Pol. J. Environ. Stud. Vol. 32, No. 2 (2023), 1799-1811
DOI: *10.15244/pjoes/158073* ONLINE PUBLICATION DATE: 2023-02-08

Original Research

Cognitive Diversity of Top Management Team, Environmental Technology and Information Identification – Evidence from Environmental Protection Enterprise in China

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Received: 8 December 2022
Accepted: 21 December 2022

Abstract

Environmental technology is the core power for environmental protection enterprise. Top management team (TMT) has an important impact on developing direction of environmental technology. In this paper, environmental protection enterprises in China are selected as samples to examine that how does cognitive diversity of TMT affect the directions of environmental technology. Environmental technology is divided into acquisition of environmental patent and independent environmental innovation. It finds that cognitive diversity has positive impacts on acquisition of environmental patent and independent environmental innovation. It also shows that environmental protection enterprise develops new environmental technology through acquisition of environmental patent. We further explore the role of ability of information identification on environmental technology. The results demonstrate that there is a promotional effect of cognitive diversity on acquisition of environmental patent and independent environmental innovation by promoting ability of information identification. Finally, the results of heterogeneity analysis show that cognitive diversity in those environmental protection enterprises with high-level technology has a significant effect on independent environmental innovation. However, for those enterprises who has no high-level technology, cognitive diversity of TMT plays a positive role on acquisition of environmental patent through ability of information identification.

Keywords: cognitive diversity, top management team, acquisition of environmental patent, independent environmental innovation, information identification

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Introduction

When environmental protection enterprises want to develop technology, they usually have two choices: technological acquisition or independent innovation. Through technological acquisition, enterprises can quickly capture outer technical forces to achieve technological progress [1]. Independent innovation puts forward higher requirements for enterprises and is full of risks and uncertainties. Meanwhile, environmental protection enterprises also need to invest a huge amount of funds to provide continuous support for innovation activities in the long term [2]. The top management team (TMT) must carefully design and implement the technology strategy to reduce unknown risks, ensure the stable development and safeguard the interests of shareholders.

Whether it is technological acquisition or independent innovation, TMT have to collect tremendous information about the industry and competitors, design reasonable technological strategies, and achieve competitive advantages relying on the identification and analysis of information content [3]. Before implementing technology strategy, TMT would analyze existing information about technology, policy, market, customers and competitors, and make decisions in line with the interests of the enterprise and shareholders. The cognitive diversity of TMT members provides different perspectives and depth for decision-making, which is conducive to the generation of new cognition and creativity [4-6]. Different educational levels and majors of members change the breadth and depth of cognition of TMT, and they can interpret the information from different perspectives [7]. Information integration is influenced by the background and past experience of each member in TMT. Therefore, diversified TMT members have impacts on the ability of information identification, and provide accurate judgment and reference for enterprise operation and decision-making.

This research investigates that how does cognitive diversity of TMT affect technological strategy of protection enterprises enterprise and examine the role of ability of information identification on the relationship between cognitive diversity and technological strategy. Technological strategy is divided into technological acquisition and independent innovation. Samples and data are from an official database from 2006 to 2019. It finds that cognitive diversity of TMT promotes both technological acquisition and independent innovation based on the perspective of full samples. However, results from heterogeneity analysis presents that cognitive diversity can only trigger technological acquisition in those enterprises with low-level technology. This research further examines the effect of ability of information identification as a mechanism that cognitive diversity has positive impacts on technological acquisition and independent innovation through information identification. This study also reveals a dual influence mechanism between cognitive diversity and independent innovation. This research contributes to current literature from two aspects. First, we describe technological strategy of enterprise from acquisition of environmental patent and independent environmental innovation. Many studies employ either independent innovation or technological acquisition to investigate the technological strategy of enterprises [8, 9]. However, in reality, the technological progress of enterprise depends on both internal development and external introduction simultaneously [10]. Second, we use ability of information identification and technological acquisition to construct multilevel mechanisms between cognitive diversity and independent innovation. Generally, most studies only focus on the single-level influence mechanism between driving force and innovation [11-13]. It should be pointed out that there may be a potential bridge between driving force and mechanism variables.

