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What Does a Good Top Management Team Look Like?

An Empirical Study on the Relationship between Top Management Team Characteristics and Corporate Performance in Chinese Medical Device Listed Companies

XU Wei

Doctor of Management

Supervisor:

PhD Nelson Antonio, Professor,
ISCTE University Institute of Lisbon

December, 2023



BUSINESS
SCHOOL

Marketing, Operations and General Management Department

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Abstract

China's medical device market is rapidly expanding. However, it is difficult for China investment institutions and Chinese medical device companies to effectively assess the competence of the top management team and make high-quality decisions accordingly to help the companies achieve better performance.

To solve the problems, this thesis, based on the upper echelon theory and principal-agent theory, takes the relationship between the characteristics of the top management team, R&D investment, and corporate performance of Chinese medical device listed companies as a breakthrough, selects the relevant data of 114 Chinese medical device listed companies in 2022, and draws conclusions from the research through quantitative research and case studies.

The main findings of this thesis include: for Chinese medical device listed companies, the average age, average education, and average tenure characteristics of the top management team are positively correlated with corporate performance; R&D investment has a positive impact on corporate performance; R&D investment plays a mediating effect between some of the characteristics of the top management team and corporate performance.

This thesis enriches the research gap of upper echelon theory in China. In addition, this thesis develops a competitiveness evaluation model, providing a new management application tool for Chinese medical device investment organizations and listed companies to conduct valuations and enhance corporate performance. Additionally, this thesis suggests optimizing team structures, refining training methodologies, enhancing governance, embracing global talent strategies, and augmenting investments in research and development.

Keywords: China's medical device companies; top management; corporate performance; R&D investment

JEL: A23; M1

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Resumo

O mercado chinês de dispositivos médicos está em rápida expansão. No entanto, é difícil para as instituições de investimento e para as empresas chinesas de dispositivos médicos avaliarem efetivamente a competência da equipa de gestão de topo e tomarem decisões de qualidade para ajudarem as empresas a alcançarem um melhor desempenho.

Para resolver estes problemas, esta tese baseia-se na teoria do escalão superior e na teoria do principal-agente e toma como ponto de partida a relação entre as características da equipa de gestão de topo, o investimento em I&D e o desempenho empresarial das empresas chinesas de dispositivos médicos cotadas na bolsa de valores. Seleccionamos os dados relevantes de 114 empresas chinesas de dispositivos médicos cotadas na bolsa em 2022 e retiramos conclusões da investigação através de investigação quantitativa e estudos de caso.

As principais conclusões desta tese incluem: a) para as empresas chinesas de dispositivos médicos cotadas na bolsa de valores, a idade média, a educação média e as características médias de permanência da equipa de gestão de topo estão positivamente correlacionadas com o desempenho empresarial; b) o investimento em I&D tem um impacto positivo no desempenho empresarial; c) o investimento em I&D tem um efeito mediador entre algumas das características da equipa de gestão de topo e o desempenho empresarial.

Esta tese preenche uma lacuna de investigação da teoria do escalão superior existente na China. Além disso, esta tese desenvolve um modelo de avaliação da competitividade, fornecendo uma nova ferramenta de aplicação de gestão para as organizações chinesas de investimento em dispositivos médicos e para as empresas cotadas em bolsa, que permite efetuar avaliações e melhorar o desempenho das empresas. Esta tese recomenda também, a otimização das estruturas das equipas, o aperfeiçoamento das metodologias de formação, o reforço da governação, a adoção de estratégias globais de talento e o aumento dos investimentos em investigação e desenvolvimento.

Palavras-chave: Empresas chinesas de dispositivos médicos; equipa de gestão de topo; desempenho empresarial; investimento em I&D

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摘 要

中国医疗器械市场正处于快速增长期，蕴藏着巨大的投资和发展机遇。但是中国医疗投资领域投资机构以及中国医疗器械企业存在难以有效评估高层管理团队的能力，并据此做出高质量的投资决策或管理决策以帮助企业获得更好的绩效的难题。

为解决上述难题，本论文在高阶理论和委托代理理论的基础上，以中国医疗器械企业高层管理团队特征、研发投入和企业绩效之间的关系为研究突破口，选取 2022 年 114 家中国医疗器械上市公司和3家有代表性的中国医疗器械上市公司的相关数据，通过定量研究和案例研究得出研究结论。

本论文主要发现包括：对中国医疗器械上市企业而言，高层管理团队的平均年龄、平均受教育程度、平均任期特征与企业绩效呈正相关；研发投入对企业绩效有积极影响；研发投入在部分高管团队特征和企业绩效之间发挥中介效应；作为调节变量，企业规模、资产负债率和收入增长率的调节作用不明显。

本论文丰富了高阶理论在中国医疗器械企业中的研究空白，为高层理论在中国医疗器械行业的应用提供了理论支持。此外，本论文创新性的开发出中国医疗器械企业高层管理团队特征竞争力评价模型，为中国医疗器械投资机构和医疗器械企业进行估值、提升企业绩效提供了新的管理应用工具。同时，本论文也提出了优化团队结构、培训、治理和激励机制、采用全球化人才战略以及加大研发投入等建议。

关键词：中国医疗器械企业；高层管理团队；企业绩效；研发投入

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Acknowledgments

Library of School of Economics and Management, 5th floor of Jianhua Building, Tsinghua University, Beijing, China. With the last full stop of the doctoral thesis, the time is fixed at 18:17 on 5th November 2023, and the five-year doctoral journey is coming to an end. It was a great relief, and I had a lot of mixed feelings.

First and foremost, my sincerest gratitude goes to my Doctorate supervisor, Professor Nelson Antonio. I would not have been able to complete my Doctorate thesis without the comprehensive, patient, and in-depth academic guidance I received from Professor Nelson, who provided me with strong support, demonstrated by example the depth of knowledge and keen academic insight of a management scientist, taught me to be rigorous in my studies. In addition to his research methodology and content, he revised the grammar and presentation of my 50,000-word thesis word by word, Professor Nelson is a true gentleman. Thanks to Professor Virginia Trigo, I was privileged to learn about management, values and sentiments from such an outstanding educator.

I am grateful for the warmth and guidance given to me by my teachers and elders during my 36-year-long path of study. Professor Fei Xiaotong, former Vice-Chairman of the Standing Committee of the Chinese National People's Congress and Chairman of the Central Committee of the Democratic Alliance, set an academic and moral example for me. The former President of Peking University, Professor Xu Zhihong, taught me by example how to competently fulfil the requirements of the roles of scholar, official and educator. To Professor Xu Liancang, former Director of the Institute of Psychology of the Chinese Academy of Sciences (CAS), who guided me in my doctoral career. I will always remember that in the summer of 2000 at Peking University's Teaching and Learning Centre, Professor Xu smiled and handed me one of his business cards, gently encouraging me to do my PhD at the CAS in the future, and leaving a longing for doctoral studies in my heart. Thanks to Uncle Wang Qiwen, Professor of Guanghua School of Management, Peking University, for guiding my studies over the years. I would like to thank my master's supervisor, Professor Song Lei, former Dean of the Department of Political Economy at Peking University, for his careful guidance. "Peaches and plums do not speak, but they grow their own groves underneath", Professor Song taught me how to become a qualified teacher and researcher by his own example.

I am grateful to Professor Zhang Jing of the University of International Business and Economics for patiently teaching me French and opening the door to a new world for me. I am grateful to Professor Géraldine Schmidt of the University of Paris I, France, for guiding me to enter the door of academia. I would like to thank Professor Wang Haijun, Associate Dean of the School of Public Health, Peking University, Professor Guo Xiaoling of the Department of Marketing, University of International Business and Economics, and Professor Wang Mei of the Department of Finance, WHU-Otto Beisheim School of Management, Germany, for their encouragement, support, and help in my doctoral studies. In addition, during my early years of study, my high school political science teacher, Ms. Feng, opened the door of political science and economics for me, which greatly broadened my horizons and taught me what it means to be a "teacher of high learning and a model of integrity". My primary school class teacher, Ms. Yang, was my initiator of the humanities, and she fostered my lifelong love of the humanities.

I am sincerely grateful to my father, Mr. Xu Ruping, and my mother, Ms. Hu Chengli, for giving birth to me, nurturing me, and, teaching me. Their love, spanning across time, space, and geography, has supported me to grow from a small city, to Beijing, Singapore, Paris and Hong Kong, and to grow up from a sentimental student to a corporate executive. My heartfelt thanks to my wife, Jenny, who has quietly embraced and supported me, hand in hand with each other. Thank you to my sister, Elizabeth, for helping to take care of my children during my frequent business trips abroad. I am grateful to my two lovely sons, George, and Dudu, who gave me enough motivation to move forward and extended my thesis writing time for two years, so that I could write and refine this thesis seriously and meticulously.

Sincere thanks to all those who have supported, cared, encouraged, and helped me in the writing of this thesis. "The apes on both sides of the river can't stop crying, the light boat has already crossed ten thousand mountains". In the next new stage of my life, I will shoulder more love missions and responsibilities, and continue to move forward.

致 谢

中国北京，清华大学建华楼5层，经管学院图书馆。随着博士论文的最后一个句号敲出，时间定格在2023年11月5日18点17分，历时5年的博士之旅也即将画下句号。如释重负，百感交集。

首先，最诚挚的谢意献给我的博士导师，Nelson Antonio教授。没有Nelson教授在学术上给我全面、耐心和深入的指导，我不可能能够完成博士论文。Nelson教授给予我强有力的支持，他言传身教的展示了一个管理学家深厚的学识和敏锐的学术洞察力，他细致耐心教导我应持有严谨的治学态度，除了研究方法、研究内容外，他逐字逐句修改了我的长达6万字的论文的语法和表达。Nelson教授是位真正的绅士，望之俨然，即之也温。感谢我的师娘Viginia Trigo教授/女爵士，我是何其有幸，能够向她这样一位杰出的教育家学习管理学知识、价值观和情怀。

感谢师长们在我长达36年漫长的求学道路中给予我的温暖和指导。已故原中国人大常委会副委员长、民盟中央主席、北京大学教授费孝通先生给我树立了学术和道德的榜样。原北京大学校长许智宏院士以身作则，教导我如何胜任学者、官员和教育家的角色要求。致敬我博士生涯的引路人，已故的原中国科学院心理研究所所长徐联仓教授，我永远记得2000年夏天在北大电教，徐先生从一个黑色的小名片夹里拿出一张名片，微笑着递给我，温和地鼓励我以后到中科院读博士，在我心中留下了读博士的憧憬。感谢北京大学教授、光华管理学院原党委书记王其文伯伯多年来对我学习的指导。致敬我的硕士导师，北京大学宋磊教授对我的悉心指导，“桃李不言，下自成蹊”，宋教授以身作则，教导我如何成为一个合格的教师和研究者，他指导我治学应严谨认真，以及学术品味和“大处着眼，小处着手”的风格。感谢对外经贸大学张晶教授耐心地教会我法语，为我打开新天地的大门。感谢法国巴黎第一大学的Géraldine Schmidt教授引导我真正的踏进学术之门。感谢北京大学公共卫生学院王海俊教授、对外经济贸易大学营销学系郭晓凌教授、德国WHU-Otto Beisheim School of Management 金融学系王媚教授对我博士求学的鼓励、支持和帮助。此外，在我早期的求学之路中，我的高中政治老师冯女士为我打开了政治学和经济学的门户，极大开拓了我的眼界，并教导我明白什么叫“学高为师，身正为范”。小学的班主任杨老师是我的人文学科的启蒙者，她培养了我一生对人文学

科的爱好。

衷心感恩我的父亲许如平先生和母亲胡成利女士，生我育我，教我鞠我，他们的爱，横跨时空和地域，支持我从一个小城市，到北京、新加坡、巴黎、香港，从一个稚嫩又多愁善感的学生成长为高管。衷心感谢我的太太Jenny，死生契阔，相濡以沫，携手同心，默默地包容和支持着我。感谢我的妹妹Elizabeth，在我频繁出国出差期间，帮助照顾孩子。感谢我可爱的两个儿子，乔治和嘟嘟，他们给我足够的动力前进，并延长了两年我的论文写作时间，使我能认真细致的写作和推敲本论文。

衷心感谢鼓励、支持、指导帮助我完成本论文的所有人。“两岸猿声啼不住,轻舟已过万重山”。下一个崭新的人生阶段，我将肩负更多爱的使命和责任，继续砥砺前行。

2023年11月6日 北京

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Chapter 1: Introduction

1.1 Background to the study

1.1.1 Current development of China's medical device industry

(1) Definition of medical devices in China

According to the definition in the Classification Catalogue of Medical Devices issued by the China Food and Drug Administration on 31 August 2017, Medical devices refer to instruments, equipment, appliances, in vitro diagnostic reagents and calibrators, materials and other similar or related items directly or indirectly used in the human body, including the required computer software.

Depending on the purpose of use and product performance, medical devices can be divided into categories such as medical equipment, high-value consumables, in vitro diagnostics and low-value consumables. Medical equipment includes medical imaging equipment, therapeutic and life support equipment, rehabilitation equipment and other diagnostic or auxiliary diagnostic products. High-value consumables and low-value consumables are consumable devices and equipment used for diagnosis, treatment, healthcare, rehabilitation. High-value consumables mainly include implantable or access orthopedic, cardiovascular, neurosurgical instruments and purification equipment. In vitro diagnostics refers to equipment and consumables for obtaining clinical diagnostic information, including biochemical diagnostics, immunological diagnostics, and molecular diagnostics. The Classification of Medical Devices is shown in the Table 1.1.

Table 1.1 Classification of Medical Devices

Form	Subcategory
Medical equipment	Medical imaging equipment, therapy and life support equipment, rehabilitation equipment
High-value consumables	Orthopedic implants, cardiovascular implants, ophthalmic implants, electrophysiology and pacemakers, blood purification, oral, other
in vitro diagnosis	Biochemical diagnostics, immunodiagnostics, molecular diagnostics, POCT diagnostics
Low-value consumables	Syringes, gloves, gauze, blood collection tubes

Source: China Food and Drug Administration (2017)

In addition, according to the categorization of regulatory risk, from low to high, China classifies medical devices into 3 categories according to the risk level from low to high. In

accordance with the “China Medical Device Supervision and Administration Regulations (2021)”, China adopts a filing system for the management of Class I medical devices and a registration system for Class II and III medical devices. It shows in Table 1.2.

Table 1.2 Risk Classification of Medical Devices

Form	Subcategory
Category I	Lighting equipment, passive surgical instruments, external fixation and traction instruments, general-purpose auxiliary instruments, medical equipment disinfection and sterilisation equipment
Category II	Medical dressings, medical masks, thermometers, sphygmomanometers, medical gauze decontamination
Category III	Implantable cardiac pacemakers, corneal contact lenses, IOLs, ultrasound tumour focusing knives, haemodialysis devices, implantable devices, vascular stents, comprehensive anaesthesia machines, dental implantable materials, medical absorbable sutures, intravascular catheters

Source: China National Medical Products Administration (2021)

(2) Current status of China's medical device market

China's medical device industry started late, but maintains a high growth rate. According to “China Medical Device Industry Development Report Status and Outlook of 14th Five-Year Plan (2021-2025)”, the business revenue of China's medical device industry will reach 1007.76 billion euros in 2022, and it is predicted that it will reach 1454.06 billion euros in 2025, with a cumulative growth of 197.88%, and the compound annual growth rate of 11.5% in 10 years, which is twice the growth rate of the global market. The average compound growth rate in 10 years is 11.5%, which is about two times of the growth rate of the world market. It shows in Figure 1.1.

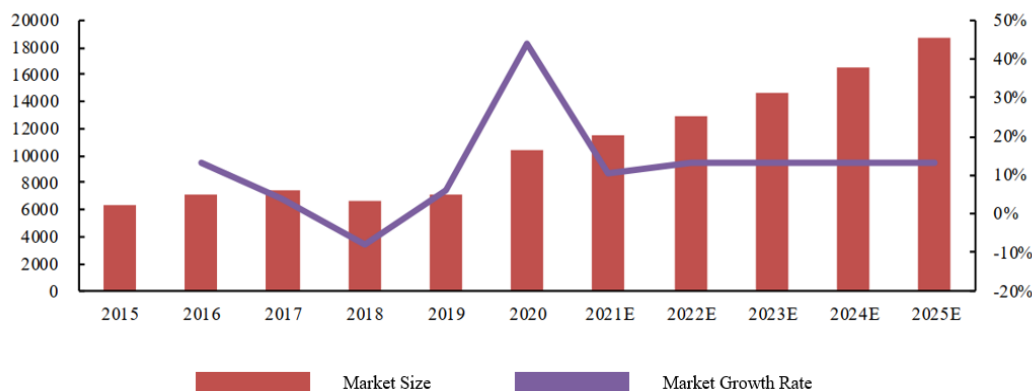


Figure 1.1 China Medical Devices Market

Source: China Medical Device Industry Development Report Status and Outlook of the 14th Five-Year Plan (2021)

(3) The competitive landscape of China's medical device market is characterized by four features:

a) The number of production enterprises has increased, and there is homogeneous

competition.

According to the data of the blue book of China 's medical device industry, by the end of 2021, there were 28,900 medical device manufacturers nationwide. There are 19,569 enterprises that can produce Class I products, 13,971 enterprises that can produce Class II products, and 2,033 enterprises that can produce Class III products. The number of Chinese medical device companies has increased, and there is a high degree of homogenization competition in the low-end market.

b) The overall revenue scale is small, and the revenue scale of some enterprises continues to grow.

Compared with the well-known Europe or the United States medical device enterprises, the revenue scale of Chinese medical device enterprises is small. According to date of wind database, in 2021, the total annual revenue of the top 10 medical device companies in the US stock market exceeded USD 200 billion, and the total annual revenue of the top 10 medical device companies in China 's A-share operating income was less than USD 10 billion. However, the scale of some leading medical device enterprises in China continues to increase. For example, Mindray Medical (300760: SZ) will have revenue of RMB 30.37 billion in 2022, an increase of 20.17 % year-on-year. On the contrary, Medtronic will have revenue of US 31.69 billion in 2022, an increase of only 5.21 % year-on-year.

c) The layout is dominated by China 's domestic market, and the foreign market share is growing.

At present, most Chinese medical device enterprises operate in China. Chinese medical device enterprises mainly export low-end products such as gloves, new corona detection reagents, masks, disinfectants, and medical dressings. However, some well-known Chinese medical device enterprises to speed up the layout of the international market, including the establishment of regional R&D centers, regional sales centers, and actively mergers and acquisitions of foreign technology medical equipment enterprises. The export volume of high-end products such as CT and cardiac pacemakers in some Chinese enterprises continues to increase.

d) Innovative enterprises with independent research and development are gradually showing their advantages in competition.

With the accumulation of technical strength of Chinese medical device enterprises, some enterprises hold a large number of patents. The competitive advantage of Chinese medical device enterprises with high-tech moat is gradually emerging, occupying the first or second position in some domestic market segments, and starting to expand abroad.

(4) Opportunities in China's Medical Device Market

China's medical device market is currently in a period of rapid growth, and the external environment is very favorable to the development of Chinese medical device companies.

a) The trend of population ageing is becoming more and more obvious, and the need for high-quality medical device products continues to increase.

According to the data from the Institute of Population Ageing of Renmin University of China, China's population aged 60 years and above will reach 280 million in 2022, and it is expected that by 2050, China's population aged 60 years and above will grow to nearly 500 million. With the increasing trend of population aging, the demand for various types of medical device, rehabilitation equipment and diagnostic equipment for the elderly will rise significantly, and there is a huge market opportunity for medical device products in China.

b) The Chinese government has introduced a number of good industrial policies to support the development of the industry.

The Chinese government has provided strong policy support in the research and development, approval and listing of medical devices. In terms of industrial planning, it has issued industrial plans such as the 14th Five-Year Plan for the Development of Medical Equipment Industry (2021-2025) and the 14th Five-Year Plan for the Development of Biological Economy (2021-2025), which have made institutional arrangements for the overall development of China's medical device industry. In terms of approval, the Chinese government has optimized the approval process and formulated approval and regulatory documents such as the *Priority Approval Procedure for Medical Devices*, the *Guiding Principles for Conditional Approval of Medical Devices for Marketing*, and the *Special Review Procedure for Innovative Medical Devices*, in order to improve the efficiency of the approval process. In terms of financial convenience, the Chinese government has formulated off government financial and tax support, financial and credit support policies such as the *Notice on Financial Subsidized Loans for Renewal and Reconstruction of Medical Devices by the National Healthcare Commission of China*, to help Chinese medical device enterprises to solve their financial difficulties.

c) The technology of China's medical device industry is gradually maturing, and some of the technologies are already ahead of others.

With the accumulation of technology of Chinese medical device enterprises, some leading Chinese medical device enterprises have matured their technology in niche markets, and their technology level has caught up with or exceeded that of famous international medical device companies in some niche fields such as CT (Computed Tomography), which provides a

technical guarantee for Chinese medical device enterprises to compete in the international market.

(5) Future Challenges and Prospects of China's Medical Device Market

a) Increased industrial concentration and fierce competition

China's low-end and mid-range medical device market is becoming increasingly homogenized with the increase in the number of enterprises, and competition is mainly focused on channels and prices. The middle and high-end market is only competing among a limited number of enterprises due to technical barriers. With the increase of M&A and restructuring among enterprises, the market will definitely eliminate part of the backward production capacity, and the industrial concentration will rise.

b) Enterprises must reduce costs and increase efficiency

The Chinese government has led a series of healthcare system reforms. From medical insurance fee control, centralized purchasing, substitution of imported products by localized products, and anti-corruption of hospitals and healthcare competent government departments from 2023, the Chinese government intends to reduce the profit margins of hospital and medical device companies, and control the cost of healthcare paid by the state and individuals. As a result, Chinese medical device companies must carry out refined management, strictly control all costs of the enterprise, and improve efficiency and output.

c) The urgency of independent innovation and independent development under the Sino-US confrontation

Frictions and confrontations between China and the United States in trade and politics are intensifying. Some of the raw materials, parts and technology of Chinese medical device enterprises are from the United States and its allies. If the intensity of confrontation between China and the United States increases, China will inevitably seek alternative sources of raw materials and alternative technologies in an all-round way, and the cooperation and technical exchanges between the two sides will also be blocked or interrupted. Therefore, Chinese medical device enterprises will inevitably solve the dependence on foreign products and technologies through independent innovation and independent research and development to ensure the stable development of the China medical device industry.

1.2 Research problem and research question

1.2.1 Research problem

The research problem of this study is to address the challenge that it is difficult for Chinese investment institutions in the field of medical investment and Chinese medical device enterprises to effectively evaluate the competency of top management teams, and make high-quality investment decisions or management decisions accordingly to help enterprises achieve better performance.

The management difficulties faced by venture capital and private equity investment in China's medical investment field are mainly concentrated in the pre-investment and post-investment management stages. In the pre-investment stage, the dilemma faced by VCs or PEs in China's healthcare corporate investment sector is the lack of sufficiently effective management criteria and tools to assess the competence of the top management team of a proposed medical device company. At this stage, VCs or PEs in the Chinese medical enterprise investment field need to select suitable medical device companies to invest in. The top management team is one of the most important subjects of investment due diligence and one of the most important bases for investment decisions. A good top management team is crucial for a company. In many cases, when a company's business model is not clear and revenue cannot be fully predicted, the configuration and competency of the top management team is one of the most important bases for VC or PE to decide whether to approve investment in a potential medical device company and what kind of valuation to give.

In the post-investment management stage, VC or PE in the investment field of Chinese medical enterprises need to evaluate the ability, stability, and development potential of the senior management team of the invested medical device enterprises from the perspective of long-term equity investment, and decide whether to adjust or how to adjust the allocation of senior executives, so as to obtain better shareholder returns and promote the development of the invested enterprises.

For Chinese medical device companies, it is a difficult task to evaluate the competency of the top management team. When the enterprise is in the start-up period or the growth period, the original top management team has played an important role in promoting. However, with the growth of enterprises, especially when enterprises enter a period of rapid development, enterprises need to be listed or develop faster and better. Internally, they need to make wiser management decisions, adjust strategies and actions in a timely and flexible manner according

to market changes; externally, it is necessary to introduce external strategic investors or financial institutions to properly handle the relationship with the government, scientific research institutions and suppliers. These demands require a highly competent top management team to organize and implement. If an enterprise wants to develop, it needs to evaluate the competency of its executive team in time, eliminate incompetent executives in time, and supplement new executives in line with the enterprise development strategy and talent strategy in time. Therefore, it is very important to evaluate the competency of top management team for Chinese medical device enterprises.

The research problem of this thesis has not been solved, there are two main reasons: Firstly, in China, there is a lack of sufficient empirical research on the relationship between the competence and performance of the top management team of Chinese medical device enterprises. The research on the relationship between top management team and performance in Chinese academic circles is more concentrated in financial and manufacturing enterprises. Since China 's medical device industry has entered a period of rapid development in recent years, the special research on the top management team of China 's medical device listed enterprises is a blank. Secondly, in the industry, VC or PE and other investment institutions and enterprises lack a special management framework and management tools, therefore, it is difficult to make an effective, comprehensive, and scientific evaluation of the competency of an executive team in a relatively short period of time, and it can only rely more on the experience and cognitive judgment of individual investors or executives. Therefore, this thesis hopes that this research question can be solved through the research.

1.2.2 Research question

The research questions of this thesis focus on the following questions: a) How does the characteristics of top management team of listed medical device companies in China affect corporate performance? b) What is the impact of R&D investment on the performance of Chinese medical device listed companies? c) What is the relationship between the characteristics of the top management team and the research investment in China 's medical device listed companies?

The top management team characteristics of Chinese listed medical device enterprises in this thesis refer to the demographic characteristics of the top management team, including homogeneous and heterogeneous characteristics; homogeneous characteristics refer to the average age, average tenure, and average education level of the top management team, and

heterogeneous characteristics refer to the age heterogeneity, tenure heterogeneity, and education level heterogeneity of the top management team.

1.2.3 Research purpose

At the theoretical level, this thesis aims to further fill the research gap of upper echelons theory in Chinese medical device enterprises by exploring the relationship between the characteristics of the top management team and corporate performance of Chinese medical device enterprises, and provide research cases and theoretical support for the application of upper echelons theory in Chinese medical device industry.

At the practical level, this thesis hopes to identify 'useful' top management team characteristics and develop simple and practical management tools that can improve the performance of China's medical device enterprises. On the one hand, it helps VCs or PEs to conduct more scientific valuation and assessment of Chinese medical device companies with reference to the characteristics of the top management team, so as to improve the quality of investment decisions and the efficiency of post-investment management decisions. On the other hand, it provides support for Chinese medical device companies, consulting institutions, and research institutions to adjust and optimize human resource strategies and scientifically configure top management teams to achieve better enterprise performance and higher shareholder returns.

1.3 Research methodology

The vast majority of top management team research methods in academia use quantitative research methods, using statistical methods to analyze the company's annual report and other public information and draw conclusions. Some of the research methods adopt the case study method, following the norms of case study and selecting representative cases to carry out the research.

This thesis adopts a mixed research method combining quantitative empirical research and case study. In the quantitative empirical research, descriptive statistics, correlation analysis, multiple regression analysis and stability test are carried out on the sample enterprise data studied. In the case study, three representative Chinese medical device listed companies were selected for multi-case study.

The advantage of quantitative empirical research is that the research is more rigorous and objective. The case study method can describe the objective facts in a real and comprehensive

way, accurately describe the characteristics of the research object, deeply analyze the causes of the problems behind the phenomenon, and effectively refine the theory. The combination of the two research methods can greatly enhance the reliability and validity of this thesis. Therefore, this thesis adopts a mixed research method combining quantitative empirical research and case study.

1.4 Outline of thesis

This thesis investigates the relationship between top management teams and corporate performance of Chinese medical device listed enterprises. This thesis is divided into five parts.

The first chapter is a basic introduction to this thesis. It mainly introduces the research background, the research problem, and the research questions of this thesis. The chapter goes on to describe the research methodology, the research purpose, and the research line of this thesis.

The second chapter is the literature review of this thesis. This part mainly discusses the main research results and research progress of upper echelons theory, principal-agent theory, R&D investment, and enterprise performance theory, which provides theoretical support for the follow-up research of this thesis.

The third chapter is the research methodology. Firstly, based on the inadequacy of existing research, on the basis of upper echelon theory and principal-agent theory, this part puts forward the research hypotheses of this thesis focusing on the relationship between the characteristics of top management team and enterprise performance of Chinese medical device listed enterprises, clarifies the research data source, and elaborates the sample selection, data source, variable design and measurement of quantitative empirical research. Then, the case sample selection and data collection of the case study are introduced in detail.

The fourth chapter is the empirical analysis. Firstly, quantitative empirical analysis is carried out, including descriptive statistics, correlation analysis, multiple regression analysis and robustness analysis. Secondly, a case study was conducted. After that, the empirical research results are explained by using the upper echelon theory and other related theories.

The fifth chapter is the research conclusion. Combined with quantitative research and case study, this part summarizes and elaborates the conclusions of empirical research. According to the research results, this part puts forward the Competitiveness Assessment Model for Top management team Characteristics of Chinese Medical Device Companies, and puts forward relevant management suggestions for Chinese medical device enterprises. Finally, the

shortcomings of this thesis are discussed and prospected.

The research roadmap for this thesis is shown in Figure 1.2.

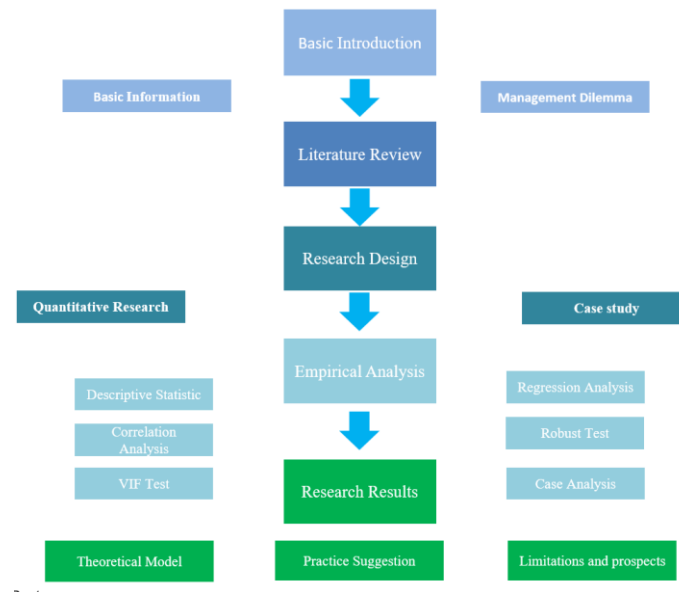


Figure 1.2 Research Pathway

Chapter 2: Literature Review

2.1 Relevant theories

The external environment for Chinese companies is changing as the confrontation between China and the United States intensifies and the war conflict between Russia and Ukraine continues. Chinese researchers Tong and Ju (2022) conducted a systematic study on the external environmental factors of China's economic development, and concluded that the world situation is increasingly developing towards regionalization and anti-globalization. L. Ma and Wang (2023) analyzed the impact of the Russia-Ukraine conflict and global political and economic transformation on Chinese enterprises and concluded that the Russia-Ukraine war has increased the risk of the global industrial chain. Changes in the international order and national development paradigm will continue for decades. Being on the frontline of the confrontation between the two camps of the East and the West, changes in geopolitics and the logic of global governance make the survival and development of Chinese enterprises face more uncertainties. Therefore, it is difficult to rely solely on individual managers to solve the challenges encountered in business operations. Under the current situation, it is even more necessary to have a strong management team to make high-quality decisions in a timely and efficient manner, so as to ensure the safety and development of the enterprise.

