A meta-analysis of top management team heterogeneity and corporate innovation performance in China

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Abstract. Numerous studies have focused on the relationship between top management teams (TMTs) and corporate innovation performance in China, but whether TMTs heterogeneity can promote innovation has not been consistently concluded. To explain the inconsistency of the empirical results and to reconcile the relevant theoretical contradictions, we conducted a meta-analysis of the effects of TMTs heterogeneity on innovation performance in China and explored potential moderators of the relationship between TMTs heterogeneity and corporate innovation. Based on 51 effect sizes from 21 studies, we find that heterogeneity in functional and educational backgrounds can significantly contribute to innovation performance. The findings of the paper not only help to understand the inconsistent relationship between TMTs heterogeneity and innovation performance, but also help Chinese enterprises in the context of economic transition to promote corporate innovation by improving the composition characteristics of TMTs.

Keywords: China; innovation performance; top management team; heterogeneity

1 Introduction

In the field of strategic management, the relationship between TMTs and corporate innovation performance has been one of the topics of great interest. The formulation of Upper echelons theory provides a theoretical basis for the relationship relationship between the top management team and corporate performance. Then a great deal of academic research has focused on the impact of TMTs on corporate performance. Today, Chinese companies face a range of uncertainties due to complex political policies and a highly competitive environment. On the one hand, along with the rapid development of China's economy and society, China has gained a great deal of attention from scholars. Against the background of economic transition, Chinese corporations must build their own core competencies to get rid of the label of low-end manufacturing. This means an increase in risk and uncertainty. On the other hand, the huge economic potential of our market has attracted companies from all over the world, which in turn has increased the uncertainty of the competitive environment. The influence of TMTs on

S. Yacob et al. (eds.), *Proceedings of the 2023 7th International Seminar on Education, Management and Social Sciences (ISEMSS 2023)*, Advances in Social Science, Education and Humanities Research 779,
https://doi.org/10.2991/978-2-38476-126-5_193

the company's strategy and the structural response is an effective way for the organization to deal with the complexity of the environment (Murray, 1989)[1]. Chinese companies urgently need to address these uncertainties through a reasonable composition of their top management teams. Therefore, it is relevant to study the characteristics of executive teams of Chinese companies. In established studies, scholars have extensively explored TMTs homogeneity and heterogeneity (Nielsen, 2010; Ndofor, Sirmon, and He, 2015)[23]. Heterogeneity in TMTs refers to the degree of variation in the characteristics possessed by an executive team. Scholars have conducted numerous studies around the relationship between TMTs heterogeneity and firm innovation performance, but have not yet reached a consistent conclusion.

In addition, research results based on the Chinese context are published in Chinese journals, limiting the knowledge of scholars from other countries about Chinese issues. Therefore, this study takes China as the research context, searches relevant Chinese and English literature, and conducts a meta-analysis of the relationship between TMTs heterogeneity and innovation performance in China in an attempt to identify the reasons for inconsistencies in previous studies and form conclusions that are appropriate for the actual situation in China.

Meta-analysis is a methodological approach. Researchers are able to aggregate the results of multiple studies under a common theme and verify the magnitude of the empirical study effects through meta-analysis. Moreover, meta-analysis allows researchers to explore the brief conditions of the relationship between variables and test for potential moderating effects (Certo et al., 2006)[4]. In this paper, 21 studies with Chinese firms as samples are selected to conduct meta-analysis on the Pearson correlation coefficient between TMTs heterogeneity and innovation performance to form a conclusion that is suitable for the actual situation in China. On the one hand, it can enrich the research on executive team heterogeneity, and on the other hand, it can help Chinese companies seek a reasonable TMTs composition.

2 Literature Review And Hypotheses Development

2.1 Definition Of Related Concepts

Academics generally agree that TMTs heterogeneity consists of two main aspects, on the one hand, measurable differences in demographic characteristics such as race, age, team tenure, educational background; on the other hand, unmeasurable differences in values, cognitive abilities, etc. Considering the ease of data availability, much of the existing research has focused on easily identifiable and accessible difference characteristics. A review of the literature on the topic of TMTs heterogeneity and corporate performance reveals that the vast majority of the literature on TMTs heterogeneity focuses on five areas: age, tenure, gender, educational background and functional background (Smith et al.,1994; Zhao and Yuan, 2022)[56]. This study examines the relevant literature according to the above classification of heterogeneity.

