proposed:

Hypothesis 1. Organizational climate can be positively associated with knowledge workers' innovative work behavior.

Hypothesis 2. Innovation orientation can be positively associated with knowledge worker's innovative work behavior.

2.2.2. Organizational Climate, Innovation-Orientation, and Psychological Safety. From the perspective of psychology, external environmental stimuli can affect the individual's mental state, and individuals will integrate their characteristics with environmental characteristics to form an internal psychological response to a given environment [20]. The high level of psychological safety of knowledge workers is mainly manifested in the following aspects: first, knowledge workers can speak freely and fully express their personal views; second, managers allow that knowledge workers engage in some meaningful or potentially valuable event without achieving the expected goals, and knowledge workers will not be punished or negatively pressured; third, knowledge workers maintain a high degree of trust and share common visions and dreams [21].

The organization's implementation of an innovation-orientation allows knowledge workers to recognize that their innovative behavior is consistent with the organization's strategic goals. Edmondson and Lei [22] believe that knowledge workers' behavior will be impacted by their cognition of interpersonal relationships in the work environment, the awareness of the innvoative climate, and the perception of organizational fairness procedures. On this basis, Kahn [23] believes that people in a trust relationship can effectively improve psychological safety. This kind of support and the trust-friendly relationship has a flexible mechanism that enables knowledge workers to dare to try new affairs. Thus, the following hypothesis is proposed:

Hypothesis 3. Organizational climate can be positively associated with knowledge workers' psychological safety.

Hypothesis 4. Innovation orientation can be positively associated with knowledge worker's psychological safety.

2.2.3. Organizational Climate, Innovation-Orientation, and Intrinsic Motivation. Research by Shahin et al. [24] confirmed that a friendly organizational climate could increase knowledge workers' satisfaction, organizational commitment, and professional engagement and reduce knowledge workers' pressure and turnover tendency. Therefore, higher job satisfaction and lower turnover can increase knowledge workers' intrinsic motivation.

Innovation orientation means that knowledge workers can perceive that their innovative and new ideas are encouraged and supported. Innovation orientation continuously impacts knowledge workers' intrinsic motivation, attitudes, and behaviors. According to Farr and West [25]'s research, innovation orientation has a significant positive impact on knowledge workers' psychological state. A higher degree of innovation orientation is more conducive to the enhancement of knowledge workers' inner motivation. In addition, Hon [26] believes that innovation orientation can affect the inner motivation of individuals and affect the creativity of knowledge workers. Some scholars believe that factors such as fairness and knowledge workers' sense of responsibility for work have an essential impact on improving knowledge workers' intrinsic motivation [27, 28]. Therefore, this study proposes the following hypothesis:

Hypothesis 5. Organizational climate can be positively associated with knowledge workers' intrinsic motivation.

Hypothesis 6. Innovation orientation can be positively associated with knowledge worker's intrinsic motivation.

2.2.4. Psychological Safety, Intrinsic Motivation, and Innovative Work Behavior. Brink et al. [29] believe that when facing psychological threats and feeling psychologically insecure, people are more likely to show defensive tendencies and not to show innovative behaviors. Suppose

knowledge workers have a higher level of psychological safety, they will reduce the judgment of uncertain factors in the work environment. They tend to think that others will understand their innovative behaviors and their even risk-taking behaviors. Ford [30] proposed that safety signals are one of the essential situation variables related to innovation. The higher the knowledge worker's level of psychological safety, the higher the level of innovative behavior.

In the theory of creativity and innovation composition, Hennessey and Amabile [31] proposed that intrinsic motivation is crucial for individuals to generate creativity and innovation. Such positive emotions can enhance knowledge workers' psychological participation and energy for their continuous effort [32]. For example, they are more likely to expand the scope of searching for cognitive information actively, and it is easier to absorb and assimilate broader ideas. Self-determination theory believes that the self-confidence and sense of interest generated by intrinsic motivation can encourage knowledge workers to focus more on improving work effectiveness when facing challenging, complex, and unfamiliar work content. Therefore, this study proposes the following hypothesis:

Hypothesis 7. Psychological safety is positively related to innovative work behavior.

Hypothesis 8. Intrinsic motivation is positively related to innovative work behavior.

