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Research Article

Industry Development Tendency and Innovation Strategy Preference of Five Typical Industries under the Background of Low-Carbon Sustainable Development in China

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This paper tries to investigate the future development tendency of five typical industries in China and find out whether there exists a different innovation strategy preference between Chinese firms of low- and high-knowledge density industry in the background of low-carbon sustainable development. First, this paper finds that the innovation driven-based trend of industrial development is further accelerated in China. Firms in industries with high knowledge and technology density, such as specialized-supplier, scale-intensive, and science-based industries, are more likely to choose exploratory innovation strategy than exploitative innovation strategy. Firms in industries with low knowledge and technology density like service- and supplier-dominated industries are more likely to choose the exploitative innovation strategy. Second, results indicate that exploratory innovation can bring higher technological innovation performance than exploitative innovation. And the effect of the ambidextrous strategy is better than the single exploitative strategy in industries with high knowledge and technology density like specialized-supplier, scale-intensive, and science-based industries. Third, this paper suggests that innovation strategy preference plays a mediating role between industry type and technology innovation and a moderating effect of knowledge management capacity between innovation strategy and firms' technology innovation.

1. Introduction

In the increasingly complex and rapidly changing environment, technology innovation becomes a critical enabler for firms to create value and sustain competitive advantage [1, 2]. As a developing country, China is vigorously promoting the economic development mode transformation and striving to achieve low-carbon sustainable development. Technological innovation is also one of the core driving forces to promote the transformation of low-carbon sustainable development. Under this circumstance, Chinese firms with greater innovativeness will be more successful in responding to the requirements for low-carbon sustainable development and in developing new capabilities that allow them to achieve better technology innovation performance.

Pavitt divided the industry into four categories: suppliers-oriented industry, scale-intensive industry, specialized suppliers, and science-based industries [3]. Each industry differs from others in the amount of intellectual capital, knowledge storage, and technology utilization efficiency, which are important antecedents to technology innovation [1, 4]. Because of the difference in knowledge, technology, and the ability to use them, firms in different industries may choose different innovation strategies to pursue technology innovation. Atuahene-Gima and Murray used exploratory innovation and exploitative innovation to define the type of enterprise innovation strategy [5]. Their research indicates that different enterprise innovation strategies will influence the configuration of enterprise resources and innovative elements and thus will have a significant impact on the formation of effective technological innovation performance.

Industry type can be seen as a natural character of a firm or external environment that the firm faces [6]. Yet, among the factors that affect the technological innovation of enterprises, researchers rarely mention the industry type. Thus, as potential factors that affect technological innovation, researchers should not neglect the industry types that the enterprises belong to. Accordingly, the present study attempts to address the link of industry type and the firm's technology innovation firstly.

Prior research on exploratory and exploitation is burgeoning. Those notions are widely used in studies on organizational learning, strategic renewal, and technological innovation [5, 7, 8]. However, our understanding of the antecedents and consequences of both exploratory and exploitation activities remain rather unclear [9]. As mentioned above, we can either treat the type of industry as enterprise's own natural character or the external environment of the enterprise, which may be an unexplored antecedent of firms' innovation strategy choice and technology innovation. Enterprises are seen as the microunits of economic activities, and their choice of technological innovation strategy not only affects the effect of technological innovation but also affects the transformation and change of the whole industry. Thus, the second goal of this study is to figure out the relationships between industry type, innovation strategy, and technology innovation, especially to exam the mediating effect of innovation strategy.

From the knowledge perspective, an organization's innovativeness is closely tied to its ability to utilize its knowledge resources [4, 10, 11]. Knowledge management capacity plays a pivotal role in supporting and fostering innovation [12, 13]. Firms that exhibit a higher level of knowledge management capacity can improve their capabilities in developing creative ideas and innovation, facilitating knowledge communication and exchanging required in the innovation process and then further enhance innovation performance through the development of new insights and capabilities [14]. Therefore, if firms that take exploratory innovation strategy have a stronger knowledge management capacity, they are more likely to achieve better technology innovation performance. In other words, a knowledge management capacity firm may play a moderating role in the process that innovation strategies support and foster technology innovation. Strong knowledge management ability is also an inevitable requirement for enterprises in the low-carbon sustainable development. This is the last issue this study tries to probe into.