2.2 TMTs Heterogeneity And Corporate Innovation Performance

Age heterogeneity refers to the degree of variation in the age distribution. As China is in a period of economic transition and facing a rapidly changing market environment and social structure, higher age heterogeneity often leads to value conflicts among team members, thus causing discord within the team and negatively impacting innovation decisions. In addition, innovation activities imply uncertainty, high risk factors and long payback periods. The age of an executive is a proxy for the level of experience, as well as a signal of attitude toward adventure and change (Escribá-Esteve, Sánchez-Peinado and Sánchez-Peinado, 2009)[7]. Younger executives are more inclined to make high-risk, high-return investment decisions, while older executives are more likely to seek stable, less risky decisions. Differences in risk appetite can also result in poor team communication, which can reduce innovation performance.

Task-related heterogeneity can be considered as resources, so TMTs of different tenures have access to more information (Li, 2013)[8]. According to Information and Decision-Making Theory, diversified sources of information facilitate team members to examine problems from multiple perspectives, thus improving innovation performance. It has been suggested that the higher the level of tenure diversity, the more insightful the discussion of strategic options (Smith et al., 1994; Bantel and Jackson, 1989)[59].

According to Social role theory, the gender composition of TMTs is determined by complex social processes arising from human activity and corporate governance (Kirsch, 2018)[10]. In China, men and women play different social roles, which in turn will influence the decision-making and management behavior related to corporate innovation (Huang, 2021)[11]. On the one hand, compared with male executives, women can create an open and relaxed working environment for their teams, which is conducive to improving the company's ability to innovate. On the other hand, the participation of female executives adjusts the gender structure of TMTs. This facilitates corporate team building and enhances team creativity (Zhao and Yuan, 2022)[6]. In addition, a gender-diverse executive team brings a broader knowledge base, which may help create a competitive advantage (Erhardt, Werbel and Shrader, 2003)[12].

Functional background heterogeneity can influence executives' perceptions of the industry and understanding of the R&D investment required for innovation. Functional diversity has a positive impact on organizational creativity. Executives can accumulate a great deal of intangible knowledge from long professional experience, which is an important source of innovation (Castellani et al., 2021)[13].

Amason and Sapienza (1997) showed that top management team members with different backgrounds can examine and analyze a complex problem from different perspectives, and thus educational background diversity contributes to better decision quality[14]. And the education level of top management team members is positively correlated with their thinking and vision. The higher the education level, the more open-minded the executives are and the more receptive they are to innovation, so the education level of executives is positively correlated with corporate innovation (Camelo-Ordaz et al.,2005)[15]. Based on this, the following hypothesis is proposed in this paper. Based on the above analysis, the following hypotheses are proposed.

H1: Age heterogeneity of TMTs is negatively related to innovation performance.

H2: Tenure heterogeneity of TMTs is positively related to innovation performance.

H3: Gender heterogeneity of TMTs is positively related to innovation performance.

H4: Functional background heterogeneity of TMTs is positively related to innovation performance.

H5: Educational background heterogeneity of TMTs is positively related to innovation performance.

2.3 Moderating Variable

Different studies obtain data in different ways, and the data can be divided into primary data and secondary data (Hox, 2005)[16] according to the differences in data sources, Among them, primary data are mainly obtained through questionnaire surveys and interview methods; secondary data are mainly obtained through databases, annual reports of listed companies and other sources. Primary data often have higher relevance, applicability and timeliness, and require higher labor cost and time cost. Secondary data do not have such qualities, and researchers can obtain data more conveniently, but the timeliness and reliability of the data obtained are lower than primary data.

3 Methodology

3.1 Literature Search

We relied on computer-assisted keyword searches as well as manual searchs to identify applicable empirical studies in the title, abstract or keywords. To reduce publication bias, we searched as much literature as possible using the China context as the study background. We searched for articles (limited to research articles) containing the terms "top management team heterogeneity", "top management team diversity", 'top management team characteristics", "TMTs heterogeneity", "TMTs diversity", "TMTs characteristics", "performance" and "China" in title, abstract, or keywords in the databases of Web of Science and Elsevier. Chinese literature was mainly searched in the database of CNKI by the same search formula for English literature. 593 Chinese and English articles related to the topic of this study were obtained.

