The Research on the Influence of Top Management Team Heterogeneity on Enterprise Technological Innovation

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Abstracts

This paper examines the relationship between the heterogeneity of the TMT and the company's technological innovation. The data comprising of ChiNext companies from 2012 to 2019 are selected and a system of structural equations are estimated for the study.

From three aspects of heterogeneity, this paper suggests that gender and age heterogeneity have a significantly negative correlation with enterprise technological innovation, and occupational background heterogeneity has a positive effect on enterprise technological innovation. The paper also finds evidence suggesting that the ownership concentration plays a moderating role between the heterogeneity of the TMT and the company's technological innovation.

Keywords: The Research on the Influence of Top Management; Heterogeneity; Enterprise; Technological Innovation

Introduction

Faced with severe practical challenges and rare development opportunities, Enterprises cannot rely on a single executive any longer to cope with the complex and changing competitive environment (Hambrick&Mason,1984: 193-206). The knowledge structure and cognitive level of the members of the TMT largely determine the strategic decision-making and performance of the company (Yanfei,2015:1). The high-level team theory believes that the TMT affects the performance of the company through strategic decision-making. Heterogeneity refers to the functional experience of the high-level team.Including age, gender, tenure, professional background, educational background, etc. Top management teams with different backgrounds have different management styles, and different management styles shape different corporate performance (Tanikawa, Kim&Jung,2017:2).

At present, the research conclusions on how the background heterogeneity of the top management team affects the innovation ability of enterprises are inconsistent (Lin, Lin&Song,2009:1). The inconsistency may be related to the research situational factors, but it is more likely to be caused by unclear understanding of the mechanism of the relationship between the two (Cui Xiaoyu, Chen Chunhua&Su Tao,2018: 152-163). This paper attempts to study this issue. On the basis of the relevant empirical conclusions of previous scholars, this paper, taking GEM companies as samples, examines the influence of TMT heterogeneity from three dimensions on the technological innovation of enterprises by the scientific and reasonable measurement as well as estimation.

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Literature Review and Theoretical Assumptions

1.TMT Heterogeneity and the Technological Innovation of Enterprises

The heterogeneity of the TMT refers to the different combinations of the members of the TMT in various dimensions. Top management team heterogeneity is an important method to measure the characteristics of top management teams,and has become a research focus in the field of top management teams. The diversity of the TMT involves demographic characteristics. Hambrick (1996: 193-206) made a relatively comprehensive definition of the heterogeneity of the TMT in the early stage. Most scholars agree with Hambrick's research and views. Differences in age, gender, tenure, education, occupation, etc. are an intuitive manifestation of heterogeneity, and some differences in concepts, values, and views of things among senior executives can be obtained through the above-mentioned external demographic background characteristics manifested. Lin et al. (2009:2) divided the TMT into the task-oriented and relationship-oriented, in which the relationship-oriented mainly includes the basic characteristics of the TMT, such as gender, age, etc., and the task-oriented mainly includes the characteristics related to ability,such as educational background, occupational background, etc. Yanfei (2015:1) divided it into low job relevance and high job relevance according to the job matching. Low job relevance refers to job characteristics that have a low degree of achievement of task goals, such as gender, age, etc., and high job relevance refers to the completion of the work objectives with high work characteristics, such as educational background. In spite of different dimensions of top management team, the background heterogeneity of the top management team has a greater impact on the technological innovation of the enterprise. Through the above-mentioned sorting out of the definition of the heterogeneity of the top management team, this paper divides the heterogeneiity of the top management team into three dimensions, including gender, age, and occupational background.

2. Age Heterogeneity and the Technological Innovation of Enterprises

Age is a powerful trigger for social categorization based on social identity theory, for individuals of similar age share similar beliefs and ideas.Similarities in opinions and beliefs encourage individuals to communicate and interact with other individuals of similar age, but hinder communication with different age groups, leading to conflict and reducing social integration. Cognitive differences brought about by age heterogeneity may cause intergenerational conflicts among top management team members on innovation issues. Senior executives belonging to different age groups do not understand each other, do not agree with each other, and even have prejudice against each other,resulting in little coordination and communication to build consensus and low efficiency and quality of decision-making, thus hindering the technological innovation activities of enterprises. The research of Tanikawa et al. (2017:2) and Cui Xiaoyu et al. (2018: 152-163) showed that the age heterogeneity of the TMT hinders organizational performance. Based on the above analysis, this study proposes the following assumption:

H1: The age heterogeneity of the TMT has a negative impact on the technological innovation of enterprises.