2. Literature Review and Hypotheses

2.1. Industry Type and Technology Innovation. A low-carbon economy can improve the energy efficiency and reduce pollution emissions by optimizing the layout of industrial structure. It helps to improve the emission standards of existing emission subjects by adopting advanced processes and technologies, so as to reduce carbon emissions [2]. Through energy conservation and emission reduction, low-carbon economy reduces resource loss and improves resource output rate. By promoting low-carbon development, developing economies can improve environmental and energy efficiency standards, reduce costs, leverage low-carbon technological progress, and guide industrial transformation and upgrading. However, due to the misunderstanding of the border between the government and the market, the Chinese government faces many obstacles in upgrading the low-carbon sustainable development now. Therefore, a thorough knowledge of the optimal combination of the adjustment policy between the government and the market is a prerequisite to deepen the economic reform. In the future, the transformation and upgrading of China's industrial structure will focus on two directions. On the one hand, the government needs to insist on an industrial policy with Chinese characteristics. On the other hand, the government must actively push the industrial structure reform to achieve low-carbon sustainable development, rationally balance the development between the traditional industries and emerging industries, and vigorously promote the technological innovation of enterprises.

According to different characteristics of the innovation and the innovation processes (activities), Pavitt divided industries into four categories: suppliers dominated, scale intensive, specialized suppliers, and science-based [3]. These four major categories have their own representative industry, and each of them shows a consistent pattern of innovation activities. Supplier-dominated industry is represented by textile and clothing industry, some hotels, financial services, tourism, and management consultancy industries [15, 16]. Supplier-dominated industry innovates throughout the incorporation of technological elements developed by its suppliers and does not have too many endogenous technological opportunities [17]. The enterprises' R&D investment is low, and the main source of technology innovation is in equipment, raw materials, and other inputs. They tend to make only incremental improvements and adapt new technology from upstream suppliers [18]. Scale-intensive industry mainly includes firms that produce transportation equipment, metal, chemistry, and durable consumer goods [19, 20]. It has more technology opportunities and internal R&D investments than supplier-dominated industry. Enterprises tend to cut costs and combine innovation with improving their product or equipment [18]. Specialized-supplier industry owns more external technology innovation opportunities, and the technology innovation activities are mainly related to product innovation, which are used as inputs into other sectors [18, 21]. Specialized-supplier industry mainly includes machinery tool manufacturing, professional equipment manufacturing, and other industries. In the science-based industry, firms depend heavily on R&D activity and technological learning [18, 22]. Innovation activities mainly occur in the formal research and development laboratories, and technology innovation often comes with new technological paradigm brought about by scientific progress. Science-based industries include the electronic industry, organic chemistry, pharmaceutical engineering, biological engineering, etc., [23]. On the basis of Pavitt's classification, we added service industry and classified our sample into five industry clusters. Service industry refers to the enterprises that directly provide products or sell service products. In this paper, we define the service industry as a traditional service industry which has the lowest level of knowledge density and technology usage, including real estate companies, food and beverage companies, and other service firms which has a low knowledge density and low level of innovation [24].

As can be seen from the industry classification above, there exist natural differences in knowledge density and technology usage in different industry types. These differences are seen in R&D investment, patent activity and productivity, and so on. According to [3, 24], we firstly scored those 5 types of industries mentioned above from 1 to 5 based on their own knowledge and technology densities (the service industry: 1, the supplier-dominated industry: 2, the specialized-supplier industry: 3, the scale-intensive industry: 4, the science-based industry: 5). So, we treat industry type as a continuous variable when we explore the relation between industry type and firms' technology innovation.

According to the theory of technological innovation, firms in different industry types have different knowledge-based abilities and resources. In the present knowledge-based economy, intellectual capital (IC) has been seen as the key element for corporate success owing to its value-creating potential [25]. It is widely accepted that an organization's capability to innovate is closely tied to its intellectual capital or its ability to utilize its knowledge resources. Distinct aspects of intellectual capital (human, organizational, and social capital) selectively influence different types of innovative capabilities (incremental and radical) [1] and then affect firms' technology innovation. However, in the enterprises in different industry environments, such as knowledge-intensive companies and traditional product-based companies, the knowledge and intellectual capital amount is not the same [26–28]. So industry type may have an influence on firms' technology innovation performance.

From another point of view, the industry type determines the external environment faced by the enterprise. Banerjee et al. called strategies regarding entering new businesses, choice of technology, plant locations, and research investments in environmental corporate strategies [6]. Banerjee et al. suggest that firms in different industries tend to choose different environmental corporate strategies to manage its relationship with the natural environment, and the choice and quality of different strategies will dependently have different impacts on firms' technology innovation performance. So, industry type may influence firms' technology innovation performance through their business and technology strategic decision.