The structure of this article is as follows. Section 2 is literature review. Section 3 describes samples, data, and variable selection. Section 4 presents empirical evidence and further analysis, and Section 5 provides conclusions and implications.

Literature Review

Technological strategy is considered one of the key resources for competitive advantage [14, 15]. Researchers suggest that technological capacity are from external and internal channels [16]. Independent innovation as an internal channel is a very challenging project that enterprise has to focus on a certain technology in a long period and provide continuous funding, personnel, equipment and technology for innovation activities [17]. However, there are many risks and uncertainties in this process, which leads to the failure of innovation activities and cannot offset the previous input. Independent innovation makes enterprise enter into unknown technology field that all technological obstacles and gaps encountered in this process are unknown and difficult [18]. Besides, stock price fluctuations and financial distress for listed companies directly affect innovation activities and may lead the failure of innovation activities [19]. Enterprise should adopt a dual-channel perspective concerning improving capacity of innovation [20]. Furthermore, it is difficult for a company that acquires all the technologies it needs through independent innovation. Technology acquisition is an effective way to improve technology and support future innovation activities that help enterprise overcome technical barriers, clear technology direction and quickly enter the market compared with other competitors [21]. Technological acquisition through commercial operation has some advantages of lower initial investment, fast technology growth, requirement meeting in a short time, and access organizational boundary [22]. Some researches confirm

that acquisitions can bridge the gap between where they are and where they would like to be in relation to innovation [23-25]. Technology from acquisitions can also support independent innovation that there is a high degree of overlap between independent innovation and technological acquisition [8, 26]. The purpose of technological acquisition by many enterprises is to break through the technological bottleneck in the process of independent innovation.

Although enterprises can upgrade their technology and overcome technical barriers through technology acquisition, the TMT still needs to analyze the existing information and determine next technology strategy. Prior studies confirm that cognitive diversity could have a positive impact on organizational performance, especially in strategic planning and technology [27, 28]. Cognitive diversity is defined as the difference in skills, thinking styles, knowledge, and preferences held by the TMT members [20], and reflects on the ability and level of information exchange and knowledge integration [29]. According to the upper-echelons theory, past experiences from TMT members may have impacts on cognition and understanding, which finally reflect on strategic decisions and technological choice by TMT members [4, 30].

The identification of technology information includes many aspects, such as the technology direction of competitors, the suppliers of technology in the market and the cost of acquiring technology [31]. In the process of independent innovation or technology acquisition, enterprise may face unknown patent litigation or legal disputes during innovation activities. Some other firms or unproductive entity may bring a lawsuit against the business for technical infringement [32]. Hence, information gathering and identification are generally seen as a way of increasing the perceptual accuracy of a TMT, and consequently, of the performance of the enterprise [33]. Cognitive diversity of TMT means that the TMT has diverse professional backgrounds and differentiated growth experiences. Different elements of these members provide different perspectives and diversified references for formulating technology strategies, identifying technologies and selecting technology strategies [34]. Different knowledge provides different perspectives for decision-making before implementing technological choice. Different viewpoints among members encourage creative and divergent thinking and enhance the ability of TMT to make connections between what they already know, which facilitates the identification of new markets and technological opportunities [35]. The variability of individual characteristics of TMT member has a significant positive influence on diversity of knowledge that can help enterprises identify technology risks and opportunities, and ultimately make appropriate decisions [36]. If the team members are mainly those who prefer risk, the technology plan and strategy of the enterprise tend to be more unpredictable and risky behaviors, such as large capital merger and acquisition or radical innovation [37]. Fig. 1 shows the relationships among all variables in this article.

Research Design

Samples and Data

In this paper, we search for listed companies in China and eliminate those companies with ST or missing data. Finally, 392 companies are selected as research samples from 2007 to 2019. We collect data from CSMAR database, which is an official database about listed companies in China. In addition, we exclude those firms with more than one third of changes in TMT for avoiding discontinuities caused by frequent changes in TMT.