2.2.5. The Mediating Role of Psychological Safety and Intrinsic Motivation. The "S–O-R" model in psychological research believe that the external environmental stimuli that knowledge workers receive can affect their inner psychological state and affect their behavior. Knowledge workers innovation behavior also regard the individual psychological states as a vital influence mediator [33]. In this study, researchers believe that psychological safety and intrinsic motivation mediate innovation orientation, organizational climate, and knowledge worker innovation behavior.

For the research on psychological safety, there is little research on innovation. But according to the current study, we can find that an excellent organizational climate can meet the psychological needs of knowledge workers, such as interpersonal relationships, emotional friendship, and organizational affiliation. Providing innovation support to knowledge workers at work can effectively promote consistency and fit between them and the organization group. This climate can enhance knowledge workers' sense of belonging, thereby enhancing knowledge workers' psychological safety of innovative behaviors, conducive to knowledge workers discovering innovation opportunities and participating in innovation activities. Due to the uncertainty of innovative behaviors, knowledge workers will consider the risks brought by their behaviors before carrying out innovative behaviors, thereby reducing innovative behaviors. The implementation of the innovation-orientation can meet an agreement between the goals of the enterprise and the knowledge workers so that protect the knowledge workers' original intention, promote the knowledge workers' innovative behavior, and stimulate their enthusiasm for innovation.

In many scholars' research, intrinsic motivation is often used as a mediating variable between the external environment and the innovative behavior of knowledge workers. This intrinsic motivation will be affected by the organization's innovation orientation and working atmosphere, affecting the knowledge workers' innovative behavior [34]. The implementation of an innovation-oriented strategy can provide knowledge workers with more strategic resource support for the implementation of innovation activities, giving them greater work autonomy and self-decision-making space, which will increase knowledge workers' inner work motivation and increase the degree of intrinsic motivation [35]. Under this kind of intrinsically enhanced motivation, knowledge workers will break through the limitations of traditional technical rules, reflect more individual flexibility and creativity, and encourage knowledge workers to show more innovative behavior. Therefore, this study proposes the following hypothesis:

Hypothesis 9. Psychological safety mediates the relationship between organizational climate and innovative work behavior.

Hypothesis 10. Psychological safety mediates the relationship between innovation orientation and innovative work behavior.

Hypothesis 11. Intrinsic motivation mediates the relationship between organizational climate and innovative work behavior.

Hypothesis 12. Intrinsic motivation mediates the relationship between innovation orientation and innovative work behavior.

2.3. Conceptual Model. Based on the above-mentioned derivation and discussion of the hypothetical relationship, this study is based on the SOR model to analyze the relationship between organizational climate and innovation orientation on innovative work behavior. At the same time, to test whether there is a significant mediating effect, this study tried to introduce two variables, psychological safety and intrinsic motivation, as the mediating variables of organizational climate, innovation orientation, and innovative work behavior. Therefore, this study constructs the following (see Figure 2) conceptual model. Meanwhile, according to existing researches, there are some control variables affecting on the innovative work behavior such as age, gender, education level, income, and job tenure.

3. Methodology

3.1. Data Collection and Samples. Participants for this study are knowledge workers working for high-tech SMEs in Zhongguancun, a technology hub in Haidian District,

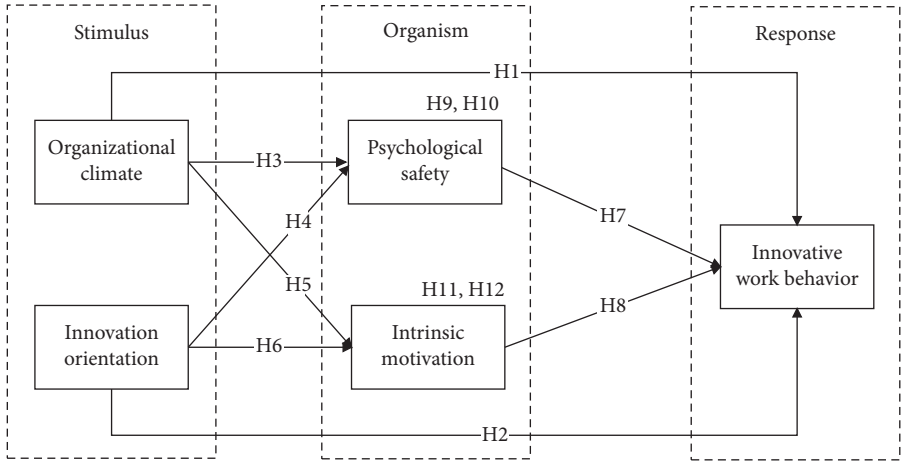

Figure 2: Conceptual model.