The link between different industry types and enterprise technological innovation can also be reflected by the technical innovation efficiency of enterprises or industries. Technological innovation efficiency refers to the ratio of input and output of technological innovation resources, which is often valued by R&D investment, patent activity, and productivity [29, 30]. Because of the differences in management, quality of labor, equipment and technology level, and the degree of mechanization, enterprises in different industries have different amounts of innovation resources, utilization degree, and efficiency [31]. Thus, different industry types, such as suppliers-dominated industry and science-based industry, have different technology innovation efficiencies.

Following the reasoning above, this study proposes the first hypothesis:

> *Hypothesis 1.* Industry type relates positively to firms' technology innovation.

2.2. Industry Type, Innovation Strategy, and Technology Innovation. The two most important goals this paper tries to achieve are to reveal under which industry type firms are more likely to use exploratory or exploitative innovation and its impact on firm's technology innovation.

Some researchers use exploratory innovation and exploitative innovation to define the type of enterprise innovation strategy [5]. Based on this classification, different innovation strategies and innovation performances have a clear structure relationship; different enterprises' innovation strategy forms will influence the configuration of enterprise resources and innovative elements and thus have a significant impact on the formation of effective technological innovation performance.

Exploitation innovation reflects that the enterprise uses existing resources to strengthen the existing knowledge, skills, and processes to be consistent with the original organizational structure [9, 32] and also that knowledge can bring high efficiency and reliability for existing products. It emphasizes providing deeper and more specific information in existing specific technologies and markets to guarantee the implementation efficiency [33]. Based on the path dependence of the learning process and the learning curve effect, the results of exploitative innovation are positive, instant, and predictable, with spatial and temporal proximity, and it has a positive effect on organizational innovation performance [34].

Exploratory innovation is that the enterprise is committed to a higher risk of investment, with access to new knowledge, skills, and processes [8]. Exploratory innovation is to find a new technology, knowledge, and ability to organize, to create new industry, product, or market. It allows more challenging and revolutionary experiments and innovations. Its essence is to attempt new choices as the enterprise will face different knowledge that exceeds existing experience or far beyond the original domain. So, the return is uncertain, long term, and often negative. These new knowledge, skills, and processes are helpful to improve the flexibility, novelty, and variety of enterprise's product innovation [9, 35]. The goal of enterprise's exploratory innovation is to provide new design, open up new markets, and develop new distribution channels. Many scholars believe that within the operating costs organization can withstand, exploratory innovation can help enterprises to seize new opportunities, open up new markets, and better adapt to the technological and market changes [36]. In addition, through the exploratory innovation, enterprises can integrate technical innovation and market information with the organizational skills and conventional activities, which contributes to product innovation and the generation of new marketing strategy. Therefore, the exploratory innovation will lead to a higher performance of new product development. Both exploratory innovation and exploitative innovation contribute to the low-carbon sustainable development. Technology and knowledge management in enterprises can make enterprises have more resources for external knowledge search and R&D and then promote low-carbon transformation through cost advantage and scarce resources.

As we said above, the difference in management level, the quality of labor, equipment and technology level, and the degree of mechanization determine that firms in different industries have different knowledge and technology densities. Thus, enterprises with low knowledge or technology storage and utilization efficiency are more likely to choose exploitative innovation, because it requires less knowledge or technology shortage and has low risk and predicable short-term payment. On the contrary, in other industries, such as science-based industry, firms with high knowledge storage and utilization efficiency are more likely use exploratory innovation strategy. Exploratory innovation is to find new technology, knowledge, and ability to organize and create new product or market, which needs more challenging and revolutionary experiment and innovation [9]. Obviously, adequate knowledge, technology, and intellectual capital provide a solid ground for enterprise's exploratory innovation. So, there must exist a different innovation strategy preference between different industry types. Firms in industries with high knowledge and technology densities, such as specialized-supplier and science-based industries, are more likely to choose exploratory innovation strategy than exploitative innovation. So, following this line of reasoning, this study proposes the given hypothesis:

Hypothesis 2a. There exists a different innovation strategy preference between low-knowledge density industry types and high-knowledge density industry types.

As we know, there is no good or bad in the use of exploitative or exploratory innovation. Each of them have their unique role in creating technology innovation. Exploitative innovation strategy has low risk and cost, and it helps firms to sustain and expand their competitiveness. Exploratory innovation is more likely to bring long-term and greater benefit. The innovative strategies that contain more adventurous spirit, openness, and willingness to cooperate are more likely to have access to market information and technical resources timely, which help to make up for the lack of internal innovation resources, and improve the innovation performance. In addition, regardless of which kind of innovation strategy form, clear and definite innovation strategy is an important factor that affects the formation of innovative enterprises [9]. To a large extent, the improvement of innovation performance comes from the consistency and adaptability of innovation strategy that an enterprise takes. In most cases, firms with high innovation performance have more clear and consistent strategic orientation than firms with low innovation performance. The consistency of this strategy is conducive to the efficiency and ability of enterprises to obtain new product development and helps enterprises to gain competitive advantage in innovation performance.