Variables and Measurement

We choose cognitive diversity of TMT as an independent variable and employ the strength of TMT fault-line by Thatcher, Jehn [38] to measure cognitive diversity of TMT (*CD_TMT*).

$$CD\_TMT = \frac{\sum_{j=1}^{m}\sum_{k=1}^{n} tg_k(\overline{x}_{jk}-\overline{x}_j)^2}{\sum_{j=1}^{m}\sum_{k=1}^{n}\sum_{i=1}^{tg_k} tg_k(\overline{x}_{ijk}-\overline{x}_j)^2} \quad (1)$$

There are four dimensions in TFS, major background, overseas experience, education level, and job responsibilities [39]. A value of 1 is assigned to the member in top management team who received a degree with natural science. People in top management team who ever studied abroad are assigned to a value of 1. The level of education is divided into five types

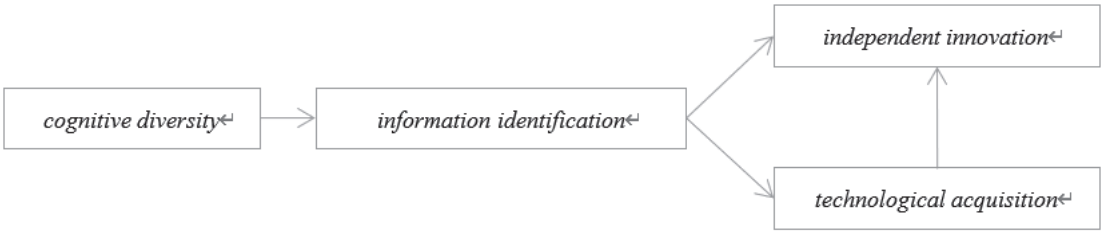

Fig. 1. Conceptual model.

of secondary school and below, junior college, bachelor, master, and doctor, which are assigned to a value of 1 to 5, respectively. And those engaged in technology and R&D are assigned a value of 1. which are measured as the ratio of the sum of squares between sub-team groups divided by the overall sum of squares. Here, it is assumed that the TMT consists of t personnel, the number of metrics contained is m, and there exit n sub-teams. tg_k denotes the number of sub-team k members under the gth classification, $\bar{x}_{jk}$ denotes the average value of executives in sub-team k on feature j, $\bar{x}_j$ denotes the average value of all executive features j, and $\bar{x}_{ijk}$ denotes the value of the i-th executive feature j in sub-team k.

Technological acquisition (*Tech-Acq*) and independent environmental innovation (*Ind-Inno*) are two dependent variables in this research. According to (Li, 2019) and Zhang and Fu [9], we employ the number of environmental patent application to measure independent environmental innovation and expenditure on acquisition of external environmental patents as a proxy of technological acquisition.

Ability of information identification (*Infor*) is measured by the ratio of discretionary accruals to real earnings management. There are also several control variables in this research. Ratio of fixed assets *(FA)* is measure by ratio of fixed assets to total assets. Debt ratio *(Debt)* is measured by ratio of total debt to total assets that high debt ratio means companies have to use their revenues to pay down debt instead of investing more in production and research and development [40]. More cash holdings *(Cash)* mean that enterprises can invest more funds in technology strategy, especially in technology acquisition and innovation [41]. The first shareholder has an important influence on the decision-making of the enterprise. Shareholders pay more attention to how to protect the interests of shareholders in the decision-making of the enterprise. When the enterprise chooses the technology strategy, the largest shareholder is more inclined to choose the decision that can obtain significant benefits in the short term. This research use shareholding ratio of the first shareholder (*shareholder*) to measure the impact of the first shareholder on technology strategy of enterprise [42]. We also consider the relationship between the chairman and general manager *(CD-GM)* that C-GM is assigned to 1 if the chairman is also general manager, ownership nature *(ON)* which is assigned to 1 if firm is state-owned, firm size *(Size)*, return on assets (Roa) and firm age *(Age).* All variables in this paper are reported in Table 1.

Results and Analysis

Descriptive Statistics

Table 2 reports the mean value and standard deviation of the all variables. Column 2 and column 3 show the mean and standard deviations of each variable. Columns 4-16 report the variable correlations. The mean values of *Tech-Acq* and *Ind-Inno* are 0.747 and 0.099 with standard deviations of 0.305 and 0.299, respectively. The *CD-TMT* has the mean of 0.655 and standard deviation of 0.230. For *Infor*, its mean value and standard deviation are -0.005 and 0.276. Table 2 also presents that there is a positive correlation of *CD-TMT* with *Tech-Acq* as well as with *Ind-Inno.* We also find that there is a positive correlation between *Tech-Acq* and *Info* as well as that between *Ind-Inno* and *Info.*

Table 1. Variable definitions.