3.2 Inclusion Criteria

We adopted four criteria to include studies in our meta-analysis. First, literature included in meta-analysis must be an empirical study based on a Chinese TMTs. Case studies and literature reviews were excluded (Zhang, Xiao and Wang, 2021)[17]. Second, it does not matter whether variables are independent, dependent, or control variables. The article was included in the study need only have reported a Pearson product-moment correlation. However, data obtained by structural equation models and regression analysis are not included. Third, the sample was limited to variables reported with sufficient frequency, that is, at least three independent samples from prior research are

needed (Dalton et al., 2003)[18]. Ultimately, 21 published studies contained the information needed to calculate effect sizes and met the inclusion criteria. Among them, 11 were in English and 10 were in Chinese.

3.3 Coding Procedures

In this study, we mainly coded the literature description item and the effect value statistics item. Among them, the description term contains the basic information of the literature, including study name, first author name, year of publication, region to which the study subject belongs, and year of sample selection; the effect value statistic term mainly includes sample size and Pearson correlation coefficient. In addition, in order to test the heterogeneity of TMT heterogeneity and corporate innovation performance, this study coded two aspects: data source and industry type. In order to avoid the subjectivity caused by personal judgment during the coding process, the coding rules were developed by the first author together with another coder during the coding process. Two researchers independently coded the data of the Chinese and English papers. Cross-checking was performed after coding was completed, and studies with inconsistent coding were discussed retrospectively to ensure that all literature was coded consistently (Lipsey and Wilson, 2001)[19].

The results of the literature coding phase showed that the study yielded a total of 51 effect values, covering 11978 firms. Based on Hunter and Schmidt's (2004)[20] psychometric analytic procedure for Meta-analysis principles, the coded data were processed by R4.2.1 software. We followed six procedures: meta-synthesis of collected estimates; heterogeneity test; testing for publication selection bias; Analysis of main effects; sensitivity analysis; subgroup analysis.

4 Meta-analysis of result

4.1 Meta-Synthesis

In this paper, Pearson's correlation coefficient r was used as an effect value, and the extracted correlation coefficient r for each study was Fisher's Z transformed, followed by a weighted average with the inverse of the standard error squared as the weight. Finally, Fisher's Z values were reconverted to correlation coefficients to obtain effect values for the included studies (Hedges and Olkin, 2014)[21].

4.2 Heterogeneity Test

Heterogeneity testing uses hypothesis testing to test whether multiple independent studies are heterogeneous. Q and I2 are used to test the heterogeneity of the sample to select the appropriate model for analysis. The Q value reflects the degree of difference between effect values, and Q>n-1 indicates the presence of heterogeneity; I2 is a measure of the degree of heterogeneity among multiple studies, and I2 > 50% indicates the presence of large heterogeneity. Insignificant heterogeneity indicates that multiple studies

are homogeneous, and a fixed-effects model is chosen, and conversely, a random-effects model is chosen. As shown in Table 1, based on the Q-test results and the I2 statistic, all variables were estimated using a random effects model.

Table 1. Tests of heterogeneity and publication bias

variable	N	K	Test of heterogeneity			Test for publication bias		model
			Q	P_Q	I^2	TE	PE	
Hage	10	3938	52.20	<0.0001	82.80%	0.14	0.8902	random
Hten	8	2431	138.56	<0.0001	94.90%	0.67	0.5262	random
Hgen	5	1963	13.17	0.0105	69.60%	-0.10	0.9242	random
Hfun	17	9542	182.99	<0.0001	91.30%	1.81	0.0903	random
Hedu	11	6025	250.36	<0.0001	96.00%	2.11	0.0636	random

N = the number of effect sizes; K = the number of teams; Q = the statistics for examining within-group heterogeneity; I^2 = percentage of variance not explained by sampling error or other study artifacts; TE = Publication bias test t-statistic.