In general, no matter which innovation strategy a company chooses, exploitative and exploratory innovations provide a bridge between the industry type this firm belongs to and its technology innovation. In other words, industry type first has an influence on firms' innovation strategy decision and then affects firms' technology innovation.

Following this line of reasoning, this study proposes the following hypotheses:

Hypothesis 2b. Exploitative innovation plays a mediating role between industry type and firms' technology innovation.

Hypothesis 2c. Exploratory innovation plays a mediating role between industry type and firms' technology innovation.

2.3. The Moderating Effects of Knowledge Management Capacity. Knowledge is the most important resource in the enterprise technological innovation activities. The technological innovation is essentially the process of absorbing, transforming, integrating, and creating the knowledge resources inside and outside the enterprise [37]. For enterprises, transforming knowledge into benefits is inseparable from a series of process of the knowledge acquisition, protection, transformation, and application. The benefit knowledge can bring to the enterprise depends on enterprise's knowledge management ability. Knowledge management ability is an important part of enterprise ability system, which is the basis of effective management of enterprise knowledge resources [38]. As a management method and effective tool, knowledge management provides favorable support for the low-carbon transformation of industrial enterprises [39]. In the face of the increasing noncontinuous environmental changes, enterprises implement knowledge management and other measures to enhance the adaptability, survival, and competitiveness of the organization. If enterprises can effectively improve their acquisition and integration of external knowledge, it is conducive to the survival and development of enterprises in the context of knowledge economy and transformation system [40].

Tanriverdi, who proposed knowledge management capability earlier, thinks knowledge management capability is the ability an organization uses to coordinate various knowledge management behavior and integrate all kinds of internal and external knowledge [41]. It will help to enhance organization's competitiveness. Chuang believes that knowledge management capability is the ability to organize, create storage, and apply knowledge resources [42]. For the research of knowledge management ability, Davenport et al. believe that knowledge management includes four processes: knowledge organization and storage, knowledge transfer, knowledge creation, and knowledge application [43]. A firm's technical knowledge management (KM) resource, its social KM resource, and its ability to leverage KM for intangible competition serve as firm-specific resources, which in combination create a firm-wide KM capability. While each of the individual KM resources is complex to gain and difficult to imitate, firms that achieve competitive advantage through KM have also learned to combine effectively their KM resources to create an overall KM capability [42].

Knowledge management ability theory integrates enterprise ability theory and knowledge theory, it suggest that the enterprise's unique knowledge management ability to use the knowledge resources determines the company's overall benefit [13], sustained competitive advantage, and financial performance [44]. Long-term sustainable competitive advantage comes from the integration and application of professional knowledge ability by enterprise members and enterprise's ability to effectively access, organize, transform, apply knowledge, and create new knowledge [45, 46].

The influence of knowledge management capability on technological innovation performance is widely discussed by researchers. Nonaka et al. think organizational innovation activities are mainly originated from the sharing tacit knowledge, creating and confirming new product idea between internal members of the organization [47]. And finally, organization members set up a prototype and spread the knowledge gained in the process to different departments or organizations. Zhang et al. also considered that the main work of new product development management is to transform the implicit knowledge existing in research team into explicit and concrete knowledge [14]. Miller et al. found that the use of cross-boundary knowledge significantly affected the technological innovation [11]. An enterprise's knowledge management capability plays a mediating role between strategic human resource practice and organizational innovation performance, namely, improvement of the technological innovation performance of enterprises brought by strategic human resources must be completed through the enterprise knowledge management ability [48].

Although the scholars directly or indirectly describe and study the relationship between knowledge management capability and innovation performance from different angles, they almost consistently trend to think that enterprise's knowledge management capability has an impact on enterprise's technological innovation performance. In this paper, we further connect KMC with innovation strategy and technology innovation. Following the reasoning above, this study proposes that KMC may play a moderating role between innovation strategies and technology innovation. Firms with stronger KMC are more likely to achieve better technology innovation after they adapt certain innovation strategy. That is to say, better knowledge management capacity enhances the effectiveness of innovation strategies by making the most use of explicit and implicit knowledge and effectively access, organize, transform, and apply the knowledge in the innovation process. Accordingly, we propose the following hypotheses:

> *Hypothesis 3a.* Knowledge management capacity plays a moderating role between exploitative innovation and firms' technology innovation.

> *Hypothesis 3b.* Knowledge management capacity plays a moderating role between exploratory innovation and firms' technology innovation.