Variables	Abbre	Definitions
Dependent variable	Tech-Acq	Acquisition of external environmental patents
	Ind-Inno	Environmental patent application
Independent variable	CD_TMT	Cognitive diversity of TMT
Mediating variable	Infor	Ability of information identification
Control variable	FA	Ratio of fixed assets in total assets
	Debt	Asset liability ratio
	Cash	Cash holdings
	Shareholder	Shareholding ratio of the first shareholder
	C-GM	If the chairman is also a general manager
	ON	Ownership nature
	Size	Firm size
	Roa	Return on assets
	Age	Firm age

Table 2. Descriptive statistics.

	Mean	Std.dev	1	2	3	4	5	6	7	8	9	10	11	12	13
1 ***Tech-Acq***	0.747	0.305	1.000												
2 ***Ind-Inno***	0.099	0.299	***0.360***	*1.000*											
3 ***Infor***	*-0.005*	*0.276*	***0.026***	***0.002***	*1.000*										
4 ***CD_TMT***	*0.655*	*0.230*	***0.022***	***0.024***	***0.007***	*1.000*									
5 ***FA***	0.966	*0.108*	*-0.016*	*0.029*	*-0.004*	***0.002***	*1.000*								
6 ***Debt***	*0.344*	*0.205*	***0.065***	*-0.020*	*-0.007*	***-0.094***	***0.156***	*1.000*							
7 ***Cash***	0.030	0.074	*-0.021*	***-0.039***	*-0.012*	*-0.015*	*0.016*	***-0.037***	*1.000*						
8 ***Shareholder***	*0.415*	*0.165*	***0.067***	***-0.032***	***-0.031***	***0.065***	*-0.018*	***-0.150***	***0.049***	*1.000*					
9 ***C-GM***	*0.260*	*0.439*	*0.001*	***0.021***	*0.018*	***0.042***	*-0.012*	***-0.082***	*0.023*	*0.012*	*1.000*				
10 ***ON***	*0.375*	*0.484*	*0.003*	***-0.115***	*0.014*	*-0.007*	*-0.023*	***0.188***	***-0.048***	***-0.081***	***-0.256***	*1.000*			
11 ***Size***	*0.215*	*0.258*	***0.044***	*0.009*	*-0.002*	*-0.017*	***0.895***	***0.278***	***0.053***	*0.001*	***-0.049***	***0.069***	1.000		
12 ***Roa***	*0.041*	*0.061*	***-0.028***	***-0.054***	*0.020*	*0.010*	***0.076***	***-0.289***	***0.229***	***0.126***	***0.037***	***-0.095***	***0.108***	*1.000*	
13 ***Age***	2.119	*0.735*	*-0.10*	*-0.010*	*0.002*	***0.026***	***0.088***	***0.192***	***-0.093***	***-0.345***	***-0.191***	***0.429***	***0.169***	***-0.125***	*1.000*

Notes: This table reports the descriptive statistics and correlations of selected variables and the number in bold indicates statistical significance at 10% level.

Baseline Regression Results

Table 3 reports the results of the baseline regression, where the first column shows the impact of CD-TMT on Tech-Acq when no control variables are added, and the second column shows the impact of CD-TMT on Tech-Acq when all control variables are added. Similarly, columns 3 and 4 report the impact of CD-TMT on independent innovation. At the same time, we control for time and individual effects in the baseline regression.

According to the results in Table 3, CD-TMT has a significant positive influence on acquisition of external environmental patent and independent environmental innovation. It means that environmental protection enterprises have various choices to implement technology strategy. Technology acquisition is a clear purpose and can improve the technical level of enterprises in a short time [43].

Independent environmental innovation is a long-term technology strategy aimed at achieving breakthroughs in key technologies that support business growth. Compared with independent innovation, technological acquisition has lower uncertainty and risk, and can provide more support for long-term independent innovation of enterprises [44]. Moreover, technological

Table 3. Baseline regression results and mechanism analysis of technological acquisition.