Beijing, China. Convenience sampling was used in the sample collection of this study because it is considered that this method can help researchers collect a large amount of data in a short period. The researchers contacted supervisors from 30 high-techSMEs and asked them to allow their knowledge workers to participate in the study. As a result, 24 companies participated in data collection from February to March 2021. Respondents were informed that participating in the survey was voluntary and anonymous, and they could get 10 CNY (1.5 USD) as a reward after the survey was completed. A total of 600 questionnaires were distributed to 24 high-techSMEs. Among them, 575 valid questionnaires were filled out, with a response rate of 95.8%. The demographic and job characteristics of the participants were reported in Table 1.

Table 1: Descriptive statistics of the samples.

Demographic factor	Descriptive statistics
Age	Mean = 31.06 (s d. = 5.861)
Gender	Male: 299 (52%)
	Female: 276 (48%)
Education level	Below bachelor's degree: 39 (6.8%)
	Bachelor's degree: 305 (53%)
	Master's degree: 205 (35.7%)
	Doctoral degree: 26 (4.6%)
Income (monthly)	≤4,000 CNY: 38 (8.8%)
	4,001–6,000 CNY: 225 (39.1%)
	6,001–8,000 CNY: 216 (37.6%)
	8,001–10,000 CNY: 63 (11%)
	≥10,000 CNY: 33 (5.7%)
Job tenure	Mean = 4.13 (s d. = 1.756)

3.2. Measure. This study used existing scales, which were reliable and verified by different researchers. All items were scored on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The organizational climate was measured using the 10-item scale designed by Zaacute et al. [36]. The measurement of innovation orientation is a three-item scale verified by Hurley and Hult [37]. They pointed out the need to pay more attention to the innovation and openness of the enterprise's overall strategy and management field. Most researchers used the three-item scale developed by Detert and Burris [38] to measure psychological safety. The scale was adapted from Edmondson and Lei [22] 's research on the perception of team psychological safety and had good reliability. The measurement of intrinsic motivation was developed by Grant and Adam [39]. The scale has 4 items and has good reliability. The measure of innovative work behavior adopted the 8-item scale designed by Janssen [40]. Control variables include age, gender, education level, income, and job tenure.

4. Results

4.1. Measurement Model. This study tests the hypothetical model. It constructs reliability of the concepts that are measured using a multiple-item scale were evaluated by using Cronbach alphas coefficient, composite reliability (CR), and average variance extracted (AVE). The AVE value of each construct in this study was, respectively, 0.562, 0.658, 0.638, and 0.568, which were all above 0.5, and all Cronbach alphas coefficients exceed the widely suggested value of 0.7. Thus, the convergent validity of this questionnaire conforms to the standard and has discriminant validity. At the same time, this paper analyzes the discriminant validity based on AVE value. It can be see that the AVE square root values 0.750, 0.811, 0.750, 0.799, 0.754 (represented in bold in Table 2) were greater than the maximum value of absolute correlation coefficient between factors, respectively, indicating that it has good discriminant validity. As shown in the above results, the reliability and validity of the scale used for this study conform to the relevant standards and requirements.

This conducted a correlation analysis to investigate the relationship between the measured variables. The means, standard deviations, reliability, and correlations among the key variables are shown in Table 2.

4.2. Structural Path Model. The modeling results of the structural equation model show that the model can be identified and converged, and there is no negative error variance in the nonstandardized estimation model, so the model identification

Table 2: Means, standard deviations, reliabilities, and correlations.

Variable	Mean	Sd	OC	IO	PS	Im	IWB
OC	3.883	0.635	**(0.750)**				
IO	3.908	0.828	0.392**	**(0.811)**			
PS	3.838	0.796	0.447**	0.446**	**(0.750)**		
IM	3.738	0.807	0.451**	0.501**	0.445**	**(0.799)**	
IWB	3.945	0.765	0.506**	0.492**	0.527**	0.594**	**(0.754)**

Notes: (1) diagonal elements are the square roots of AVE; (2) **: $p < 0.01$.