3. Methodology

3.1. Data Collection and Sample. Multi-item scales either adopted or developed from prior studies for the measurement of the variables were used to test the above hypotheses. Variables in the questionnaire include background information, industry type, exploitative innovation, exploratory innovation, knowledge management capacity, and technology innovation performance. All independent and dependent variables require seven-point Likert-style responses ranging from "strongly disagree" to "strongly agree."

This study uses a stratified random sampling method to select 500 firms in each of the five industry types in China. These enterprises are mainly distributed in the central and eastern provinces of China. The authors directly distributed 500 questionnaires to top executives (i.e. Presidents, Vice-Presidents, Directors, or General Managers) of each firm who are familiar with the topic of this study in 2020. Of the 366 returned questionnaires, 29 were incomplete. The remaining 337 valid and complete questionnaires were taken for the quantitative analysis. This represents a useable response rate of 67.4%. We categorized the valid questionnaires into early and late responses to evaluate possible nonresponse bias. As explained by Armstrong and Overton [49], those who respond later in a survey do so because of the increased stimulus and are thus expected to be similar to nonrespondents. We, therefore, considered the early respondents as the first 75% of the returned questionnaires and compared the means of all variables. No significant differences were found, suggesting that there are no significant differences between the respondent and nonrespondent groups.

3.2. Measures

3.2.1. Industry Type. We designed five questions on our own, and each item corresponds to an industry type. In every item, we introduced the definition of one type of industry and its representative enterprise. Actually, those 5 types of industries were scored from 1 to 5 according to their own knowledge and technology density. Among the 337 valid samples we collected, 45 samples came from the service industry (1), accounting for 13.4 percent of the total sample size; 75 samples came from the supplier-dominated industry (2), accounting for 22.3 percent of the total sample size; 79 samples came from the specialized-supplier industry (3), accounting for 23.4 percent of the total sample size; 51 samples came from the scale-intensive industry (4), accounting for 15.1 percent of the total sample size; and 87

Table 1: Means, standard deviations, and correlations.

Variables	Mean	S.D.	1	2	3	4	5	6	7
(1) Firm property	2.85	1.37							
(2) Number of employees	3.61	2.19	−0.121*						
(3) Number of R&D researchers	3.26	2.15	−0.099	0.753***					
(4) Industry type	2.88	1.40	0.063	0.148**	0.254***				
(5) Exploitative innovation	5.09	0.74	0.069	0.071	0.188**	0.141***			
(6) Explorative innovation	4.84	0.95	0.061	0.117*	0.207***	0.190***	0.497***		
(7) Knowledge management capacity	5.25	0.80	0.126*	−0.086	0.042	0.081	0.590***	0.587***	
(8) Technology innovation	4.95	0.91	0.022	0.145**	0.331***	0.218***	0.363***	0.634***	0.482***

$N = 337$ (two-tailed test). * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

samples came from the science-based industry (5), accounting for 25.8 percent of the total sample size.

3.2.2. Exploitative Innovation and Exploratory Innovation. Exploitative innovation and exploratory innovation questions were adapted from [9, 50]. The exploitative innovation consists of five questions to measure the extent to which enterprises put resources into the existing areas to strengthen the existing knowledge, skills, and processes ($\alpha = 0.728$). Exploratory innovation consists of five items to indicate the extent to which enterprises are committed to a higher risk of investment, access to new knowledge, skills, and processes ($\alpha = 0.854$).

3.2.3. Knowledge Management Capacity. The knowledge management capacity construct consists of eight items from [48] to indicate the extent of knowledge management capacity of the firm ($\alpha = 0.886$). According to the previous studies, knowledge management capacity construct is knowledge acquisition, sharing, and application. They appropriately represent the knowledge management capacity items.

3.2.4. Technology Innovation. The technology innovation construct was adapted from [51]. It consists of 6 questions to measure the extent to which the firm had achieved in product innovation and process innovation in the last three years ($\alpha = 0.778$).

We should also note that although it is not the focus of our study, some variables were included as controls because they were shown to affect key variables in our study. Previous studies have shown that company property, number of employees, and number of R&D researchers have important impact on the technological innovation performance of enterprises. So, we keep company property, number of employees, and number of R&D researchers as control variables.

4. Analysis and Results

This study uses variance inflation factors (VIFs) to examine the effect of multicollinearity. The values of the VIF associated with the predictors show a range from 1.02 to 2.40, which fall within acceptable limits, suggesting no need for concern with respect to multicollinearity.

This study attempts to understand the relationships among industry type, innovation strategy, knowledge management capacity, and technology innovation. Table 1 displays the means, standard deviations, and correlations of all variables.