3. Gender Heterogeneity and the Technological Innovation of Enterprises

Because the different characteristics between men and women may cause emotional conflicts within the TMT, which will have an adverse impact on corporate innovation, some scholars hold a negative attitude towards the relationship between the two. Hambrick (1996: 193-206) believes that gender differences will lead to different behavioral norms and cognitive models among top management team members, and when they make decisions it is

easy for them to have different opinions and thus internal conflicts, which not only reduces the cohesion of the team, but also affects the enterprise. The output of innovation performance poses a certain threat. Gul (2011: 314-338) argues that gender diversity may increase internal divisions, reduce team cohesion, limit team execution and impair organizational performance. High gender heterogeneity means that the proportion of men in the top management team is about the same as that of women. Men and women executives think differently and have different views on innovative behavior and decision-making, so their personality may hinder active communication with others when they making decisions and bring conflicts to negatively affect enterprise innovation when they dealing with problems.

Therefore, for the TMT with a high proportion of female executives and the TMT with a high proportion of male executives, the lower the gender heterogeneity, the stronger the cohesion of the management team; the smaller the gender heterogeneity, the better the collaboration, and thus the better the decisions. Based on the above analysis, this study proposes the following assumption:

H2: The gender heterogeneity of the TMT has a negative impact on the technological innovation of enterprises.

4. Professional Background Heterogeneity and the Technological Innovation of Enterprises

Due to different occupations, each person will form different thinking habits and thinking modes, which will also affect each person's personality, value orientation and decision-making habits. Senior executives with scientific research background are more concerned about the innovation and research and development within the enterprise, understand the importance of innovative products in the market, and are technology-oriented, but it is easy to ignore the need to combine the development of products with the current development of the enterprise; executives with a legal background are concerned about the legal resources of the company, and in their daily management, they focus on the rationality of the law, which can better protect the innovation and technology of the company from a legal perspective; managers with a marketing background, pay attention to the preference of the company's products in the market, and can make suggestions on product innovation from the perspective of the market. When executive members with different professional backgrounds make innovative decisions together, they can control the feasibility of innovative solutions from their respective professional perspectives.not only can they bring their own thinking habits and thinking habits in their areas of expertise into the improvement of corporate innovation capabilities,but also can promote mutual learning among team members, learning from each other's strengths and complementing each other's weaknesses, to make more comprehensive decisions and further to improve the quality of entereprise management.

Therefore, a corporate TMT with a large heterogeneity of occupational backgrounds can look at problems from different perspectives, obtain contribution values from different types of occupational backgrounds, and provide more information resources and decision-making solutions. This diversification enables executives to learn from each other, and to broaden the vision of the top management team, so as to analyze the direction and route of enterprise development from different angles, improve the quality of decision-making, and bring greater benefits to realize enterprise innovation performance in an open and innovative team atmosphere. Based on the above analysis, this study proposes the following assumption:

H3: The heterogeneity of the professional background of the TMT is positively related to corporate innovation.

5. Moderating Role of the Ownership concentration

Based on the perspective of principal-agent theory, Li Jing's (2012: 40-51) research results found that increasing ownership concentration of state-owned enterprises will increase the innovation investment of enterprises. Shleifer & Vishny (1997: :737-783) think that scattered small shareholders lack the motivation to supervise managers, their monitoring costs outweighing their benefits, so ownership concentration is more conducive to innovation. Baysinger et al (1991: 205-214.) used a sample of 176 Fortune 500 companies from 1981 to 1983 and found that ownership concentration has a positive impact on R&D investment.

This paper believes that ownership concentration is an important indicator to measure the corporate governance environment. The concentration or dispersion of ownership will affect the internal innovation environment of the enterprise, thereby regulating the relationship between the diversity of the TMT and the innovation ability of the enterprise. From the perspective of decision-making goals, major shareholders pay more attention to improving the innovation capability of the company so that the company can obtain the core competitiveness of long-term development, while executives tend to reduce capital investment in innovation activities due to occupational safety and risk aversion and pay more attention to the pursuit of short-term development. performance. The principal-agent believes that increasing the equity concentration is conducive to solving the principal-agent problem arising from the separation of two rights. For these reasons, this study proposes the following assumptions:

H4: Ownership concentration plays a moderating role between the heterogeneity of the TMT and the technological innovation of enterprises.