This thesis provides an overview of upper echelons theory, cross-cultural situational modeling, and principal-agent theory to provide a theoretical foundation for empirical research.

2.1.1 Top management team

To study the top management team, we first need to deeply understand the concept of the team. Kur (1996) make a persuasive view, they summarize five common team models, in their eyes, they believe that team is a unique open model. The primary value of team existence is to actively face the changes of external environment and internal environment. As a group, team members have the same goal and complement each other for the same goal. There are high trust, high commitment, and high collaboration among team members around the same mission. The team will use one face and randomly take another face according to the situation.

Nahavandi (2015) has also been widely accepted in the academic community for his view

that the team has five salient features: a) within the team, there are consistent goals. Whether there is a consistent goal is a sign to distinguish between teams and groups. Team members work together to develop consistent goals, and around the goal, work together to achieve the goal; b) responsibility is one of the core values of the team. Within the team, members are highly encouraged to have a high sense of responsibility and strive to achieve team goals; c) high trust. Team members have a strong sense of internal trust and work together around the team's mission; d) combination of collective leadership and self-leadership. Give full play to the advantages of collective leadership and self-leadership in decision-making; e) integration effect. Teams focus on the common goal of the organization, do their best, and play the overall effect to achieve the goal.

The study of teams naturally shifted to the study of the top management team that leads the teams. In 1960s, Cyert and March (1963) creatively put forward the concept of top management consortium in the book "Corporate Behavior Theory", the top management consortium refers to a common association of managers teams with strategic decision-making functions within a company, which is the first concept of top management team in academia. After Hambrick and Mason (1984) put forward the upper echelons theory, the concept of top management team began to spread widely in academia and industry. The concept of top management team has its specific historical background. In the 1970's, the model of large-scale diversified multinational companies was in the ascendant. At this stage, the scale of large multinational companies was far smaller than that of current multinational companies, and the diversification of business was not high and relatively simple. Therefore, during the 1970-1990 period, academic research focused more on senior managers. Murray (1989) study the relationship between the composition of top management team and corporate performance. During this period of research, CEO is the main research object. This is because the CEO is the main leader of the company and plays a key decisive role in the company's business decision-making. The relevant demographic characteristics have a significant impact on the CEO's values, attitudes, and behavioral tendencies, which in turn affect the company's operations.

After 1990, the trend of globalization is becoming more and more obvious. The change of enterprise strategy leads to the complexity of organizational structure and the increase of management levels within the organization. During this period, the scope of the concept of top management team extended from CEO to management team members with strategic responsibilities. Through research, K. G. Smith et al. (1994) pointed out that the scope of executives should not be limited to CEOs. Managers who have important responsibilities in the company and are qualified to participate in the formulation of strategic decisions should be

included in the category of senior managers, including the company's general manager, deputy general manager, financial director, and board secretary of listed companies. Reger (1997) defines the top management team as "a group of senior managers who are at the highest strategic formulation and implementation level of the enterprise, responsible for the organization and coordination of the entire enterprise and have great decision-making and control over the operation and management of the enterprise". Reger's concept is generally accepted by the academic community.

The top management team sampling standard is also a standard for judging the scope of top management team members, although there is no unified and convincing view of this standard in academia. Hambrick and Mason (1984) selected all senior managers as the sample range of the top management team in their study. Elron (1997) sampled executives from the CEO to the senior vice president level. Krishnan et al. (1997) believed that the top management team refers to "the CEO, the president, the chief operating officer, the chief financial officer and the next level of the highest level of personnel". Dwyer et al. (2003) have a new view on the definition of the top management team. They do not agree that the scope of the top management team is limited to senior managers. They further propose that the sampling scope of the top management team also needs to include the company's middle managers, because middle managers also play an irreplaceable role in the company's strategic decision-making and specific operations.

There are two types of Chinese scholars' research on the scope of executives. The first is to follow the definition of the scope of senior managers in Article 216 of the *"Company Law of the People's Republic of China"*. The *"Company Law of the People's Republic of China"* revised in 2018 clearly defines the scope of China's top management personnel in Article 216: *"top management personnel refer to the company's managers, deputy managers, financial leaders, board secretaries of listed companies, and other personnel specified in the articles of association"*. In the *"Company Law of the People's Republic of China"*, a separate agreement on the terms of the controlling shareholder and the actual controller is formulated, pointing out that the chairman or executive director does not belong to the scope of the top management team. This is because legislators believe that the company's specific strategy formulation and operation are performed by professional managers appointed by the board of directors. Senior managers are fully responsible for the specific operation of the company according to the authorization requirements of the chairman or the board of directors, while the role of the chairman or executive director is only as the owner of the company and does not participate in specific business. J. T. Wang and Zhang (2023) believed that senior managers include the

general manager, deputy general manager, chief financial officer and other personnel stipulated in the company's articles of association.

Another part of Chinese researchers put forward a new concept of top management team based on the current situation of Chinese state-owned enterprises. Cui (2022), through the study of senior managers of state-owned enterprises in China, believes that senior managers include the party secretary of the Communist Party of China in the company, the deputy secretary of the party committee of the Communist Party of China, the secretary of the disciplinary inspection committee of the Communist Party of China, and other senior managers. C. F. Ma (2006) believes that senior managers are a small group, composed of general managers, deputy general managers and senior managers with corporate control and decision-making power. Her views are essentially more focused on substantive control and decision-making power, rather than formal executives without power.

At present, there are three mainstream methods to define the top management team in practical research, these three methods have their own advantages and disadvantages, so they need to be selected in combination with different research questions and research situations. The first method is the questionnaire method. After the questionnaire is sent to the sample enterprise, the chairman or CEO of the sample enterprise judges who is the top management team member of the enterprise. This method is very direct. The chairman or CEO has sufficient understanding of the personnel of the enterprise. It is easy to judge the top management team member with real power and influence. However, the drawback of this method is that the chairman or CEO of the surveyed company is crucial to the determination of qualified executives. If the scope of the executives identified is limited by their cognition, it is easy to deviate from the sample selection, because in Chinese enterprises, the chairman or CEO often arranges a person to serve as the title of the executive for the purpose of appeasement. In fact, this person is just a vanity name and is not at the center of power in the mind of the chairman or CEO.

The second method is the interview confirmation method, which is specifically conducted by the researchers to conduct in-depth interviews with the chairman or general manager of the sample company. After a comprehensive understanding of the company's situation, the researchers determine the scope of the top management team based on the interview results. This method can effectively prevent the possible cognitive bias of the chairman or CEO of the company under investigation. The disadvantage is that it takes a lot of time and requires a high degree of cooperation from the chairman or CEO of the company under investigation. Many of the chairman or CEO of the company under investigation are busy and cannot cooperate well.

The third method is the title determination method, which judges the position and rank of the members of the top management team through the personnel roster, HR records and other information. This method is very convenient in operation. In fact, it is also a commonly used survey method in the field of management consulting in the industrial field. The disadvantage is that there is a larger potential for error if this method does not incorporate the specifics of the sample being investigated. For example, in China's state-owned enterprises, the Secretary of the Party Committee of the Communist Party of China (CPC), the Deputy Secretary of the Party Committee, the Secretary of the Discipline Inspection Committee, the Chief Engineer, the Chief Accountant, and the Chairman of the Labor Union of the enterprise in which they are located are all senior executives. Objectively speaking, at present, there is no standardized and unified selection standard in the operation method of defining the scope of top management team in academia, which may have an impact on the reliability of relevant empirical research results. In the future, it is necessary to define the scope of top management team more clearly to ensure the reliability and validity of the research.

To sum up, the concept and sampling criteria of the top management team are relatively mature in theory, but there are some differences in the scope of the top management team in specific countries. Follow-up research may need to further combine the research issues to carry out empirical research.

2.1.2 The upper echelons theory

Top management team is the core subject of enterprise strategy formulation and implementation. McCain et al. (1982) proposed to use demographic variables such as age, tenure, and education to study the overall stability of the top management team when studying the personnel change rate. Hambrick and Mason (1984) extracted the upper echelons theory with milestone significance through research. The upper echelons theory mainly studies the top management team and introduces the research on senior managers into a new field.

The core of upper echelons theory is to focus on executives' cognition and values, and the impact of the relationship between executives' cognition and values on the strategic choice process and final performance results. According to the research of Hambrick and Mason (1984), the main points of upper echelons theory include: first, the top management team plays a very important role in the organization. A comprehensive and in-depth understanding of the top management team is the basis for understanding the organization's operating picture and operating mechanism; secondly, the top management team makes strategic decisions according

to its own value system and cognitive model. The background characteristics of the top management team, including educational background, tenure, socio-economic foundation, financial status, can affect strategic decisions and strategic choices, thus affecting the company's performance; thirdly, for the top management team, the overall characteristics are more likely to predict the performance of the organization than individual characteristics such as CEO; fourth, demographic variables are more operational than psychological variables such as cognition and values. These views are very representative and influential and are quickly accepted by the academic community.

The upper echelons theory focuses on the influence of the overall characteristics of the top management team in the organization on the strategic decision-making of the enterprise and then on the performance of the enterprise.

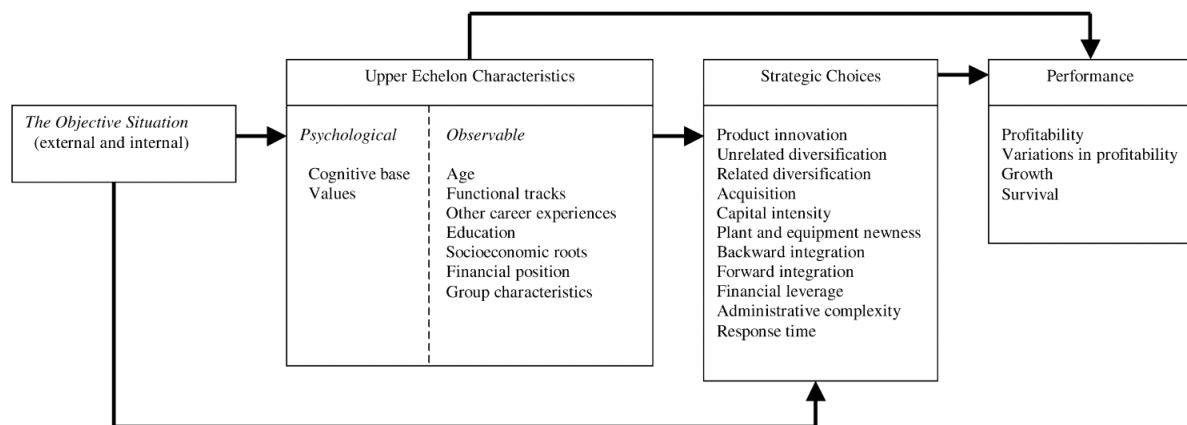


Figure 2.1 Upper echelons perspective of organizations

Source: Hambrick and Mason (1984)

Hambrick and Mason (1984) proposed the classical model of the upper echelons' theory. Figure 2.1 illustrates this theoretical model; the left side shows the internal and external conditions of the organization. Then, according to the upper echelon's theory, the characteristics of top management team can be divided into two categories. The first category is psychological characteristics. Objective characteristics such as age, functional background and educational experience are regarded as proxy variables of psychological structure. The second category is demographic characteristics. These characteristics together shape the team's interpretation of the internal and external conditions of the organization, and have an impact on the formulation of appropriate strategic choices and corresponding performance. The psychological characteristics and demographic characteristics of executives are intertwined and work together on strategic decisions. This is because when executives are making decisions, executives are facing a dynamic and complex environment. Executives' judgment of the

environment is limited by the demographic characteristics of the top management team, such as the age, education background, tenure. On the other hand, the values and cognition of executives will also directly affect the strategic choice at the time of decision-making. When executives are stimulated by a large amount of information in the internal and external environment of the organization, the processing mode of the internal and external information input by the members of the top management team is based on the psychological cognitive structure of the executives themselves. Their psychological preferences determine which part of the environment will be more valued by executives, which in turn affects strategic decision-making behavior. This model vividly shows the whole picture of the relationship between top management team characteristics, strategic choices, and corporate performance, and has been cited by a large number of subsequent studies.

Based on the existing research results, Hambrick (1994) improved the original upper echelons theoretical model, strengthened and improved the research on the internal operation structure and process of the top management team, and explained the three factors that affect the operation process of the top management team, such as the composition, structure and process of the top management team. The composition of the top management team refers to the characteristic variables such as age, educational background, and tenure of the team members. The team structure refers to the responsibility and power structure within the organization. The internal operation process of the team refers to the cooperation, information sharing and conflict management among the top management team members. Hambrick (1994) improvement of the upper echelons' theory has been widely endorsed and supported by the academic community because he proposed the concept of behavioral integration of the top management team. The concept of behavioral integration of the top management team emphasizes the interaction and integration of behaviors among top management team members. This upgrade provides a good fulcrum for subsequent research, and subsequent researchers have carried out a series of studies on this basis.

Some scholars use multi-perspective methods to continuously improve the upper echelons theory from the perspective of demographic characteristics. Cho et al. (1994), in their study on the effects of top management team characteristics on competitive behavior in the U.S. airline industry, described the process of top management team operation in a more standardized and rigorous way. Finkelstein and Hambrick (1996) collaborated to develop the concept of "behavioral integration", pointing out that characteristics such as age, function, and education play a very important role in the day-to-day business and managerial behaviors of executive team members, and that these characteristics continue to dynamically affect organizational

performance, which is a good modification of the upper echelons theory. Behavioral integration refers to the collective interaction between members of the TMT team (Top management team, similarly hereinafter) in terms of thoughts and actions, and the variables at the top management team level and the variables at the individual executive level directly affect the behavioral integration of the TMT team. Lenderman (1996) further refined the upper echelons theory by expanding the boundaries of the study on the key role of CEO leadership, proposing team composition, team structure, team motivation process, and other key factors of team operation, and finding that variables such as organizational strategy, organizational size, organizational scope, and organizational management margins are strongly correlated with the overall business performance of CEO management.

Moreover, part of researchers have extended the upper echelons theory by focusing on team compositional characteristics and behavioral performance from the top management team level. Amason (1996) examined the effects of demographic characteristics and mutual interactions of top management team members on organizational performance from the perspective of organizational conflict. Mooney and Sonnenfeld (2001) investigated the mechanism of cognitive conflict influence, they proposed that behavioral integration can serve as a moderating variable in the study of executive strategic decision making, team heterogeneity, and cognitive conflict. Hambrick et al. (2005) introduced the study of job demands after researching the job demands of executives, and found that job demands are influenced by managers' own job expectations in the individual dimension, and by the challenging nature of the job and the pressure of organizational performance in the organizational dimension, and that job demands have an impact on strategic demands. Mou and Lou (2016) showed that the organizational characteristics of the top management team have an important impact on the strategic choice of the company, and there is a positive correlation.

Several researchers have focused on the possible moderating variables between demographic characteristics and firm performance. Wiersema and Bird (1993) examined the personal characteristics of executives such as values and cognitive abilities, and paid attention to the mechanism by which organizational performance is affected by different ethnic and cultural differences. Richard and Shelor (2002) examined the effects of differences in racial diversity, culture. on organizational strategic decisions and business performance, the study found that there is a curvilinear relationship between the age heterogeneity of the top management team and the sales growth rate, age heterogeneity and return on assets show a negative correlation, race and culture play the role of moderating variables.

In addition, the research boundary of the moderating variables is also greatly extended. In

addition to the scope of the country, it also discusses the influence of variables such as industry differences and enterprise resource endowment differences, which greatly enriches the research on the relationship between the demographic characteristics of the top management team and corporate performance. For example, Miao (2020) studied the relationship between top management team heterogeneity and financial performance based on the data of listed companies in China's coal industry from 2009 to 2018. On this basis, earnings management was further added to analyze the moderating effect of earnings management on the correlation between top management team heterogeneity and financial performance. Chen et al. (2018) took 152 small and medium-sized listed companies in China as research objects and used multiple regression analysis to empirically analyze the relationship between top management team heterogeneity and corporate performance.

Furthermore, the study of TMT diversity from the perspectives of gender and culture is also one of the key directions for the improvement of upper echelons theory. Dwyer et al. (2003) have examined the impact of gender diversity on the performance of firms in terms of management and business performance, and also found that cultural diversity moderates business performance (Dwyer et al. , 2004). By Buyl et al. (2011), taking 33 IT listed companies in the Netherlands and Belgium as objects, this paper studies the moderating effect of CEO characteristics on TMT functional diversity and corporate performance from the characteristics of CEO's functional background, CEO founder identity and CEO's interaction with other executives. The results show that CEO characteristics have a moderating effect. Chinese researchers W. W. Li et al.(2023) used Meta-analysis method to empirically test the impact of TMT task-related faultiness on corporate performance, and used Meta-regression analysis method to examine the moderating effects of market environment, national culture and other moderating variables on the above relationship. The study found that TMT task-related faultiness have a significant role in promoting corporate performance. In a stable market environment and large-scale corporate context, TMT task-related faultiness is more conducive to improving corporate performance. Top management team social categorization fracture zones can better promote firm performance in turbulent market environments and collectivist national cultural contexts.

These series of studies on the upper echelons theory fully show that this theory has been widely accepted by the academic community. The upper echelons theory has become a mature management theory. The focus of research is on the theoretical improvement of higher-order theory from multiple perspectives.

In addition, the study of the upper echelons theory introduces a new and important

perspective, that is, the integration of the upper echelons theory and other organizational theories. Carpenter and Fredrickson (2001) believe that the integration of the upper echelons theory and the agency theory can better reflect the internal relationship between the top management team and strategic decision-making, which is conducive to the improvement of corporate performance. Carpenter et al. (2004), after summarizing and analyzing the results of research prior to 2004, objectively analyzed the defects of the upper echelons theory and the principal-agent theory, emphasizing that the upper echelons theory and the principal-agent theory should be integrated, and the adjustment variables should be integrated through the agency theory. Mainly based on two reasons: first, from the perspective of research objects, the influence of executives' preferences and personality on corporate performance is the cross space of two theoretical studies. Second, upper echelons theory and agency theory are complementary in research content. The upper echelons theory focuses on the influence mechanism of the demographic characteristics of the top management team on the company's strategic decision-making behavior and strategic goal achievement. The core of the agency theory is to study the rationality of the corporate governance structure through the agency problem between the owner's shareholders and the top management team as the operator. Collins and Clark (2003) summarized the theory proposed by Carpenter, which is called multi-theory integration model.

The multi-theory integration model shows that some pre-order variables will affect the demographic characteristics of the top management team, including external environmental characteristics such as external shareholders and external manager markets, as well as internal organizational factors such as corporate attributes, board of directors and management characteristics. For example, due to their own preferences, the controlling shareholder arranges board members or top management team members, and the management philosophy and values of the new executives who entered the board of directors or senior management position are similar to those of the controlling shareholders. In addition, organizational output will also lead to the reverse impact of the pre-order variables on the demographic characteristics of the top management team. For example, when companies pursue expansionary strategies or strategic changes, it is more necessary to introduce highly heterogeneous top management teams into the top management team, because highly heterogeneous top management teams often provide a diversified vision and have stronger innovation capabilities and market expansion capabilities.

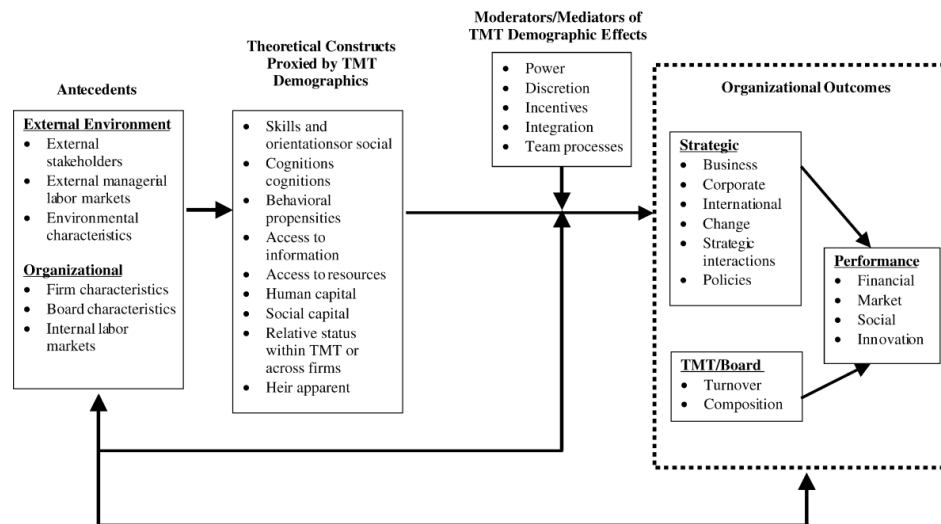


Figure 2.2 Stylized model of the upper echelons perspective

Source: Carpenter et al. (2004)

The multi-theoretical integration model believes that not only the demographic characteristic variables have an impact on the characteristics of the top management team and organizational performance, but also some insignificant influencing factors, such as the composition of the board of directors and the status quo of the industry. Sometimes the company's own situation will affect the demographic characteristics of the top management team in the opposite direction. For example, when a small and medium-sized enterprise hires and appoints executives, intending to hire executives from Fortune 500 companies often have concerns about the size and development prospects of the company when they join. Companies will also have more considerations when hiring executives from Fortune 500 companies. The multi-theoretical integration model is an important improvement and upgrade based on the upper echelons theory. It provides a more comprehensive overview of the external factors affecting the top management team and the factors affecting the characteristics of the top management team, and more clearly shows the relationship between the demographic characteristics of the executive team and corporate strategy and corporate performance.

Retracing the evolution of upper echelons theory from 1984 to the present, three prominent contributions of upper echelons theory can be identified. The first contribution is to provide a new theoretical perspective for the management community. Prior to the upper echelons theory, the research object of executive research was individuals represented by CEO, and the upper echelons theory pioneered the management team as the research object, opening a new research field (MacCurtain et al., 2010). The application of upper echelons theory is extensive and keeps pace with the times. Subsequent researchers have a lot of research on upper echelons theory and keep pace with the times. For example, in the most popular field of low-carbon management

research, Chinese researchers Yu and Xu (2023) used the upper echelons theory to conduct an empirical study on the relationship between female managers and the carbon trading level of listed companies. It can be seen that the influence of the upper echelons theory is broad and far-reaching.

The second contribution of upper echelons theory is to focus on the objective characteristics of top management team. Because some characteristics of executives such as cognition and values are difficult to measure, and executives often decline to participate in measurements for reasons of precaution or time, nevertheless, upper echelons theory solves this problem quite neatly. The upper echelons theory cites previous demographic studies, indicating that demographic characteristics can be used as proxy variables for cognition, values, and perception. Demographic indicators, despite some noise, are easier to measure than psychological characteristics. Nowadays, implicit association test (IAT) is often used to measure the psychological characteristics of executives, such as implicit attitude, in psychology. Implicit association test is a classical and widely used psychological measurement method. Based on neural network model, it mainly uses reaction time as the measurement index. The subjects are assigned specific measurement tasks by computer program, click on the measurement concept words and attribute words on the computer, and measure the implicit social cognition such as implicit attitude of the subjects through the reaction time of the concept words and attribute words and the connection between the two. Although this method can effectively measure implicit social cognition, it is time-consuming and labor-intensive. In particular, the measurement of the top management team is more likely to be resisted by the top management team, and the demographic indicators well avoid this problem, which provides a new research idea for management research.

The third contribution of upper echelons theory is to expand to the multi-theoretical integration perspective for research. The multi-theoretical integration model firstly expands the scope of factors influencing the demographic characteristics of the executive team to include external environmental factors such as the managerial market; secondly, it enriches the research variables by adding moderating and buffering variables such as power allocation, incentives, and integration, as well as demographic variables such as cognition and social capital, which are related to firm performance; and it measures organizational performance from the perspectives of corporate strategy, composition of the executive team, and board of directors' replacement from multiple perspectives to measure organizational performance.

Chinese researchers Q. Wang and Li (2015), and X. P. Zhang and Shi (2020) gave a very comprehensive overview of the defects of upper echelons theory, they concluded that upper

echelons theory have five main shortcomings. First, demographic characteristics have some noise in data collection, which has a certain impact on the reliability and validity of the study. Second, the upper echelons theory and the top management team are often confused in research. The upper echelons are hierarchical, and the top management team includes both CEOs and other executives. The hierarchical differences between CEOs and other executives are not easy to reflect. Thirdly, due to the constraints of research methods and research techniques at that time, the measurement of psychological characteristics such as cognition and values that affect the value choice of top management team has not been fully considered. Therefore, subsequent researchers, including Hambrick, have proposed new theories and models to enrich and improve upper echelons theory. Fourth, the upper echelons theory does not consider the influence of mediating variables, moderating variables, and other factors on the research of top management team. Therefore, researchers have improved in subsequent studies, such as Auh and Menguc (2005) introduced inter-functional synergy as a moderating variable into the relationship between organizational performance and Top Management Team (TMT) diversity. Fifth, the current upper echelons theory ignoring the consideration of the interaction process between the top management team, because only a detailed study of the interaction between the top management team, communication, discussion process, in order to more accurately grasp the characteristics of the top management team on strategic decision-making and even the impact of corporate performance. Hence, the shortcomings of upper echelons theory need to be taken into account and circumvented in the design of subsequent studies.

2.1.3 Cross-cultural context model

Demographic attributes, values, national culture, and other factors will affect the relationship between demographic characteristics and organizational results. In the traditional research of top management team, most of them take American enterprises as the research object, while European and Asian enterprises are not the research focus. Wiersema and Bird (1993) introduced cultural background as a moderating variable in the research of top management team and constructed a cross-cultural context model. By studying the top management team of Japanese enterprises, they found that the heterogeneity of age, team tenure and university reputation has a significant correlation with team turnover rate. And it is stronger than the same research in the United States in terms of data, indicating the impact of cultural background on demographic characteristics. This research conclusion has greatly inspired the follow-up researchers. Researchers have carried out a lot of research on the role of moderating variables

in demographic characteristics and organizational performance. Brock (2005) analyzed the mergers and acquisitions of international enterprises and found the role of cultural relevance in international mergers and acquisitions.

Weber and Hsee (1998) studied the risk investment decisions of participants in the United States, Germany, China and other countries, and found that differences in cultural backgrounds lead to differences in cognitive decision-making of venture capital. X. P. Yang (2021), a Chinese researcher, takes 477 companies listed on Shanghai and Shenzhen A-shares in China from 2013 to 2017 as research objects, and measures the relationship between top management team characteristics and corporate social responsibility and corporate value from four aspects: cultural level, overseas background, academic experience, and average age. The study believes that corporate value is positively affected by corporate culture. H. L. Ma (2017) studied the impact of corporate culture of Chinese joint ventures on top management teams and organizational performance. Joint venture is a special form of enterprise in China. Many industries in China, such as food, telecommunications, petrochemical, automobile, and other industries, cannot be directly invested by foreign investors, so they must be established by foreign investors and a local Chinese enterprise. Research shows that corporate culture has a great impact on the behavior and cognition of Chinese joint venture managers.

According to the cross-cultural context model, national cultural background has an impact on organizational performance. This study is aimed at China's medical device listed companies. The source and education level of the top management team of medical China device companies are more diversified than those of China traditional manufacturing enterprises, and the international cultural characteristics are more significant, therefore, the impact of cultural context on organizational performance must be considered in subsequent research.

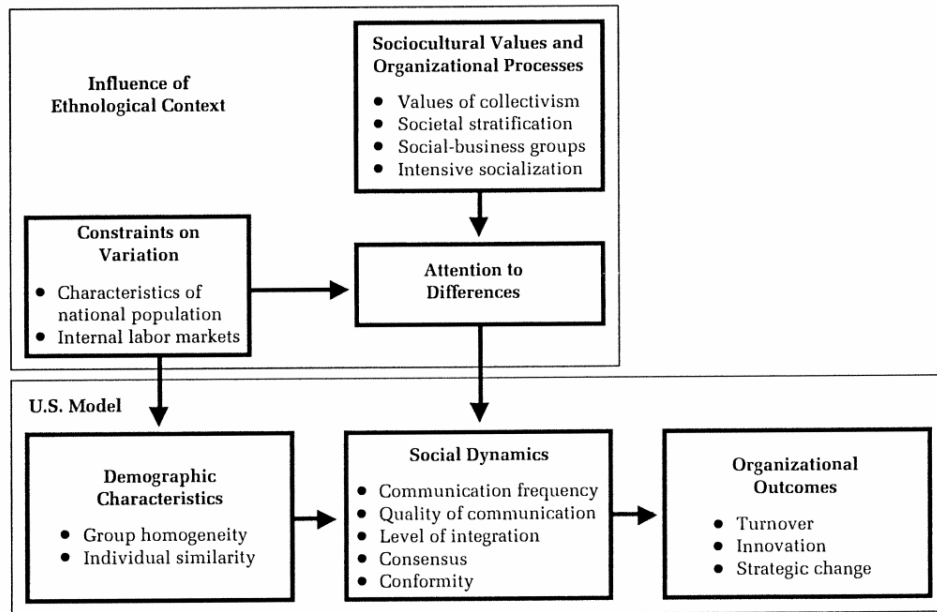


Figure 2.3 The influence of ethnological factors of organization demography

Source: Wiersema and Bird (1993)

2.1.4 Principal-agent theory

There are two mainstream theories to explain the influence mechanism of corporate executives on corporate strategy and performance. The first is Hambrick and Mason 's upper echelons theory, the second is the principal-agent theory.

The Principal-agent theory points out that the principal in order to obtain better returns, through the formal or informal contract form, entrusted the agent as a proxy within the scope of the contract agreed upon powers, the principal according to the contract agreed upon performance to pay the agent the corresponding return, thus forming a principal-agent relationship. The principal has an advantage in terms of capital and resources, the agent has a professional advantage in terms of experience and ability, the agent on behalf of the principal to exercise the rights and responsibilities agreed in the contract. The principal and the agent cooperate to obtain better returns (Grinyer & McKiernan, 1990).

The principal-agent theory in the modern sense has evolved from the 1970's to the present. Ross (1973) put forward the concept of principal-agent relationship. He believed that when the agent performs some decision-making power on behalf of the principal, the agency relationship arises. Frank et al. (1983) defined principal-agent relationship as a contract under which an agent performs certain services for the principal and is paid accordingly. Pratt and Zeckhauser (1985) pointed out that as long as one person entrusts another person to act, the principal-agent relationship is formed. The party taking action is the agent, and the party affected by the action

is the principal. Since the interests of the principal and the agent are often not the same, there may be the possibility that the agent may harm the interests of the principal for its own interests. Jensen and Meckling (1976) put forward the concept of agency costs, pointing out that it is easy for the principal and the agent to have an uncoordinated agency relationship, and that there is an economic cost of agency.

Due to the existence of agency costs, it is very necessary to establish an effective monitoring and incentive mechanism to reduce agency costs. Reinganum (1981) established a dynamic game model that can effectively incentivize agents to achieve optimal game outcomes while maintaining a long-term friendly and cooperative relationship. Laffont and Martimort (2009) advocate the establishment of an incentive mechanism in the principal-agent framework, where an incentive system that rewards high levels of effort outcomes can enable agents to pursue the goals set by the principal.