4.3 Publication Bias Test

The issue of publication bias refers to the bias of results caused by the researcher's inability to exhaust the entire body of research data in the field. Therefore, it is necessary to test whether there is publication bias in the included studies before conducting meta-analysis. The presence of publication bias in the included studies was analyzed from a quantitative perspective through the Egger test. As shown in Table 1, the Egger test shows that the PE of the test for publication bias for each dimension of TMT heterogeneity are greater than 0.05. Thus, this test result implies no significant publication bias.

4.4 Analysis Of Main Effects

The theoretical hypotheses were tested by combining the effect values and significance tests were performed based on whether the confidence interval contained 0. That is, a 95% confidence interval that did not contain 0 indicated that the combined statistic was significant. The meta-analytic estimations of the relationship between TMTs heterogeneity and innovation performance are presented in Table 2.

The effect values of each dimension of TMT heterogeneity were analyzed and the results are shown in Table 2. Age heterogeneity (Hage) (r=-0.0674, p=0.1785), tenure heterogeneity (Hten) (r=0.0986, p=0.3953) and gender heterogeneity (Hgen) (r=0.0236, p=0.6920) were not significantly correlated with corporate innovation performance. Functional background heterogeneity (Hfun) (r=0.1410, p=0.0010<0.01) and educational background heterogeneity (Hedu) (r=0.2301, p=0.0071<0.01) were significantly and positively associated with innovation performance. H4 and H5 were supported.

Table 2. Meta-analysis results

TMTs heterogeneity variety	N	K	two-tailed test			95% C.I.	
			r	Z	P	Lower	Upper
Hage	10	3938	-0.0674	-1.35	0.1785	-0.1656	0.0308
Hten	8	2431	0.0986	0.85	0.3953	-0.1287	0.3258
Hgen	5	1963	0.0236	0.40	0.6920	-0.0932	0.1404
Hfun	17	9542	0.1410	3.11	0.0019	0.0522	0.2298
Hedu	11	6025	0.2301	2.69	0.0071	0.0624	0.3977

N = the number of effect sizes; K = the number of teams; r = corrected overall correlation coefficient; the 95% C.I. is a 95% confidence interval based on the corrected overall correlation coefficient.

4.5 Sensitivity Analysis

Sensitivity analysis is used to assess the robustness and reliability of the combined results. In this study, the literature included in the meta-analysis was excluded one by one before combining the effect sizes, and the effect sizes after combining again were compared with the original effect sizes. By observing the changes in the merged results, it was assessed whether the merged results would be significantly changed by the influence of some studies. The results of the sensitivity analysis showed that the total effect values obtained after excluding the included literature one by one in the study of innovation performance did not change significantly, indicating that the Meta-analysis results are more robust (see Fig.1.-5.).