	Tech-Acq		Ind-Inno		
CD_TMT	0.220*	0.233*	0.118**	0.114**	0.113**
	(1.755)	(1.922)	(2.288)	(2.211)	(2.176)
Tech-Acq					0.013*
					(1.866)
FA		2.717***	0.533**	0.532**	2.717***
		(3.853)	(2.204)	(2.197)	(3.853)
Debt		-0.173**	-0.083**	-0.084**	-0.173**
		(2.076)	(-2.037)	(-2.065)	(2.076)
Cash		-1.003**	0.029	0.029	-1.003**
		(-2.470)	(0.476)	(0.475)	(-2.470)
Shareholder		-0.444**	0.089	0.090	-0.444**
		(-2.343)	(1.370)	(1.379)	(-2.343)
C-GM		0.001	0.008	0.008	0.001
		(0.017)	(0.493)	(0.500)	(0.017)
ON		-0.311***	0.090**	0.091**	-0.311***
		(-4.306)	(2.137)	(2.159)	(-4.306)
Size		-0.107***	0.023**	0.023**	-0.107***
		(-3.500)	(2.059)	(2.054)	(-3.500)
Roa		-0.875	-0.076	-0.078	-0.875
		(-1.623)	(-0.766)	(-0.786)	(-1.623)
Age		-0.053	0.021	0.020	-0.053
		(-1.101)	(0.952)	(0.905)	(-1.101)
_Cons	-2.415***	-2.485***	0.616***	0.563***	0.564***
	(-6.045)	(-10.989)	(16.594)	(6.438)	(6.455)
Time	Y	Y	Y	Y	Y
Individual	Y	Y	Y	Y	Y
N	5096	5096	5096	5096	5096
R^2	0.125	0.099	0.018	0.024	0.024
F value	355.52***	285.16***	15.54***	13.82***	13.67***

Notes: *t* statistics in parentheses, * p<0.1, ** p<0.05, *** p<0.01

acquisition can give full play to the diversity of TMT in terms of knowledge, educational background and resources, reduce many restrictions in the implementation of technology strategy, reduce the uncertainty of technology development, and save the cost of technology development and search. In order to further explore the impact of technological acquisition on independent innovation of enterprises, this study takes technological acquisition as an influencing mechanism between CD-TMT and independent innovation to test. The fifth column in Table 3 reports the results. The results show that technological acquisition plays a part of the mediating effect between TFS and independent innovation that CD-TMT can not only directly affect the independent innovation of enterprises, but also support independent environmental innovation through technological acquisition. As mentioned above, technological acquisition has a clear direction and purpose. The completion of technological acquisition means that the enterprise has realized the technical reserve for the future independent innovation direction to a certain extent [45]. Technological acquisition can realize the integration of technical resources and drive the re-innovation of enterprises on the basis of acquired technology [46].

Table 3 also explores the impacts of some control variables on technological acquisition and independent

Table 4. Regression results in different periods.

	Tech-Acq		*Ind-Inno*	
	before 2016	after 2012	before 2016	after 2012
CD_TMT	0.173*	0.244*	0.095*	0.112*
	(1.726)	(1.875)	(1.702)	(1.767)
FA	2.791***	2.434***	-0.343	-0.678**
	(3.738)	(3.338)	(-1.334)	(-2.134)
Debt	0.127	0.207	-0.108**	-0.014
	(0.747)	(1.244)	(-2.456)	(-0.276)
Cash	-0.886**	-1.108***	-0.004	0.110
	(-2.086)	(-2.611)	(-0.059)	(1.561)
Shareholder	-0.509**	-0.487**	0.106	-0.005
	(-2.568)	(-2.483)	(1.507)	(-0.063)
C-GM	-0.020	0.001	0.007	0.010
	(-0.292)	(0.011)	(0.407)	(0.516)
ON	-0.270***	-0.336***	0.107**	0.095
	(-3.588)	(-4.460)	(2.397)	(1.600)
Size	-0.102***	-0.096***	0.015	0.030**
	(-3.161)	(-3.011)	(1.253)	(2.019)
Roa	-0.891	-1.220**	-0.139	0.001
	(-1.556)	(-2.155)	(-1.255)	(0.011)
Age	-0.058	-0.065	0.028	0.053*
	(-1.145)	(-1.295)	(1.150)	(1.708)
_cons	-2.536***	-1.721***	0.552***	0.583***
	(-5.767)	(-4.867)	(5.978)	(5.743)
Time	Y	Y	Y	Y
Individual	Y	Y	Y	Y
N	3920	3136	3920	3136
R^2	0.130	0.072	0.022	0.026
F value	334.75***	181.36***	13.51***	13.41***