Chinese scholars have done some research based on the principal-agent theory. Yao (2022) studied how the owners of technology-based enterprises, as principals, motivate agents through institutional optimization from the perspective of equity incentives. Due to the large number of the phenomenon of two-in-one in Chinese enterprises, J. Hao (2022) discussed the effect evaluation and performance improvement of the "two-in-one" of the party secretary and chairman of the state-owned enterprises in China based on the principal-agent theory. These studies still failed to fully consider the impact of demographic and governance environment on corporate performance.

Overall, the principal-agent theory clarifies the principal-agent relationship while recognizing the existence of principal-agent costs. A proper principal-agent relationship can benefit both the principal-agent and vice versa. With the changing times, managers in the 21st century are more likely to need reasonable returns in the principal-agent relationship, which requires better design and implementation of monitoring and incentive mechanisms.

2.1.5 Summary of relevant theories

The upper echelons theory takes the top management team as the research object, and examines the influence of the characteristics of the top management team on the strategic decision-making and even the business performance of the enterprise. The principal-agent theory focuses on the agency problem between shareholders and managers and the rationality of corporate governance structure. According to the cross-cultural context model, demographic attributes, values, national culture, and other factors will affect the relationship between demographic

characteristics and organizational results. The current changeable external environment has an important impact on the survival and development of Chinese enterprises. Chinese enterprises need to match the governance structure in the development, and rationally allocate the board of directors and top management team to have an important impact on the business performance of enterprises.

Jensen and Zajac (2004) put forward that upper echelons theory and principal-agent theory are very excellent theories, and there are a large number of cutting-edge research results in each other's research field. However, upper echelons theory and principal-agent theory are difficult to fully explain the impact on enterprises independently. The research of upper echelons theory emphasizes more on demographic characteristics and ignores the impact of governance environment on the top management team. The principal-agent theory focuses on the analysis of corporate governance results, and the research focuses on the maximization of shareholders' interests and the protection of managers' team interests. Therefore, the distribution of board seats, voting rights, and voting power are the center of attention of agency theory. For example, the chairman and CEO are held by one person or two independent individuals, the role of the board of supervisors, and the role of independent directors, although the research of principal-agent theory attaches importance to the governance environment of senior executives, it often does not fully consider the demographic characteristics of the top management team, such as education, age, gender, social values, and functions. Thus, this thesis attempts to integrate the upper echelons theory, cross-cultural context model and principal-agent theory to form the theoretical basis of the research topic.

2.2 Top management team characteristics and corporate performance

This thesis focuses on the influence mechanism of the characteristics of the top management team of Chinese medical device enterprises on enterprise performance. The characteristics of the top management team can be divided into demographic characteristics and psychological characteristics. Because the quantitative measurement of demographic characteristics is easier to operate and the research is more convenient, this study chooses demographic characteristics for research. Enterprise performance is one of the core concepts and research hotspots of management. Venkatraman and Ramanujam (1986) pointed out that enterprise performance is a set of core index system used to comprehensively measure and evaluate the performance of enterprises, and also as a reference target system for the direction of enterprise operation. Currently, there is a lack of sufficient academic research on the influence mechanism between

executive team characteristics and corporate performance in Chinese medical device companies, so the research in this dissertation has strong practical and academic value.

2.2.1 The homogeneity and heterogeneity of top management team characteristics

The demographic characteristics of the top management team in the existing research mainly include gender, age, education level, tenure, and other factors. The demographic characteristics of the top management team are divided into two dimensions: homogeneity and heterogeneity. The homogeneity of top management team characteristics refers to the convergence of individual characteristics, values, and important attitudes of top management team members. In research practice, homogeneity is used to measure the average level of top management team. The heterogeneity of TMT characteristics means the degree of differentiation among TMT members, including empirical differences and cognitive differences (Carpenter et al., 2004). Homogeneity reflects the common attributes of each unit in the whole, and heterogeneity reflects the degree of characteristic difference of all individuals.

The homogeneity of the top management team is more suitable for solving the daily business problems of the enterprise, because similar background and experience can reduce the communication barriers between the top management teams and make it easier to communicate. At the same time, the members of the top management team have similar feelings and views on dealing with problems in terms of values and thinking patterns, which is conducive to increasing the overall recognition and cohesion of the top management team (Huang et al., 2011). However, due to the excessive convergence of thinking among top management team members, it often leads to blind areas of group thinking, loss of sensitivity to the surrounding environment and missed business opportunities. Therefore, in a relatively simple environment, the homogeneity of the top management team leads to more efficient communication, which significantly contributes to the improvement of corporate performance.

Heterogeneity is more suitable for solving special and unconventional problems (Mei & Xu, 2012). In a relatively simple environment, the homogeneity between the members of the top management team can improve the efficiency of internal communication of the top management team, which is conducive to improving the performance of the organization; in a relatively complex environment, the heterogeneity among top management team members can enhance the flexibility and diversity of strategic decision-making and can also help enterprises improve business performance. Due to the differences in the industry and the differences in research objects, it is not possible to simply evaluate whether the homogeneity and

heterogeneity of top management team members are good or bad, and it is necessary to comprehensively combine specific industries and scenarios for specific analysis.

This thesis combines the characteristics of the top management team members of Chinese medical device companies and conducts research from the dimensions of homogeneity and heterogeneity.

2.2.2 Enterprise performance

Enterprise performance can be viewed from two levels: the financial level of enterprise performance is based on the company's financial index system as the evaluation index of the company's operating performance. Common financial indicators include operating income, net profit, return on investment, sales growth rate, stock price. Corporate performance at the strategic management level includes financial performance, business performance and organizational effectiveness. Financial performance is to reflect the business results of the enterprise in the form of financial indicators; on the basis of financial performance, from the perspective of strategic operation, business performance expands the indicators that can improve business performance, including ROE (Return on Equity), IRR (Internal Return Rate), repurchase rate, Tobin's Q (Tobin's Q Ratio) and other indicators. Organizational effectiveness is a higher level of performance, including not only financial performance and business performance, but also a comprehensive consideration of the impact of stakeholders, more comprehensive, involving the company's brand goodwill, customer satisfaction, social responsibility (Venkatraman & Ramanujam, 1986).

Different researchers choose performance measurement indicators from different dimensions. Finkelstein and Hambrick (1990) used the ROA (Return on total assets) to study corporate performance. In recent years, some Chinese researchers have chosen ROA (return on total assets) and ROE (return on equity) as performance evaluation indicators (Z. N. Liu, 2022; L. C. Wang, 2022). Generally speaking, enterprise performance is essentially the result index of enterprise strategy and enterprise goal, and enterprise performance should be evaluated objectively from multiple indicators and multiple dimensions. From the perspective of the measurement results of enterprise performance, the financial index data is relatively perfect, easy to obtain, easy to quantify, convenient to compare, and easy to understand. However, the disadvantage of financial indicators is to measure the operating results of enterprises in a short period of time, and cannot comprehensively measure the medium and long-term development ability of enterprises in a long period of time. Therefore, the measurement of enterprise

performance indicators should be based on the long-term. In addition, the differences in the type and nature of enterprises affect the accounting of their performance indicators, such as non-profit organizations, which evaluate their social contributions more than economic indicators. It is necessary to pay special attention to that the performance indicators of Chinese state-owned enterprises also have great particularity. In addition to traditional economic indicators, they also need to include indicators for the preservation and appreciation of state-owned assets, safety and stability. Therefore, it is necessary to take into account the impact of differences in the types and nature of Chinese enterprises.

2.2.3 Top management team homogeneity

A large number of studies have provided the basis for the study of the homogeneity of the executive team, but there are also obvious limitations. The existing research has no consistent and generally accepted research conclusions on the relationship between the average age, average tenure, average education level of the top management team and corporate performance, which leads to the lack of explanatory power of the existing research on the relationship between the top management team and organizational performance of Chinese medical device companies.

2.2.3.1 Average age of top management team

Until now, the academic community has not formed a unified opinion on the impact of the average age of the top management team on the strategic decision-making and strategic performance of the enterprise. After studying 199 banks, Bantel and Jackson (1989) found that there is a positive correlation between the average age of top management team and the innovation behavior and performance of enterprises. Tihanyi et al. (2000) studied the influence of the characteristics of the top management team on the internationalization strategy of the company, the results show that the lower the average age of the top management team, the better the implementation of the internationalization strategy. As far as Chinese companies are concerned, X. Y. Cai (2018) empirically analyzed the data of 4 A-share insurance listed companies, 15 banking listed companies and 18 securities listed companies based on the current situation of listed companies in China 's insurance industry. It was found that the average age of the top management team was significantly positively correlated with its financial performance. L. L. Dai and Jiang (2009) found that the average age of top management team members in the sample was significantly positively correlated with corporate performance; in view of the special culture and system of Chinese enterprises, Wei (2002) 's empirical results

show that the older the average age of executives is, the better the profit performance of enterprises is.

On the contrary, some scholars' research results support the opposite view. Y. Li (2023) used meta-analysis and other methods to study the relationship between the characteristics of top management team and the diversification strategy of enterprises. The average age of top management team has a significant negative correlation with the diversification strategy of enterprises, in which national and industry characteristics play a regulatory role. Chinese researcher Q. M. Li (2021) studied the Chinese pharmaceutical company Pien Tze Huang and found that the average age is negatively correlated with the cash dividend distribution rate. J. C. Xu and Wang (2010), based on the sample of listed companies in China's Shanghai and Shenzhen stock markets from 2004 to 2006, found that there was a significant correlation between corporate performance and the average age of top management team. W. P. Zhu (2004) empirically studied the data of listed companies in Hunan Province, China. The research results show that the average age of the top management team members of the sample enterprises is significantly negatively correlated with the financial performance indicators of the enterprises.

In general, senior executives in Chinese companies have more advantages in government resources, network resources and experience, and younger executives have more momentum in innovation and change. In the context of Eastern culture, respecting the elderly is a default value, while the new generation of young senior managers is more equal, open, and innovative. Differences in values lead to differences in behavior style and behavior results, which have an impact on the business performance of enterprises.

2.2.3.2 Average term of top management team

The term the top management team members refer to the length of time the top management team members serve. There are two different research views on the tenure of top management team. One view is that the longer the tenure of the top management team, the deeper the emotional connection with the organization, the stronger the sense of identity, and the better the team stability. Hou (2022) studied the research data of 792 technology-based enterprises in China from 2015 to 2020, and found that top management team tenure has a positive impact on enterprise innovation performance. Zhong (2020) concluded that CEO tenure, TMT average tenure, and TMT tenure heterogeneity have a significant positive impact on corporate performance. C. Lee et al. (2017) used the number of patents of 89 high-tech enterprises in the United States from 2006 to 2009 as a sample to empirically study the relationship between the innovation experience and innovation strategy of the top management team. The empirical

results show that the average tenure of the top management team has a significant role in promoting the implementation of the innovation strategy, that is, the longer the average tenure of the top management team, the greater the support for innovation. In the early days, some researchers have similar conclusions, that is, the relationship between the average tenure of the top management team and the performance of the company is positively correlated. The longer the tenure of the executive members of the company, the more conducive it is to improving the business performance of the company (J. L. Wang & Li , 2007).

Another view is that the longer the average tenure of the top management team, will hinder the improvement of corporate performance. Because the tenure process leads to the polarization of group thinking, it will be more stable and conservative in organizational change and innovation, which will affect the improvement of organizational performance. Chinese researcher J. J. Li (2019) empirically studied the impact of executives' background characteristics on corporate innovation investment in China's GEM listed companies. The study found that the average tenure of top management team is 'inverted U-shaped' related to corporate innovation investment. The study shows that 3.5 years is a milestone between executive tenure and R&D investment. When the average tenure of top management team members is greater than 3.5 years, the company's investment in innovation will decrease with the increase of the tenure of top management team members. On the contrary, when the average tenure of top management team members is less than 3.5 years, the company's innovation investment will increase with the extension of tenure. The research of Mikulay et al. (2001) reveals that with the extension of the tenure of top management team members, the top management team members of American enterprises lack sufficient enthusiasm for innovative investment projects with risks, and the development of their enterprises is stagnant.

2.2.3.3 Average education level of top management team

The vast majority of studies have shown that there is a positive correlation between the average education level of the top management team and corporate performance. The reason for this is that the higher the level of education of the members of the top management team, the broader the vision of the members of the top management team, the more thorough they think about their work, and the more perfect their professional skills become. Xian et al. (2019) took China's A-share listed companies from 2007 to 2018 as samples to conduct an empirical study on the mediating role between the average education level of the top management team and corporate performance. The results show that there is a positive correlation between the average education level of the top management team and corporate performance. M. Q. Zhu and Zhang (2018)

took the data of China 's GEM enterprises from 2009 to 2016 as samples, and found that the higher the average education level of the top management team, the more conducive it is to improving the performance of China 's GEM enterprises. Cullinane and Dundon (2006) found that there is a positive correlation between the average education level of the company's top management team and the degree of internationalization of the company. These studies also reflect the higher the average education level of the company's top management team, the higher the sensitivity to external information, which is conducive to improving the speed of response to market competition and market changes, and thus gaining a competitive advantage.

There are also some different research conclusions on the average education level of top management team and corporate performance in academia. H. P. Wang (2011) analyzed the characteristics of top management team and the investment level of Chinese enterprises, and found that the average education level is negatively correlated with the investment level of enterprises. H. Zhang and An (2006) , based on a sample of 578 listed companies on the Shanghai Stock Exchange, conducted an in-depth study of the relationship between the academic distribution of board members and corporate performance of listed companies in China. It was found that there was no correlation between the academic distribution of board members and corporate performance in the financial industry, except for the low positive correlation between the academic distribution of board members and corporate performance in the financial industry. In the financial industry, the difference in the academic distribution of board members is an explanatory variable for the difference in corporate performance, but it is not the main determinant.

2.2.3.4 Summary of top management team homogeneity and firm performance

To sum up, there are great differences in views on the impact of top management team homogeneity on corporate strategy and performance. In general, there is no unified conclusion on the relationship between top management team homogeneity and corporate performance. Divergence may be due to industry attributes, countries and other factors play a regulatory role. Therefore, it is necessary to do more in-depth targeted research on specific countries and specific industries.

2.2.4 Heterogeneity of top management team

Existing research measures the heterogeneity of top management teams from different variable perspectives. At present, the research on the heterogeneity of top management team mainly analyzes the relationship between the heterogeneity of top management team and the strategic

choice and performance of enterprises based on variables such as age heterogeneity, education heterogeneity, function heterogeneity and term heterogeneity (See Table 2.1). Whether it is age heterogeneity, tenure heterogeneity, and education heterogeneity, the existing research conclusions are quite different, and have positive and negative effects from different directions. Therefore, further empirical research may be combined with specific industries.

Table 2.1 Top Management Team Heterogeneity Classification

Author	Delineation criteria
Kilduff and Mehra (2000)	Antecedent variables: Age, tenure, education level, etc. Independent variables: Cognitive characteristics, behavioral characteristics
Simons et al. (1999)	Working team characteristics: Professional experience, functional background, education Non-work team characteristics: Age, gender
Pelled (1996)	Dominant demographic background characteristic variables: Age, gender, race Hidden demographic background characteristics variables: Education, tenure, culture
P. B. Smith et al. (1996)	<u>Demographic statistics, psychological dimension, process category</u>

The research on heterogeneity in this thesis also focuses on these three variables.

2.2.4.1 Age heterogeneity

Up until today, there is no consensus on the impact of age heterogeneity on corporate strategy and corporate performance. Many empirical studies have proved that in the top management team, the greater the age heterogeneity, the more likely it is to cause conflict, and even lead to the division of the top management team, which in turn affects the performance of the organization. Some empirical research results support this view. Zenger and Lawrence (1989) empirically studied the measurement data of American electronics companies. The results show that within American electronics companies, when the age heterogeneity of the team is greater, the exchange of technology sharing and technology discussion that helps R&D will be less. Jehn et al. (1997) conducted a field survey of 88 teams and proved that differences in demographic characteristics, including age and gender, will increase the emotional conflict among top management team members, which in turn affects corporate performance. Some studies by Chinese scholars also support this view. Chinese researcher K. K. Li (2022) used the data of A-share listed companies from 2010 to 2019 to empirically test the relationship between executive heterogeneity, corporate social responsibility and corporate performance, and found that age heterogeneity is significantly negatively correlated with corporate performance.

Another view is that age heterogeneity has a positive impact on the organization. When the top management team member is making decisions, having enough high-quality information can greatly improve the quality of the executives' decisions. At the same time, the top

management team members with large age heterogeneity have a diversified knowledge system and information sources, which ensures that they have enough high-quality information, which will lead to a high level of decision-making performance of the team. Empirical studies by many supporters have proved this conclusion. Nemeth and Kwan (2006) shows that age heterogeneity is very helpful to improve the quality of top management team decision-making and improve the business performance of enterprises. Q. M. Li (2021) takes 5579 listed companies in China's stable development period from 2013 to 2018 as the research object, and discusses the influence of TMT heterogeneity on corporate performance through the intermediary role of internal control quality. The research results show that in the listed companies in the stable development period, the age heterogeneity of TMT has a significant positive correlation with the quality of internal control and corporate performance. P. Zhang (2020) found that the age heterogeneity of Venture Capital (VC) members is positively correlated with the performance of the invested enterprises after studying 607 enterprises in Shanghai and Shenzhen Main Board, GEM and SME Board that were invested by VC from 2008 to 2018 and successfully IPO. In the case of VC investment, if the time interval between the establishment of VC is larger, the invested enterprises can achieve better IPO performance.

There is also a view in academia that attempts to integrate the impact of age heterogeneity on enterprises from an integrated perspective. This view holds that there is a similar quadratic curve relationship between the age heterogeneity of the top management team and corporate performance (Amason, 1996). That is to say, when the age heterogeneity of the top management team is small, it cannot have too much negative impact on corporate performance. When the age heterogeneity of the top management team increases moderately, diversified information sources will help improve the company's decision-making quality and improve corporate performance. However, when the age heterogeneity of the top management team exceeds a reasonable threshold and becomes too high, the conflicts and contradictions of the top management team members will intensify, resulting in a decline in the quality and efficiency of team decision-making. This adverse effect is transmitted to corporate performance. Through empirical research, Richard and Shelor (2002) revealed that there is a negative correlation between age heterogeneity of top management team and return on assets, and there is a positive correlation between age heterogeneity and sales growth. At the same time, there is a curve relationship between TMT age heterogeneity and sales growth, that is, TMT age heterogeneity is positively correlated with sales growth at low and medium levels, and negatively correlated with sales growth at high levels. Background factors regulate linear and nonlinear relationships.

2.2.4.2 Term heterogeneity

The tenure of the top management team is divided into two types, one is the term of office at the company level, that is, the time that executives serve in the current company (Wiersema, 1992), and the other is the term of office at the team level, which refers to the length of time that top management team member work with the top management team (Boeker, 1997).

Certain scholars posit that heterogeneity in tenure exerts a favorable influence on both strategic orientation and performance. Katz (1982) believed that executives have different understandings of the organization 's strategy and management as they experience different stages of development when they enter the company. Within an organizational context, the variegated tenures of top management team (TMT) members contribute to a comprehensive analysis of the company's challenges from diverse standpoints. This diversity fosters ideational stimulation and insight, thereby facilitating holistic deliberation and engendering organizational solutions to drive corporate progress.

Finkelstein and Hambrick (1990) found that the willingness of top management team members to take risks and responsibilities is largely influenced by the heterogeneity of top management team members' tenure, with long-serving management teams tending to make higher-caliber strategic decisions, which subsequently manifest in performance levels surpassing industry norms. In a parallel vein, Smith et al. (1994) found that the higher the degree of team tenure heterogeneity, the easier it is to utilize executives' personal management experience and social resources to obtain high-value information, this propensity facilitates the acquisition of invaluable insights and bolsters strategic adaptability, thereby contributing to enterprise-level strategic transformations and development. Furthermore, Dai's (2021) investigation corroborates that both age heterogeneity and tenure heterogeneity within TMTs exhibit a statistically significant positive association with corporate strategic change.

Some scholars insist that tenure heterogeneity has a negative impact on strategy and performance. Hambrick (1989) believes that there is unknowability and unaccountability in the process of production and operation. If the tenure heterogeneity of the top management team is too high, in daily work, due to their differences in experience, values and ways of thinking, internal conflicts will intensify, which will reduce the efficiency of decision-making, make the company unable to respond quickly and correctly in the face of competition, and limit the development of the company. Some research results of Chinese researchers also support Hambrick 's point of view. Y. W. Zhang (2021) took China 's Shanghai and Shenzhen A-share listed companies from 2010 to 2019 as research samples, and studied the influence of five

heterogeneity indicators such as education, profession, tenure, professional background, and relationship between board members on inefficient investment of enterprises. The study found that the heterogeneity of education, profession, tenure, and professional background of the board of directors has a significant inhibitory effect on inefficient investment of enterprises.

Therefore, the effect of term heterogeneity on organizational performance cannot be simply generalized. It needs to be combined with the development stage of the enterprise and the external market environment. For example, if an enterprise is in a fiercely competitive external environment and needs rapid decision-making and response, the use of a top management team with a small term heterogeneity is more conducive to efficient internal communication. Through the tacit cooperation between team members, the resources and capabilities of the top management team are efficiently integrated to improve the organization's response speed and respond to market competition in a timelier manner. If the company's external environment is stable, adopting an executive team with a high degree of tenure heterogeneity can help capitalize on strengths such as high-quality decision-making, which can contribute to the company's growth.

2.2.4.3 Education heterogeneity

Education heterogeneity has been one of the hot topics in the study of top management team characteristics. Educational heterogeneity has two meanings. The first meaning refers to the differences in the degree of academic education received by the degree of the top management team, such as bachelor's degree, master's degree, or doctoral degree, and the second meaning refers to the differences in the majors and educational backgrounds of the members of the top management team, for example, whether they were educated in the top 100 QS ranked universities or in ordinary universities. It is well recognized in academic circles that the average education level of the top management team is an important influence on strategic decisions and firm performance. However, in fact, as with age heterogeneity and tenure heterogeneity, there is no consistent academic finding on the relationship between the average education level of the top management team and corporate strategy and performance.

Scholars represented by Smith (1994) believe that the heterogeneity of education level can provide diversified information for enterprises by broadening the information source channels of enterprises, so as to help enterprises improve the quality of strategic decision-making. Because senior managers with different educational backgrounds receive different academic training, the paradigms and perspectives of thinking are also diversified. The discussion and collision of different concepts from a multidisciplinary perspective will help to produce better

solutions. Wiersema (1992) pointed out that the greater the difference in the professional background of team members, the more conducive to the organization to absorb diversified information, ideas, and skills, and often the greater the possibility of strategic change. The research of Carpenter (2002) shows that the top management team with high educational heterogeneity is more suitable for carrying out transnational business and implementing global competitive strategy. Chinese researchers P. Liu and Wu (2022) empirically studied the sample data of A-share listed companies in China 's manufacturing industry from 2015 to 2019, and analyzed the specific impact of TMT heterogeneity on corporate growth through empirical research. The study found that the heterogeneity of executive education background and functional background has a significant positive impact on corporate growth, and adaptability plays an intermediary role in the impact of education heterogeneity on corporate growth. Y. M. Wang et al. (2015) used the data of listed companies in China 's pharmaceutical industry from 2008 to 2011 as a sample, and found that the heterogeneity of executive education in listed companies in China 's pharmaceutical industry was positively correlated with corporate performance.

The core view of the other group of scholars who hold the opposite view is negative. Knight et al. (1999) found that the education heterogeneity of top management team is negatively correlated with strategic consensus. The greater the difference in the education level of top team members, the less likely it is to generate consensus, which is not conducive to the formation of a consistent strategic consensus, limiting the team 's collaboration and affecting the performance of the organization. P. Luo and Ge (2018) took the top management team data of A-share information technology listed companies in Shanghai and Shenzhen from 2013 to 2015 as a sample to study the impact of top management team heterogeneity on corporate innovation performance. At the same time, the moderating variable of top management team power distribution was introduced to empirically study the mechanism of top management team power distribution between top management team heterogeneity and corporate innovation performance. The study found that the heterogeneity of top management team education level was significantly negatively correlated with corporate innovation performance. The degree of imbalance in the distribution of top management team power has a significant negative moderating effect on the relationship between the heterogeneity of top management team education level and enterprise innovation performance. J. J. Gu and Hu (2008) empirically studied Chinese private enterprises, and found that the heterogeneity of education level of top management team in Chinese private enterprises will lead to the decline of decision-making efficiency, and enterprises lack the motivation of innovation and change, which will restrict the

development of enterprises.

2.2.4.4 Functional background heterogeneity

The professional background of top management team member is divided into two categories : the first type of work is business work, business work is to help enterprises gain advantages over other enterprises long-term advantages of business activities, specifically, marketing, sales, management and other work; the second type of professional background is auxiliary functional work, which specifically refers to the work of human resources, administration, operation and accounting in enterprises.

Generally speaking, the higher the heterogeneity of the functional background of the top management team, the stronger the awareness of management innovation and strategic change, which can help enterprises to formulate high-quality strategies and initiatives. A series of studies in academia support this view. Hambrick and D'aveni (1992) conducted an exploratory study of 57 large-scale bankrupt enterprises and 57 matched survivors, examined the characteristics of top management teams related to the bankruptcy of large enterprises, and found that the deterioration of top management teams is the core factor of the spiral decline of large enterprise bankruptcy. Therefore, in the complex competitive environment, large diversified enterprises increasingly need top management teams with diversified backgrounds. The top management team with rich cross-industry and cross-departmental experience has a great influence on the thinking mode, working habits and leadership style, which can help managers formulate high-quality strategies to cope with competition. Z. N. Liu et al. (2022) took China 's manufacturing listed companies from 2011 to 2019 as the research object, and empirically tested the impact of functional background heterogeneity of top management team on corporate green innovation. J. W. Zhu and Zhao (2021) used the data of 247 GEM enterprises in China from 2014 to 2019 to study the impact of functional heterogeneity of top management team on enterprise innovation performance. The results show that functional heterogeneity of top management team has a significant positive impact on enterprise innovation performance.

Some scholars believe that the heterogeneity of professional background is not always conducive to the long-term development of enterprises. Sutcliffe (1994) argues that excessive career heterogeneity of top management team will hinder communication and communication among top management team members, affect executives' perception of the external environment, and lead to a decline in the ability of enterprises to identify opportunities and crises in the external environment. Chinese scholars Sheng and Long (2023) used the data of China 's Shanghai and Shenzhen A-share listed companies from 2009 to 2020 as a sample to

empirically test the impact of the heterogeneity of the top management team on the total factor productivity of enterprises. The results show that in the financial industry, the heterogeneity of the financial background of the top management team has a significant negative effect on the total factor productivity of enterprises.

In the face of different views, Shank (1988) tried to put forward a unified point of view from a neutral point of view. Through the establishment of an information processing model, it was found that the heterogeneity of the professional background of top management team members and their perception of the company's strategic environment are quadratic.

2.2.5 Summary of top management team heterogeneity and firm performance

There are large differences in opinions on the impact of top management team heterogeneity on corporate strategy and performance. In summary, it can be found that although there are a large number of empirical studies on the impact of top management team heterogeneity on corporate strategy and organizational performance, but there is still no coherent viewpoint. This thesis studies the impact of top management team heterogeneity on the strategic and organizational performance of Chinese medical device enterprises in specific industries and situations.

2.3 Correlational study of top management team characteristics, R&D investment and firm performance

R&D investment is an important strategic decision for enterprises, and the amount and intensity of R&D investment are important factors affecting the innovation capability of enterprises. On the one hand, the gender, age, education level, tenure and other characteristics of the top management team can affect the strategic decisions of the executive team, which in turn affects the performance of the enterprise, and the R&D strategy, as a functional strategy, is also inevitably affected by the characteristics of the top management team; on the other hand, it has been recognized that there is an important impact of R&D investment on the performance of the enterprise.

It has been recognized that R&D investment has a significant impact on corporate performance. It is a very special phenomenon that many Chinese medical device companies claim to be "R&D oriented", actually invest very little in R&D, but invest very much in marketing expenses. It is necessary to use R&D investment as a mediating variable to

empirically investigate the influence of top management team background characteristics on firm performance through R&D investment. By identifying the relationship between top management team characteristics, R&D investment, and firm performance, we can provide a theoretical basis for the formation of a suitable top management team and the formulation of a correct strategy.

2.3.1 Top management team Characteristics and R&D Investment

Upper echelons theory believes that managers' gender, education level, tenure, professional background, and other characteristics of the organization's strategy have an impact, which in turn affects organizational performance. R&D strategy is a very important functional strategy of enterprises. The direction, amount and cycle of R&D investment are important contents of R&D strategy. Therefore, R&D investment and top management team characteristics are widely valued by academia.

There are two research directions on R&D investment in academia. The research direction of external environment is from the perspective of policy environment, economic environment, industrial environment, and technical environment. The research perspective of internal environment is to focus on the influence of demographic characteristics or psychological characteristics, governance structure and company development stage of the top management team on R&D investment.

2.3.1.1 Age of the top management team and R&D investment

Regarding the relationship between the age of the top management team and R&D investment, the mainstream research conclusion is that the age characteristics of the top management team are negatively correlated with R&D investment. Generally speaking, the older the manager is, the stronger the conservative consciousness is, and the lower the investment in R&D is. Barker and Mueller (2002)'s research on American companies shows that the younger the age of the top management team, especially the CEO, the greater the intensity and resources for R&D investment. Y. Y. Liu (2022) found that the age heterogeneity of the top management team will significantly negatively affect the amount of R&D investment of enterprises, that is, the higher the heterogeneity of the top management team, the lower the R&D investment of enterprises, through the study of the influence of the heterogeneity of the top management team on the R&D investment of enterprises in China's A-share market from 2014 to 2020. W. Y. Zhu (2016) conducted an empirical study on the relationship between the background characteristics of the top management team of listed companies in China's information technology industry and

corporate R&D from the two levels of executive demographic background characteristics from a static perspective and social background characteristics from a dynamic perspective. The study found that the average age of executive members has a negative correlation with corporate R&D investment. The older the executive, the less investment in R&D by the company in which the executive is located.

H. L. Hao (2014) takes 1216 groups of effective data of Chinese listed companies from 2010 to 2012 as samples, selects 16 indicators to measure the R&D intensity of enterprises, the characteristics of top management team and executive incentive, and empirically studies the relationship between the characteristics of top management team and the R&D intensity of enterprises. The research shows that the average age of the top management team has a significant negative impact on the R&D intensity of enterprises, that is, the younger the members of the top management team, the more R&D investment. Kang et al. (2011) empirically studied the company data of R&D expenses disclosed in Chinese listed companies from 2003 to 2006. The study found that there was a significant negative correlation between the average age of top management team members and the company's R&D investment.

2.3.1.2 Term of top management team and R&D investment

There are two main views on the tenure of top management team and R&D investment. The first view is that there is a negative correlation between the tenure of executives and the R&D investment of enterprises. Executives with long tenure often have more concerns and are more stable. The longer the tenure, the less support for the R&D investment of enterprises. On the contrary, executives with shorter tenure will pay attention to the new information conveyed by the internal and external environment of enterprises, take new strategies in time, and increase support for R&D investment (Barker & Mueller, 2002). Zheng and lu (2015) took 130 listed companies in western China as samples to empirically study the impact of the characteristics of the top management team on the efficiency of corporate R&D investment. The empirical research conclusions show that the average tenure of the top management team in the western region is significantly negatively correlated with the efficiency of corporate R&D investment.