To test the construct validity of our model, we carried out a confirmatory factor analysis (CFA) on the data set. As can be seen from Table 2, the χ^2/df values less than 3 indicate a good fit. The TLI, IFI, and CFI values are greater than 0.9 (NFI is very close to 0.9, which is acceptable), and RMSEA value is less than 0.08. All of these indicate a good model fit.

First of all, hierarchical regression analysis is used to test the mediating effects of innovation strategy on industry type and technology innovation. As shown in Table 3, Model 1 is the base model that includes the control variables. Model 2 shows the relationship between industry type and the technology innovation. Their relation is significant at $p < 0.05$ level ($\beta = 0.130$ $p = 0.014$). Accordingly, the results moderately support Hypothesis 1, which states that industry type relates positively to technology innovation. This finding indicates that firms would achieve a higher level of technology innovation if they belong to an industry that has higher knowledge and technology density. Model 3a captures the mediating effects of exploitative innovation between industry type and technology innovation. And Model 3b shows the mediating effect of exploratory innovation between industry type and technology innovation. In Model 3a, the coefficient of exploitative innovation is 0.287 ($p \leq 0.001$). And the coefficient of industry type decreases to 0.105 ($p = 0.037$). Those findings indicate that the exploitative innovation significantly reduces the effects of industry type on the dependent variable. It means that exploitative innovation attenuates the relationships between industry type and technology innovation. Thus, exploitative innovation plays a mediating role between industry type and technology innovation, supporting the mediation effect in Hypothesis 2b. Similar to the above, in Model 3b, the coefficient of exploitative innovation is 0.557 ($p \leq 0.001$). And the coefficient of industry type decreases to 0.051 ($p = 0.232$), which is not significant. So, explorative innovation plays a mediating role between industry type and technology innovation, supporting the mediation effect in Hypothesis 2c. Those findings show us that industry type

Table 2: Construct validity fitting index.

Model	χ^2	χ^2/df	RMSEA	NFI	IFI	TLI	CFI
Default model	244.892	2.633	0.070	0.896	0.933	0.912	0.932
Independence model	2349.029	19.575	0.235				

Table 3: Results of mediating effect analyses of innovation strategy.

Variables	Dependent variable: technology innovation			
	Model 1	Model 2	Model 3a	Model 3b
Control variables				
Firm property	0.045	0.034	0.012	−0.005
Number of employees	−0.236**	−0.224**	−0.182*	−0.185**
Number of R&D researchers	0.513***	0.470***	0.38***	0.338***
Independent variable				
Industry type		0.130*	0.105	0.051
Mediating variable				
Exploitative innovation (a)			0.287***	
Exploratory innovation (b)				0.557***
R^2	0.137	0.152	0.230	0.461
F	17.562***	14.902***	19.748***	56.726***

$N = 337$ (two-tailed test). * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

affects the choice of innovation strategy and then influence a firm's technology innovation.

To test hypotheses 2a, we carried out an independent sample t-test to test whether there is a significant difference between the means of two independent samples. If means of two industry samples are different significantly, it means there really are differences in the choice of innovation strategy for different industry types. As can be seen from Table 4, we find that there does exist significant negative differences between the means of type 1 (service industry) and other three industries (specialized-supplier, scale-intensive, and science-based industries) about exploratory innovation, and so does type 2 (supplier dominated). And type 1 and type 2 both have positive differences to type 3 and type 4. This means low knowledge density industry types (service and supplier dominated) and high knowledge density industry types do have a preference difference in innovation strategy. Firms in service industry and supplier-dominated industry are more likely to choose exploitation innovation, and firms in specialized-supplier, scale-intensive, and science-based industries are more likely to choose exploration innovation. So hypothesis 2a is proved. It is interesting that there are no significant differences between type 5 and other 4 types of exploitation innovation. This may mean that firms in science-based industry are likely to use both exploitation innovation and exploratory innovation strategies, namely, ambidextrous innovation strategy.

Table 5 presents the results of regression analysis regarding the moderating effects of knowledge management capacity on exploitation innovation and technology innovation. We have carried out the central processing of the independent variables and the moderating variable. Model 1 is the base model that includes the control variables. Model 2 shows the relationship between exploitation innovation and the technology innovation. Their relation is significant at the $p \leq 0.001$ level ($\beta = 0.296$, $p \leq 0.001$, $R^2 = 0.210$). Model 4 put the moderating variable in the regression equation. Then, in order to test hypothesis 3b, we put the product term of exploitation innovation and knowledge management capacity into the equation. And it turns out, its interaction influence is significant ($\beta = 0.164$, $p \leq 0.001$). Knowledge management capacity has a moderating effect between exploitation innovation and technology innovation. Those findings indicate that if an enterprise has relatively high (low) knowledge management capacity, the relationship between exploitation innovation and technological

Table 4: Results of the independent sample t-test.