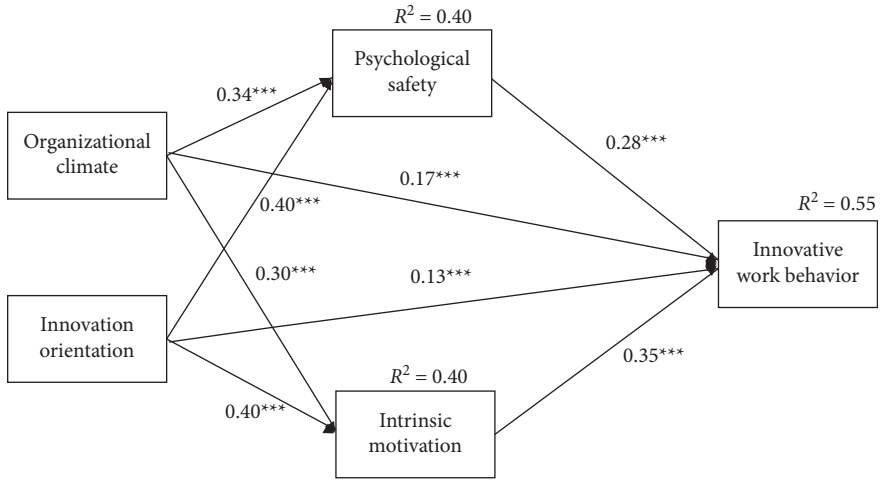

Figure 3: Structural Model. Notes: ** $p < 0.01$ and *** $p < 0.001$; standardized coefficients are reported.

Table 3: Standardized direct, indirect, and total effects.

	Point estimate	Product of coefficients		Percentile 95% CI		Bootstrapping Bias-corrected 95% CI		Two-tailed significance
		SE	*Z*	Lower	Upper	Lower	Upper	
				Direct effects				
OC ⟶ IWB	0.171	0.048	3.563	0.078	0.268	0.076	0.267	0.000 (***)
IO ⟶ IWB	0.131	0.054	2.426	0.027	0.234	0.028	0.235	0.013 (*)
				Indirect effects				
OC ⟶ IWB	0.199	0.034	5.853	0.137	0.270	0.137	0.271	0.000 (***)
IO ⟶ IWB	0.268	0.037	7.243	0.201	0.344	0.204	0.348	0.000 (***)
				Total effects				
OC ⟶ IWB	0.370	0.045	8.222	0.283	0.456	0.282	0.455	0.000 (***)
IO ⟶ IWB	0.400	0.043	9.302	0.312	0.480	0.313	0.480	0.000 (***)

Notes: standardized estimation of 5,000 bootstrap samples; * $p < 0.05$ and *** $p < 0.001$. Abbreviations: OC, organizational climate; IO, innovation orientation; IWB, innovative work behavior.

rules are not violated. Besides, the fit between the model and the data is also good ($\chi 2 = 534.749$, df = 341, $\chi 2/df = 1.568$, CFI = 0.979, GFI = 0.939, AGFI = 0.927, RMSEA = 0.031). The structural equation modeling is shown in Figure 3.

Hypothesis 1 predicted that organizational climate positively associates with innovative work behavior. The result significantly confirms their positive link ($\beta = 0.171$; $p < 0.001$). Thus, hypothesis 1 is supported. Hypothesis 2 predicted that innovation orientation positively associates with innovative work behavior. The result also significantly confirms their positive link ($\beta = 0.131$; $pp < 0.01$). Thus, hypothesis 2 is supported.

Hypotheses 3 and 4 predicted that the organizational climate and innovation orientation positively associate with psychological safety, respectively. Results that the organizational climate positively associates with psychological safety ($\beta = 0.340$; $p < 0.001$). And innovation orientation positively associates with psychological safety ($\beta = 0.402$; $p < 0.001$). Hypotheses 5 and 6 predicted that the organizational climate and innovation orientation negatively associate with intrinsic motivation, respectively. Results that the organizational climate positively associates with intrinsic motivation ($\beta = 0.297$; $p < 0.001$). And innovation orientation positively associates with

intrinsic motivation ($\beta = 0.446$; $p < 0.001$). Therefore, hypotheses 3,4,5, and 6 are supported.