Cognitive differences brought about by age heterogeneity may cause intergenerational conflicts among top management team members on innovation issues. Senior executives belonging to different age groups do not understand each other, do not agree with each other, and even have prejudice against each other. , resulting in difficulties in coordination and communication. In a highly heterogeneous TMT, the relative concentration of ownership will make their differences tend to be consistent. Based on this, a hypothesis is proposed.

H4a: Ownership concentration weakens the negative correlation between the age heterogeneity of the TMT and corporate technological innovation.

The high-level team theory shows that the TMT is responsible for the formulation and execution of corporate decisions, and its characteristics affect corporate performance. Enterprise technology innovation is a high-risk activity. Compared with women, men show stronger risk appetite, risk-taking spirit, and overconfidence. As a result, male executives will be more decisive and bold in driving innovation, potentially enabling companies to make breakthroughs in innovation. When the ownership concentration is relatively concentrated, the executives with larger shares will reach a consensus on the technological innovation of the enterprise. Based on the above analysis, this study proposes the following assumption:

H4b: Ownership concentration weakens the negative correlation between the gender heterogeneity of the TMT and corporate technological innovation.

6.Theoretical Research Model

Based on the information decision theory, the higher the heterogeneity of the functional background of the TMT, the more diverse the information obtained within the team, the greater the difference in the way of thinking and the focus of attention. At the same time, the social interaction between executives with different viewpoints can generate new insights and the reconstruction of ideas, and the concentration of ownership concentration will make such different viewpoints tend to be the same, and the more innovative behavior

will be enhanced. Based on the above analysis, this study proposes the following assumption:

H4c: Ownership concentration enhances the positive relationship between the occupational background heterogeneity of the TMT and the technological innovation of enterprises.

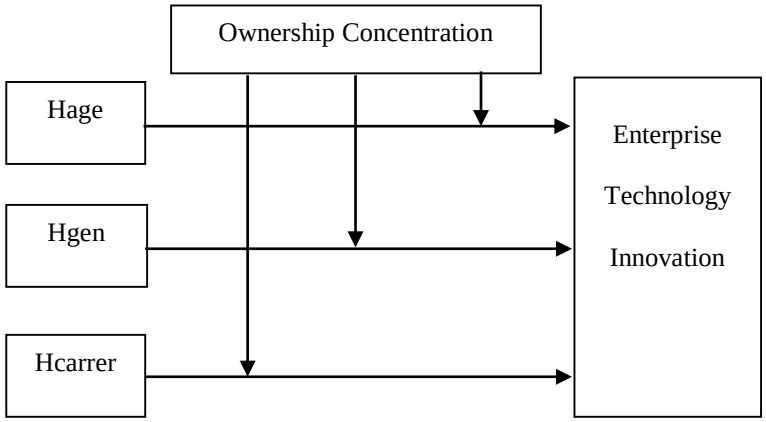

Figure 1. theoretical research model

Research Methodology

By consulting Guotai 'an database for data collection and cleaning, SPSS and STATA were used for empirical analysis of the data, and descriptive statistics of the data were carried out to preliminarily understand the structure and basic characteristics of the sample data. Correlation analysis is performed to understand the relationship between individual variables and to compare them with assumptions. Through the multicollinearity analysis, we can judge whether there is multicollinearity between variables, and make a good preparation for the panel data regression. Through panel data regression, this paper verifies the impact of executive team heterogeneity on enterprise technological innovation, and further examines the regulating effect of ownership concentration, so as to verify whether the hypothesis is valid.

Source of Data

This article selected GEM companies from 2012-2019 as research samples. The reason why GEM companies are selected is that GEM companies have stronger technological innovation capabilities and put more importance on R&D and innovation, and they will continue to invest and develop new technologies to adapt to the market environment. Therefore, it is more practical to choose GEM companies as research objects. The background profiles of the members of the top management team come from the characteristics database of listed companies in Cathay Pacific (CSMAR), and the variable data for final use is obtained by manual sorting; the R&D innovation data of enterprises comes from the R&D innovation database of listed companies in Cathay Pacific; The annual report is collected and sorted by hand.

Population and Sampling

The empirical analysis of this paper is carried out using SPSS22.0 and STATA statistical software. A series of financial indicators of listed companies come from Guotai'an database, Wind database, etc. The GEM companies are screened as follows: (1) Eliminate st

or *st companies; (2) Eliminate financial and insurance companies. Selecting 2012-2019 GEM companies as the research object, a total of 4314 valid observations were obtained.