Hou (2022) studied the data of Chinese GEM enterprises from 2015 to 2020, and found that the tenure of top management team has a positive impact on enterprises. Deng (2013) studied the R&D investment data of China's listed high-tech enterprises from 2007 to 2011, and found that the average tenure of top management team is positively correlated with corporate R&D. In addition, it is also found that the influence of the tenure characteristics of executives of non-state-owned listed companies on corporate R&D is more significant than that

of state-owned listed companies in China. Y. G. Liu and W. Liu (2007) empirically studied the R&D expenditure data disclosed by 454 listed companies from 2001 to 2004. Empirical studies have found that there is a significant positive relationship between corporate R&D investment and the tenure of executives. The longer the tenure of executives, the higher the R&D investment of enterprises, and the negative correlation between the intention of executives to leave and R&D expenditure. That is to say, the outgoing executives lack sufficient enthusiasm to support the increase of R&D expenditure. In addition, executives of different ages have significant differences in their support for R&D expenditure during their tenure, and the younger executives are. The more inclined to increase R&D investment during the term of office, the older the executives, the more inclined to reduce R&D investment during the term of office.

Chinese researcher Wu (2017) deeply studied the impact of senior management tenure on corporate R&D, and proposed that there is not a simple linear relationship between the tenure of top management team and corporate R&D, but an inverted U-shaped relationship. If the existing tenure of top management team members cannot be extended, they tend to support increasing investment in R&D. However, if the tenure of top management team continues to increase, it will increase its managerial entrenchment and reduce corporate R&D investment. In addition, due to the higher degree of managerial entrenchment, the inverted U-shaped relationship between its existing tenure and corporate R&D investment is more obvious.

2.3.1.3 Education background of top management team and R&D investment

There is a general consensus on the education background of top management team and R&D investment. The average educational level of the top management team is positively correlated with R&D investment. The reason is that with the improvement of the educational level of the top management team, lighter the contact surface of the external information, the more comprehensive the perspective of the problem, so the higher the emphasis on R&D investment.

Goll et al. (2008) conducted a long-term (1972-1995) longitudinal study. The results of the study show that higher levels of education of the top management team members help firms to develop new business areas, pursue competitive differentiation strategies and promote corporate innovation. J. Wang et al. (2023) takes China's A-share listed companies from 2014 to 2019 as the research object, constructs an individual time point double fixed effect model, and studies the impact of R&D investment continuity on enterprise innovation performance through empirical analysis. The results show that there is a significant positive correlation between executive education level and R&D investment.

There are a range of other research findings that support this view. Line and Ma (2021) used the data of listed companies in Guangdong Province from 2008 to 2020 to study the relationship between the gender, age and education of the top management team and the intensity of corporate innovation. The research shows that the education of the top management team has a significant positive correlation with the intensity of corporate innovation. Y. Z. Ma (2017)' research studies the relationship between top management members characteristics and enterprises ' innovation R&D funds from the perspective of executive individuals and executive groups, and finds that the education level of executives has a significant role in promoting enterprises ' innovation investment. Ye and Chen (2016) empirically studied the relationship between the background characteristics of executives and R&D funds of 124 Chinese private enterprises from 2011 to 2013. It was found that there was a positive relationship between the education level of executives and R&D investment. If the top management team members have a master 's degree or above, the greater the R&D investment in the enterprise. Guo and Zhang (2013) selected the data of China 's GEM enterprises from 2009 to 2012 as the research object, and empirically tested the influence of the characteristics of the top management team of small and medium-sized innovative enterprises on R&D investment behavior. The results show that the average education level of the top management team is significantly positively correlated with the intensity of R&D investment.

In addition, there is a positive correlation between top management team education and the sustainability of R&D investment. Chinese researcher M. Li (2022) empirically studied the relationship between R&D investment persistence, executive education background and enterprise innovation performance based on the sample of China 's A-share listed companies from 2014 to 2020. The study found that the level of executive education has a positive impact on the persistence of R&D investment and enterprise innovation performance. It can have a strengthened regulatory role, that is, the higher the level of executive education, the higher the persistence of R&D investment, and the greater the positive impact of R&D investment persistence on enterprise innovation performance.

2.3.1.4 Functional background of the top management team and R&D investment

In the academic research, it is generally recognized that the functional background of the top management team is positively correlated with R&D investment.

Urs et al. (1999) studied the relationship between the background characteristics of the top management team and innovation from the perspective of innovation commitment. The results show that there is a positive correlation between CEO 's technical preference and orientation in

the top management team and R&D investment. Many companies will adjust the amount of R&D investment due to the preference of CEO or top management team. R. Liu et al. (2022) used 2010-2019 Chinese Shanghai and Shenzhen A-share listed companies as research samples. The study found that R&D investment is an intermediary mechanism for the functional background of the top management team to affect corporate performance, and the functional background of the top management team has a significant positive impact on R&D investment.

M. L. Wang (2020) uses the data of China's GEM listed companies from 2012 to 2018 as the research sample to empirically study the relationship between the heterogeneity of top management team's professional background and corporate R&D investment. The research results show that the differences among top management team members are reflected in cognitive ability, information analysis and resource integration. These differences are reflected in the heterogeneity of top management team's professional background. Specifically for Chinese enterprises, the promotion effect of the heterogeneity of top management team's professional background on R&D investment in state-owned enterprises is weaker than that in non-state-owned enterprises. Peng and Mao (2017) empirically studied the relationship between top management team background and R&D of Chinese high-tech listed companies. The study found that the R&D technical background of executives helps to increase the R&D investment of their high-tech companies. Top management team members with professional R&D technical background are more likely to be recognized by external investors and help companies obtain additional financing and resources.

Xue and Chen (2014) take the R&D investment data of China's manufacturing listed companies from 2009 to 2011 as the research sample to explore the relationship between CEO's ability, motivation, power and other characteristics and R&D investment. The results show that there is a significant positive correlation between CEO's work background and R&D investment. CEOs with technical background pay more attention to R&D and invest more resources. Z. Y. Luo et al. (2013) selected the data of Chinese A-share listed companies in 2008 to analyze the relationship between human capital and R&D intensity of enterprises. The study found that the professional and technical background of top management team members was significantly positively correlated with the R&D intensity of enterprises. The proportion of executives with professional and technical background directly affects the position of R&D in the company's strategy and the resources obtained.

2.3.1.5 Top management gender and R&D investment

At present, there is no consensus on the relationship between executive gender and R&D

investment in academia.

One view is that male executives will promote R&D investment, and female executives will tend to reduce R&D investment. The basis of this view is that men are more adventurous than women, more tolerant of innovation and change, and more willing to invest resources in research and development. D. Yang (2022) took the A-share listed companies on China's main board from 2009 to 2018 as a sample. The empirical study found that the participation of female executives had a moderating effect on the relationship between debt from different sources and R&D investment, and the participation of female executives was negatively correlated with R&D investment. Q. Gu et al. (2017) used the data of listed companies in Shenzhen Stock Exchange from 2008 to 2014 to explore the impact of female executives' participation on corporate R&D investment. The research shows that female executives' participation has a significant negative correlation with corporate R&D investment. Q. Wang and Zhou (2015) take China's A-share listed companies from 2009 to 2012 as a sample to empirically analyze the impact of female executives on R&D investment. The research shows that female executives will inhibit the innovation of enterprises, and male executives will increase R&D investment and promote enterprise innovation. F. Yang et al. (2016) used the data of GEM listed companies in Shenzhen Stock Exchange from 2009 to 2014 to empirically study the relationship between power separation, background characteristics of top management team and innovation intensity of enterprises. The research shows that the background characteristics of top management team can affect the R&D investment of enterprises. The background characteristics of management and chairman have a significant impact on the innovation intensity of enterprises. Male executives will increase the R&D investment of enterprises and contribute to innovation.

There is also a diametrically opposite view that the increase in the proportion of women in the top management team is positively correlated with R&D investment. An extended study by Yang (2022) found that, unlike ordinary female executives, female CEOs can significantly increase R&D investment. Torchia et al. (2011) examined the role of female executives in the board of directors. The study found that gender differences can regulate corporate innovation. The increase in the proportion of female executives contributes to high-quality decision-making and promotes the formation of innovative solutions.

2.3.2 R&D investment and corporate performance

The academic community mainly studies the relationship between R&D investment and corporate performance from two dimensions: linear relationship and nonlinear relationship.

In terms of linear relationship, most of the research results support that there is a positive correlation between R&D investment and enterprise performance. Branch (1974) conducted a long-term tracking study on the R&D data of 111 large companies in the United States from 1950 to 1965. The results show that there is a positive correlation between R&D investment and performance of sample companies. When sample companies increase R&D funds, production efficiency and output will increase accordingly, which will promote the improvement of corporate performance of companies. Round (1978)'s research results show that the proportion of R&D investment, the proportion of R&D personnel and the proportion of professional and technical personnel have a significant positive correlation with technological innovation performance. Griliches (1979) studied the R&D investment of R&D-intensive enterprises, and found that R&D investment has a positive impact on enterprise productivity.

Ettlie and John (1998) analyzed the data of 600 durable goods enterprises in 20 countries, the study found that there was a significant positive correlation between R&D investment intensity and market performance. Increasing R&D investment will help improve corporate performance. O'Mahony and Vecchi (2009) empirically studied the data of the United States, Britain, Japan, Germany and France, and found that R&D investment can improve the performance of technology-intensive industries more than factor-intensive industries. Bosworth and Rogers (2001) examined the relationship between Australian companies' R&D activities and the company's market value in 1994-1996. The empirical results show that the investment in intellectual property rights such as patent and trademark R&D is positively correlated with the company's market value. The increase in R&D investment can promote the company's market value and competitiveness. Lichtenthaler (2016) studied the relationship between absorptive capacity and corporate performance. The results show that different enterprises have different performance in innovation ability, and the growth of internal R&D investment is positively correlated with the improvement of enterprise business. Vanderpal (2017) empirically studied the data of 103 companies in the United States with a high proportion of R&D investment from 1979 to 2013. The empirical results show that there is a positive correlation between R&D investment and financial performance. In 34 years, the higher the R&D investment, the better the financial performance.

A series of studies by Chinese researchers also support the positive correlation between R&D investment and corporate performance. L. Han (2022) took listed companies in the auto parts manufacturing industry from 2011 to 2020 as research objects to explore the relationship between R&D investment and corporate performance. The study found that R&D investment and corporate performance of Chinese auto parts manufacturing enterprises are positively

correlated. L. L. Wang et al. (2021)'s research on the panel data of small and medium-sized listed companies in China from 2010 to 2018 proves that there is a positive correlation between R&D investment and corporate performance. J. Y. Li (2018) empirically studied the data of 672 high-tech enterprises listed on the Shenzhen Stock Exchange in China from 2009 to 2012. The research results show that R&D investment can positively affect the improvement of enterprise performance, and there are two lags. X. Liu and Wang (2018)'s empirical research on the data of 46 A-share listed companies on the Shanghai Stock Exchange in 2015 proves that R&D investment has a significant positive effect on the financial performance of sample companies. Wu (2018) empirically studied the impact mechanism of corporate R&D investment on corporate performance. Her study found that the company's governance relationship helps to increase the company's R&D investment, thereby promoting the improvement of corporate performance.

H. J. Li et al. (2017) studied the data of 70 new energy listed companies from 2013 to 2015. Empirical research shows that the current R&D expenditure of China's new energy companies is generally not high, and increasing R&D funds of China's new energy companies can significantly improve corporate value. P. P. Xu (2016) conducted an empirical study on China's GEM manufacturing enterprises from 2010 to 2013. The study found that the R&D intensity of Chinese manufacturing enterprises has a significant positive correlation with corporate performance. Zou et al. (2014) selected the data of high-tech SMEs in China's GEM from 2009 to 2013, and empirically studied the relationship between R&D innovation activities and corporate performance. The results show that R&D funding intensity can have a positive impact on performance, and increasing R&D investment can positively improve the financial performance of China's high-tech SMEs.

Some researchers hold different views on the relationship between R&D investment and corporate performance. They believe that there is no positive correlation between R&D investment and corporate performance. Some empirical research results show that R&D investment and corporate performance show weak correlation or no correlation, and some research results show that there is a negative correlation between the two. J. J. Ma and Ji (2023) empirically studied the data of all A-share listed companies in China from 2017 to 2021. The results show that increasing R&D investment intensity can improve corporate performance. There is a negative correlation between the proportion of technical personnel and corporate performance, and there is a lag between R&D investment intensity and performance. Y. F. Cai (2022) selected the panel data of Chinese manufacturing industry listed companies on the main board of Shanghai Stock Exchange from 2016 to 2020 as a sample to empirically test the

correlation between R&D investment, social responsibility, and corporate performance of manufacturing enterprises. The study found that R&D investment of Chinese manufacturing enterprises is significantly negatively correlated with short-term corporate performance and significantly positively correlated with long-term corporate performance.

W. L. Zhu and Chen (2017) summarized and combed the research on the impact of R&D investment on performance, and believed that the life cycle stage of the enterprise determines the impact of R&D investment on performance. The R&D investment of enterprises in the start-up period has no significant impact on corporate performance. The increase in R&D investment of enterprises in the development and maturity periods can significantly affect corporate performance. The R&D investment of enterprises in the recession period has a negative relationship with corporate performance. W. P. Zhu and Lun (2004) found that R&D investment and enterprise performance failed to pass the significance test in the empirical study of the relationship between R&D investment and performance of China's high-tech enterprises. The main reason is that the high-tech enterprises at that time lacked planning in R&D investment. Blind investment, R&D departments, and business departments in the R&D of the central door wall phenomenon, communication, and cooperation difficulties, seriously affect and limit the R&D effect.

In addition, a series of research results show that there is a non-linear relationship between R&D investment and enterprise performance. Hartmann et al. (2006) empirically studied the R&D investment and operating income of technology-based enterprises. The research results found that there is an inverted U-shaped relationship between R&D investment and corporate performance. That is to say, R&D intensity and corporate performance are not linear. There is an optimal threshold for R&D investment. When R&D investment exceeds the optimal threshold, there will be a diminishing marginal effect. R&D investment exceeding the optimal threshold cannot increase corporate performance in equal proportions. I. H. Lee and Marvel (2009) used the data of 2676 South Korean small and medium-sized enterprises as samples. The empirical results show that there is a horizontal inverted S-shaped curve between R&D investment and corporate financial performance, rather than a linear relationship.

The research results of Chinese researchers also prove the existence of nonlinear relationships. Bioh (2022) took the data of M & A transactions and financial statements of 1083 listed companies listed on Shanghai Stock Exchange (SHSE) and Shenzhen Stock Exchange (SZSE) from 2007 to 2019 as samples to empirically study whether innovation investment affects the value of M & A enterprises. The results show that there is a non-linear relationship between R&D investment and corporate performance. R&D intensity has a U-shaped

relationship with the current company's performance, but it has an inverted U-shaped impact on the company's performance in the next period. Based on the fixed effect panel threshold model, Zhao et al. (2021) studied the relationship between R&D and performance of Chinese science and technology start-ups. The results show that there is a nonlinear relationship between R&D intensity and enterprise performance in different R&D intensity and output scale. Only when the output scale reaches a certain level, R&D expenditure can promote the improvement of enterprise performance. The optimal R&D intensity that maximizes R&D return and R&D output elasticity is 2.42 % ~ 4.42 % (or 2.42 % ~ 4.11 %) and 2.42 % ~ 4.59 %, respectively.

Z. C. Xu and Hou (2019) took the data of China 's manufacturing listed companies from 2012 to 2016 as object of study. The study found that if manufacturing companies invest too much in innovation, it will put pressure on the cash flow security of enterprises and is not conducive to the improvement of corporate performance. With the continuous improvement of enterprise R&D investment, R&D investment and enterprise performance level show an inverted U-shaped relationship that rises first and then falls. The relationship between the two is significantly positively regulated by competitive strategy and enterprise growth. The adjustment variable can promote the improvement of innovation investment on enterprise performance level. X. F. Han and Dong (2018) took the data of listed companies providing China 's smart city services as the research sample. The empirical study found that the impact of R&D investment on corporate performance is not linear, but ' inverted U-shaped ', that is, R&D investment beyond a reasonable R&D investment intensity threshold has a limiting effect on corporate performance, which is not conducive to the improvement of corporate performance. Y. H. Sheng and Lu (2016) took China 's A-share listed companies from 2010 to 2014 as samples, and found that there was an inverted N-shaped cubic curve relationship between R&D investment and corporate performance. Cheng et al. (2015) empirically studied the listed companies in China 's computer and electronic communication industries from 2009 to 2013, and used the panel threshold regression model to empirically study the relationship between R&D investment intensity and corporate performance. The study found that there is a significant negative correlation between the R&D investment intensity of Chinese computer and electronic communication enterprises and the performance of sample enterprises. At the same time, the R&D investment intensity exceeding a reasonable threshold cannot significantly affect corporate performance.

Overall, although some conclusions suggest that there is a nonlinear relationship between R&D investment and firm performance, most of the current research results can support the existence of a positive relationship between R&D investment and firm performance. Therefore,

from both theoretical and practical needs, more focused and targeted research is needed specifically for Chinese medical device firms.

2.3.3 Top management team characteristics, R&D investment and corporate performance

At present, there are two main research directions in the academic community on the relationship between the characteristics of the top management team, R&D investment and corporate performance.

The first is the study of the regulatory role. Chinese researcher P. Y. Xu (2023) selected 4739 objects of study data of 733 heavily polluting enterprises in China from 2015 to 2021 as objects of study. The empirical results show that the moderating effect of top management team heterogeneity significantly affects corporate performance. In the short term, the heterogeneity of educational background positively regulates the negative correlation between environmental regulation and corporate financial performance, and the heterogeneity of professional background negatively regulates the negative correlation between environmental regulation and corporate financial performance. In the long run, the heterogeneity of educational background has a significant negative moderating effect on the relationship between environmental regulation and corporate financial performance, and the heterogeneity of professional background has a positive moderating effect on the relationship between environmental regulation and corporate long-term financial performance.

Guo (2016) takes the relevant data disclosed by listed companies in the manufacturing industry of China's A-share market from 2010 to 2012 as a sample, and empirically studies the role of executive heterogeneity as a moderating variable. The research results show that as a moderating variable, the age heterogeneity of the top management team can have a positive adjustment effect on the relationship between R&D investment and corporate performance of the sample companies. The increase in the heterogeneity of the education level of the top management team will correspondingly weaken the relationship between R&D investment and corporate performance. The heterogeneity of executive tenure and executive tenure do not play a regulatory role in the relationship between R&D investment and corporate performance. There is only a positive correlation. W. H. Wang et al. (2014) empirically studied the moderating effect of the background characteristics of the top management team. The results show that the R&D investment of the sample enterprises has a positive impact on corporate performance. The human capital structure and quality of the top management team can actively and effectively regulate the relationship between R&D investment and corporate performance.

The more reasonable the human capital structure of the top management team is, the higher the quality of human capital is, and the more significant the moderating effect is.

The second is about the study of mediating variables. Feng (2021) conducted an empirical study on the relationship between top management team heterogeneity, innovation investment and corporate performance of China's GEM listed companies. The study found that innovation investment played a mediating role in the process of top management team heterogeneity affecting corporate performance. Based on the sample of Chinese GEM listed companies from 2013 to 2017, X. W. Wang and Wu (2019) empirically tested the mediating effect of R&D investment on the background characteristics of top management team and corporate performance. The study found that R&D investment plays a mediating role in the process of TMT background characteristics such as age, education, tenure, technical background, and proportion of female executives affecting corporate performance. W. Wang et al. (2016) regression analyzed the panel data of high-tech listed companies in China's small and medium-sized board from 2009 to 2013, and discussed the relationship between CEO background characteristics, R&D investment, and enterprise value. The study found that R&D investment was significantly positively correlated with enterprise value, and CEO education background and technical background played a mediating role.

From the above research, it can be seen that the relationship between top management team characteristics, R&D investment and corporate performance is mainly studied from the perspective of moderating variables and mediating variables, R&D investment can be used as a moderating variable or mediating variable, and this conclusion has been empirically supported.

2.3.4 Summary of top management team characteristics, R&D investment and firm Performance

In summary, the consensus formed by the academic community is that the characteristics of the top management team affect the organization's strategy, which in turn affects organizational performance, and corporate R&D has a correlation with corporate performance. Enterprise R&D can be used as a mediating variable between top management team characteristics and organizational performance.

Current research on Chinese medical device companies mostly focuses on the relationship between the top management team background and R&D investment, and the relationship between R&D investment and firm performance. A search of the literature did not reveal sufficient research on the relationship between top management team background, R&D

investment, and firm performance in Chinese medical device firms. This thesis is based on the boundary conditions of influence and reason, and more R&D investment is used as an intermediary variable.

2.4 Summary of literature review

This chapter mainly systematically combs the relevant theories involved in this thesis, and constructs the theoretical basis of this study. For the direction of this thesis research, there are three main shortcomings in the existing related research, the existing related research mainly has three shortcomings. First, the empirical research of upper echelons theory in China is mostly concentrated in the manufacturing industry, information technology industry and financial industry, and the research on China's medical device market and China's medical device enterprises is lacking. Second, the relationship between the homogeneity and heterogeneity of the top management team and corporate strategy and corporate performance. There are several different views in the current research. Specific to Chinese medical device companies, there is a lack of corresponding empirical research. Third, a large number of studies directly analyze the relationship between the characteristics of the top management team and corporate performance. As the core competitiveness of the medical device industry, R&D capability lacks sufficient attention to the research of R&D investment as an intermediary variable, which cannot support the practical needs of Chinese medical device companies. Therefore, the mechanism among top management team characteristics, R&D investment and enterprise performance of Chinese medical device enterprises need to be further explored. This chapter provides a review of the relevant literature, which lays the foundation for and clarifies the direction of the subsequent empirical research.

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Chapter 3: Research Methodology and Research Hypotheses

3.1 Research methodology

A series of studies in upper echelons theory have proved that there is a correlation between top management team characteristics and organizational performance. However, there are two obvious shortcomings in the existing research: first, there is no unified and widely accepted conclusion in the academic circle on the correlation between the characteristics of the top management team and enterprise performance. For example, in the relationship between top management team heterogeneity and organizational performance, some empirical studies have proved that the cognitive differences of the team are conducive to the complementarity of team members, to make more comprehensive strategic decisions (Wiersema, 1992), and some studies believe that the heterogeneity of the top management team is too strong, which will lead to the intensification of contradictions within the team, not easy to communicate, thus affecting organizational performance (Gu & Hu, 2008). Second, the existing studies are more likely to be large-sample, cross-industry studies, but specific empirical studies are often not available for specific industries in specific countries, so there is a lack of targeted theoretical guidance on the current state of management in specific industries.

In view of the above shortcomings, this thesis focuses on the relationship between top management team characteristics, R&D investment, and enterprise performance of Chinese medical device enterprises based on Upper Echelons Theory and Principal-Agent Theory. This thesis will use empirical analysis and case study methods to carry out research. The specific methods are as follows:

(1) Empirical research. This thesis collects data on Chinese medical device enterprises listed on the Shanghai Stock Exchange and Shenzhen Stock Exchange from 2019 to 2022. A-share refers to the common stock issued by companies in China for domestic institutions, organizations, or individuals (excluding Taiwan, Hong Kong, and Macao investors) to subscribe and trade in RMB. The collected data objects were classified and processed by statistical software SPSS 27, including descriptive statistics, correlation analysis, and multiple linear regression analysis. Among them, descriptive statistical analysis is a statistical description of the relevant data of all variables. Correlation analysis is to study the correlation

and change trend of the relationship between two or more correlated variables. Regression analysis is to estimate the value of another variable with one or more variable values and to express the relationship between variables in the form of models.

(2) Case study. This thesis focuses on the influence mechanism of top management team characteristics and organizational performance of Chinese medical device enterprises. At present, there is no sufficient relevant research in China. The case study method is a qualitative research method, which is suitable for exploratory research in new fields where the existing theoretical research is insufficient. The case study method can also make up for the shortcomings of relying solely on statistical data for analysis, helping researchers to understand responsible social phenomena more systematically and deal with complex problems more deeply (Eisenhardt, 1989). Therefore, based on the empirical research method, this thesis adopts the case analysis method. At the same time, to improve the stability and accuracy of case studies, this thesis adopts a multi-case study method. In this thesis, three representative Chinese medical device enterprises are selected to conduct semi-structured in-depth interviews to understand the research content, and the relevant information of the case enterprises is obtained through public channels, so as to obtain the results related to the research problems to support the research of this thesis.

3.2 Research hypotheses

This thesis is divided into three parts to explore the relationship between the characteristics of the top management teams, R&D investment, and enterprise performance in Chinese medical device enterprises. It puts forward the hypotheses of the relationship between the heterogeneity of top management teams, R&D investment, and enterprise performance in Chinese medical device enterprises, and constructs the hypotheses model of this thesis.

3.2.1 Top management team characteristics and enterprise performance of Chinese medical device enterprises

In this thesis, the characteristics of the top management team refer to the demographic characteristics of the top management team. The characteristics of the top management team are divided into homogeneity and heterogeneity. The homogeneity characteristics of the top management team reflect the convergence of individual characteristics, values, and important attitudes of top management team members, which is used to measure the average level of the top management team. The heterogeneity characteristics of the top management team refer to

the degree of differentiation among top management team members, which reflects the degree of differentiation of all individual characteristics.

From the previous research, the homogeneity of the top management team is more suitable for solving the daily management problems of the enterprise, which is conducive to increasing the overall recognition and cohesion of the top management team, and has a significant role in promoting the performance of the enterprise (Huang et al., 2011). The heterogeneity of the top management team can enhance the flexibility and diversity of strategic decision-making in a relatively complex environment, which is helpful to improve corporate performance. Many empirical studies have proved that age heterogeneity and tenure heterogeneity are very helpful to improve the decision-making quality of top management teams and improve the performance of enterprises (Finkelstein & Hambrick, 1990; Nemeth & Kwan, 2006). However, there are still many empirical studies that suggest that there is a negative correlation between the homogeneity and heterogeneity of the top management team and corporate performance. Especially in the context of Chinese culture, the negative impact of the heterogeneity of top management team characteristics of Chinese enterprises is far greater than that of enterprises outside China (M. Q. Sheng & Long, 2023; P. Zhang, 2005).

Specifically, there is no unified conclusion on the impact of homogeneous and heterogeneous characteristics of the top management teams on enterprise performance in Chinese medical device firms. There are two main reasons : first, the lack of relevant empirical research on Chinese medical device enterprises; second, there is a big difference between Chinese collectivism culture and foreign individualism culture. Wei (2002) confirmed that in China's institutional environment, the relationship between top management team characteristics and corporate performance of Chinese listed companies is different from that of American and European companies, which is determined by China's special national conditions and political systems. At the same time, in China's collectivism culture, executives who often express different opinions are easily excluded by others, so there is more silent behavior, and the role of heterogeneity in promoting organizational performance is not easy to play (Yu, 2023).

As a Doctoral thesis of management, this thesis will specifically combine the actual situation of Chinese medical device enterprises to explore the relationship between the homogeneity and heterogeneity characteristics of the top management team of Chinese medical device enterprises and corporate performance and R&D investment.

3.2.1.1 Homogeneous characteristics of the top management team and enterprise performance of Chinese medical device enterprises

(1) The average age of top management team and corporate performance of Chinese medical device enterprises

Age is an important indicator of the characteristics of the top management team, and age has an impact on the working tendency and attitude of the top management team. On the one hand, elder executive team members are more experienced in their work, have long-term planning in their thinking, and more comprehensive in their decision-making, and also have more social resources and relationship networks, which can help in the operation of the enterprise; on the other hand, older executives are relatively slower in accepting new matters, and may be more conservative in their decision-making and behaviors (Tihanyi et al., 2000), and elder executives may pay less attention to diversified and innovative businesses, while younger executives are more willing to take risks. Executives will pay less attention to diversified and innovative businesses, while younger executives are more willing to take risks, more actively accept innovative behaviors, and are more likely to adopt relatively positive strategies and behaviors, which will have a corresponding impact on the performance of the firm. Chinese medical device firms face a complex competitive environment, and firms need to be more aggressive in their strategies (H. B. Zhang, 2006), which requires the top management team to have the ability to learn quickly and adapt to changes in new technologies and new demands.

Therefore, the following hypothesis is proposed:

H1a: There is a negative correlation between the average age of the top management team and enterprise performance in Chinese medical device firms.

(2) The average tenure of top management team and corporate performance in Chinese medical device enterprises

In China's medical device enterprises, executives with longer tenure have rich work experience and work ability. Within the members of the top management team with longer tenure, they have a longer time of mutual understanding and cooperation, a deeper emotion with the organization, and a stronger sense of trust within the organization. It is conducive to reducing internal conflicts among the members of the top management team and improving the efficiency of strategic decision-making, and promoting the overall performance of the enterprise. The research conclusions of many Chinese researchers also prove that the longer the term of TMT is, the more conducive it is to the improvement of corporate performance (Hou, 2022). The disadvantage of long-term executives is that they work too long in the same

position, which is prone to job burnout, easy to solidify their thinking, slows down their perception and response to the external environment, and long-term executives are more likely to adopt a conservative attitude towards innovation. Executives with shorter tenure can bring new ideas and new organizational capabilities to enterprises, and are more innovative and enterprising. However, they lack a comprehensive understanding of the overall situation of the enterprise. Trust between top management team members, especially between the CEO and chairman, is not easy to form in the short term, which is not conducive to efficient cooperation and innovation within the team, and may affect the overall performance of the enterprise.

Therefore, the following hypothesis is proposed:

H1b: There is a positive correlation between the average tenure of the top management team and enterprise performance in Chinese medical device enterprises.

(3) The average education level of top management team and enterprise performance in Chinese medical device enterprises

The vast majority of researchers in academia support that there is a positive correlation between the average education level of top management team members and corporate performance. The higher the education level of top management team members, the stronger the comprehensiveness and thoroughness of the decision-making of the enterprise, and the higher the quality of the decision-making. This is because highly educated executives have perfect knowledge reserves. Their own knowledge structure and cognitive ability help them to perceive external market information more keenly, and adapt to the needs of information processing from multiple perspectives to identify market demand and meet the needs of the market. At the same time, highly educated executives learn new knowledge faster, and the speed of knowledge transfer and application is faster than that of low-educated managers, which helps to quickly formulate new product strategies and marketing strategies, so as to gain a competitive advantage. An empirical study by Y. F. Zhang (2022) found that highly educated managers are better at identifying and grasping new opportunities in the market, making timely decisions, and obtaining a strong competitive position.

Therefore, the following hypothesis is proposed:

H1c: There is a positive correlation between the average education level of the top management team and enterprise performance in Chinese medical device enterprises.