Hypotheses 7 and 8 predicted that psychological safety and intrinsic motivation positively associate with innovative work behavior. The relationship between psychological safety and innovative work behavior is positive and statistically significant ($\beta = 0.281$; $p < 0.001$). The relationship between intrinsic motivation and innovative work behavior is positive and statistically significant ($\beta = 0.348$; $p < 0.001$). Therefore, hypotheses 7 and 8 are supported.

The bootstrapping approach has been adopted in this study to test the mediating effect. According to Preacher and Hayes (2004) suggested, 5,000 bootstrap samples were generated with bias-corrected and percentile bootstrapping at a 95% confidence interval (see Table 3). There is no zero value within the 95% confidence interval, and the Z values were all greater than 1.96, so the effect can be considered significant. Hypothesis 9 to 12 predicted that psychological safety and intrinsic motivation play mediating role between organizational climate and innovative work behavior, respectively. As shown in Table 3, psychological safety positively and significantly mediates the relationship between organizational climate and innovative work behavior, and the relationship between intrinsic motivation and innovative work behavior (standardized indirect effect = 0.199, $p < 0.001$). Therefore, hypotheses 9 and 10 are supported. Intrinsic motivation positively and significantly mediates the relationship between organizational climate and innovative work behavior, and the relationship between intrinsic motivation and innovative work behavior (standardized indirect effect = 0.268, $p < 0.001$). Therefore, hypotheses 11 and 12 are supported.

5. Conclusion

5.1. Theoretical Implication. This study has made the following contributions to research on innovative behavior. First, the authors developed a new model to discuss the influences of external, psychological factors on innovative work behavior based on the "S–O-R" model. The results indicated that organizational climate and innovation orientation as the external stimulus factors have a significant and positive impact on psychological safety, intrinsic motivation, and innovative work behavior. The results are consistent with previous studies [41–43]. Innovation orientation has the strongest influence on psychological safety. Implementing innovation-oriented strategies can inspire knowledge workers' enthusiasm for innovation to take risks and dare to try constantly, significantly reduce knowledge workers' perception of the dangers of innovation, eliminate various internal obstacles to engaging in transformation activities, and effectively promote knowledge workers' innovative behavior. Although the innovation orientation at the strategic organizational level can provide knowledge workers with strategic guidance and activity arrangements, the environment in which they work should have a closer influence on selecting knowledge workers' work behaviors and activities. Supervisor's task arrangement, colleagues' mutual assistance and cooperation, fair performance system, etc., all have a more significant impact on knowledge workers.

Second, The SOR theory points out that the combination of individual differences and external environmental stimuli forms a mediating variable between stimulus and response. Based on this, this study takes psychological safety and intrinsic motivation as the mediating variables that influence innovation orientation and organizational climate on knowledge workers' innovative behavior [43]. There are four hypotheses. The results of sample data analysis support the viewpoints of this study. This study found that the relationship between organizational climate and innovative work behavior is positive and significantly mediated by psychological safety and intrinsic motivation. The relationship between innovation orientation and innovative work behavior is positive and significantly mediated by psychological safety and intrinsic motivation. It can be found that comparing the mediating variables, the mediating role of intrinsic motivation is higher than the role of psychological safety. The intrinsic motivation perceived by knowledge workers is an important mediating variable of innovation orientation and organizational climate for knowledge workers' innovative behavior. This conclusion is consistent with previous research.

5.2. Practical Implication. This study has made the following contributions to managerial implications on innovative behavior. Firstly, psychological factors (i.e., intrinsic motivation, psychological safety) have the most significant impact on knowledge workers' innovative work behaviors and mediate the relationship between the external environment (i.e., organizational atmosphere, innovation orientation) and innovative work behavior. Because of the particularity of innovative work behavior, it is a process that requires knowledge workers to fully mobilize their intrinsic motivation to create new value. Therefore, if the goal is only to complete the task mechanically, then it is impossible to achieve true innovation. Regarding how to improve knowledge workers' intrinsic motivation, the company should build the following two aspects to make knowledge workers like their work because interest is always the best teacher. On the one hand, company should create a harmonious and equal atmosphere, respect the needs of knowledge workers, understand the difficulties and problems encountered by knowledge workers at work, and attach importance to cooperation and sharing between knowledge workers. In Eastern culture, companies mainly use top-down management method, lacking down-top expression. Using the down-top expression approach can effectively improve the company's atmosphere. On the other hand, companies should establish an innovation orientation of corporate strategy, emphasizing corporate culture, goals, and vision so that knowledge workers feel that their innovative behavior is consistent with its objectives.