Data Collecting and Measurement of variables

Measurement of explained variables

At present, there are two main types of measures related to technological innovation of enterprises. One is to measure innovation level by enterprise innovation investment, such as the ratio of total enterprise R&D investment to operating income (Wen Fang and Hu Yuming, 2009: 84-91), total enterprise R&D investment (Wang Deying, 2009: 45-52,Liu Jianhe, 2011: 45-52), and ratio of total R&D investment to total assets of an enterprise (Liu Yunguo and Liu Wen, 2007: 128-136).The other is by enterprise innovation output, such as the number of patent applications (Zheng Mingbo, 2019: 137-144) or the number of new products. this paper studies the impact of the heterogeneity of the top management team on the technological innovation of enterprises. In order to better verify the hypothesis, the level of technological innovation is measured by innovation input and innovation output. The ratio of income is used as the explained variable and recorded as RD.

Measurement of explanatory variables

(1) Age: The age of the top management team members is measured as a continuous variable using the standard deviation coefficient, which is recorded as Hage. The calculation formula is:

$H_{age} = \frac{\sigma_{age}}{Aage}$, 其中 , $A_{age} = \sum age_i/n$, σ_{age}=$\sqrt{\sum(age_i - A_{age})^2/n}$, $age_i$is the age of the i-th TMT member, and n is the total number of TMT members.

(2) Gender: According to the measurement to the heterogeneity of educational level and occupational background by Deying, Liu Jianhe (2011: 45-52), Sperber and Linder (2018: 285-316), the gender heterogeneity is expressed by Herfindal-Hirschman coefficient. The higher the value,the higher the gender diversity of the team.It is recorded as Hgen.

$$H_{gen} = 1 - \sum_{i=1}^{2} P_{gen\,i}^2$$

$P_{gen\,i}$Indicates the proportion of the i-th gender to the total number of top management teams, where i is the gender classification.

(3) Occupational background: This article adopted the measurement by Chinese scholars Huang Yue et al. (2010) and Wu Xiaobo (2015: 1-8) to divide the functional background of the TMT into 9 categories according to the professional background of executives, and the specific codes are: 1= Production, 2=R&D, 3=Design, 4=Human Resources, 5=Management, 6=Marketing, 7=Finance, 8=Finance, 9=Legal. The Blau index is used to measure the categorical variables. The formula is:

$$H_{career} = 1 - \sum_{k=1}^{9} P_{career\,i}^2$$

Among them, $P_{career\,i}$ represents the proportion of executive members with the i-th occupational background in the total number of TMT members, i is the functional background classification, and n is the total number of TMT members.

Measurement of Manipulated Variables

Duan Haiyan (2017: 87-93.) found that equity concentration is not conducive to SMEs' innovation investment. this paper measures the shareholding concentration by the sum of the shareholding ratios of the top ten shareholders, which is marked as CR10. The higher the value, the higher the shareholding concentration.

Measurement of Control Variables

Considering that the technological innovation of enterprises is not only affected by the characteristics of the TMT, but also by other factors, this paper chooses enterprise scale, enterprise age, enterprise capital structure, and annual dummy as control variables to improve the fitting degree of the model.

Table 1. Variable Definition Table

Variable Type	Variable Symbol	Variable Description
Independent Variables	Hage	Standard Deviation Coefficient
	Hgen	Herfindal-Hirschman Coefficient
	Hcarrer	Herfindal-Hirschman Coefficient
Dependent Variables	RD	Ratio Of Total R&D Investment To Operating Income
Moderator Variables	CR10	The Ratio Of The Top Ten Shareholders
Control Variables	Size	The Natural Logarithm Of The Company's Total Assets
	Age	From The Year Of Establishment To The End Of Period T
	Leverage	Gearing Ratio
	Year	Virtual Variable

The construction of an empirical model on the effect of the heterogeneity of the TMT on the technological innovation of enterprises

First, verify the validity of the control variables and establish model 1:

$$RD_{it} = \beta_0 + \beta_1 Age_{it} + \beta_2 Size_{it} + \beta_3 Leverage_{it} + \sum Year + \mu_{it}$$

Among them, $\beta_0$is the fixed intercept term,μ_{it}represents a random disturbance term that varies with firm and year.