3.2.1.2 The heterogeneity characteristics of top management team and enterprise performance in Chinese medical device enterprises

Some studies have found that greater heterogeneity in executive teams leads to increased

emotional conflict and less communication among executive team members, which in turn affects enterprise performance (Jehn et al., 1997). However, some research results in China have the opposite conclusion. Chinese researcher Q. M. Li (2021) found that there is a significant positive correlation between the age heterogeneity of top management team and corporate performance in listed companies in stable development period. The reason may be that Chinese firms, especially state-owned firms, are deeply influenced by the collectivist culture, which emphasizes the priority of age and position rank, leading to the prioritization of the opinions of high-positioned and elder executives in the decision-making process of the executive team, which leads to a positive association between age heterogeneity and enterprise performance. Specific to China's medical device enterprises, executives of different ages have great differences in values and ways of thinking, and the competition in China's medical device market is very fierce. There may be great conflicts and differences in the decision-making and judgment of executives of different ages.

Therefore, the following hypothesis is proposed:

H2a: There is a negative correlation between age heterogeneity and enterprise performance of top management team in Chinese medical device enterprises.

(2) Top management team tenure heterogeneity and enterprise performance in Chinese medical device firms

In this thesis, the tenure of the top management team refers to the total length of time since the executives joined the current corporate job. Some studies support that tenure heterogeneity positively affects strategy and performance: first, top management team members with different tenures can think and argue more comprehensively about the problems and solutions faced by the firm from more diversified perspectives; second, the higher the degree of team tenure heterogeneity is, the easier it is for executives to use organizational resources to push for strategic changes that are beneficial to their firms (Z. Y. Dai , 2021); furthermore, teams with less tenure heterogeneity are more likely to have more exchanges, and more likely to have more communication, which leads to internal buy-in and helps drive performance improvement.

Other studies have argued that too much tenure heterogeneity limits communication and trust within the team and affects cooperation among the executive team, thereby affecting enterprise performance (Hambrick,1989). This thesis argues that, specifically for Chinese medical device firms, because important business lines such as operations, marketing, R&D, and finance need to work closely together, on the one hand, if there are frequent changes in the executive team, there will be a lack of internal trust and tacit understanding among executive team members, which is not conducive to communication and cooperation within the firm; on

the other hand, the performance goals, work commitments, and risk orientations of top management team members with different tenures are different, which may have a negative impact on organizational performance negatively.

Therefore, the following hypothesis is proposed:

H2b: There is a negative relationship between top management team tenure heterogeneity and enterprise performance in Chinese medical device firms.

(3) Top management team education heterogeneity and corporate performance in Chinese medical device enterprises

The education level received by executive managers affects their cognitive styles, knowledge structure, and potential for competence. Although the education level of executive managers does not represent their leadership and work ability, however, the differences in cognition among top management team members are often influenced by the heterogeneity of their education level. This is due to the fact that the teachers, classmates, and other people that top management team members come into contact with during their school education have a subtle influence on their values and cognitive styles and internalize them into their values, cognitive and behavioral styles. Teams with high educational heterogeneity are prone to conflicts in values and decision-making styles due to cognitive differences, which have a negative impact on enterprise performance. On the contrary, top management team with higher educational heterogeneity are more adaptable (P. Liu & Wu, 2022), more suitable for the intense market environment, and can help improve enterprise performance.

In many Chinese firms, executives with the same educational background are more likely to recognize each other and cooperate efficiently. In particular, some Chinese universities, such as Tsinghua University, are known for the solidarity among their alumni, and Tsinghua alumni in the executive team within a company often form small teams to work together. Bubble Mart (HK:09992), one of China's largest toymakers, has a CEO, COO, and CFO all from the same class of 2014 at Peking University's Guanghua School of Management. In addition, in the real workplace in China, executive team members who graduated from prestigious schools such as Harvard, Yale, Peking University, and Tsinghua University often implicitly discriminate against executive team members who graduated from non-prestigious schools, and communication and conflicts between the two parties due to differences in education levels are difficult to coordinate and resolve, and may negatively affect enterprise performance.

Therefore, the following hypothesis is proposed:

H2c: There is a negative correlation between educational heterogeneity of top management team and enterprise performance in Chinese medical device firms.

3.2.2 Top management team characteristics and R&D investment of Chinese medical device enterprises

3.2.2.1 Homogeneity characteristics and R&D investment of top management team in Chinese medical device enterprises

(1) The average age of the top management team and R&D investment in Chinese medical device enterprises.

Regarding the relationship between the average age of the top management team and R&D investment, the mainstream research conclusion is that the average age of the top management team is negatively correlated with R&D investment. Generally speaking, the older the top managers are, the more conservative they are, and the less they invest in R&D. The lower the age of top managers, the more open-minded they are, the more entrepreneurial they are, the more risks they are willing to take, and the more attention and resources they invest in R&D. W. Y. Zhu (2016)'s research shows that the average age of executive members is negatively correlated with corporate R&D investment. The older the executive is, the less R&D investment his company has. For Chinese medical device enterprises, R&D is precisely one of the key competitiveness.

Therefore, the following hypothesis is proposed:

H3a: There is a negative correlation between the average age of the top management team and R&D investment in Chinese medical device enterprises.

(2) The average tenure of top management team and R&D investment in Chinese medical device enterprises

The average tenure of executives is negatively correlated with corporate R&D investment. For the stability of their own career, executives with long tenure avoid being affected by the risks in R&D innovation and often have little support for R&D investment. Senior managers with shorter tenures will be more adventurous and innovative, and will increase their support for R&D investment (Barker & Mueller, 2002). In Chinese traditional culture, the elderly is given more stable role requirements in the social role and pay more attention to safety and robustness in decision-making, and the acceptance and popularity of innovation affairs are low. This style also has an impact on the R&D investment of enterprises.

Therefore, the following hypothesis is proposed:

H3b: There is a negative correlation between the average tenure of top management team and R&D investment in Chinese medical device enterprises.

(3) The average education level of the top management team and R&D investment in

Chinese medical device enterprises

There is a general consensus in the academic community on the relationship between the educational background of the top management team and R&D investment, that is, the average educational level of the top management team is positively correlated with R&D investment. The reason is that the highly educated top management team has a stronger cognitive ability and the ability to identify external environmental opportunities. The perspective of the problem is more comprehensive, and the emphasis on R&D investment will be higher. A series of research conclusions support this view. The latest research results of J. Wang et al. (2023) found that the educational level of Chinese executives is significantly positively correlated with R&D investment.

Therefore, the following hypothesis is proposed:

H3c: There is a positive correlation between the average education level of the top management team and R&D investment in Chinese medical device enterprises.

3.2.2.2 The heterogeneity characteristics of top management team and R&D investment in Chinese medical device enterprises

(1) The age heterogeneity of top management team and R&D investment in Chinese medical device enterprises

In China, elder executives tend to favor an incremental strategy implementation tempo when making strategic decisions, while younger senior managers tend to adopt an aggressive strategy implementation tempo. In terms of R&D strategy, this tendency is directly reflected in R&D investment and R&D intensity.

Therefore, the following hypothesis is proposed:

H4a: There is a negative correlation between the age heterogeneity of the top management team and R&D investment in Chinese medical device enterprises.

(2) The tenure heterogeneity of top management team and R&D investment in Chinese medical device enterprises

Generally speaking, executives with different tenures have very different understanding and acceptance of the company's strategy and performance goals, and therefore have different levels of commitment to the work that executives are responsible for. The research of Finkelstein and Hambrick (1990) shows that the willingness of top management team members to take responsibility and risk is affected by the heterogeneity of top management team members' tenure. Long-term executives have higher quality of strategies and can show higher performance than the industry average. However, in China, especially in China's private

medical device enterprises, the turnover rate of top management team members is relatively high. In addition to some senior executives who follow the founder's entrepreneurship and are deeply trusted, professional managers with uncertain tenure may pay more attention to short-term interests and are prone to conflict and disagreement with long-term executives.

Therefore, the following hypothesis is proposed:

H4b: There is a negative correlation between the tenure heterogeneity of the top management team and R&D investment in Chinese medical device enterprises.

(3) The educational heterogeneity of top management team and R&D investment in Chinese medical device enterprises

The education level of the top management team is reflected in its cognitive style and learning ability. The education level of top team members is quite different. Due to the differences in cognitive style and thinking mode, it is not easy to produce a consistent decision-making consensus in decision-making, which will limit the team's collaboration and affect the performance of the organization. At the same time, in the development process of Chinese medical device enterprises, in order to make the resume of the top management team look better for investors, some senior executives with high academic backgrounds such as doctoral degree will be selected to enter the board of directors or top management team. These executives and other executives often have some cognitive conflicts that affect teamwork.

Therefore, the following hypothesis is proposed:

H4c: There is a negative correlation between education heterogeneity of top management team and R&D investment in Chinese medical device enterprises.

3.2.3 R&D investment and enterprise performance of Chinese medical device enterprises

At present, most of the research results support that there is a positive correlation between R&D investment and enterprise performance. Sufficient R&D investment is conducive to the improvement of R&D capability, which is one of the core competitiveness of enterprises. Sufficient R&D investment can increase the proportion of R&D investment, the proportion of R&D personnel and the proportion of professional and technical personnel, so that enterprises can quickly apply new technologies and new ideas to products and form competitive advantages. The empirical studies of Vanderpal (2017) and J. Y. Li (2018) have confirmed that there is a positive correlation between R&D investment and financial performance. For Chinese medical device enterprises, R&D investment is also an important guarantee to ensure that Chinese medical device enterprises have international competitiveness.

Therefore, the following hypothesis is proposed:

H5: R&D investment of Chinese medical device enterprises has a positive impact on enterprise's performance.

3.2.4 The mediating role of R&D investment between the characteristics of top management team and enterprise performance in Chinese medical device enterprises

In this thesis, R&D investment is used as a mediating variable to empirically investigate the relationship among top management team characteristics, R&D investment, and enterprise performance. According to the analytical framework of the top echelon theory, the top management team members are affected by their age, education, tenure, and functional background, and their values and cognitive styles are different, and they have different understandings of the internal and external environments of the company, so they will make different decisions, which will affect the enterprise performance. This difference is directly reflected in R&D investment in R&D strategy, which plays a mediating role between top management team characteristics and enterprise performance, and the amount quantity of R&D investment affects the competitiveness and performance of the firm. An empirical study by X. W. Wang and Wu (2019) demonstrated that R&D investment plays a mediating effect in the process of TMT background characteristics such as age, education, tenure, and technical background of the executive team affecting enterprise performance.

For Chinese medical device firms, on the one hand, R&D investment reflect the real expectations of the top management team for the future of the firm, and many firms advertise themselves as R&D-oriented firms with little actual R&D investment, and the actual controller more often wants to cash out and leave the market; on the other hand, it is difficult for firms lacking R&D capabilities and technological advantages to be competitive in the long run in China, and thus R&D investment also determines the subsequent competitive potential of the firm.

Therefore, the following hypotheses are proposed:

H6a: R&D investment mediates the relationship between average age (H1a), average tenure (H1b), average education (H1c) of the top management team and enterprise performance.

H6b: R&D investment mediates between top management team age heterogeneity, tenure heterogeneity, educational heterogeneity, and enterprise performance.

3.2.5 Summary of research hypotheses

The research conceptual model for this thesis is shown in Figure 3.1 and the research hypotheses are shown in Table 3.1:

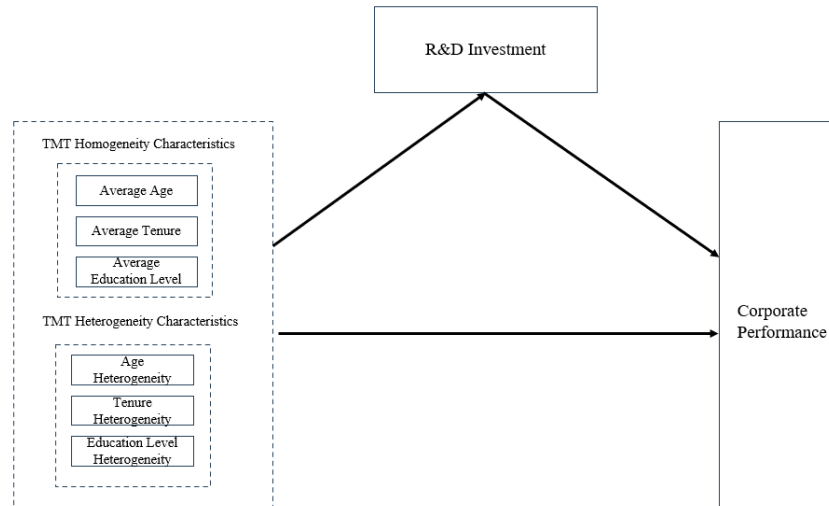


Figure 3.1 Research Conceptual Model

Table 3.1 Summary of Research Hypotheses

Number	Hypothetical contents
H1a	There is a negative correlation between the average age of the top management team and enterprise performance in Chinese medical device enterprises
H1b	There is a positive correlation between the average tenure of top management team and enterprise performance in Chinese medical device enterprises
H1c	There is a positive correlation between the average education level of top management team and enterprise performance in Chinese medical device enterprises
H2a	There is a negative correlation between age heterogeneity and enterprise performance of top management team in Chinese medical device enterprises
H2b	There is a negative relationship between top management team tenure heterogeneity and enterprise performance in Chinese medical device enterprises
H2c	There is a negative correlation between educational heterogeneity of top management team and enterprise performance in Chinese medical device enterprises
H3a	There is a negative correlation between the average age of top management team and R&D investment in Chinese medical device enterprises
H3b	There is a negative correlation between the average tenure of top management team and R&D investment in Chinese medical device enterprises
H3c	There is a positive correlation between the average education level of the top management team and R&D investment in Chinese medical device enterprises
H4a	There is a negative correlation between age heterogeneity of top management team and R&D investment in Chinese medical device enterprises
H4b	There is a negative correlation between the tenure heterogeneity of the top management team and R&D investment in Chinese medical device enterprises
H4c	There is a negative correlation between education heterogeneity of top management team and R&D investment in Chinese medical device enterprises
H5	R&D investment of Chinese medical device enterprises has a positive impact on enterprises performance
H6a	R&D investment mediates the relationship between average age (H1a), average tenure (H1b), average education (H1c) of the top management team and enterprise performance

H6b	R&D investment mediates between top management team age heterogeneity, tenure heterogeneity, educational heterogeneity, and enterprise performance
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3.3 Empirical research design

3.3.1 Sample selection and data sources

3.3.1.1 Sample selection

This thesis studies the relationship between top management team characteristics, R&D investment, and enterprise performance in Chinese medical device enterprises. China's medical device industry is developing rapidly, but how to establish a top management team that can maximize value creation for Chinese medical device enterprises lacks sufficient research support. Therefore, this thesis has strong theoretical value and practical value.

This thesis selects all medical device enterprises listed on the A-shares of the China Shanghai Stock Exchange and the Shenzhen Stock Exchange before December 31, 2022 as the sample population. The research time span is 2020-2022. Because the comprehensiveness of information disclosure in China's capital market needs to be strengthened, in order to ensure the validity and reliability of this study, the data samples are eliminated:

(1) Excluding ST, *ST and other enterprises with abnormal financial status. According to the provisions of the China Securities Regulatory Commission, ST refers to the stock that the company has lost for more than 3 years. If the ST stock cannot turn losses within the specified period, it should be delisted; *ST refers to stocks that have a bad financial position and a risk of delisting despite a loss of less than 3 years.

(2) Excluding enterprises with missing or incomplete data for the relevant sample. For example, firms with missing and incomplete information on top management personnel.

(3) Excluding enterprises with extreme outliers in relevant variables.

(4) Excluding enterprises with large changes in top management team members during 2020-2022. The change criterion is that the change rate of the entire executive team exceeds 1/2.

(5) Excluding enterprises that were publicly warned by the China Securities Regulatory Commission during the study period.

(6) Excluding enterprises listed for less than 3 years in the period of 2020-2022.

After the above elimination, a total of 114 valid enterprise research samples were obtained.

3.3.1.2 Data sources

There are two data sources in this thesis. The first is public data, including annual reports, IPO data and bond issuance data of China's medical device A-share listed companies. The second is from CSMAR database and Wind database. These two databases are the most authoritative and most frequently used economic and financial databases in China, and their data are widely used by Chinese research institutions and researchers.

3.3.2 Variable design and measurement

According to the conceptual model of Figure 3.1 and the research hypotheses of Table 3.1, there are four types of research variables in this thesis. First, the explained variable, the explained variable of this thesis is the corporate performance of Chinese medical device enterprises. Second, the explanatory variables, including the homogeneity characteristics of the top management team of Chinese medical device enterprises and the heterogeneity characteristics of the top management team. Third, the mediating variable, the mediating variable of this thesis is the R&D investment of Chinese medical device enterprises, which measured by the R&D investment intensity indicator. Fourth, control variables, including the enterprise scale, team size, and operating income growth rate of Chinese medical device enterprises.

The variables of this thesis are summarized in Table 3.2.

Table 3.2 Summary of research variables

Variable Type	Variable Name		Variable Symbol	Definition
Explained Variable	Corporate performance of A-share listed companies of Chinese medical device enterprises		ROE	Rate of Return on Common Stockholders' Equity
Explanatory Variables	TMT homogeneity characteristics of Chinese medical device enterprises	Average age	Age	Average age of top management team members
		Average tenure	Ten	Average tenure of top management team members
		Average education level	Aedu	Average education level of top management team members
	TMT heterogeneity characteristics of Chinese medical device enterprises	Age heterogeneity	Agehe	Standard deviation coefficient of age of top management team members
		Tenure heterogeneity	Tenhe	Coefficient of standard deviation of tenure of top management team members
		Education heterogeneity	Eduhe	Standard deviation coefficient of education level of top management team members

Mediator Variable	R&D investment intensity	RDI	Enterprise R&D expenses / enterprise operating income × 100 %
Control Variables	Assets-liability ratio	Debt	Total liabilities / Total assets
	Size of enterprise	Size	The natural logarithm of the company's total assets
	Operating income growth rate	REVINR	Increase rate of main business revenue

3.3.2.1 Explained variable

In this thesis, the explained variable is the enterprise performance of China's medical device A-share listed companies. In this thesis, the definition of enterprise performance is the production and operating results of enterprises in a certain period of time.

The academic community generally selects two indicators for the evaluation of corporate performance. The first is the financial indicators. The financial indicators are mainly indicators to evaluate the financial status and operating results of the company, it mainly includes asset-liability ratio, current ratio, quick ratio, accounts receivable turnover rate, inventory turnover rate, sales profit rate, cost profit rate, and return on net assets. The second is non-financial indicators, including market share, corporate goodwill, customer satisfaction, and brand awareness indicators.

Whether from the research or from the practice of enterprise management, financial indicators are the first choice to measure enterprise performance. The main reasons are as follows: first, the use of financial indicators to measure corporate performance is more objective and direct, which can well reflect the business performance of enterprises in a period of time, and is widely accepted by enterprise management, investors, government and banking institutions. Second, financial indicators are more convenient for measurement. The financial indicators of listed companies after audit and supervision are more reliable in research, which guarantees the reliability of data quality from the legal level. Third, the measurement of non-financial indicators has certain subjectivity, and non-financial indicators reflect the value creation ability of an enterprise, which is more of a system for the future development potential of the enterprise, and is not suitable for the research of this thesis. Therefore, this thesis chooses financial indicators as the measurement index of business performance.

EVA is the abbreviation of the economic value-added model. The additional economic value refers to the balance after deducting the cost of capital or the cost of capital from the after-tax profit. EVA is considered to be a comprehensive measure of a company's true profitability or value creation. It is often used in China, especially in the assessment of Chinese state-owned enterprises. The shortcomings of EVA are as follows : first, the calculation method of EVA is

complex, the amount of accounting data processed is large, and the operation is difficult; secondly, in China, EVA is mostly calculated by third-party companies without formal audit by accounting firms, and the data is not within the scope of statutory disclosure information stipulated by the China Securities Regulatory Association; third, at present, in China, there are differences in the calculation of EVA in accounting adjustment subjects and asset pricing methods, which affect the validity of the research.

EPS (Earnings per share) refers to the ratio of after-tax profit to total equity of the enterprise, which is the net profit of the enterprise or the net loss of the enterprise for each share held by the common shareholders. EPS is used to measure the profit level and investment risk of common shares. EPS reflects the income level of shareholders, but it cannot reflect all the risks faced by corporate capital, so it is only used as supplementary information for EVA in actual operation.

ROE (Return on equity) is the ratio of net profit to average net assets of enterprises. ROE is the main indicator and the most commonly used to evaluate the performance of listed companies in China. It is widely used by securities regulatory authorities, investment institutions and investors. The ROE indicator can directly reflect the level of compensation for owner 's equity, and can also reflect the company's profitability and operational efficiency. It is simple and easy to calculate in operation, so it is widely used. This thesis uses ROE indicators to measure corporate performance.

According to the China Securities Regulatory Commission issued in 2010 ' public offering securities company information disclosure rules No.9-the calculation and disclosure of return on equity and earnings per share ', the weighted return on equity of listed companies in China is calculated as follows:

$$ROE = P / (E_0 + NP \div 2 + E_i \times M_i \div M_0 - E_j \times M_j \div M_0) \quad (3.1)$$

Among them, P refers to the profit of the company's common shareholders, NP refers to the net profit of the company's common shareholders, E_0 refers to the initial net assets of the company's common shareholders, E_i refers to the net assets added to the company's common shareholders such as the issuance of new shares or debt-to-equity swaps during the reporting period, E_j refers to the net assets of the company's common shareholders reduced by repurchase or cash dividends during the reporting period, M_0 is the number of months of the reporting period, M_i represents the cumulative number of months from the second month of the new net assets to the end of the reporting period, and M_j is the cumulative number of months from the second month of the net assets to the end of the reporting period.

3.3.2.2 Explanatory variables

The explanatory variables are the demographic characteristics of the top management team of Chinese medical device enterprises, including the homogeneity characteristics of the top management team and the heterogeneity characteristics of the top management team. Among them, the Chinese medical device enterprises in this thesis refer to the medical device enterprises listed on the A-shares of the Shanghai Stock Exchange and the Shenzhen Stock Exchange; the top management team of Chinese medical device enterprises in this thesis refers to the senior management personnel at the level of chairman, CEO, and deputy general manager. The homogeneity characteristics of the top management team include the average age, average tenure, and average education level of the top management team members. The heterogeneity characteristics of top management team include age heterogeneity, tenure heterogeneity, education heterogeneity, and function heterogeneity.

(1) Top management team homogeneity characteristics

a) Average age (Age)

The average age of all members of the top management team of Chinese medical device enterprises. The calculation method is to calculate the arithmetic average of the collected age information data of the top management team and take the integer.

b) Average tenure (Ten)

The average term of the top management team of China's medical device enterprises in the current working enterprise. The calculation method is based on the annual report and other public information to comprehensively judge the tenure of each executive and obtain the arithmetic average. If the top management team members change their positions, but they still serve in the concept of the top management team defined in this study, and the service time is continuous, the term of office is calculated continuously from the first position of the top management team, and the term of office is less than 1 year but more than half a year.

c) Average education level (Edu)

The average education level of all members of the top management team of Chinese medical device enterprises. Use the data in the CSMAR Chinese listed company executive characteristics database. Firstly, the education level of the top management team members is assigned, among which the education level of senior high school and below is 1, junior college is 2, undergraduate is 3, master's degree is 4, doctoral degree or above is 5, and then the average value is calculated.

(2) Top management team heterogeneity characteristics

The measurement methods of demographic heterogeneity of the top management team in academia mainly include the standard deviation coefficient method and HHI (Herfindal Hirschman index).

The standard deviation coefficient method is to divide the standard deviation of the variable by the mean. Since the standard deviation coefficient is a constant proportion of the measurement index, the accuracy is better than the standard deviation and variance when measuring continuous data such as age and time (Allison, 1978). Therefore, this method is widely accepted by the academic community. In this thesis, the standard deviation coefficient is used to measure the all-heterogeneity indicators of the top management team of Chinese medical device enterprises.

a) Age heterogeneity and tenure heterogeneity

The calculation method is the standard deviation of the variable divided by the mean value. The larger the result value is, the greater the difference between age heterogeneity or tenure heterogeneity is.

b) Educational heterogeneity

To measure the heterogeneity of education, this thesis first needs to classify the educational background. There are three kinds of educational background classification in the academic circle. The first is to divide the majors according to the majors they study. Wiersema (1992) divides the majors of senior managers into two categories: engineering and science. In addition, the classification of the Ministry of Education of China refers to the original Soviet Union model, and divides the majors into liberal arts, science, engineering, agriculture, and medicine. The second is classified according to the level of education received, such as junior college, undergraduate, and master. The third is to unify the professional and academic qualifications. The third is a mixed classification method. Tihanyi et al. (2000) combined the professional and academic qualifications of senior executives and proposed 10 classification methods such as science and engineering undergraduate, literature undergraduate, MBA, and Ph.D. Due to the strong professionalism of China's medical device industry, this thesis uses the educational level of the top management team to measure the heterogeneity of education.

Educational heterogeneity was measured by standard deviation coefficient. In operation, the heterogeneity of education distinguished and assigned according to the category. The level of education is 1 for high school and below, 2 for junior college, 3 for undergraduate, 4 for master's degree, and 5 for doctor 's degree. The specific categorization is detailed in Table 3.3.

Table 3.3 Classification of top management team heterogeneity characteristics

Number	Classification of Educational levels
1	High school and below
2	Junior college
3	Undergraduate
4	Master
5	Doctor

3.3.2.3 Mediator variable

The measurement of enterprise R&D investment is generally measured from three indicators. The first category is to calculate the ratio of R&D personnel to total employees, the second category is the number of patents, and the third category is the intensity of R&D investment.

The method of calculating the ratio of R&D personnel to total employees is not applicable in this thesis, because different enterprises have different classification criteria for R&D personnel, which is easy to cause data distortion. The number of patents to measure R&D is also not applicable in this thesis. The time from application to approval of many patents in China is uncertain and has a large lag. At the same time, the classification method of Chinese patents is special. Chinese patents are divided into appearance patents, invention patents and utility model patents according to their characteristics. The technical content of appearance patents and utility model patents is not high, and it is impossible to measure the real R&D ability.

Therefore, this thesis uses RDI (R&D investment intensity) as a mediating variable.

$$\text{R\&D investment intensity} = \frac{\text{Enterprise R\&D expenses}}{\text{Enterprise operating income}} \times 100 \% \quad (3.2)$$

Among them, the R&D expenses of enterprises refer to the expenditure of enterprises for research, experiment, and technology transfer in a certain period of time, and the total operating income of enterprises refers to the total business income of enterprises in a certain period of time. R&D investment intensity indicator can objectively and truly measure the investment of enterprises in R&D.

3.3.2.4 Control variable

Control variables are variables that affect the results of the research and need to be considered in the research in addition to explanatory variables and explained variables. Many factors affect the characteristics of top management team, R&D investment, and enterprise performance of Chinese medical device enterprises. This thesis chooses three indicators of asset-liability ratio, enterprise scale and operating income growth rate as control variables.

The asset-liability ratio is the ratio between the total liabilities and total assets of the enterprise, reflecting the asset-liability situation and equity ratio of the enterprise. The firm size

indicator was chosen because executive heterogeneity characteristics are affected by the number of top management team members, and differences in the number of top management team in firms of different sizes may affect the level of team heterogeneity. The Increase rate of main business revenue is an important indicator to evaluate the growth status and development ability of enterprises. It refers to the ratio of the increase of operating income in the current year to the total operating income in the previous year, reflecting the increase or decrease of main business income. Some medical device enterprises in China claim that they are R&D enterprises in propaganda, but they are actually sales-driven enterprises. So, the true impact of revenue growth on R&D investment intensity needs to be examined and therefore control variables are included.

3.4 Case study

This thesis explores the relationship between executive team characteristics, R&D investment, and enterprise performance in Chinese medical device firms. From the existing literature, firstly, there is a lack of relevant literature exploring the influence mechanism of top management team characteristics for Chinese medical device enterprises; secondly, the existing papers on the influence mechanism of executive group characteristics mostly use empirical research methods such as statistical analysis and questionnaire research, and fewer use qualitative research methods such as case study and narrative research. This is because it is difficult to obtain the cooperation of the researcher in executive team research, especially the executives of Chinese companies have a very strong guarded mentality and have a low willingness to cooperate in accepting interviews and cooperating with the case study.

Because there is no complete theoretical framework for the existing research, this thesis is suitable to use exploratory case study methodology based on quantitative empirical research to explore the influence mechanism of executive team characteristics, R&D investment, and enterprise performance in Chinese medical device firms. The exploratory case study is very suitable for answering the questions of "what" and "how", which can echo the research questions of this thesis, clarify the relationship between each variable, and serve as a good supplement to the quantitative empirical research.

3.4.1 Introduction of case study method

Case study is a common research method in management. According to the number of cases, case studies are divided into two different categories: single case and multiple cases (Eisenhardt,

1989). According to the research purpose, case studies can be divided into four types: exploratory, descriptive, evaluative, and explanatory (Birkinshaw et al., 2008).

Chinese researcher Hu (2008) summarized and analyzed the common advantages and disadvantages of case study method: First, the research object of single case study is generally a typical, unique or extreme case where the theory has matured. In multi-case study, multiple cases are used for the same research topic. Second, the effect of single case study is greatly affected by the nature of the case, and multi-case studies can provide conclusion support for each other, so the research results are more explanatory and effective. Third, single case study is often used to verify the authenticity of a certain aspect of the existing theory or to analyze a unique, extreme, or rare event situation, and the scope of multi-case studies is relatively wider. Fourth, the single case study can reveal the background of the research phenomenon presented by the case in a simple way. Because the number of cases is relatively rich and they all point to the same conclusion, the multi-case study can reflect the different aspects of the case background more comprehensively. Fifthly, from the perspective of deficiency, single case study has shortcomings in the construction of new theories and the promotion of research results. The multi-case study has more requirements on researchers' time, energy, research ability and data use, and its reliability and validity may be questioned.

Combined with the research purpose of this thesis, this thesis adopts multi-case study method.

3.4.2 Case study design

This thesis adopts the method of exploratory case study. This thesis refers to the cases of the previous exploratory case study method. The main research steps include: sample selection, brief description of research cases, analysis of case studies, and presentation of research results. This study also attempts to use a semi-structured interview outline to conduct field interviews to understand the mechanism by which the characteristics of the top management team affect corporate performance.

3.4.2.1 Case sample selection

In case study, it is necessary to select the research sample. Graebner (2007) argues that the purpose of case study is to develop theories rather than to test theories, therefore, case study adopts theoretical sampling. Theoretical sampling needs to select the cases that have the effect of replication and expanding the emerging theories, in other words, select the cases that are suitable to elucidate and extend the logical relationship between the concepts. Patton (1990)

points out that, unlike the large sample sizes of quantitative research, the sample sizes of case studies are generally small, and in theoretical sampling, the size of the sample is not a key factor in determining the validity of the findings, which depend on whether the sample is able to answer the researcher's research questions more completely and accurately.

In this thesis, three enterprises are selected for case study, and the following factors are considered in the selection of cases:

(1) Representativeness: as a well-known enterprise of medical devices in China, the status, brand reputation, and management mode in the industry are representative.

(2) Differentiation: the three companies have certain differentiations in the characteristics of the top management team and corporate culture.