Notes: *t* statistics in parentheses, * p<0.1, ** p<0.05, *** p<0.01

innovation. The ratio of fixed assets in total assets has a significant positive impact on technological acquisition and independent innovation. A high ratio of fixed assets reflects the hardware level of an enterprise to a certain extent, such as abundant scientific research equipment and analysis equipment. High debt makes it impossible for enterprises to provide more support for technological acquisition or independent innovation, and enterprises have to use more revenues to repay debt, which has a negative impact on technological acquisition and independent innovation.

Robustness Test

There are two methods to examine robustness of baseline results in this paper. First, according to Yang and Li [10], we select two different time windows randomly to examine the relationship between CD-TMT and technological acquisition as well as that between CD-TMT and independent innovation. Table 4 presents the two results and supports that CD-TMT has positive impacts on technological acquisition and independent innovation.

Second, we employ tobit regression and pooled regression to examine the relationship between

Table 5. Changing regression methods.

	Tech-Acq		Ind-Inno	
	Tobit	Pooled	N-Binomial	Pooled
CD_TMT	0.035*	0.035*	0.036*	0.041**
	(1.831)	(1.827)	(1.649)	(2.179)
FA	0.320***	0.320***	-0.646***	-0.636***
	(3.213)	(3.206)	(-4.181)	(-5.458)
Debt	0.025	0.025	-0.018	0.069**
	(0.983)	(0.980)	(-0.551)	(2.336)
Cash	-0.145**	-0.145**	-0.007	-0.093
	(-2.350)	(-2.344)	(-0.126)	(-1.317)
Shareholder	-0.075**	-0.075**	0.085*	0.124***
	(-2.556)	(-2.551)	(1.928)	(3.763)
C-GM	0.002	0.002	0.006	0.010
	(0.203)	(0.203)	(0.444)	(0.845)
ON	-0.046***	-0.046***	0.018	-0.001
	(-4.303)	(-4.293)	(0.976)	(-0.053)
Size	-0.013***	-0.013***	0.029***	0.027***
	(-2.909)	(-2.903)	(4.050)	(5.288)
Roa	-0.156*	-0.156*	-0.117	-0.122
	(-1.933)	(-1.928)	(-1.304)	(-1.264)
Age	-0.008	-0.008	-0.008	-0.010
	(-1.048)	(-1.045)	(-0.676)	(-1.199)
_cons	0.026	0.026	0.682***	0.663***
	(0.548)	(0.547)	(11.734)	(11.948)
Time	Y	Y	Y	Y
Individual	Y	Y	Y	Y
N	5096	5096	5096	5096
R^2	0.176	0.071	0.021	0.031
F value	323.73***	17.60***	85.99***	16.40***

Notes: *t* statistics in parentheses, * p<0.1, ** p<0.05, *** p<0.01

CD-TMT and technological acquisition. Negative binomial regression and pooled regression are employed to examine the relationship between CD-TMT and independent innovation. The enterprise who has technological acquisition is assigned to 1 and others are assigned to 0. Table 5 reports the results and show that the results from changing regression method are in keeping with baseline regression results in Table 3.

Mechanism Analysis

In this part, we discuss the effect of ability of information seeking as an influencing mechanism between diversity of top management team and technological strategy. In Table 6, the first column shows the result of the relationship between CD-TMT and Infor. We find that diversity of top management team has a positive impact on ability of information

Table 6. Mechanism analysis.