In order to verify the assumptions H1 to H3 add explanatory variables on the basis of model 1, establish the following regression model 2:

$$RD_{it} = \beta_0 + \beta_1 Age_{it} + \beta_2 Size_{it} + \beta_3 Leverage_{it} + \beta_4 Hge_{it} + \beta_5 Hgen_{it} + \beta_6 Hcarrer_{it} + \sum Year + \mu_{it}$$

In order to verify the moderating effect of ownership concentration, the interaction term of CR10 was introduced on the basis of Model 2 to verify hypothesis H4, and the following regression model 3 was established:

$$RD_{it} = \beta_0 + \beta_1 Age_{it} + \beta_2 Size_{it} + \beta_3 Leverage_{it} + \beta_4 Hage_{it} + \beta_5 Hgen_{it} + \beta_6 Hcarrer_{it} + \beta_7 CR10_{it} + \beta_8 CR10_{it} \times Hage_{it} + \beta_9 CR10_{it} \times Hgen_{it} + \beta_{10} CR10_{it} \times Hcarrer_{it} + \sum Year + \mu_{it}$$

Analysis of Data

Descriptive Statistical Analysis

Table 2 reports the descriptive statistics of the main variables of the model, including the number of observed cases N, the minimum, the maximum, the mean, the median, and the standard deviation. From the analysis results of the explained variable enterprise technology, the sample enterprises have great differences in the performance of innovation ability, the maximum value 0.227and the minimum value is 0.001. the mean of age heterogeneity (Hage) is 0.139, and the mean of gender heterogeneity (Hgen) is 0.252, indicating that the top management team in the research sample is of relatively low heterogeneity in age and gender. The minimum value of occupational background heterogeneity is 0.278, and the maximum value is 0.810, indicating that t occupational background heterogeneity is relatively large.
The analysis results of ownership concentration degree show that the ownership structure of sample enterprises is very different, the minimum value is 0.223, the maximum value is 0.911, and the average value is 0.609.

Table 2. Descriptive Statistics

Variables	N	Min	Max	Mean	Median	Standard Deviation
RD	4314	0.001	0.227	0.070	0.053	0.051
Hage	4314	0.034	0.273	0.139	0.135	0.051
Hgen	4314	0.000	0.500	0.254	0.278	0.180
Hcarrer	4314	0.278	0.810	0.694	0.711	0.079
CR10	4314	0.223	0.911	0.609	0.625	0.122
Size	4314	19.371	25.342	21.296	21.186	0.832
Age	4314	4	32	15.787	16	4.756
Leverage	4314	0.048	0.972	0.306	0.282	0.171

Correlation analysis

In this paper, the Pearson correlation coefficient is used to test the correlation between variables, and on this basis, the specific relationship is explored. When the correlation coefficient is positive, it indicates that there is a positive correlation between the two variables, and when the correlation coefficient is negative, it indicates that there is a negative correlation between the two variables. The closer the absolute value of the correlation coefficient is to 1, the higher the degree of correlation between the two variables, and the closer the absolute value of the correlation coefficient is to 0, the lower the degree of correlation between the two variables.

In order to make a preliminary judgment on the correlation between the diversity of the TMT and the innovation ability of enterprises, this paper uses the STATA data processing software to conduct correlation analysis on all variables, and analyzes the technological

innovation, age heterogeneity, gender heterogeneity, tenure Heterogeneity, educational background heterogeneity, occupational background heterogeneity, overseas background heterogeneity,etc.Control variables were analyzed for correlation, and the Pearson correlation coefficient and significance were obtained. The analysis results are shown in Table 3. From the correlation analysis results of each variable, it can be seen that age heterogeneity is negatively correlated with technological innovation of enterprises, with a significance level of 1%; gender heterogeneity is negatively correlated with technological innovation of enterprises, which is in line with the preliminary prediction of the theoretical analysis in this paper.

In addition, it can be seen from Table 3 that the correlation coefficient of each variable is less than 0.5, and the VIF value between each variable is less than 10, indicating that there is no multicollinearity problem between the main variables, the selected variables , and the analysis and interpretation of the statistical results of the sample data is also reliable.