(3) Researchable: Top management team research requires the cooperation of executives, in fact, it is very difficult in China. The author of this thesis graduated from Peking University and is also an EMBA alumnus of the School of Economics and Management of Tsinghua University. These two universities are the top universities in China. A large number of CEOs and government executives graduated from these two universities. Through the strong alumni network of Peking University and Tsinghua University, the cooperation and support of the alumni executives of the sample enterprises can be obtained, so as to accept the interview and research of the author of this thesis.

The interviewees of this thesis are the deputy general managers and above of the sample enterprises. Because the sample enterprises are listed companies, affected by the information disclosure regulations of the regulatory agencies, business secrets and personal privacy, this thesis will hide the enterprise name and the specific information of the interviewees in all the data identifications, and use letters instead.

3.4.2.2 Case data collection

Case studies have six common data sources: documents, archival records, interviews, direct observations, participant observations, and physical evidence (Marshall and Rossman, 2014). This study mainly uses two data sources.

(1) Public information

Detailed and authentic data can increase the reliability of case studies. The three companies selected in this thesis are listed companies. China has a strict information disclosure system for listed companies. This thesis can obtain audited and legal official information from the official channels of the China Securities Regulatory Commission, Shanghai, and Shenzhen Stock Exchanges, and can obtain a large amount of corporate information from the official channels

of sample companies, magazines, books, and websites. In order to ensure that the research enterprises have enough understanding, and more convenient dialogue with the interview enterprise executives, this thesis uses a large number of public information to understand the sample enterprises.

(2) Semi-structured in-depth interviews

In-depth interviews are in-depth exchanges between researchers and interviewees face-to-face. Through interviews, it can fully understand the interviewees' views and attitudes on specific affairs (Aroni & Minichiello, 2008). For this study, in-depth interviews can deeply understand the real thinking and real attitude of managers in decision-making.

This study plans to conduct interviews in five steps: a) through the author's personal relationship network to find the research enterprise, and communication to obtain the intention of the sample enterprise main decision makers to support; b) through the public information to understand the background information of the sample enterprises, the interview outline is prepared in a targeted manner; c) send the interview outline to the interviewee in advance; d) Face-to-face unstructured interviews with the chairman, CEO, and other executives of the three companies, recorded with the consent of the interviewees; e) in order to improve the reliability and validity of the case study, the interview records were completed in the 24 hours after the interview. When sorting out the interview records, the researchers and the interviewees maintain communication, further improve the supplementary materials, and ensure the authenticity and accuracy of the research materials.

3.5 Summary of research methodology

This section discusses the research methodology and research design of this thesis. Quantitative empirical research and exploratory case study methods are specifically used in this thesis. Firstly, quantitative empirical research empirically investigates the relationship between top management team characteristics, R&D investment and corporate performance for Chinese A-share medical device listed companies, based on which three typical Chinese medical performance companies are selected for exploratory case studies. Finally, through the combination of empirical analysis and exploratory case studies, high-quality research conclusions will be formed.

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Chapter 4: The Empirical Study

This chapter aims to verify the research hypotheses through quantitative empirical research and case empirical research. The quantitative empirical study is carried out first. After the quantitative empirical study, this thesis selects three cases of Chinese listed medical device companies to carry out exploratory case studies, as a supplement to quantitative empirical research and the improvement of the thesis.

4.1 The quantitative empirical research

This section examines the research hypotheses through a quantitative empirical study. The first step is to carry out descriptive statistics on the sample data, the second step is to conduct correlation analysis, the third step is to carry out multiple regression analysis on the sample data, and the fourth step is to examine the stability of the evaluation methodology and the capability of the indicators through the robustness test.

4.1.1 Description of the sample

The sample data for this thesis is taken from the CSMAR database. The classification of Chinese medical device companies in the sample is based on the SYWG (Shenyin Wanguo) Industry Classification, Revision 2021. SYWG is one of the largest securities companies in China. The SYWG industry classification methodology has 2 advantages: the first is the comprehensive scope of industry statistics and the timely updating of industry catalogs, and the second is that it can take into account the needs of investors and industry researchers, and is highly practical. Therefore, this industry classification standard is widely adopted by researchers.

The data in this thesis are taken from the data of sample enterprises in 2022. Because of the COVID-19 pandemic, the Chinese government has implemented a quarantine policy for COVID-19 infections for three consecutive years from 2020-2022. The quarantine policy has seriously affected the normal flow and communication of people. In 2020 and 2021, many Chinese medical device companies can make excessive profits as long as they can produce medical devices such as face masks, antigens, and temperature-measuring guns, so there is an

abnormal surge in performance in 2020 and 2021, which can no longer truly reflect the business capabilities of the companies. Nevertheless, the year 2022 is the third year after the quarantine of the COVID-19 pandemic, Chinese medical device enterprises have adapted to the impact of the Chinese government's policy during the COVID-19 pandemic, the overall business operation of the enterprises is stable, and there will be no abnormal opportunistic profitability due to the COVID-19 pandemic, therefore, adopting the data of the year 2022 can maximize the guarantee of the credibility and validity of the research of this thesis.

4.1.2 Descriptive statistics

After data cleaning of the original data, a total of 114 Chinese medical device listed enterprises and 920 executives' valid sample data were obtained. The mean, median, maximum, minimum, and standard deviation of the main variables were analyzed in this thesis by using SPSS27 software. The descriptive statistics of each variable are shown in Table 4.1:

Table 4.1 Descriptive statistics of relevant variables

Variable	N	Mean	SD	Median	Max	Min
ROE	114	0.1	0.22	0.1	0.82	-1.49
AGE	920	46.91	7.85	46	84	26
TEN	920	50.13	39.33	37	219	1
AEDU	920	3.56	0.82	3	1	5
AGEHE	920	0.15	0.55	0.15	0.34	0.26
TENHE	920	0.56	0.33	0.56	1.95	0.00
EDUHE	920	0.20	0.11	0.20	0.65	0.00
RDI	114	0.12	0.13	0.09	0.01	1.08
DEBT	114	0.22	0.13	0.2	0.83	0.06
SIZE	114	21.9	0.91	21.8	24.57	20.11
REVINR	114	0.14	0.55	0.03	4.3	-0.8

4.1.2.1 The explained variable

The minimum value of the explained variable ROE is -1.49 and the maximum value is 0.82, with a large difference between the maximum and minimum values. The minimum value is negative and it can be inferred that some companies have losses. The mean and median of ROE of the sample data are 0.1, and the standard deviation is 0.22, which is slightly higher than the mean, this shows that the overall data dispersion is relatively stable, and there is a certain degree of difference in profitability between different Chinese medical device listed enterprises.

4.1.2.2 The explanatory variable

(1) Average age

The mean of average age (AGE) of the top management team of Chinese medical device listed enterprises is 46.91 and the median is 46, the mean and median are approaching, which indicates

that most of the members of the top management team are middle-aged and in their golden age with rich working experience. The maximum value of the average age is 84, the minimum value is 26, and the standard deviation is 7.85, which indicates that there are differences in the age structure of the top management team. On the one hand, the reason is due to the family inheritance of entrepreneurs, because China implemented the reform and opening up only in 1978, and a few of the first-generation entrepreneurs are still unretired, and the second and third generations of the family business are entering into the family business one after the other. On the other hand, there are differences in the sources of executives of Chinese medical device companies. Some come from entrepreneurs in different periods, and some come from professional managers.

(2) Average Tenure

The mean value of the average tenure (TEN) of the Chinese medical device listed enterprises' executive teams is 50.13 months, and the median is 37 months, indicating that the tenure of most top management team members is lower than the mean value. The difference between the mean and the median is 13.13 months, indicating that the tenure of top management teams in Chinese medical device listed enterprises is relatively volatile. The maximum value of the mean tenure is 219, the minimum value is 1, and the standard deviation is 39.33, which shows that with the rapid development of Chinese medical device listed enterprises, the dispersion of the tenure of executives is increasing.

(3) Average Education Level

The mean of average education level (AEDU) of the top management team of Chinese medical device listed enterprises is 3.56, the median is 3, and the standard deviation is 0.82. There is not much difference between the mean and median of education level, which indicates that the education level of the executives of Chinese medical device listed enterprises is close to each other, which means that the majority of the executives have a bachelor's degree or higher education level. The education level matches the highly competitive threshold and high-tech industry characteristics of Chinese medical device listed enterprises. The maximum value of the average education level is 5 and the minimum value is 1. On the one hand, it indicates that some executives in the Chinese medical device top management team have a high educational level and as doctoral degree, which is in line with the competency requirements of the medical device industry, and at the same time, it also reflects that some of the executives have a low level of original educational level, they can serve as executives because they have grown from the start-up stage as the business has grown.

(4) Age heterogeneity

The age heterogeneity, tenure heterogeneity, and education level heterogeneity of the top management team of Chinese medical device listed enterprises were calculated using the standard deviation coefficient. The standard deviation coefficient is the ratio of the standard deviation to the mean.

The maximum value of the standard deviation coefficient for age heterogeneity is 0.34, the minimum value is 0.26, and the mean and median are both 0.15, which shows that the age of the top management team of China's medical device companies is relatively centralized, and age heterogeneity is not high.

(5) Tenure Heterogeneity

The maximum value of the standard deviation coefficient of tenure heterogeneity of Chinese medical device firms' executive teams is 1.95, the minimum value is 0, and the mean value is 0.56, which illustrates that there is a high degree of heterogeneity in the tenure of top management teams. Unstable tenure reflects changes in corporate governance, which may be detrimental to the implementation of future-oriented long-term strategic decisions.

(6) Educational level heterogeneity

The maximum value of the standard deviation coefficient of the education level heterogeneity of the top management team is 0.65, the minimum value is 0, and the mean and median are both 0.2, which indicates that the education level of the top management team of Chinese medical device listed enterprises is relatively more centralized, and the majority of the executives have received similar levels of higher education.

4.1.2.3 The mediating variable

The mediating variable of this thesis is the RDI (Research and Development Intensity), which is calculated as $\text{R\&D expenditure} / \text{total expenditure} * 100\%$. The average RDI index of the sample is 0.12, and the median is 0.09. According to the "*China Medical Device Development Report 2022*" of the State Drug Administration of China, the median R&D intensity of Chinese medical device listed enterprises in 2021 is 6.39%. It can be seen that the RDI index of listed medical device companies in China is higher than that of ordinary medical device companies. It also shows that listed medical device companies generally attach importance to research and development. The standard deviation of RDI of China's medical device listed enterprises is 0.13, the maximum value is 1.07, and the minimum value is 0.01, indicating that enterprises attach different importance to R&D investment, and the R&D intensity varies greatly.

4.1.2.4 The control variable

(1) Asset-liability ratio

The mean value of the asset-liability ratio of China's medical device listed enterprises is 0.22, the median is 0.2, and the mean and median are very close. The maximum value of the asset-liability ratio is 0.83, the minimum value is 0.06, and there is a big difference. The standard deviation is 0.13, indicating that the asset-liability ratio of China's medical device companies has changed relatively little over a period of time, the debt level is relatively stable, and the overall financial risk of China's medical device companies is not high.

(2) Enterprise size

The size of the enterprise is calculated by the natural logarithm of the total assets of the company. The mean value of enterprise size is 21.9, the median is 21.8, and the mean and median are close. The standard deviation of the enterprise scale is 0.91, the maximum value is 24.51, and the minimum value is 20.11. Since the enterprise scale is calculated by the natural logarithm of the total assets of the company, corresponding to the total assets scale, it can be found that there are great differences in the scale of Chinese medical device enterprises.

(3) Operating income growth rate

The average value of the growth rate of operating income of Chinese medical device enterprises is 0.14, the median is 0.03, the standard deviation of the growth rate of operating income is 0.55, the maximum value is 4.3, and the minimum value is -0.8, indicating that the growth of operating income of Chinese medical device enterprises is quite different, and some enterprises even have negative growth.

4.1.3 The correlation analysis

4.1.3.1 The pearson correlation analysis

To ensure the reliability and validity of this study and ensure the accuracy of multiple regression data, the correlation between top management team characteristics, R&D investment, and corporate performance is tested in advance. The specific data are shown in Table 4.2.

Table 4.2 Pearson correlation analysis

	ROE	AGE	TEN	AEDU	AGEHE	TENHE	EDUHE	RDI	DEBT	SIZE	REVINR
ROE	1										
AGE	0.182*	1									
TEN	-0.11	-0.02	1								
AEDU	0.038*	0.028	-0.022	1							
AGEHE	-0.17**	0.094	0.136	0.067	1						
TENHE	0.059	-0.021	-0.152	-0.032	0.073	1					
EDUHE	0.012*	-0.138	0.043	-0.11	0.204*	0.094	1				
RDI	0.229*	-0.09	0.004	0.01	0.017	-0.111	0.024	1			
DEBT	-0.356	-0.026	-0.025	0.204*	0.108	0.231*	0.027	-0.14	1		
SIZE	0.299	0.132	0.026	0.015	-0.085	0.133	-0.022	-0.294**	0.347*	1	
REVINR	0.105*	-0.049	0.195	0.078	0.151	-0.097	-0.009	0.117	0.371	0.087*	1

Note: * represents a significant correlation at the 0.05 level, * * represents a significant correlation at the 0.01 level, * * * represents a significant correlation at the 0.1 level

(1) The correlation analysis between top management team characteristics and corporate performance

From the results of the correlation analysis between the characteristics of the top management team and the performance of the enterprise, the average age, average education level, education heterogeneity and ROE of the top management team of Chinese medical device enterprises are positive and significant. The average term and the correlation coefficient with ROE are negative. The correlation coefficient between age heterogeneity and ROE is negative and significant, and the correlation coefficient between term heterogeneity and ROE is positive, but not significant.

(2) The correlation analysis between top management team characteristics and R&D investment

From the results of the correlation analysis between the characteristics of the top management team and R&D investment, the correlation coefficient between the average age of the top management team of China's medical device listed enterprises and R&D investment is -0.09 , and the correlation coefficient between the average tenure, the average education level and R&D investment are positive. The correlation coefficient between tenure heterogeneity and R&D investment of top management team in Chinese medical device listed enterprises is -0.111 , and the correlation coefficient between age heterogeneity, education heterogeneity, and RDI is positive, but not significant.

(3) The correlation analysis between R&D investment and enterprise performance

There is a significant positive correlation between RDI and corporate performance at the 5% confidence interval level. This shows that R&D investment in China's medical device industry has a positive effect on the improvement of corporate performance.

4.1.3.2 The multiple linear tests of variables

Multicollinearity means that the model estimation is distorted or difficult to estimate accurately due to the existence of accurate correlation or high correlation between the explanatory variables in the linear regression model. Therefore, the collinearity test is usually performed using the VIF method after the Pearson test. VIF test has two criteria: a) Mean VIF > 2 ; b) the maximum value of VIF > 10 . When one of the two conditions is satisfied, it shows that there is multicollinearity. The VIF test results of this thesis are shown in Table 4.3.

Table 4.3 Multiple Linearity Tests for Variables

Variable	VIF	Tolerance
Age	1.076	0.929
Ten	1.122	0.891
Aedu	1.108	0.903
Agehe	1.143	0.875
Tenhe	1.142	0.876
Eduhe	1.101	0.908
RDI	1.141	0.876
Debt	1.523	0.657
Size	1.279	0.782
REVINR	1.523	0.756
Mean VIF	1.216	

The VIF test results of each variable in this thesis show that the maximum VIF value is 1.532, the average VIF is 1.216, and it does not meet the standard of the VIF test. It can be inferred that there is no multiple linear relationship between variables, and the next regression analysis can be carried out.

4.1.3.2 Multivariate normality test

Multivariate normal distribution means that all components of a random vector obey normal distribution. In the multivariate normal distribution test, K-S test (Kolmogorov-Smirnov test) was used when the sample size exceeded 100 according to the statistical provisions. The K-S test is a non-parametric test for the equality of continuous or discontinuous one-dimensional probability distributions. The K-S test results of this thesis are shown in Table 4.4.

Table 4.4 Multivariate normality test

Variable	K-S Test
ROE	0.168
Age	0.07
Ten	0.154
Aedu	0.245
Agehe	0.055
Tenhe	0.085
Eduhe	0.105
RDI	0.192
Debt	0.097
Size	0.081
REVINR	0.202

According to the statistical principle, in the K-S test results, if $P > 0.05$, it conforms to the specified normal distribution, $P < 0.05$, it does not conform to the specified normal distribution. From the K-S test results of each variable in this thesis, the P values are all greater than 0.05, so it can be inferred that the variables conform to the multivariate normal distribution, and the next regression analysis can be carried out.

4.1.3.3 Homoscedasticity test

In this thesis, the variance homogeneity test is performed on variables that pass the normality test. The homogeneity of variance test is used to examine whether there is a significant difference between two sets of data with equal variances and to help the researcher determine whether the difference between two sets of data is related to chance. Levene's method test is used in this thesis. The results of the homoscedasticity test for this thesis are shown in Table 4.5.

Table 4.5 Homoscedasticity test of variables

Variable	Levene	P Value
Age	1.126	0.336
Ten	1.301	0.204
Aedu	1.582	0.184
Agehe	1.664	0.246
Tenhe	1.114	0.286
Eduhe	1.392	0.245
RDI	1.208	0.198
Debt	1.674	0.188
Size	1.021	0.988
REVINR	1.251	0.168

According to statistics, if the significance is less than 0.05, it means that the variance is not homogeneous. From the result of homoscedasticity test in table 4.5, it is found that $p > 0.05$, hence the data passes the homoscedasticity test.

4.1.4 The regression analysis

This chapter takes the data of China's medical device A-share listed enterprises in 2022 as a sample and conducts multiple regression analysis through SPSS27 software to test the six research hypotheses proposed in this thesis.

4.1.4.1 The regression analysis of top management team characteristics and enterprise performance

The regression analysis results of the characteristics of the top management team and corporate performance of Chinese medical device listed enterprises is shown in Table 4.6.

Table 4.6 The regression analysis results of top management team characteristics and corporate performance

Variable	(1)	(2)	(3)	(4)	(5)	(6)
AGE	0.211* (1.438)					
TEN		-0.068 (0.621)				
AEDU			0.019* (0.891)			
AGEHE				-0.245** (-0.807)		
TENHE					0.031 (0.615)	
EDUHE						0.077* (0.792)
DEBT	-0.351 (-0.403)	-0.119 (1.355)	0.015* (0.063)	-0.133 (-1.505)	0.148 (1.628)	0.009 (0.104)
SIZE	0.172 (0.186)	-0.078 (-0.839)	0.016 (0.137)	0.168 (-1.781)	0.02 (0.218)	0.074 (0.792)
REVINR	0.179 (2.151)	0.007* (0.082)	-0.008 (-0.097)	-0.128 (-1.448)	0.021 (0.256)	0.056* (0.65)

Note: The value in parentheses is the t-test value of the coefficient

(1) There is a significant positive correlation between the average age of the top management team and corporate performance in Chinese medical device listed enterprises, and the regression coefficient is 0.211. This result is opposite to the null hypothesis H1a. This hypothesis is rejected. The reason is that the average age of the top management team of China's medical device companies is older, the older executives have more management experience and have closer cooperation and contact with stakeholders such as governments, research institutions, and suppliers, which is conducive to the improvement of corporate performance.

(2) The regression coefficient of the average tenure and corporate performance of the top management team of China's medical device listed enterprises is -0.068 . The null hypothesis H1b is rejected. According to the descriptive statistical results, it can be found that the average tenure of the top management team of China's medical device enterprises is relatively long, and there is a high degree of competition in China's medical device industry. The long tenure can easily lead to the polarization of the thinking of the top management team, which is not conducive to organizational innovation and change, so it has a negative impact on organizational performance.

(3) The regression coefficient of the average education level of the top management team and corporate performance of China's medical device listed enterprises is 0.019, and the average education level of the top management team significantly affects corporate performance. It is assumed that H1c is not rejected.

(4) The regression coefficient of the age heterogeneity and corporate performance of the

top management team of China's medical device listed enterprises is -0.245, and the age heterogeneity of the top management team has a significant negative impact on corporate performance. H2a is not rejected.

(5) The regression coefficient of the tenure heterogeneity and corporate performance of the top management team of China's medical device listed enterprises is 0.031, and the tenure heterogeneity of the top management team has a significant positive impact on corporate performance. This result is contrary to H2b. Therefore, this hypothesis is rejected. The reason is that the heterogeneity of the top management team of Chinese medical enterprises is not high, and executives are more willing to invest more time and personal resources in the development of enterprises, which is conducive to the improvement of corporate performance.

(6) The regression coefficient of the heterogeneity of executive education level and corporate performance in China's medical device listed enterprises is 0.077, and the heterogeneity of top management team education positively affects corporate performance. It is assumed that H2c is rejected. This is because the heterogeneity of the education level of executives in Chinese medical device companies can help executives think from different perspectives, learn new ideas quickly, and respond to market information promptly, so as to make higher-quality strategic decisions.

4.1.4.2 The regression analysis of top management team characteristics and R&D Investment

The regression analysis results of the characteristics of the top management team and R&D investment in China's medical device listed enterprises are shown in Table 4.7.

Table 4.7 Results of Regression Analysis of Top Management Team Characteristics and R&D Investment

	RDI	RDI	RDI	RDI	RDI	RDI
AGE	-0.094* (-0.97)					
TEN		-0.024 (-0.243)				
AEDU			0.01* (0.106)			
AGEHE				0.034* (0.34)		
TENHE					-0.012 (-1.233)	
EDUHE						0.017 (0.171)
DEBT	-0.098* (-1.015)	-0.029 (-0.297)	0.039* (0.395)	0.045 (0.453)	-0.09 (0.898)	0.186* (0.853)
SIZE	-0.053*	0.013	0.016	0.001	-0.079	0.02

	(-0.561)	(-0.139)	(0.174)	(0.012)	(-0.826)	(0.203)
REVINR	-0.087	-0.041	0.007*	0.018	-0.112	0.022**
	(-0.895)	(-0.409)	(0.068)	(0.178)	(-1.142)	(0.219)

(1) The regression coefficient of the average age and R&D investment of the top management team of China's medical device listed enterprises is -0.094. H3a is not rejected.

(2) The regression coefficient of the average tenure and R&D investment of the top management team of Chinese medical device listed enterprises is -0.024. H3b is not rejected.

(3) The regression coefficient of the average education level and R&D investment of the top management team of China's medical device listed enterprises is 0.01, and the education level of the top management team positively affects the R&D investment of the company. It is assumed that H3c is not rejected.

(4) The regression coefficient of the age heterogeneity and R&D investment of the top management team of China's medical device listed enterprises is 0.034, and the age heterogeneity of the top management team has a significant positive impact on the R&D investment of the company. The assumption that H4a is rejected. The reason is that China is different from other countries, and the age heterogeneity of the top management team of China's medical device listed companies is low. Therefore, the top management team can easily reach an agreement on R&D investment, R&D intensity, and other R&D decisions, therefore the company can maintain appropriate R&D investment.

(5) The regression coefficient of the tenure heterogeneity and R&D investment of the top management team of China's medical device listed enterprises is - 0.012, and the tenure heterogeneity of the top management team negatively affects the R&D investment of the company. Suppose H4b is not rejected.

(6) The regression coefficient of top management team education heterogeneity and R&D investment in China's medical device listed enterprises is 0.017, and the heterogeneity of top management team education positively affects the R&D investment of enterprises. It is assumed that H4c is rejected. This is because Chinese medical device companies are different from traditional manufacturing industries. The overall education level of the top management team is high, and the heterogeneity of the education level of the top management team is low. The top management team that has received higher education can recognize the importance of corporate R&D investment.

4.1.4.3 The regression analysis of R&D investment and enterprise performance of listed medical device companies in China

Table 4.8 is the regression analysis results of R&D investment and corporate performance of

Chinese medical device listed enterprises. The regression coefficient of R&D investment and corporate performance of China's medical device listed enterprises is 0.408, and R&D investment has a positive impact on corporate performance. Therefore, it is assumed that H5 is not rejected.

Table 4.8 The regression analysis results of R&D investment and enterprise performance

Variable	Regression Coefficient	T-values
RDI	0.408*	0.489

4.1.5 The mediating effect of R&D investment on the characteristics of top management team and enterprise performance

4.1.5.1 The mediation effect test method

Mediator is a statistical concept. Mediator refers to the intermediary variable that the independent variable affects the dependent variable. When the independent variable X affects the variable Y by affecting the variable M, the variable M is the intermediary variable of the variable X and the variable Y.

Baron (1986) used the causal step method to test the mediating effect for the first time. This aspect is widely welcomed and used by the academic community, with a citation of 81,000 times. Figure 4.1 shows the test steps of the mediating effect. The causal step method is divided into three steps: a) test the regression coefficient of variable X to variable Y, and clarify the significance of coefficient C; b) test the regression coefficient of variable X to variable M, and check the significance of coefficient a; c) variable X and variable M are put into the same equation to test whether the regression coefficient of variable X to variable Y is significant. If variable X does not affect variable Y, it means that the influence of the independent variable on the dependent variable is completely realized by the mediating variable. If variable X has little effect on the variable Y, it indicates that the mediating variable plays a partial mediating effect. The specific diagram is shown in the figure 4.1.

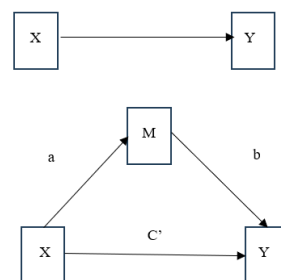


Figure 4.1 The diagram of the mediating effect test

Source: Baron (1986)

Chinese scholar Wen et al. (2005) proposed a new method to test the mediating effect based on the causal test. This method can better test the complete mediating effect or partial mediating effect. This method first tests the significance of the regression coefficient C of the variable X to the variable Y , then tests the significance of the coefficients a and b in turn, and finally tests the significance of the coefficient C' . The specific diagram is shown in the figure 4.2.

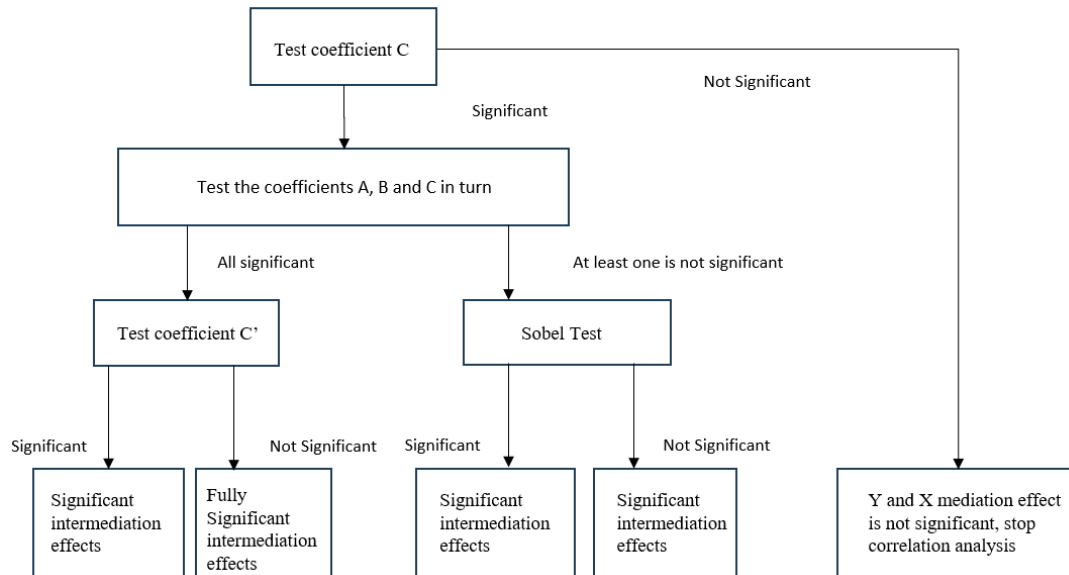


Figure 4.2 Mediation effect test procedure

Source: Wen (2005)

4.1.5.2 The test results of R&D investment, top management team characteristics, and enterprise performance

This thesis uses the models of Figure 4.1 and Figure 4.2 to test the mediating effect of R&D investment. After testing, it is found that the average tenure, tenure heterogeneity and education level heterogeneity of the top management team have no significant impact on corporate performance, which cannot meet the first step of the mediating effect, so the mediating effect test is stopped. The remaining top management team characteristics have a significant correlation with corporate performance; thus, the mediating effect test is continued for the variables with significant relationships. The mediating effect test results are shown in Table 4.9.

Table 4.9 The regression analysis results of R&D investment, top management team characteristics, and corporate performance

Variable	Regression Coefficient	T-values
RDI	0.214	1.324
AGE	0.168*	1.805
AEDU	0.053*	0.578
AGEHE	- 0.18	-1.985
DEBT	-0.116	-1.109
SIZE	-0.265	-2.676

REVINR	0.185	1.870
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(1) The mediating effect of R&D investment between the average age of top management team and corporate performance in Chinese medical device listed enterprises

Firstly, the coefficient C was tested, and it was found that the regression coefficient of the independent variable AGE and the dependent variable ROE was 0.211, and AGE and ROE were significant at the 5% level. Secondly, a is obtained by further regression, that is, the regression coefficient of AGE and RDI is -0.094, which is significant at the level of 5%. The regression coefficient of RDI and corporate performance is 0.048, which is significant at the level of 5%. The regression coefficient C' of AGE and ROE was 0.168. Therefore, it can be judged that there is a mediating effect between the average age of the top management team and corporate performance in Chinese medical device listed enterprises, and the mediating effect is a partial mediating effect.

(2) The mediating effect of R&D investment between the average education level of top management team and firm performance of listed medical device firms in China

Testing the coefficient C, it is found that the regression coefficient of the independent variable AEDU and the dependent variable ROE is 0.019, and AEDU and ROE are significant at the 5% level. Further regression was obtained a, that is, the regression coefficient of AEDU and RDI is 0.01. The regression coefficient C' of AEDU and ROE is 0.053, which is significant at the 10% level. From this, it can be judged that there is a mediation effect between the average education level of the top management team and the corporate performance of Chinese medical device listed enterprises, and this mediation effect is partial mediation effect.

(3) The mediating effect of R&D investment between age heterogeneity of top management team and firm performance in Chinese medical device listed enterprises

Testing the coefficient C, it is found that the regression coefficient of the independent variable AGEHE and the dependent variable ROE is -0.245, and there is a significant relationship between AGEHE and ROE. Further regression was obtained a, that is, the regression coefficient of AGEHE and RDI is 0.014, which is significant at the 1% level. The regression coefficient C' of AGEHE and ROE is -0.18, which is not significantly related. It can be inferred that there is no mediating effect between the age heterogeneity of top management team and firm performance in Chinese medical device listed enterprises.

It can be inferred from this that:

1) Hypothesis H6a is partially supported, that is, R&D investment plays a mediating role between the average age (H1a), average education (H1c) of the top management team and corporate performance. R&D investment has no mediating effect between the average tenure

of the top management team (H1b) and corporate performance.

2) H6b is rejected, that is, R&D investment does not play a mediating role between age heterogeneity, tenure heterogeneity, education heterogeneity, functional heterogeneity, and corporate performance.

The regression results show that R&D investment has no mediating effect between the average tenure, age heterogeneity, tenure heterogeneity, education heterogeneity of top management team and corporate performance in Chinese medical device enterprises. There are two main reasons: first, China's medical device enterprises are highly competitive market, and enterprises are facing great competitive pressure and survival pressure. In this context, R&D strategy is one of the basic competitive strategies that a rational Chinese medical device company's top management team must choose. Therefore, some characteristics of top management team, such as the average tenure of top management team, have little impact on R &D strategy. Secondly, China's medical device industry is different from other traditional industries, the overall level of age heterogeneity, term heterogeneity and education heterogeneity of the top management team is relatively low.