	Infor	Tech-Acq	Ind-Inno	Ind-Inno
CD_TMT	0.135**	0.185**		0.107*
	(2.084)	(2.395)		(1.919)
Infor		0.018***	0.008**	0.019**
		(3.198)	(2.044)	(2.698)
Tech-Acq			0.009**	
			(2.040)	
FA	-0.053	2.891***	-0.147	-0.573**
	(-0.189)	(3.554)	(-1.296)	(-2.241)
Debt	-0.108**	0.150	-0.059***	-0.092**
	(-2.212)	(0.871)	(-2.624)	(-2.144)
Cash	-0.018	-0.986**	0.006	0.013
	(-0.243)	(-2.268)	(0.162)	(0.209)
Shareholder	-0.020	-0.349*	0.064*	0.090
	(-0.254)	(-1.751)	(1.845)	(1.271)
C-GM	0.009	-0.017	0.005	0.008
	(0.487)	(-0.243)	(0.613)	(0.481)
ON	0.001	-0.296***	0.017	0.095**
	(0.027)	(-3.918)	(0.890)	(2.234)
Size	0.004	-0.099***	0.009*	0.023*
	(0.339)	(-3.016)	(1.736)	(1.954)
Roa	-0.019	-1.071*	-0.069	-0.119
	(-0.168)	(-1.838)	(-1.378)	(-1.122)
Age	0.004	-0.117**	0.034**	0.030
	(0.106)	(-2.035)	(2.252)	(0.931)
_cons	-0.099	-2.547***	0.584***	0.576***
	(-0.825)	(-4.489)	(12.164)	(5.196)
Time	Y	Y	Y	Y
Individual	Y	Y	Y	Y
N	5096	5096	5096	5096
R^2	0.006	0.120	0.035	0.028
F value	19.97***	305.18***	13.51***	13.77***

Notes: *t* statistics in parentheses, * p<0.1, ** p<0.05, *** p<0.01

seeking. The fourth column reports the result of the relationship between CD-TMT and Ind-Inno including Infor and confirms that Infor is a direct influencing mechanism between CD-TMT and Ind-Inno. We further examine multiple layers of influencing mechanisms. First, we examine Infor as an influencing mechanism between CD-TMT and Tech-Acq and find that CD-TMT and Info both have positive impacts on Tech-Acq. Then we examine Tech-Acq as an influencing mechanism between Infor and Ind-Inno and find that Tech-Acq and Info both have positive impacts on Ind-Inno. Hence, we find that there are multiple layers of influencing mechanisms between.

Heterogeneity Analysis

Technological strategy is a core force for enterprises, however, different types of enterprises have different sensitivities to technology [47]. This research will further explore the relationship between diversity of

Table 7. Heterogeneity analysis based on technological level.

	Tech-Acq	*Ind-Inno*	*Tech-Acq*	*Ind-Inno*
	Group with high-level technology		Group with low-level technology	
CD_TMT	0.126***	0.087***	0.758*	0.155
	(2.892)	(3.514)	(1.727)	(0.821)
Infor	0.086**	0.023*	0.052**	0.017**
	(2.473)	(1.865)	(2.340)	(2.167)
FA	2.418***	-0.702***	9.983**	-0.511
	(2.785)	(-2.652)	(2.336)	(-0.562)
Debt	0.155	-0.058	0.550	-0.312**
	(0.821)	(-1.299)	(1.130)	(-2.093)
Cash	-0.966**	-0.034	-1.736*	0.164
	(-1.973)	(-0.494)	(-1.678)	(0.849)
Shareholder	-0.242	0.118	-1.129**	0.062
	(-1.106)	(1.642)	(-2.198)	(0.230)
C-GM	-0.045	-0.003	0.174	0.063
	(-0.595)	(-0.190)	(1.035)	(1.238)
ON	-0.265***	0.091*	-0.490**	0.227
	(-3.194)	(1.961)	(-2.455)	(1.450)
Size	-0.081**	0.028**	-0.242**	0.032
	(-2.264)	(2.281)	(-2.412)	(0.720)
Roa	-0.411	-0.076	-2.970**	-0.348
	(-0.623)	(-0.677)	(-2.021)	(-1.050)
Age	-0.127**	0.071**	-0.127	-0.220*
	(-1.981)	(2.156)	(-0.863)	(-1.833)
_cons	-2.398***	0.539***	-5.183	0.729*
	(-4.200)	(4.784)	(-1.169)	(1.753)
Time	Y	Y	Y	Y
Individual	Y	Y	Y	Y
N	2834	2834	2262	2262
R^2	0.119	0.027	0.168	0.084
F value	248.56***	13.10***	72.05***	11.75***