Table 3. Pearson's correlations for continuous variables

变量	RD	Hage	Hgen	Hcarrer	CR10	Size	Age	Leverage
RD	1							
Hage	-0.087***	1						
Hgen	-0.002*	0.119***	1					
Hcarrer	0.030*	-0.027**	-0.045***	1				
CR10	-0.083***	0.012	-0.030***	-0.034**	1			
Size	-0.132***	-0.031**	-0.053***	-0.023	-0.298***	1		
Age	-0.020	0.086***	0.053***	-0.013	-0.103***	0.118***	1	
Leverage	-0.276***	-0.017	-0.047***	-0.033**	-0.174***	0.451***	0.084***	1

***p<.01, **p<.05, * p<.1

Multiple Linear Regression Analysis

According to the Hausman test, fixed-effect models are better than random-effect in Models 1-3. In order to further test whether there is a significant correlation between the explained variables, explanatory variables, moderator variables and control variables, this paper uses panel data to perform multiple regression analysis on the model by Stata software. In the process of multiple regression, the correlation between the control variable and the explained variable is first tested. On this basis, the correlation among the explained variable, the explanatory variable and the control variable is studied. Finally, the interaction term between the explanatory variable and the moderator variable is tested to study the moderating effect of ownership concentration between the diversity of the TMT and the innovation ability of enterprises.

As can be seen from the third column of Table 4, after the introduction of ownership concentration, the regression coefficient with the age heterogeneity of the TMT is 0.364, and the significance level is 1%, which weakens the negative effect of the age heterogeneity of the TMT on enterprise technology, so hypothesis H4a is supported.
The regression coefficient with the gender heterogeneity of the top management team is 0.064, and the significance level is 5%, which weakens the negative impact of the gender heterogeneity of the top management team on the technological innovation of enterprises. Hypothesis H4b is verified.

The regression coefficient of the heterogeneity of the top management team's occupational background is 0.150, and the significance level is 5%, which enhances the positive impact of the background heterogeneity of the top management team on the technological innovation of enterprises. Hypothesis H4c is verified.

Table 4. Regression analysis results

Variables	MOD1	MOD 2	MOD 3
Size	-0.001	-0.001	-0.002**
	(-0.60)	(-0.87)	(-2.48)
Age	-0.001***	-0.001***	-0.001***
	(-3.66)	(-3.37)	(-3.63)
Leverage	-0.079***	-0.079***	-0.080***
	(-16.99)	(-17.13)	(-17.22)
Hage		-0.052***	-0.054***
		(-3.77)	(-3.93)
Hgen		-0.006*	-0.007*
		(-1.74)	(-1.70)
Hcarrer		0.021**	0.018**
		(2.37)	(2.03)
CR10			-0.037***
			(-6.08)
Hage*CR10			0.364***
			(3.22)
Hgen* CR10			0.064**
			(2.01)
Hcarrer* CR10			0.150**
			(2.09)

N	4314	4314	4314
F值	118.95	63.93	44.49
Sig	0.000	0.000	0.000
Adj-R^2	0.208	0.213	0.223

***p<.01, **p<.05, * p<.1 In parentheses are the coefficient t values。

Conclusion and Suggestion

This paper takes the GEM companies from 2012-2019 as the research object, starts from the perspective of the heterogeneity of the TMT, and explores the technological innovation of GEM companies through theoretical deduction and empirical testing.

1.Conclusion and Discussion

Based on the analysis and discussion of the previous empirical research results, this paper tests the impact of the characteristics of the TMT on the technological innovation of enterprises and the empirical analysis results show that: (1) The heterogeneity of top management team has an impact on technological innovation ; (2)The regression results support the hypothesis that the age and gender differences of the TMT has a negative impact on the technological innovation of the enterprise; the heterogeneity of the professional background of the top management team has a positive impact on the technological innovation of the enterprise. (3) Equity concentration plays a moderating role, enhancing the impact of the professional background of the top management team on technological innovation, and weakening the impact of the age and gender heterogeneity of the top management team on technological innovation;(4) This heterogeneity may be influenced by the nature of the firm.

2.Suggestion and Further Research

The heterogeneity of the TMT has different effects on the technological innovation of enterprises. For enterprises, it is necessary to reduce the heterogeneity of age and gender, enhance the diversity of occupational backgrounds, and build a reasonable and efficient top management team. The inevitable requirement of maintaining core competitiveness can bring more information and resources to enterprises, form complementary advantages, and contribute to technological innovation of enterprises. Multiple channels to release high-level talent recruitment information and generous treatment can to some extent ensure the stable introduction of executives with different professional backgrounds and overseas backgrounds. In the next step, we will further study the impact of heterogeneity of senior management team on technological innovation of enterprises under different enterprise ownership. Most senior management members of state-owned enterprises are appointed by their superiors, while private enterprises have flexible mechanisms, because the impact of such heterogeneity will be different under different enterprise natures.

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