4.1.6 The robustness analysis

Robustness analysis is a statistical test method to examine the ability of evaluation methods and indicators to explain. Robustness analysis examines whether the evaluation methods and indicators still maintain a relatively consistent and stable interpretation of the evaluation results when certain parameters are changed. When a specific parameter is changed, if the empirical results change with the change of parameter setting, resulting in the change of symbol and significance, it shows that the statistical method and index interpretation do not have robustness, and the rigor and reliability of the research cannot be guaranteed.

There is no unified standard and paradigm for robustness analysis in academia. In specific research, different robustness analysis methods are adopted according to different research contents. Common methods include adjusting data classification, replacing variables, or measuring tests. This study adopts the replacement variable method for the robustness test. In the specific operation, the regression analysis is carried out by Tobin's Q coefficient instead of ROE. Tobin's Q ratio is a measure of market performance. It refers to the ratio of the market value of an enterprise to its asset replacement cost, which is used to measure whether the market value of an asset is overestimated or underestimated. The advantage of Tobin's Q coefficient is that it can fully consider factors such as inflation, can truly reflect the value of assets, and can

avoid the difficulty of estimating the rate of return and marginal cost. Therefore, it is widely used in academia and investment circles.

The specific regression results are shown in Table 4.10.

Table 4.10 Regression analysis results of R&D investment, top management team characteristics, and Tobin-Q value

Variable	Regression Coefficient	T-values
RDI	0.164	1.759
AGE	0.13*	1.381
AEDU	0.078*	0.835
AGEHE	- 0.071	-0.755
DEBT	-0.122	-1.14
SIZE	-0.263	-2.653
REVNR	0.184	1.862

From the regression results, it can be found that:

(1) There is a significant correlation between the average age, average education level, age heterogeneity of the top management team and the Tobin's Q coefficient, which meets the requirements of the first step test of the mediating effect.

(2) R&D investment has a partial mediating effect between the average age of the top management team AGE and the corporate performance indicator Tobin' Q. The correlation coefficient between the AEDU and the corporate performance indicator Tobin' Q is 0.078, which is significant at the level of 1%. R&D investment has a partial mediating effect, and R&D investment has no mediating effect between the age heterogeneity of the top management team and the corporate performance indicator Tobin 'Q.

Therefore, the stability test results are basically consistent with the hypothesis research conclusions of this thesis. Through the robustness test, the rigor and reliability of the research are ensured.

4.1.7 Summary of quantitative empirical research

This section first describes the various variables of this thesis. Secondly, through the correlation analysis, the relationship between the characteristics of the top management team, R&D investment, and corporate performance of Chinese medical device listed enterprises is summarized, and the multicollinearity test is carried out, which excludes the multiple linear relationships between variables and creates conditions for regression analysis. After that, through multiple regression analysis, the relationship between the characteristics of the top management team and the corporate performance of listed medical device companies in China was clarified. On this basis, this thesis carries out the mediation effect test of R&D investment. Finally, this thesis conducts a robustness analysis, and the results of the analysis support the

relevant research hypotheses that have been verified above.

All the hypotheses and test results in this thesis are shown in Table 4.11.

Table 4.11 Summary of research hypotheses testing

Number	Hypothetical contents	Verified results
H1a	There is a negative correlation between the average age of the top management team and enterprise performance in Chinese medical device enterprises	Rejected
H1b	There is a positive correlation between the average tenure of top management team and enterprise performance in Chinese medical device enterprises	Rejected
H1c	There is a positive correlation between the average education level of top management team and enterprise performance in Chinese medical device enterprises	Not Rejected
H2a	There is a negative correlation between age heterogeneity and enterprise performance of top management team in Chinese medical device enterprises	Not Rejected
H2b	There is a negative relationship between top management team tenure heterogeneity and enterprise performance in Chinese medical device enterprises	Rejected
H2c	There is a negative correlation between educational heterogeneity of top management team and enterprise performance in Chinese medical device enterprises	Rejected
H3a	There is a negative correlation between the average age of top management team and R&D investment in Chinese medical device enterprises	Not Rejected
H3b	There is a negative correlation between the average tenure of top management team and R&D investment in Chinese medical device enterprises	Not Rejected
H3c	There is a positive correlation between the average education level of the top management team and R&D investment in Chinese medical device enterprises	Not Rejected
H4a	There is a negative correlation between age heterogeneity of top management team and R&D investment in Chinese medical device enterprises	Rejected
H4b	There is a negative correlation between the tenure heterogeneity of the top management team and R&D investment in Chinese medical device enterprises	Not Rejected
H4c	There is a negative correlation between education heterogeneity of top management team and R&D investment in Chinese medical device enterprises	Rejected
H5	R&D investment of Chinese medical device enterprises has a positive impact on enterprises performance	Not Rejected
H6a	R&D investment mediates the relationship between average age (H1a), average tenure (H1b), average education (H1c) of the top management team and enterprise performance	Partial Rejected
H6b	R&D investment mediates between top management team age heterogeneity, tenure heterogeneity, educational heterogeneity and enterprise performance	Rejected

The quantitative empirical study in this thesis has the following findings:

1. There is a positive correlation between the average tenure of the top management team and corporate performance in Chinese medical device enterprises.

The average tenure of the top management team of China's medical device companies is long. When executives work for a long time in the company, on the one hand, the emotional connection between executives and enterprises continues to deepen. On the other hand, executives usually hold shares of the company as their tenure increases. Executives are willing to invest more working hours and personal resources for the development of the company, which is conducive to the improvement of corporate performance.

2. There is a positive correlation between the average education level of the top management team and the performance of Chinese medical device enterprises.

The average education level of China's top management team is high. According to the upper echelons theory, the higher the education level of top management team members is, the better the top management team members can understand the external market information and make decisions carefully and efficiently, so as to promote the improvement of enterprise performance.

3. There is a negative correlation between the age heterogeneity of the top management team and corporate performance in Chinese medical device enterprises.

Some studies of upper echelons theory believe that there is a negative correlation between age heterogeneity and corporate performance in top management teams. For example, K. X. Li (2022) empirically found that age heterogeneity is significantly negatively correlated with corporate performance based on the data of A-share listed companies from 2010 to 2019. For Chinese medical device companies, the higher the age heterogeneity of the top management team, the more likely it is to cause conflicts between top management teams, which is not conducive to discussions and exchanges within top management team, and thus affects the performance of the organization.

4. There is a negative correlation between the average age of the executive team and R&D investment.

The mainstream research of upper echelons theory believes that the age characteristics of the top management team are negatively correlated with R&D investment. Generally speaking, the older the manager is, the stronger the conservative consciousness is, and the lower the investment in R&D is. The overall age of the top management team of Chinese medical device enterprises is too old, which may have a certain impact on R&D investment.

5. There is a negative correlation between the average tenure of top management team and R&D investment in Chinese medical device enterprises.

Barker and Mueller (2002) found that executive tenure is negatively correlated with corporate R&D investment. Executives with long tenure tend to consider many problems and

avoid risks, thus, executives with longer tenure have less support for corporate R&D investment. The average term of the top management team of Chinese medical device enterprises is too long, so it may have a negative impact on the intensity of R&D investment.

6. There is a positive correlation between the average education level of the top management team and R&D investment in Chinese medical device enterprises.

A series of studies support the positive correlation between the average education level of the executive team and R&D investment. The findings of Goll et al. (2008) suggest that a higher level of education among executives helps firms to develop new business areas, pursue competitive differentiation strategies, and promote corporate innovation. The average education level of the top management team of Chinese medical device enterprises is relatively high, so it is easy to be consistent in the judgment and decision-making of R&D investment.

7. There is a negative correlation between the tenure heterogeneity of top management team and R&D investment in Chinese medical device enterprises.

The term heterogeneity of the top management team of China's medical device listed companies is not high, and the overall term of the top management team members is too long. Therefore, they may hold a conservative attitude towards large-scale R&D investment, thus affecting R&D investment.

8. The R&D investment of Chinese medical device enterprises has a positive impact on enterprise performance.

Most of the empirical research in academia supports that R&D investment has a positive impact on corporate performance. When enterprises increase R&D funds and R&D intensity investment, the technology and quality of products are correspondingly improved. China's medical device enterprises belong to the high-tech industry, which has high requirements for technology and R&D. A large amount of R&D investment helps to promote the performance of China's medical device enterprises.

9. R&D investment plays a mediating role between the average age (H1a), average education (H1c) of the top management team and corporate performance.

A series of studies of upper echelons theory have proved that R&D investment can play a mediating role between top management team characteristics and corporate performance. For the top management team of Chinese medical device companies, the more reasonable the reasonable age structure of the executive team and the higher the level of education, based on the strategic purpose of improving the overall performance of the company, the executive team has a strong willingness to increase the investment in R&D, and therefore the mediating effect of R&D investment is also more obvious.

4.2 Case study

4.2.1 Basic information of case study enterprise

In this thesis, three representative Chinese A-share listed medical device companies were selected for the case study. According to the relevant provisions of the " *Measures for the Administration of Information Disclosure of Listed enterprises in China* " implemented by the China Securities Regulatory Commission in May 2021, as well as the strong confidentiality requirements of the three companies involved in the case study, this thesis cannot publicly disclose the specific names and confidential information of the case companies without approval and consent. Therefore, the names of the three companies are replaced by A, B, and C respectively in this thesis. The basic information of the three case companies is shown in Table 4.12.

Table 4.12 Basic information of case companies

Basic Information	Company A	Company B	Company C
Founding Date	2011	1999	2009
Location	China Shanghai	China Beijing	China Beijing
Main business	High-performance medical imaging equipment, radiotherapy products, life science instruments and medical digital, intelligent solutions	Cardiovascular and Anastomotic Devices and Cardiovascular Full Cycle Solutions	Ophthalmology, medical cosmetology and wound care, orthopedics, surgical instruments
Gross asset (Year2022)	24.2 billion (¥)	24.48 billion (¥)	6.89 billion (¥)

4.2.2 Specific Cases

4.2.2.1 Company A

(1) Basic introduction of Company A

Founded in 2011, Company A mainly provides high-performance medical imaging equipment, radiotherapy products, life science instruments and medical digital, and intelligent solutions. Company A has established a global R&D, production, and service network. The company is headquartered in Shanghai, and has set up regional headquarters and R&D centers in the United States, Malaysia, the United Arab Emirates, Poland, and other places.

Company A is a leader in high-performance medical imaging diagnosis and treatment equipment in China. Company A's products have been used in more than 1000 tertiary hospitals in China. The top 10 medical institutions in China are all users of Company A. Among the top

50 medical institutions, Company A has 49 users. According to the new market share in China in 2022, Company A's computed tomography system (CT), Positron Emission Tomography (PET)/CT, PET/ Magnetic resonance imaging system (MR), and X-ray imaging system (XR) products rank first in China's industry. At the same time, Company A is a small number of Chinese enterprises that have entered the international market competition. Because the products have strong technical competitiveness, the customer base has covered more than 50 countries and regions around the world, including the University of California, Davis, University of California, San Diego, University of Washington, Italian Sacramento Calabria Hospital and other international top medical institutions all use Company A's products.

China's medical device market is growing rapidly. According to the research of Zhuoshi Consulting, from 2015 to 2020, the scale of China's medical device market has increased from 40.59 billion euros to 102.51 billion euros, with an annual compound growth rate of about 20%. In the future, with the improvement of market demand and the increasing support of the Chinese government for the medical industry, China's medical device industry will continue to grow at a high speed, and self-developed products will gradually replace imported high-end products.

In terms of business strategy, Company A aims to become a global leader in high-performance medical imaging diagnosis and treatment solutions. The CEO of Company A introduced : *“On the one hand, Company A implements ' the comprehensive layout, leading performance ' strategy, forms a rich product line around high-end medical imaging equipment, and increases R&D to maintain its advantages in product performance; on the other hand, Company A strengthens the product life cycle management ability of R&D, production, sales and after-sales maintenance, and expands the diversified three-dimensional marketing network covering the Chinese and international markets, from top scientific research institutes, universities, tertiary hospitals and grass-roots institutions, so as to ensure the company's competitive advantage”.*

(2) The characteristics of Company A's top management team

Company A has 12 senior executives, including one chairman and co-CEO, one CEO, and nine other senior executives.

The average age of the top management team is 53.33 years old, which is distributed in the range of 41-62 years old. There are 9 senior executives over 50 years old, and the age heterogeneity is small.

The average tenure of Company A's top management team is 85 months, and the heterogeneity of tenure is low, distributed in the range of 36-144 months. Among them, except for one executive who joined A company 48 months ago, other executives have served in A

company for a long time. Four executives have been promoted to senior executives for three years, but previously served as a subsidiary or division CEO in Company A in the early stages of the start-up. A company's executive said in an interview said: *"A company has always attached importance to the stability of the top management team, in the enterprise culture attaches great importance to the loyalty of employees to the enterprise"*.

Company A's top management team has a high level of education and a low degree of heterogeneity. 84% of the executives holds master's degree or above, and 16% of the executives have undergraduate degrees. More than 90% of the executives of Company A graduated from Tsinghua University, Peking University, Shanghai Jiao Tong University, Fudan University, and other top universities in China. The chairman and CEO obtain their Ph.D. in bioengineering or medicine from famous United States universities such like the University of Michigan. The CEO of Company A and the author of this thesis are alumni of Peking University. The CEO of A company said: *"A company's market is a market with a very high threshold of professional competition, and it needs enough high-quality talents to be qualified for executive positions"*.

(3) R&D investment of Company A

The chairman and CEO of Company A have a doctorate in biology or medicine. The top management team attaches great importance to R&D work, adheres to the principle of *"full coverage of independent R&D, mastery of all core technologies, benchmarking of international top standards"*, and builds a competitive moat through R&D. Company A cooperates with Chinese Union Medical College, Peking University, Stanford University, Massachusetts General Hospital and Oxford University to build a whole chain of basic research, clinical application, translational medicine and industrial transformation. In 2022, A company's revenue was 93.32 billion RMB, R&D investment accounted for 15.87%, an increase of 1.42% over 2021, and 3088 R&D personnel, accounting for 42.99% of the total number of the company. In 2022, the company obtained 499 patents after approval, and accumulated 4357 patents, forming a strong intellectual property barrier.

(4) Company A's R&D investment and corporate performance

According to the CEO of Company A, *"Company A's long-standing 'R&D priority' strategy has helped the company enter the dividend period"*. In terms of financial indicators, in 2022, A company's operating income of 92.38 billion RMB, an increase of 27.36% year-on-year, ROE is 9.4%, an increase of 21.17% year-on-year. At the market level, Company A has launched more than 90 products to the market, including MR, CT, XR, molecular imaging system (PET/CT, ET/MR), medical linear accelerator system (RT) and life science instruments, and is a leader or challenger in multiple market segments. For example, China's CT market share

below 40 rows ranks first, China's PET / MR product market share ranks first, and has a large number of loyal customers. In terms of high-end products, Company A has been able to compete with international brands such as GE and Philips, and some technologies have been leading international brands. The comparison of some products is shown in Figure 4.3.

Device category	Company A	GE	Siemens Medical	Philips
MR Products				
5.0T and above	▲	▲	▲	
3.0T	▲	▲	▲	▲
1.5T and below	▲	▲	▲	▲
CT Products				
320 Rows / 640 Floors	▲			
256 Rows / 512 Floors		▲	▲	
128 Rows and below	▲	▲	▲	▲

Figure 4.3 Comparison between some of Company A's products and competitive products

(5) The impact of moderating variables on top management team characteristics and R&D investment

By the end of 2022, Company A's total assets were CNY 24.2 billion, net profit was CNY 1.65 billion, asset-liability ratio was 27.8%, and operating income growth rate was 100.38%. The interview found that Company A executives believe that: *"company A's overall operating conditions and cash flow are in good condition, which can provide sufficient financial support for Company A to expand our R&D investment and expand our new business"*.

4.2.2.2 Company B

(1) Basic introduction of Company B

Company B was founded in 1999, headquartered in Beijing. Company B is the only overall solution provider covering the whole life cycle of cardiovascular disease in China, and is a leader in the field of cardiovascular and stapler devices in China. Company B has developed and produced the first coronary stent, the first cardiac pacemaker, the first bioabsorbable stent, the first coronary cutting balloon and the first AI-ECG Platform in China.

According to the *"China Cardiovascular Health and Disease Report 2022"* released by the National Cardiovascular Center of China, the number of cardiovascular patients in China is about 330 million, and the prevalence and mortality of cardiovascular diseases in China are still on the rise. The income of innovative products such as coronary bioabsorbable stents, coronary

drug balloons, congenital heart occludes and coronary cutting balloons produced by Company B ranks among the top three in the Chinese market. Company B strategically intends to continue to become a long-term leader in the field of cardiovascular and stapler instruments by increasing technological innovation and consolidating the advantages of consumption channels.

(2) Top management team characteristics of Company B

There are 10 executives in Company B, including chairman, CEO, and eight other executives.

The average age of the top management team is 48.7 years old, ranging from 42 to 63 years old. Except for the chairman, who is 63 years old, the other executives are concentrated in the 40-50 years old, and the age heterogeneity is low. According to the interview, the main reason is that Company B was reorganized in 2017. After the replacement of the controlling shareholder, the original top management team was replaced except the chairman.

The average tenure of B company's top management team is 72 months, distributed in the range of 12-288 months. Among them, except for one executive whose tenure is 288 months, other executives are less than 60 months. The tenure heterogeneity of the top management team of Company B is high. The executives except the chairman are appointed by the controlling shareholders. The chairman of Company B mentioned in the interview: *"After the acquisition by the major shareholder, I was left behind because I was needed to coordinate government and customer resources, and all other executives were appointed by the acquirer"*.

The heterogeneity of the top management team of Company B is not high, 60% of the executives are master's degree or above, and 40% of the executives are undergraduate degree. The chairman of Company B is the founder of the Company and has a PhD in biological and pharmaceutical engineering from the University of Pennsylvania. The chairman of Company B noted that *"the newly replaced executive team generally worked well together and that there were few differences of opinion in important decisions"*.

(3) R&D investment of B company

In 2022, Company B's R&D investment accounted for 12.1% of its operating income, with 1875 R&D personnel and 17.6% of its total employees. The R&D center of Company B is located in Beijing, and the internal R&D is divided into two levels. The R&D team of the headquarters focuses on basic research, technology platform upgrading and clinical trial management, and the R&D team of the subsidiary focuses on product development in specific fields. The chairman of company B emphasized in the interview: *"Since the beginning of the company's business, the company has taken the route of segmentation and differentiation in research and development, and built our defense castle around market segments"*.

Company B has a strong R&D capability. Because Company B has 20 years of experience

in the field of coronary artery implantation in China, the company is well aware of the needs of clinical products, and can accurately develop products based on the needs of doctors and patients. In the research and development efficiency of cardiovascular implant interventional medical devices, B company's research and development speed is significantly better than its peers. The average R&D cycle from the establishment of the same product in the industry to the final registration and approval is about 6 years, but the average R&D cycle of Company B is about 4 years. According to the interview, Company B has a mature and advanced precision manufacturing and technology platform, and has a complete R&D talent echelon reserve. The clinical team has rich experience in the clinical program formulation and clinical experiment implementation of cardiovascular implant interventional medical devices, and has a deep understanding of the relevant laws and regulations of medical device registration. Company B also has a cardiovascular tertiary hospital, which is equipped with an animal experiment center and a clinical experiment center. Therefore, the overall R&D process can be completed in a closed loop within B company, and the R&D efficiency and R&D ability are greatly improved.

(4) R&D investment and enterprise performance of Company B

The research of Company B has formed a strong technical barrier in the field of cardiovascular instruments. As of December 31, 2022, Company B has applied for 1650 patents, more than 600 China domestic and foreign listed products, 569 MPA-approved Class II and III medical device registration certificates, 33 US FDA certifications, and 224 EU CE certifications. In 2022, the operating income under the control of the innovative product portfolio of cardiovascular implant intervention increased by 43.60% year-on-year. At the same time, Company B has more than 30 new R&D products, involving coronary intervention, peripheral intervention, structural heart disease, cardiac rhythm management and other sub-areas. Therefore, the head of Company B believes *“that Company B can maintain its competitive advantage in the field of cardiovascular equipment for a long time”*.

In 2022, Company B achieved operating income of 10.61 billion CNY and net profit of 2.2 billion CNY, an increase of 28.12% year-on-year; the return on net assets was 17.60%, an increase of 1.6% year-on-year; the net cash flow generated by operating activities is 2.79 billion CNY.

(5) The impact of moderating variables on top management team characteristics and R&D investment

In 2022, Company B has total assets of \$24.48 billion, a gearing ratio of 33.13%, and a growth rate of operating income of 17.27%. The executives of Company B who participated in the interviews believed *“that the company's size and gearing ratio did not have a substantial impact*

on the company's layout in R&D and strategy, and that the increase in the growth rate of operating income increased the confidence to increase investment”.

4.2.2.3 Company C

(1) Basic introduction of Company C

Founded in 2009 and headquartered in Beijing, Company C is a leading medical biotherapeutic materials company in China, and a longtime leader in China's surgical, ophthalmic, orthopedic, and other medical biomaterials segments. In the field of ophthalmology, Company C is the world's seventh largest producer of IOLs and the first largest producer of ophthalmic viscoelastic products in China. In the field of medical aesthetics, Company C is one of the well-known producers of hyaluronic acid in China; in the field of wound care, Company C is the second largest producer of topical human epidermal growth factor in China; and in the field of orthopedics, Company C is the first largest producer of viscoelastic supplements for orthopedic joint cavities in China.

Company C's vision *“is to become a leading domestic and internationally recognized biopharmaceutical company in the field of biomedical materials”*. At the strategic level, Company C executes a focused differentiation strategy, focusing on four fast-growing therapeutic areas, namely ophthalmology, medical aesthetics and wound care, orthopedics, and surgery, and continues to maintain Company C's technological leadership through cooperation with renowned research and development institutes in China and internationally, as well as through in-house research and development, and the introduction of technology, all at the same time. In addition, Company C is very good at using M&A strategy, continuously acquiring and merging with potential companies to expand and improve product lines and integrate the industry chain, thus enhancing Company C's competitiveness and overall market capitalization.

(2) Characteristics of C company's top management team

The number of top management team of Company C is small, and there are 7 senior managers, including chairman, CEO, and five other senior managers.

The average age of the top management team is 57.71 years old, ranging from 48 to 64 years old. Among the 7 executives, there are 5 people over 50 years old, the chairman and CEO are 62 and 59 years old respectively, with low age heterogeneity. In the interview, the chairman of Company C noted, *“Our management team is small and older, but efficient, with the benefit of being steady and pragmatic and patient, which is important in our industry”*.

The average tenure of B company's top management team is 74 months. Among them, four executives, including the chairman and CEO, are all senior executives during the company's

start-up period, that is, 156 months of service time. Therefore, the heterogeneity of the tenure of Company C's top management team is not high, and the overall top management team is relatively stable. The chairman of Company C mentioned in the interview *"that because the top management team has worked together for a long time and is familiar with each other, it has a good degree of cooperation and tacit understanding in the company's strategic decision-making and daily operation, and there are fewer disputes"*.

The academic heterogeneity of the top management team of company C is very low. Among the seven executives, four executives are PhDs, two executives are Masters, and one is Bachelor. The chairman of Company C is the founder of the company. He graduated from Peking University Medical Department with a bachelor's degree, also has a doctorate in pharmacology from the University of Michigan in the United States, and also serves as a researcher and doctoral supervisor at a well-known university. The CEO of Company C was once a well-known surgeon. Deputy General Manager of Company C, who is in charge of R&D, graduated from the University of Oxford in the UK and served as a researcher or research director in a number of internationally renowned medical device companies. Chairman of Company C said in the interview: *"Company C in the early start-up to build a top management team, intentionally choose to have excellent educational background, in the international well-known universities or medical equipment companies have work experience into the top management team"*. In fact, when it comes to technical and professional aspects of strategic decision-making, the top management team communication is smooth, strong internal consistency.

(3) R&D investment of Company C

During the interviews, it was learned that Company C adopts the strategy of combining independent R&D and M&A introduction. For independent R&D, there are 344 people in the R&D team of Company C, accounting for 17.29% of the total number of people in the company. Company C has one China National Enterprise Technology Center, one national postdoctoral research station, two national R&D platforms, as well as four provincial and ministerial-level technology and R&D transformation platforms and one Shanghai academician expert workstation. It should be noted that the R&D expenses of Company C in 2022 amounted to RMB 182 million, representing an increase of RMB 14.59 million, or approximately 8.71%, over the previous year. The R&D investment ratio of 8.55% is lower than the R&D investment ratio of 12% of the same type of enterprises. This is because Company C has implemented the strategy of technological mergers and acquisitions and established an integrated R&D system in the U.S., the U.K., France, and Israel, and, with respect to advanced foreign technologies,

timely mergers and acquisitions and introduction to form a R&D layout with interaction at home and abroad. The vice president in charge of R&D of Company C mentioned in the interview that *"self-build and M&A are the two wings of Company C's R&D strategy, which helps Company C to realize bending the road faster at a smaller cost"*.

The technology level of Company C's main products is all industry-leading and have independent intellectual property rights. In 2022, Company C was granted 36 new patents for approval and accumulated 366 patents.

(4) R&D investment and enterprise performance of C company

Focusing on market segments, C company has strong technical advantages in multiple products. The intraocular lens products of C company's ophthalmic product line cover a full range of products from public foldable monotonal to high-end foldable functional intraocular lens. ' *Research and development of new intraocular lens and high-end ophthalmic implant materials* ' is a national key research and development support project in China. Company C produced the first medical chitosan product successfully applied to the human body in the world, and developed the first registered human epidermal growth factor product for external use in the world. The self-developed PRL product for refractive lens surgery is one of the only two approved products in China, which has scarcity and good growth prospects.

The advantages of products effectively support the improvement of Company C 's performance. In 2022, Company C 's revenue was 2.13 billion RMB, an increase of 363 million RMB over the previous year, and the return on net assets was 15.21%, a year-on-year increase of 3.55%. The chairman of Company C mentioned: *"Our management team has a unified mindset on R&D, which is our competitive tool, and we are determined to invest in R&D. The fact that we have gained the desired return on our investment proves that our mindset is correct"*.

(5) The impact of moderating variables on top management team characteristics and R&D investment

In 2022, the total assets of Company C were 6.892 billion RMB, the asset-liability ratio will be only 12.81%, and the operating income growth rate were 5.59%. The chairman of C company who participated in the interview pointed out: *"Company C is to become a world-class ' hidden champion ' enterprise"*. On the premise of ensuring the safety of cash flow, Company C does not pursue the size of the company, and flexibly adjusts the proportion of R&D investment according to the market cycle, product feedback and changes in the external situation.

4.2.3 Case studies discussion

4.2.3.1 Case description analysis

This thesis chooses three representative cases in China's medical device industry in 2022 as the case study object. In this thesis, the characteristics of the top management team of listed Chinese medical device companies are used as independent variables to study their impact on corporate performance, including the average age of the top management team, the average tenure of executives, the average level of education, age heterogeneity, term heterogeneity, education level heterogeneity. In the case study, it is analyzed together with the mediating variable (R&D investment) and the moderating variable (enterprise size, asset-liability ratio, and operating income growth rate). Through descriptive analysis, the relationship between the three is summarized. The characteristics of the top management team of the case enterprise are shown in Table 4.13.

Table 4.13 The characteristics of the top management team of the case enterprise

TMT 's Characteristics	Company A	Company B	Company C
Age	12 executives. The average age is 53.33 years old, ranging from 41 to 62 years old, and there are 9 executives over 50 years old	10 executives. The average age is 48.7 years old, ranging from 42 to 63 years old. Except for the chairman, who is 63 years old, the other executives are concentrated in the 40-50 years old	7 executives. The average age was 57.71 years. The age range is from 48 to 64 years old. Among the 7 executives, there are 5 people over 50 years old
Tenure	The average term of office is 85 months, ranging from 36 to 144 months. Except for one executive who joined A company 48 months ago, other executives have served in A company for a long time	The average term of office is 72 months, ranging from 12 to 288 months. Among them, except for one executive whose tenure is 288 months, other executives are less than 60 months	The average term of office is 74 months. Four executives, including the chairman and CEO, are senior executives during the company's entrepreneurial period, that is, 156 months of service
Education	84% of executives are master 's degree or above, and 16% of executives are undergraduate degree. Executives such as the chairman and CEO have received a doctorate in bioengineering or medicine from schools such as MIT and the University of Michigan	60% of the executives are master 's degree or above, 40% of the executives are undergraduate degree. The company's founder holds a PhD in biological and pharmaceutical engineering from the University of Pennsylvania	Among the 7 executives, 4 are PhD, 2 are Master, and 1 is Bachelor

Age heterogeneity	in the United States Relatively low	Low	Relatively low
Tenure heterogeneity	Relatively low	Relatively high	Ordinary
Education heterogeneity	Relatively low	low	Very low

The basic information of R&D investment and enterprise performance of the case enterprise is shown in table 4.14.

Table 4.14 R&D investment and enterprise performance of case enterprises

	Company A	Company B	Company C
R&D Investment	R&D investment accounted for 15.87%, R&D personnel 3088, accounting for 42.99% of the total number of the company. In 2022, 499 patents were obtained after examination and approval, and 4357 patents were accumulated	In 2022, R&D investment accounted for 12.1% of operating income, 1875 R&D personnel, and 17.6% of R&D personnel. A total of 1650 patents have been applied for.	The R&D team has 344 people, or 17.29% of the company's total headcount. 2022 R&D expenses are \$182 million, an increase of approximately 8.71% year-over-year
Enterprise Performance	In 2022, operating income of 92.38 billion yuan, an increase of 27.36%, ROE 9.4%, an increase of 21.17%. CT, PET / CT, PET / MR and XR products rank first in China	In 2022, operating income was 10.609 billion yuan, net profit was 2.203 billion yuan, an increase of 28.12% year-on-year; rOE17.60%, an increase of 1.6%. Leader in the field of cardiovascular and anastomotic instruments in China, China's market share of the top three	Operating income of 2.13 billion yuan in 2022, up 363-million-yuan year-on-year, and return on net assets of 15.21%, up 3.55% year-on-year. No.1 market share of ophthalmic viscoelastic agent in China, No.1 market share of orthopedic joint cavity viscoelastic supplement in China.

This thesis decomposes and summarizes the interview data of three case enterprises, and encodes the specific variables in the case. This thesis first conceptualizes the data, then summarizes the same kind of genus concept into the initial category, and then integrates the same kind of concept into the same initial category. Based on the above steps, 13 important concepts and 4 initial categories are extracted. The coding of the case is divided into two steps: the first step is to carry out preliminary coding according to the content of description analysis; the second step is to invite three experts with a doctorate in management to guide and correct the initial coding to form the final coding, as shown in Table 4.15.