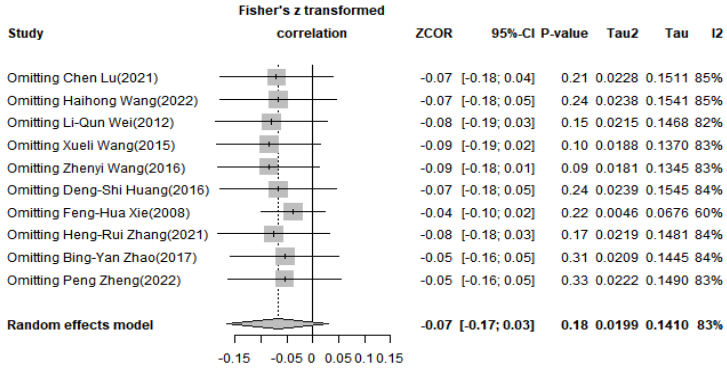

Fig. 1. Age heterogeneity

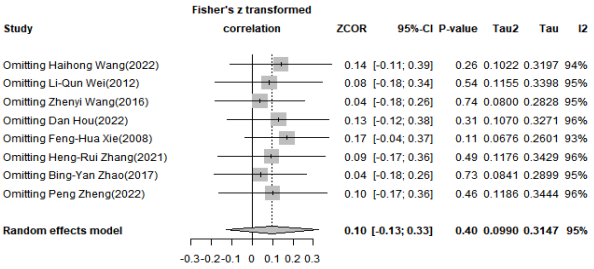

Fig. 2. Tenure heterogeneity

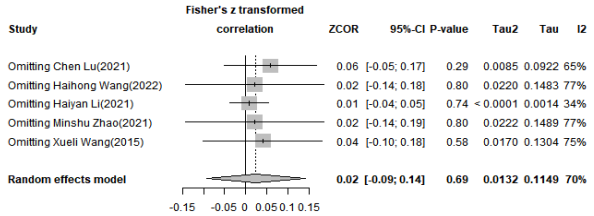

Fig. 3. Gender heterogeneity

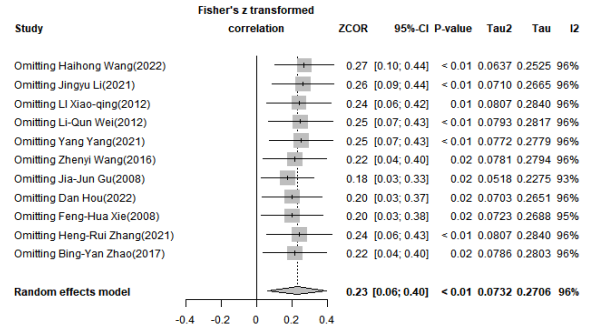

Fig. 4. Educational background heterogeneity

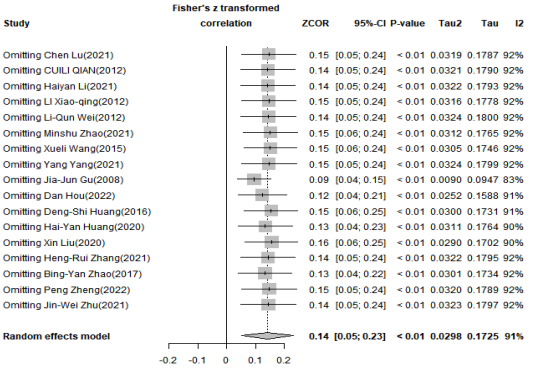

Fig. 5. Functional background heterogeneity

4.6 Subgroup Analysis

The test of heterogeneity showed a high degree of heterogeneity among the independent studies, indicating the existence of potential moderating variables affecting the relationship between TMT heterogeneity and innovation performance. Therefore, this paper conducts a moderating role analysis to explore the sources of heterogeneity. The data included in the literature were divided into primary and secondary data. Table 3 presents the results of the tests for the moderating effect of TMT heterogeneity and innovation performance. The models used for different subgroups are given in Table 3.

If the Q statistic of between-group heterogeneity is significant, it indicates that the moderating variable significantly reduces the heterogeneity between subgroups and has a moderating effect on the relationship between variables.

The effect values obtained for the primary data were higher than the secondary data under each heterogeneity dimension of TMT (r_{agep} = -0.1893 < r_{ages} = -0.0383; r_{tenp} = 0.11 > r_{tens} = 0.0918; r_{genp} = 0.2554 > r_{gens} = 0.0079; r_{funp} = 0.2647 > r_{funs} = 0.0459; r_{edup} = 0.4075 > r_{edus} = 0.1106). The results of the subgroup analysis showed that gender heterogeneity, functional background heterogeneity and educational background heterogeneity were significantly and positively associated with innovation performance based on primary data, while the statistical results for secondary data were not significant. The moderating effect of data source on gender heterogeneity (Q=8.64, p=0.0033) and functional background heterogeneity (Q=6.12, p=0.0133) passed the between-group heterogeneity test, indicating that data source can play a moderating role in the study of these two types of heterogeneity and innovation performance. The remaining subgroup analyses of TMTs heterogeneity and firm innovation performance did not pass the between-group heterogeneity test, i.e., the data source failed to significantly moderate the relationship between age heterogeneity, tenure heterogeneity and educational background heterogeneity and firm innovation performance.