Variables	Exploratory innovation	Exploitation innovation
Industry type	t	t
Type 1 and type 2	0.770	−0.185
Type 1 and type 3	−2.479*	2.753**
Type 1 and type 4	−3.181**	2.640**
Type 1 and type 5	−2.616**	1.179
Type 2 and type 3	−2.503**	2.645**
Type 2 and type 4	−3.103**	2.536*
Type 2 and type 5	−2.718**	1.235
Type 3 and type 4	−1.066	−0.203
Type 3 and type 5	−0.776	−1.478
Type 4 and type 5	0.187	−1.344

* $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

Table 5: Results of moderating effect analyses of knowledge management capacity.

Variables	Dependent variable: technology innovation			
	Model 1	Model 2	Model 3	Model 4
Control variables				
Firm property	0.045	0.021	−0.010	−0.002
Number of employees	−0.236**	−0.109*	−0.117	−0.120
Number of R&D researchers	0.513***	0.421***	0.392***	0.397***
Independent variable				
Exploitation innovation		0.296***	0.045	0.040
Moderating variable				
Knowledge management capacity			0.430***	0.453***
Interaction term				
Exploratory innovation × KMC				0.164***
R^2	0.129	0.210	0.326	0.350
F	17.562***	23.353***	33.460***	31.218***

$N = 337$ (two-tailed test). * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

Table 6: Results of moderating effect analyses of knowledge management capacity.

Variables	Dependent variable: technology innovation			
	Model 1	Model 2	Model 3	Model 4
Control variables				
Firm property	0.045	−0.001	−0.014	−0.008
Number of employees	−0.236**	−0.189**	−0.152*	−0.155*
Number of R&D researchers	0.513***	0.353***	0.337***	339***
Independent variable				
Exploratory innovation		0.583***	0.481*	468***
Moderating variable				
Knowledge management capacity	.		0.174***	183***
Interaction term				
Exploitation innovation × KMC				0.091*
R^2	0.129	0.453	0.470	0.477
F	17.562***	70.459***	60.619***	52.035***

$N = 337$ (two-tailed test). * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

innovation becomes stronger (weaker) and hypothesis 3b is proved.

Table 6 presents the results of regression analysis regarding the moderating effects of knowledge management capacity on exploratory innovation and technology innovation. We have carried out the central processing of the independent variables and the moderating variable. Model 1 is the base model that includes the control variables. Model 2 shows the relationship between exploratory innovation and the technology innovation. Their relation is significant at the $p \leq 0.001$ level ($\beta = 0.583$, $p \leq 0.001$, $R^2 = 0.453$). Model 4 puts the moderating variable in the regression equation. Then, in order to test hypothesis 3b, we put the product term of exploratory innovation and knowledge management capacity into the equation. And it turns out, its interaction influence is significant ($\beta = 0.091$, p = 0.023). Those findings indicate that if an enterprise has relatively high (low) knowledge management capacity, the relationship between industry type and technological innovation becomes stronger (weaker). Knowledge management capacity has a moderating effect between exploratory innovation and technology innovation, and hypothesis 3b is proved. It means that if firms that take exploratory innovation strategy has a stronger knowledge management capacity, they are more likely to achieve better technology innovation performance.

5. Discussion and Conclusions

This study focuses on the technological innovation of Chinese enterprises under the background of low-carbon sustainable development. Our results indicate that industry type relates positively to exploitative innovation performance and exploratory innovation performance, which relate positively to firm's technology innovation performance. And the industry with different knowledge and technology densities differs from each other in the innovation strategy choice. Our findings also show support for the mediating effect of innovation strategy on the relationship between industry type and technology innovation. An industry type that has high knowledge density and technology utilization level works their beneficial effects on firm's technology innovation through exploitation innovation and exploratory innovation strategy.

These findings reveal the innovation strategy preference of enterprises in different industries under the background of low-carbon sustainable development and highlight the different effects of different innovation strategies. First, no matter how we treat the type of industry, as enterprise's own nature character or the external environment of the enterprise, industry type's influence on technology innovation cannot be ignored. Second, no matter which industry type a firm belongs to, the impact of industry types on technological innovation needs to be realized through innovative strategies. Furthermore, this study also demonstrates the moderating effect of knowledge management capacity on the relationship between innovation strategy and technology innovation. After taking certain innovation strategy, firms with higher knowledge management capacity are more likely to achieve better technology innovation performance.