Secondly, based on the feedback from the returned questionnaires, the researchers found that under the influence of East Asian culture (e.g., high power distance),

knowledge workers dare not express their true thoughts to their leaders when their ideas are inconsistent. This is because most knowledge workers are worried that they might get the negation of their leaders when expressing different views, and the different views might even have a bad influence on their work. To improve knowledge workers' psychological safety in East Asian countries, leaders should first let knowledge workers know that it is safe to express true thought in the company and that they will not be punished if they raise the company's problems and even get rewards if the ideas are adopted. The two methods can effectively improve knowledge workers' psychological safety in the work of innovative behavior.

Thirdly, organizational climate and innovation orientation also have a significant impact on the innovation behavior of knowledge workers. This shows that implementing innovation orientation and building an excellent corporate climate in high-techSMEscan effectively promote knowledge workers' innovative behaviour. Therefore, for the management practice of high-tech SMEs, it is necessary to persist in formulating scientific innovation-oriented strategies and create an excellent organizational climate. On the one hand, in terms of strategy formulation, it is essential to "slogan" and "reimplement." When implementing an innovation orientation strategy, it is necessary to formulate a specific business development strategy and decompose it layer by layer through target management methods so that knowledge workers at all levels in the organization can receive innovation-oriented strategic support, to fully mobilize the enthusiasm of knowledge workers for innovation. Only then can they more positively influence their innovation activities. On the other hand, companies need to be persistent, and long-term focused on creating an organizational climate. Creating an excellent organizational climate is a long-term investment. It should not only look at the immediate situation but requires persistent implementation.

Fourthly, In the daily management of an enterprise, the following methods can be used to create an appropriate organizational climate and innovation orientation. On the one hand, create a innovation-oriented corporate culture or strategy. Because when employees feel relaxed and happy in the organizational innovative activity, they are more willing to communicate and trust with their colleagues and share their experience, skills and other knowledge, therefore it can affect on innovative behavior. The other hand, establish a good and fair climate. Because when employees feel that there is a fair climate in the organization, their efforts will be rewarded fairly, which will stimulate the inner potential of employees, enhance communication between employees, and enable employees to produce innovative behaviors.

5.3. Limitation and Future Research. Based on the proposed objectives, this study investigated knowledge workers' innovative work behavior based on SOR theory. This study extracts that psychological safety and intrinsic motivation are the mediating factors that affect knowledge workers' innovative behavior. It analyzes the mechanism of innovation orientation and organizational climate on knowledge workers' innovative behavior. It constructs a corresponding relationship hypothesis model. The survey of technology-based SMEs for quantitative analysis uncovered the "black box" of the internal psychological factors of innovation-orientation, organizational climate as external environmental variables affecting innovative behavior. Research results show that intrinsic motivation and psychological safety have the greatest impact on innovative work behavior, followed by organizational climate and innovation orientation. Besides, intrinsic motivation and psychological safety mediate the relationship between organizational climate and innovative work behavior and innovation orientation and innovative work behavior.

This study has certain limitations. Firstly, the innovation behavior of knowledge workers is the result of multiple factors. Due to the limitation of the research theme, personal energy and time, this study only explores the relationship between innovation orientation, organizational climate, psychological safety, internal motivation, and knowledge workers' innovation behavior. It does not involve more antecedent and mediating variables, with certain limitations. In the follow-up research, it may be necessary to introduce more mediating variables and moderating variables, and further explore the mechanism of the influence of innovation orientation and organizational climate on the innovation behavior of knowledge workers. Secondly, when discussing the effect of innovation orientation and organizational climate on knowledge worker innovation behavior, this study did not give too much analysis and explanation to the control variables involved, mainly considering that these variables are not the main research variables of this study. In this study, the control variables do not significantly influence the relationship with knowledge workers' innovative behavior. Future research can analyze the relationship between knowledge workers' experience years, income, etc., and their innovative behaviors. Thirdly, this study did not consider the influence of moderating variables, especially the influence of innovation orientation, the organizational climate on psychological safety, and the formation of different moderating variables among internal dynamics. In future research, it is necessary to extract the possible moderating variables in different relationship paths and then conduct an in-depth analysis and inspection of the detailed interaction relationship between these elements.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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