Notes: *t* statistics in parentheses, * p<0.1, ** p<0.05, *** p<0.01.

top management team and technological strategy and its mechanism. Here, we divide these enterprises into two groups according to an official report named China Statistical Yearbook on High Technology Industry 2021. There are 218 enterprises belonging to high-tech group and other enterprises are in the non-high-tech group. The results are reported in Table 7. Table 7 presents that CD-TMT has positive effects on both Tech-Acq and Ind-Inno through Infor in high-tech group. Although CD-TMT has a positive effect on Tech-Acq through Infor, we have no evidence that CD-TMT can promote Ind-Inno.

Conclusions and Implications

Conclusions

This research focuses on the relationship between cognitive diversity of TMT and technological strategy and further examine information identification as an influencing in this relationship according to the data from 2007 to 2019 based on the listed companies in China. Technological strategy in this research is divided into technological acquisition and independent innovation. In order to compare the technology strategies in different types of enterprises, this study groups these enterprises into high-tech group and non-high-tech group and further compares the relationships among the variables mentioned above. There are three conclusions from this research as follows.

First, the cognitive diversity of TMT members can promote the technological acquisition and independent innovation of enterprises. It is because the cognitive diversity of TMT improves the ability of information identification of enterprises. Different members have diverse knowledge background, educational experience and social resources, which enables enterprises to quickly locate the urgently needed technology in a large number of technology information. At the same time, diverse backgrounds of members can also promote independent innovation by identifying potential risks and reducing uncertainty.

Second, technological acquisition is an important support for independent innovation of enterprise. Independent innovation not only depends on its own exploration and development, but also on the absorption and re-creation of existing technologies after technological acquisition, which is an important way to quickly improve the technological level of enterprises. High-tech enterprises pay more attention to the dual technology strategy of technological acquisition and independent innovation. However, for non-high-tech enterprises, it is more consistent with their business practice to improve their technological level through technological acquisition.

Third, there is a multi-level influence mechanism between cognitive diversity of TMT and independent innovation, which is due to the supporting effect of technological acquisition mentioned above on independent innovation. In order to reduce the risk and uncertainty of independent innovation, enterprises will meet the demand for certain technologies in the short term through technological acquisition. Ability of information identification plays an important role in technological acquisition, which enables enterprises to better understand the trend of technology development and the level of current competitors. At the same time, excellent ability of information identification can also help enterprise understand the current technology risk and the future market demand for technology, avoid losing the goal in the process of independent innovation. It should be pointed out that the ability of information identification is due to cognitive diversity of TMT members' backgrounds.

Implications

The innovation process of an enterprise is full of risks and uncertainties, which requires the TMT to grasp rich information and make correct decisions. The TMT should make full use of the diversity of members' backgrounds, accurately identify technology information and technology development trends, and design and implement the enterprise's technology strategy. At the same time, the TMT should also establish the department of technological information management and improve the information seeking ability of the enterprise.

Enterprises with different technological levels should design differentiated technology development strategies according to their own technological base and existing resources. For those with urgent requirement of technology, enterprises should quickly target in the industry or technology market by information seeking for business acquisitions or cooperation, to solve the needs of enterprises in a short period of time. In the long run, enterprises should establish a dual technology development strategy, that is, independent innovation and re-absorption of introduced technology. It will form the support and supplement for the independent innovation of the enterprise through the analysis and deconstruction of the introduced technology.

Acknowledgments

This work was supported by the [National Natural Science Foundation of China #1] under Grant [number 72002071]; [Natural Science Foundation of Hunan Province #2] under Grant [number 2020JJ5110]; and [Outstanding Young Talent Foundation of Education Department of Hunan Province #3] under Grant [number 21B0575].

Conflict of Interest

The authors report there are no competing interests to declare.

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