The practical implication of the results is as follows. First, as an important factor, industry type should not be neglected by firms desiring to achieve superior innovation and sustainable competitive advantages. The viewpoints of this study highlight the crucial importance of the mediating role of exploitative innovation and exploratory innovation when examining the relationship between industry type and technology innovation. Industry type influences firms' innovation strategy decision and then influences firms' technology innovation efficiency. It also means that firms of different industry types should choose the suitable transformation path in low-carbon sustainable development. Considering the type of industry manager's firm belongs to and the firm's own situation itself, managers should carefully choose exploitative innovation or exploratory innovation strategy that suits them best according to the demanding of low-carbon sustainable development. Second, managers need to recognize that knowledge management capacity and strengthen the influence of innovation strategy on firms' technology innovation. Then they should take more efforts to strengthen the knowledge management capacity of the enterprise itself. Furthermore, only by maintaining strong knowledge management capacity can firms adapt to the requirements of low-carbon sustainable development in the era of knowledge economy. Finally, it is very important for both enterprise managers and policy makers to reasonably guide enterprises of different industry types to choose technological innovation strategies suitable for industry characteristics and needs. Optimizing innovation strategy, enhancing innovation ability, and knowledge management ability are of great value to industrial upgrading and economic prosperity.

The findings of this study contribute to the theoretical development of a conceptual model for explaining the relationships among industry type, innovation strategy, knowledge management strategy, and technology innovation from the enterprise level. In addition, the conclusion of this study explores the methods and paths to improve the efficiency of low-carbon sustainable development of China from the microlevel of enterprises, Prior research studies on such questions mainly focus on the comparison of the differences in industrial technical innovation between different countries, and research on industry type's influence on enterprise technology innovation within one nation is rare. Different from other studies before, our study first proposes the impact of industry types on the innovation strategy and reminds researchers to notice the different preferences of innovation strategy in different industries. From the innovation strategy view, this study builds up the conceptual model and hypotheses to indicate the mediating role of two innovation strategies between industry type and technology innovation. And from the knowledge management view, we also build up the conceptual model and hypotheses to indicate the moderating role of knowledge management capacity between innovation strategy and technology innovation. The second contribution of this study is the derivation of empirical support for the models' prediction using data from actual cases. This study contributes to the literature by empirically examining the relationships among industry type, exploitative innovation, exploratory innovation, knowledge management capacity, and technology innovation. The results prove that the use of innovation strategy including exploitative innovation and exploratory innovation positively explains the how industry type a firm belongs to influence technology innovation. The findings of this study fill the gap in the literature that is the lack of empirically examining the relationships between those important variables.

This study has some limitations. First, due to data limitations, we could not further compare the impact of industry type on explorative and exploitative innovation. Although our study proved firms in different industries have different preferences in exploitative innovation and exploratory innovation separately, further research should find if firms in low knowledge and technology density industries are more likely to choose exploitative innovation than exploratory innovation, and on the contrary, if firms in high knowledge and technology density industries are more likely to choose explorative innovation than exploitation innovation. Second, there exists a balance of exploitative innovation and exploratory innovation in practical technology innovation process. Further studies should investigate the effect of ambidexterity innovation strategy and the influence of industry type to the optimal balance between exploratory and exploitation innovation. Third, since this study only investigates Chinese firms, potential cultural limitation may exist and future research can do the empirical work in different cultural contexts to generalize or modify the concepts.

Data Availability

This study uses a stratified random sampling method to select 500 firms in each of the five industry types in China. The authors directly distribute 500 questionnaires to top executives (i.e., Presidents, Vice-Presidents, Directors, or General Managers) of each firm who are familiar with the topic of this study in 2020. Of the 366 returned questionnaires, 29 are incomplete. The remaining 337 valid and complete questionnaires are for the quantitative analysis. The questionnaire data used to support the findings of this study are included within the supplementary information files. The data are available from the corresponding author upon request (zll@zzu.edu.cn).

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Supplementary Materials

The supplementary files consist of data which are composed of four main variables and three control variables. First, we designed five questions on our own and each item corresponds to an industry type. In every item, we introduce the definition of one type of industry and its representative enterprise. Actually, those 5 types of industries were scored from 1 to 5 according to their own knowledge and technology densities (seen in Industry type). Then, C1–C7 represent knowledge management capacity, D1–D5 represent exploitative innovation, D6–D10 represent exploratory innovation, and E1–E6 represent technology innovation performance. We keep company property, number of employees, and number of R&D researchers as control variables. (*Supplementary Materials*)

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