Table 3. Moderating analysis

Hetero-geneity	Sub-groups	N	K	r	two-tailed test		95% C.I.		Test of heterogeneity			Model
					Z	P	Lower	Upper	Q	P	I^{2C}	
									1.27	0.2599		
Hage	Pd	3	991	-0.1893	-1.46	0.1439	-0.4432	0.0646	36.24	<0.0001	94.50%	random
	Sd	7	2947	-0.0383	-1.11	0.2659	-0.1058	0.0292	13.38	0.0373	55.20%	random
									0.06	0.8095		
Hten	Pd	3	991	0.11	0.42	0.6738	-0.4021	0.6221	89.85	<0.0001	97.80%	random
	Sd	5	1440	0.0918	0.72	0.4691	-0.1567	0.3402	45.8	<0.0001	91.30%	random
									8.64	0.0033		
Hgen	Pd	1	156	0.2554	3.16	0.0016	0.0970	0.4139				common
	Sd	4	1807	0.0079	0.33	0.7385	-0.0384	0.0542	4.53	0.2096	33.80%	common
Hfun	Pd	6	2031	0.2647	3.13	0.0017	0.0991	0.4304	6.12 61.26	0.0133 <0.0001	91.80%	random

Hedu	Sd	11	7511	0.0459	1.76	0.0780	-0.0051	0.0970	41.29	<0.0001	75.80%	random
	Pd	4	1286	0.4075	3.05	0.0023	0.1452	0.6698	3.4786.23	0.0626<0.0001	96.50%	random
	Sd	7	4739	0.1106	1.28	0.2015	-0.0591	0.2804	44.99	<0.0001	86.70%	random

Pd = Primary data; Sd = Secondary data.

5 Discussion and conclusion

Based on empirical studies published in previous journals, this study aims to provide a quantitative review of the relationship between TMTs heterogeneity and innovation performance through Meta-analysis. Through hypothesis testing, the paper proved that functional background heterogeneity and educational background heterogeneity generally promote corporate innovation performance.

Among them, the effect of educational background heterogeneity on innovation performance is significantly higher than that of functional background heterogeneity. Members of TMTs with different levels of education experience different methods of knowledge intake and educational models, leading to different ways of thinking and behaving. As a result, TMTs with higher heterogeneity in education levels have a clearer division of labor in the process of innovation investment and technology renewal strategy development, and are able to take advantage of development opportunities and contribute to corporate innovation. Functional background heterogeneity reflects the range of expertise and skills that executive members possess across the spectrum. Higher functional background heterogeneity implies that team members have diverse social resources and a wealth of expertise. Functional diversity based on the fields of expertise can help groups generate more innovative ideas and improve strategic recommendations (Daveri and Parisi, 2015; Dou et al., 2015)[2223], thus contributing to corporate innovation. Heterogeneity in educational backgrounds can provide management teams with a broader perspective and a comprehensive view, whereas TMTs with different functional backgrounds tend to be limited to their own departments and find it difficult to think in terms of overall organizational issues. It can be seen that this intrinsic difference is likely the reason why educational background heterogeneity has a greater impact on innovation performance.

Age heterogeneity inhibits firm innovation performance, but the combined effect values are not statistically significant. The special market environment may be the reason for the insignificant age heterogeneity. In addition, the development stages of enterprises in various industries in China are highly differentiated, and the relationship between age heterogeneity and innovation performance cannot be fully explained by the analysis of data based on the whole Chinese market. Neither tenure heterogeneity nor gender heterogeneity has a significant effect on firm innovation performance. According to the Information and Decision-Making Theory, tenure heterogeneity helps team members to have thought collisions in communication, stimulate innovative thinking, and promote enterprise innovation performance. At the same time, tenure heterogeneity can also lead to differences in members' familiarity and practical experience

with related businesses, which can easily cause conflicts and internal conflicts in the management decision-making process. Under the influence of these two effects, tenure heterogeneity does not have a significant impact on innovation performance. In addition, gender differences lead to different social responsibilities for women and men, with male executives tending to dominate the team. The low proportion of female executives may be the reason for the statistically insignificant gender heterogeneity in China.

The study of innovation performance by data source revealed that the correlation coefficients obtained from primary data were all greater than those obtained from secondary data. This may be due to the degree of subjectivity that inevitably exists in the process of obtaining primary data. Respondents may subjectively perceive that heterogeneous TMTs have a stronger contribution to firm innovation performance. In addition, primary data are relevant and timely, which better reflects the current development of Chinese enterprises and produces more reliable results. This may be the reason that leads to a stronger contribution of primary data.

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