Table 4.15 The coding of the case enterprise

Variable	Company A	Company B	Company C
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TMT Characteristics	Age	8	7	9
	Tenure	9	7	8
	Education	8	6	9
	Age Heterogeneity	4	5	3
	Tenure Heterogeneity	3	5	2
	Education Heterogeneity	3	5	3
R&D Investment	RDI	8	5	8
Moderating effect	DEBT	4	6	5
	SIZE	9	5	3
	REVINR	8	9	3
Performance	Financial Performance	9	8	7

This thesis uses the scale of 0-9 to evaluate the coding intensity. The main evaluation basis comes from the following aspects: a) the description of executive interviews; b) Company-related information; c) Financial data of companies. Coding intensity from 1 to 9, 1 represents very low, 9 represents very high.

From the coding results, it can be found that the coding intensity of age characteristics, tenure characteristics and education level characteristics of the executive team of Company A and Company C is high, and the coding intensity of age heterogeneity, tenure heterogeneity and education heterogeneity is low, which is because the executive team of Company A and Company C is overall older, with longer tenure and higher education level. The coding intensity of the above concepts of Company B is lower than that of Companies A and C, which is in line with the actual situation of Company B. The coding intensity of R&D investment in Company A and Company C is greater than that of Company B. This is because in practice, Company A and Company C pay more attention to R&D investment, and the percentage of investment is much greater than that of Company B. Meanwhile, in terms of DEBT, SIZE, REVINR and financial performance, it is in line with the actual operating conditions of Company A, Company B and Company C.

4.2.3.2 Cases discussion

Through the analysis of the three case companies, it can be found that there is a correlation between the characteristics of the top management team, R&D investment and corporate performance of China's medical device listed enterprises.

(1) Top management team age characteristics, R&D investment, and enterprise performance

The age characteristics of the case firm's executive team are an older average age and low heterogeneity in age. The average age of the top management team of the three case companies

is the lowest 48.7 years old, the highest 57.7 years old, the vast majority of executives are over 50 years old, and the chairman / founder of the three case companies is over 60 years old.

The age structure of the executive team of a case firm is favorable to the performance of the firm. Wei (2002) empirical research on Chinese listed firms combined with the special culture and political system of Chinese firms showed that the older the average age of the executive members of the firm, the better the profit performance of the firm. Cai (2018)'s research and development on Chinese listed firms in the banking and insurance industries found that the average age of the executive team is significantly and positively related to their financial performance. For Chinese medical device firms, older executives have rich work experience, and in some cases the chairman or CEO of the case firms are part-time deputies to the Chinese National People's Congress (NPC) or members of the Chinese People's Political Consultative Conference (CPPCC), and in some cases the chairman of the case firms himself is also a professor or doctoral supervisor.

At the same time, China's medical device market is a policy-oriented market, often facing administrative intervention, such as in the approval of medical devices, hospital anti-corruption and other major challenges in the external environment. In addition, older executives have more social resources, have experienced more things, and have a better understanding of government policies, which can help to avoid major risk factors. In particular, executives with rich social resources can easily coordinate with the government, scientific research institutes, suppliers, and channel resources to help solve problems encountered in the development of the enterprise, and thus improve the performance of the enterprise. In the interview, the founder of one of the case companies said, *"Our generation is the generation that has grown up following the development of China's medical device industry, and we have experienced many unexpected challenges and risks."*

The age characteristics of executives in the case have little impact on corporate R&D. One CEO of a research company said: *"When I started my business, I continued to pay attention to the latest development trend of medical device technology in this field abroad, and see what good new technologies can be used. This habit has been used for decades and will not change with age "*. In the investigation of three case enterprises, it is also found that many executives who in charge of R&D are obsessed with R&D and technology, and this enthusiasm for technology has crossed the age limit.

(2) Top management team tenure, R&D investment, and corporate performance

The tenure heterogeneity of executives in the three cases is relatively low. The average tenure of top management team is from 72 to 85 months. The top management teams of the two case

companies are relatively stable. Most of the executives entered the company in the early stage of the company and have been in the company. In company B, the executive team had been with the company for a short period of time due to mergers and acquisitions, with the exception of the company's founder.

Some studies in upper echelons theory have found that longer average tenure of the top management team favors R&D investment. Hou (2022) found that the tenure of top management team has a positive impact on the innovation performance of Chinese technology-based enterprises. The tenure of the executive team members of the three case companies also supports this result. In the interview, many people involved in the interview have always believed that long-term work has the following advantages: mutual understanding, convenient communication, good work coordination, and tacit understanding. The executives of the company with high heterogeneity of tenure who participated in the survey feedback: *“There is a period of running-in and adaptation period after joining the company. After the adaptation period, the executives gradually have a tacit understanding with each other, and the work is easy to do”*.

Due to the long tenure of the top management team members, the R&D strategy and R&D investment are stable and there will be no ups and downs. The acquired case enterprise B made some adjustments to its original R&D strategy based on the controlling shareholder's opinion, further increased its R&D investment, and stepped up its R&D efforts in some hot market segments, Company B's market share increased. It can be seen that the average tenure of top management team has a promoting effect on corporate strategic decision-making and corporate performance.

(3) The characteristics of top management team education level, R&D investment, and enterprise performance

The average education level of the top management team of the three case companies is generally high, and the heterogeneity of education level is low. In the three case companies, 60%-85% of executive team members have graduate degrees. According to the survey, most executives graduated from China's top universities such as Peking University, Tsinghua University, Shanghai Jiao Tong University, Fudan University, Chinese Academy of Sciences, and well-known foreign universities such as MIT, University of Michigan, and Oxford University. The founders of the three companies all have doctorates in medicine or engineering from well-known universities. English is the working language in the daily work of a company's executive team. Many times, the executives contact their American or European subsidiaries or external experts directly for discussions during meetings.

Most studies support the conclusion that highly educated executive teams are conducive to improved firm performance. This is because a high level of education directly facilitates the top management team to deepen the depth of understanding and consistency of important decisions involving the business model, corporate strategy, company's technological routes, R&D strategy, and facilitates the executive team's access to information about the industry and the market through multiple channels and the ability to take appropriate actions. Three cases support the above view. China's medical device industry is an industry with high technical barriers. Common educational backgrounds do not support executives in making quality decisions in highly specialized areas. Some company founders mentioned: *"Our company is a talent-driven company, we look for competent people all over the world, regardless of salary"*.

(4) R&D investment and enterprise performance

Most of the current research results support that there is a positive correlation between R&D investment and enterprise performance. The research results of Branch (1974) show that there is a positive correlation between R&D investment and performance of sample enterprises. When the studied enterprises increase R&D funds, production efficiency and output will increase accordingly, thus promoting the improvement of corporate performance of sample enterprises.

The R&D investment of the three case companies has a positive correlation with the enterprise. All three companies have continuously increased their R&D investment, and the high R&D investment has increased by at least 8 % year-on-year. They have a large number of patents in the market segment, built a strong technical moat, and become the leader of the market segment. High R&D investment also helps the three companies produce high-quality products recognized by the market, saving sales costs, obtaining brand premiums, enhancing the company's competitive position, and effectively improving company performance. In the research interview, executives from every participating company expressed a high level of recognition of the importance of R&D and technology.

(5) The influence of moderating variables

According to the cases studied, most of the executives participating believe that the scale of the enterprise and the asset-liability ratio have no impact on the R&D investment of the enterprise, and the revenue growth rate is only the reference index for decision-making. First, because the asset-liability ratio of most Chinese medical device listed enterprises is very low, the minimum asset-liability ratio of the three sample companies is 12%, which does not affect the decision-making in R&D. Second, because the R&D investment intensity of the enterprise depends on the strategy of the enterprise, the expansion strategy and the leading strategy need to match the

corresponding R&D investment. The intensity of R&D investment depends on the company's financial capacity and market feedback.

4.2.4 Summary of empirical research

This chapter tests the research hypotheses through a combination of quantitative empirical research and case-based empirical evidence. Quantitative empirical research is carried out first. After the quantitative empirical study, this thesis selects three cases of Chinese listed medical device companies to conduct exploratory case studies, analyzing and studying the relationship between executive team characteristics, R&D investment and corporate performance of three Chinese listed medical device companies. In the order of the case studies, first describe the cases, followed by coding to verify the hypotheses. In the case study sequence, the cases are first described, followed by specific analysis of different cases, then coded to verify the hypotheses, and finally the case study results are formed. The case study results can be combined with the quantitative empirical findings to jointly verify the final hypotheses and conclusions of this thesis.

4.2.5 Assessment model

Based on the quantitative and qualitative findings of this thesis, combined with the actual situation of Chinese medical device listed companies, this thesis proposes the “*Competitiveness Assessment Model for Top management team Characteristics of Chinese Medical Device Enterprises*”, which is also known as the “*Eight-Star Model*”. The model is shown in Figure 4.4. This Model is used to assess the competitiveness of top management team characteristics of Chinese medical device enterprises.

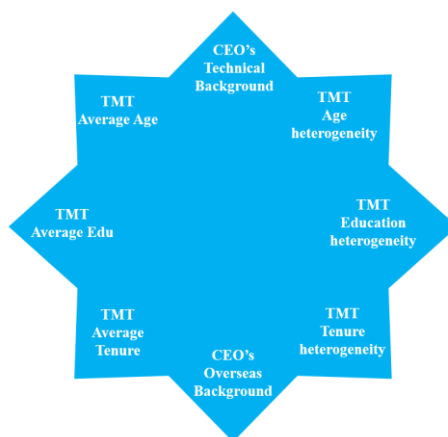


Figure 4.4 Competitiveness assessment model for top management team characteristics of Chinese medical device enterprises

Chapter 5: Conclusions and Implications

5.1 Research conclusions

China's medical device industry is in a period of rapid development, and the top management team has an irreplaceable role in corporate development. In order to explore the relationship between the top management team characteristics, R&D investment and corporate performance of Chinese listed medical device enterprises, this thesis selects 114 Chinese A-share listed medical device companies as a sample to conduct an empirical study. This thesis firstly conducts a quantitative study, and on the basis of the quantitative study, in order to further enhance the validity of this study and to enrich the theory, this thesis selects three cases of Chinese listed medical device enterprises to conduct an exploratory case study. Through the mixed research method combining quantitative research and case studies, the research quality of this thesis can be more comprehensively enhanced. Synthesizing the results of the quantitative research and the case studies, the research conclusions of this thesis are as follows:

(1) The average age, average education, and average tenure of the top management team of listed medical device enterprises in China can significantly affect corporate performance.

The market competition in China's medical device industry is fierce, and corporate development requires the top management team to have sufficient policy comprehension, resource integration, professional knowledge, and management ability. From the research in this thesis, it is found that for Chinese medical device enterprises, the characteristics of top management team members with a higher average age, higher average education level, and longer tenure can promote the improvement of corporate performance.

(2) High heterogeneity of top management teams in Chinese listed medical device enterprises is detrimental to enterprise development.

In this study, it is found that the higher the age heterogeneity of the top management team, the worse the performance of the enterprise; higher heterogeneity in the education level of the top management team is detrimental to the development of the enterprise; and high heterogeneity in the tenure of the top management team is detrimental to the performance of the enterprise. The results of this study reflect that in the Chinese cultural context, the top management team focuses more on the values of “*seeking common ground*” and “*harmony*”,

and emphasizes long-term cooperation and effective collaboration; and it also reflects the need for consistency in the education level of the top management team in China's medical device industry. It also reflects the need for the medical device industry in China to maintain consistency in the education level of the top management team.

(3) R&D investment can contribute to performance improvement of Chinese medical device enterprises.

The results of the quantitative research and case studies in this thesis indicate that R&D investment has a significant contribution to the performance improvement of Chinese medical device enterprises. This finding is consistent with the mainstream academic view that R&D investment has a positive impact on firm performance. Therefore, in the competition in the Chinese medical device industry, enterprises can improve the competitiveness of their products and then enhance their performance through R&D investment; conversely, if they invest too little in R&D, they will soon lose their long-term competitiveness.

(4) The education level of the top management team members of listed Chinese medical device enterprises can influence the intensity of R&D investment of the enterprises.

In this study, it is found that the age factor and the length of tenure of highly educated top executives of listed Chinese medical device enterprises do not have a significant impact on R&D investment. Executives with high education level focus more on R&D as an important means to improve the competitiveness of their enterprises, and adopt a rational attitude towards R&D and make relevant R&D investment decisions according to the actual strategic needs.

(5) The top management team should be more rational and objective in their decision-making reference for R&D strategy.

The moderating effects of enterprise size, gearing ratio and revenue growth rate indicators selected as moderating variables in this study are not obvious in the moderating effects between the characteristics of the top management team and the performance of Chinese medical device listed enterprises. This proves that firm size, gearing ratio and revenue growth rate indicators are only used as reference indicators for decision-making in corporate strategic planning, and are not key indicators for strategic decision-making. The top management team's decision-making on R&D strategy is more based on the market competition pattern, the overall strategic objectives of the enterprise and the resource capacity of the enterprise. Therefore, decision-making cannot be mechanized by relying on a few individual reference indicators.

5.2 Research implications and suggestions

This thesis takes Chinese medical device listed companies as the research object, explores the influence mechanism of top management team characteristics on corporate performance of Chinese medical device listed companies, and provides theoretical and applied support for Chinese medical device listed companies to configure and build competent top management teams. The theoretical insights and practical suggestions of this thesis are presented below.

5.2.1 Theoretical implications

This thesis enriches the boundaries of the application of upper echelon theory in China's medical device industry and proposes the “*Competitiveness Assessment Model of Top management team Characteristics in Chinese Medical Device Enterprises*”. The model is applicable to pre-investment due diligence and post-investment management of proposed investment companies by investment institutions, as well as to Chinese medical device companies in assessing the quality of their own top management teams and optimizing their talent strategies and organizational capabilities.

This model has eight indicators to assess the competitiveness of top management team characteristics in Chinese medical device companies. The left variable is the average age, average education level and average tenure of the top management team, and the right variable is the age heterogeneity, education level heterogeneity and tenure heterogeneity of the top management team. The upper variable is the technical background of the CEO of that firm. The lower variable is the overseas background of the CEO of that company, and the overseas background includes the experience of receiving education and working in countries or regions outside of China.

Specifically for the scoring rules, the average age, average education level, and average tenure of the top management team are scored from low to high according to a scale of 1-5; age heterogeneity, education level heterogeneity, and tenure heterogeneity are scored from high to low according to a scale of 1-5; CEO's technical background and overseas background are rated on a scale of 1-5 according to the strength of the technical background and the length and strength of the overseas background in descending order.

According to the research of this thesis, the competitive characteristics of the top management team of Chinese medical device enterprises should meet the following principles: “*appropriate average age of the top management team, high average education level,*

appropriate average tenure; low age heterogeneity, low education level heterogeneity, low tenure heterogeneity; CEO has technical background and overseas background”.

5.2.2 Practical suggestions

(1) Optimizing the age structure and controlling the age heterogeneity of the top management team.

Chinese medical device companies need to optimize the age structure of their top management team members. Unlike the Internet and IT industries, China's medical device industry is highly specialized in medicine, and the cultivation cycle of executives in China's medical device companies is relatively long. The overall age of the top management team in China's medical device industry is on the older side, and the older top management team has richer management experience and social resources, which internally helps China's medical device companies to improve their management level and strengthen their refined operation, and externally helps to consolidate the relationship with the government and coordinate the resources of the government, colleges and universities, and suppliers required for the development of the company, so that it can safeguard the development of the company.

However, a top management team with an older age structure may result in a lack of innovation and aggressiveness. In addition, the cultivation of the executive team needs enough time, and it takes a long time for a vice president to be promoted to a senior vice president or CEO. Therefore, Chinese medical device companies need to optimize the age structure of the top management team, absorb young executives into the top management team appropriately, and ensure that the age structure of the entire top management team is reasonable, so as to maintain the stability of the top management team and to enhance the vitality and innovativeness of the top management team. At the same time, the age heterogeneity of the top management team should be carefully controlled to avoid conflicts arising from the high age heterogeneity of the top management team, which may affect the company's decision-making and overall performance.

(2) Strengthening executive training and hiring highly educated individuals who graduated from prestigious institutions.

While strengthening the training of existing executives, Chinese medical device companies employ highly educated talents from prestigious universities. This thesis finds that top management teams with high education levels have a significant contribution to corporate performance. Executives with a high level of education have three advantages: Firstly, they

have active thinking, broad strategic vision, fast learning ability and strong adaptability. Secondly, due to the rigorous academic training and close mindset, it is easier to communicate among colleagues and the communication cost is lower. Thirdly, executives who graduated from the same famous university have a larger alumni network and a rich source of information, and can coordinate more government and academic resources, and customers, investors, and governments are more likely to recognize the companies where senior executives graduate from prestigious universities. All these advantages contribute to the improvement of corporate performance and the long-term development of the company.

Therefore, on the one hand, Chinese medical device companies should employ more competent and highly educated talents graduated from prestigious universities, and at the same time optimize the company's training strategy, strengthen the training for the existing top management team, and send more executives to some top universities to participate in management and business training, so as to improve the comprehensive competence of the existing executives.

(3) Improvement of corporate governance mechanisms to ensure a certain degree of stability for the top management team.

Strengthening top management team tenure management mechanism. From the results of the case studies in this thesis, it can be found that the executive tenure of leading medical device companies in China is generally long, which is due to the highly specialized and complex nature of the medical device industry in China, which requires companies to maintain a certain degree of stability in their top management teams both internally and externally.

Internally, stable top management team members have lower communication costs between executives, and are more experienced and efficient in the management of the business department they are responsible for, which can steadily promote strategic decision-making and strategic change implementation; externally, a stable top management team can appease stakeholders and give confidence to investors, government and other stakeholders, which is conducive to the long-term development of the enterprise. Therefore, it is recommended to improve the corporate governance mechanism, give full play to the role of the company's nomination committee, formulate, and optimize the system related to the tenure of senior executives, further improve the succession plan of senior executives, and ensure the stability of the tenure of senior executives.

(4) Strengthening effective incentive and performance management system, enhance the competence of the top management team.

Improve the incentive mechanism. The top management team has rich work experience and

high positions. It is necessary to combine the company's development strategy with the ability, contribution, and development potential of senior executives to motivate. First of all, in terms of executive team compensation, we should set up a suitable fixed-floating ratio, strengthen the application of incentive tools such as stocks, options and profit pools, and ensure the timeliness and sustainability of incentive effects; secondly, in terms of top management team positions, Chinese medical device companies need to establish appropriate career development channels and ranks, and clarify the rules of promotion and reward; finally, Chinese medical device companies need to strengthen spiritual incentives and set up a variety of honors and spiritual incentives.

Strengthen performance appraisal to ensure the competency of the top management team. China's medical device companies need to give full play to the role of the assessment committee, establish a diversified assessment system and assessment indicators, and objectively and impartially evaluate, assess and feedback the contribution of top management team members; the human resources department should reasonably set the assessment cycle, combine short-term performance assessment with long-term contribution, and give executives relatively sufficient time to promote business and avoid quick success. China's medical device companies should strengthen the elimination of efforts to dismiss incompetent executives in a timely manner to ensure the overall competence of the executive team.

(5) Implementation of a global talent strategy to increase the number of decision makers in the top management team with professional and technical backgrounds and international experience.

Through case studies, this paper finds that enterprises led by executives with professional and technical background and international experience perform well in terms of market share, return on equity and brand. Due to the very high technical barriers of China's medical device industry, if top management team members lack enough professional knowledge, it is difficult to communicate efficiently in R&D, competitive strategy, marketing mix and other decision-making, and it is difficult to make high-quality decisions. Executives with professional and technical background can easily be competent for communication involving professional and technical aspects. In the context of Chinese culture, the final decision maker is the chairman or CEO of the company. If the decision maker lacks sufficient professional knowledge, it will greatly affect the efficiency and quality of decision-making. The author of this paper is currently the chairman and CEO of a Chinese bio-health technology company. Because the author of this paper does not have a lot of medical background and medical knowledge, relying on the professional opinions of CTO or external experts in professional decision-making may not be

conducive to the development of enterprises.

In addition, executives with learning experience or work experience in well-known foreign universities or foreign well-known medical device companies have received good academic training or vocational training. Their thinking perspectives are more open, and they track world-class professional frontiers. It is very beneficial for enterprises to operate from a global perspective and can effectively improve the business performance and development potential of enterprises. Therefore, it is necessary to increase the number of decision makers with professional and international experience.

(6) Increase investment in R&D and independent innovation.

This thesis study finds that R&D investment can significantly improve the business performance of Chinese medical device listed companies. With the development of Chinese medical device companies, in many market segments, the technology content and market share of Chinese products have caught up with or even surpassed that of nationally renowned medical device companies such as Philips and GE Health. An important driving force behind this is the continuous R&D investment and innovation of Chinese medical device companies. China's medical device enterprises actively implement independent innovation strategy, and invest heavily in R&D personnel ratio, R&D capital investment and R&D intensity, thus promoting the rapid development of enterprises. Therefore, Chinese medical device companies should persist in their R&D and independent innovation investment and match their R&D investment with their overall strategy to promote their business performance.

(7) Selection of appropriate strategic paths and implementation of differentiation strategies.

S. C. Wang and al. (2022) used Porter 's competitive strategy to analyze the development strategy of Chinese biomedical enterprises, and proposed that Chinese biomedical enterprises in the high-speed development period and the outbreak period were suitable for differentiation strategy. China 's medical device enterprises are also in a period of rapid development, and the competition is very fierce. The main competitors are international well-known medical device enterprises. From the case results, the three case enterprises all implement the differentiation strategy, invest a lot of R&D personnel and R&D funds in a medical device market segment, and rely on technological innovation and R&D to obtain technical barriers and technical moats. In fact, it proves that the case enterprise has applied the differentiation strategy very successfully and has achieved a very high market share in the market segment. Compared with foreign well-known medical device enterprises, Chinese medical device enterprises have a gap in capital and technology accumulation. The application of differentiation strategy in market segments can achieve technological and market share breakthroughs to the greatest extent and

avoid their own shortcomings. Therefore, Chinese medical device enterprises need to choose the appropriate strategic path according to their own resource endowments.

5.3 Research limitations and outlook

(1) The research methods need to be further enriched.

This thesis studies the relationship between top management team characteristics, R&D investment and corporate performance of Chinese listed medical device enterprises. In terms of research methodology, this thesis constructs an efficient research portfolio through descriptive statistics, regression analysis, and other quantitative research on the demographic characteristics of the top management team, as well as case study methodology, which effectively explores and validates the research objectives.

Top management team characteristics can be categorized into demographic and psychological characteristics, with psychological characteristics including factors such as perceptions of the top management team and attention. Psychological characteristics can reflect the deeper psychological characteristics of the top management team in strategic thinking and decision making through the IAT (Implicit Association Test) method and text analysis method that can be used. In the context of Chinese culture, the top management team members have a very strong sense of prevention and it is difficult to cooperate with the participation in the experiment. Therefore, this study does not do further research on the psychological characteristics of the top management team, which needs to be further studied in the future.

(2) Indicators for measuring enterprise performance are not yet comprehensive.

This thesis uses ROE as a measure of the performance of Chinese medical device companies. At the same time, the Tobin-Q value was used for robustness analysis. Although these two indicators can better reflect corporate performance, however, the scope of corporate performance indicators can be more diversified, and more indicators can be used to measure, such as ROA, EPS and other indicators. Therefore, the comprehensiveness of the measurement of performance indicators in this thesis needs to be strengthened.

(3) The innovative tools proposed in this thesis need to be further tested.

Combined with the research conclusions of this thesis, the author innovatively developed the “Competitiveness Assessment Model for Top management team Characteristics of Chinese Medical Device Companies”. This model is a simple but very practical evaluation tool, which can help investment institutions and related enterprises to quickly evaluate the competitiveness of a Chinese medical device company's top management team characteristics, and accordingly

make relevant investment decisions, post-investment management, and talent strategy adjustments. Although this model has been communicated with some senior managers of venture capital funds and has received positive evaluation, this tool is still relatively simple and has not passed the large-scale test, which needs further large-scale continuous optimization and improvement.

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Bibliography

- Allison, P. D. (1978). Measures of inequality. *American Sociological Review*, 43(6), 865–880.
- Amason, A. C. (1996). Distinguishing the effects of functional and dysfunctional conflict on strategic decision making: resolving a paradox for top management teams. *Academy of Management Journal*, 39(1), 123–148.
- Aroni, & Minichiello, V. (2008). *In depth interviewing*. Pearson Australia Group.
- Auh, S., & Menguc, B. (2005). Top management team diversity and innovativeness: the moderating role of inter functional coordination. *Industrial Marketing Management*, 34(3), 249–261.
- Bantel, K. A., & Jackson, S. E. (1989). Top management and innovations in banking: does the composition of the top team make a difference? *Strategic Management Journal*, 10(S1), 107-124.
- Barker, L., & Mueller, G. C. (2002). CEO characteristics and firm R&D spending. *Management Science*, 48(6), 782–801.
- Baron, R. M., & Kenny, A. D. (1986). The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, 51(6), 1173-1182.
- Bioh, M. (2022). *Does innovation investment affect M&A firm value* [Master's thesis]. Shandong University.
- Birkinshaw, J., Hamel, G., & Mol, M. J. (2008). Management innovation. *The Academy of Management Review*, 33(4), 825-845.
- Boeker, W. (1997). Strategic change: the influence of managerial characteristics and organizational growth. *Academy of Management Journal*, 40(1), 152–170.
- Bosworth, D., & Rogers, M. (2001). Market value, R&D and intellectual property: an empirical analysis of large Australian firms. *Economic Record*, 77(239), 323-337.
- Branch, B. S. (1974). *Research and development and profits: a distributed lag analysis*. Berkeley Electronic Press.
- Brock, D. M. (2005). Multinational acquisition integration: the role of national culture in creating synergies. *International Business Review*, 14(3), 269–288.
- Buyl, T., Boone, C., Hendriks, W., & Matthyssens, P. (2011). Top management team functional diversity and firm performance: the moderating role of CEO characteristics. *Journal of Management Studies*, 48(1), 151–177.
- Cai, X. Y. (2018). *A study of demographic characteristics of executive teams and financial performance of insurance companies* [Master's thesis]. Southwest University of Finance and Economics.
- Cai, Y. F. (2022). 研发投入、社会责任与制造企业财务绩效 [R&D investment, social responsibility and financial performance of manufacturing companies]. *Journal of Hunan College of Finance and Economics*, 38(6), 78-87.
- Carpenter, M. A. (2002). The implications of strategy and social context for the relationship between top management team heterogeneity and firm performance. *Strategic Management Journal*, 23(3), 275–284.
- Carpenter, M. A., & Fredrickson, J. W. (2001). Top management teams, global strategic posture, and the moderating role of uncertainty. *Academy of Management Journal*, 44(3), 533–545.
- Carpenter, M. A., Geletkanycz, M. A., & Sanders, Wm. G. (2004). Upper echelons research revisited: antecedents, elements, and consequences of top management team composition.

- Journal of Management*, 30(6), 749–778.
- Chen, H., Liu, Y. L., & Xu, H. J. (2018). 股权结构调节作用下的高管团队异质性与企业绩效关系研究 [Research on the relationship between executive team heterogeneity and corporate performance under the moderating effect of equity structure]. *Journal of Beijing University of Posts and Telecommunications (Social Science Edition)*, 20(3), 76–86.
- Chen, J. L., Meng, L. J., & Wang, Q. (2015). 上市公司研发投入与企业绩效的非线性关系 [The non-linear relationship between R&D investment and firm performance of listed companies]. *China Science and Technology*, (5), 67-73.
- Cho, T. S., Hambrick, D. C., & Chen, M. J. (1994). Effects of top management team characteristics on competitive behaviors of firms. *Academy of Management Annual Meeting Proceedings*, 1994(1), 12–16.
- Collins, C. J., & Clark, K. D. (2003). Strategic human resource practices, top management team social networks, and firm performance: the role of human resource practices in creating organizational competitive advantage. *The Academy of Management Journal*, 46(6), 740–751.
- Cui, Z. W. (2022). 国有企业高管薪酬制度研究 [Research on executive compensation system of state-owned enterprises]. *Modern Business*, (10), 62–64.
- Cullinane, N., & Dundon, T. (2006). The psychological contract: a critical review. *International Journal of Management Reviews*, 8(2), 113–129.
- Cyert, R. M., & March, J. G. (1963). *A Behavioral Theory of the Firm*. Social Science Electronic Publishing.
- D'Aveni, H. R. A. (1992). Top team deterioration as part of the downward spiral of large corporate bankruptcies. *Management Science*, 38(10), 1445–1466.
- Dai, Z. Y. (2021). *Executive team heterogeneity and corporate strategic change* [Master's thesis]. Jinan University.
- Dai, L. L., & Dai, P. J. (2009). 管理者特征与公司绩效关系——基于 2006 年沪深 A 股上市公司的实证研究 [Relationship between managerial characteristics and firm performance - An empirical study based on A-share listed companies in Shanghai and Shenzhen in 2006]. *Accounting Newsletter*, (7), 99-101.
- Deng, M. Y. (2013). *A study on the impact of demographic characteristics of executive team on R&D investment in listed high-tech enterprises* [Master's thesis]. Southwest University of Finance and Economics.
- Dwyer, S., Richard, O. C., & Chadwick, K. (2004). Gender diversity in management and firm performance: The influence of growth orientation and organizational culture. *Journal of Business Research*, 56(12), 1009–1019.
- Eisenhardt, K. M. (1989). Building theories from Case Study Research. *Academy of Management Review*, 14(4), 532–550.
- Elron, E. (1997). Top management teams within multinational corporations: effects of cultural heterogeneity. *Leadership Quarterly*, 8(4), 393–412.
- Ettlie, J. E., & John, E. (1998). R&D and global manufacturing performance. *Management Science*, 44(1), 1–11.
- Feng, J. (2021). *A study of the relationship between executive team heterogeneity, innovation investment and firm performance of GEM listed companies* [Master's thesis]. Shaanxi Normal University.
- Finkelstein, S., & Hambrick, D. C. (1990). Top-management-team tenure and organizational outcomes: the moderating role of managerial discretion. *Administrative Science Quarterly*, 35(3), 484-503.
- Finkelstein, S., & Hambrick, D. C. (1996). *Strategic leadership: top executives and their effects on organization*. West Educational.

- Frank, H., Clarke, and, Masako, N., & Darrough. (1983). Optimal employment contracts in a principal-agent relationship. *Journal of Economic Behavior & Organization*, 4(2-3), 69-90.
- Goll, I., Brown, J. N., & Rasheed, A. A. (2008). Top management team demographic characteristics, business strategy, and firm performance in the US airline industry: The role of managerial discretion. *Management Decision*, 46(2), 201-222.
- Graebner, E. M. E. (2007). Theory building from cases: opportunities and challenges. *Academy of Management Journal*, 50(1), 25-32.
- Griliches, Z. (1979). Issues in assessing the contribution of R&D to productivity. *The Bell Journal of Economics*, 10(1), 92-116.
- Grinyer, P., & McKiernan, P. (1990). Generating major change in stagnating companies. *Strategic Management Journal*, 11, 131-146.
- Gu, J. J., & Hu, P. (2008). 企业高层管理团队特征异质性对战略决策的影响——基于中国民营企业的实证研究 [The effect of heterogeneity of corporate top management team characteristics on strategic decision-making: an empirical study based on Chinese private firms]. *Journal of Management Engineering*, 20(3), 30-35.
- Gu, Q., Wu, Z. Y., & Wu, J. D. (2017). 所有权性质、女性高管参与及企业 R&D 投入——来自科技型中小企业的经验证据 [Ownership Nature, Female Executive Participation and Corporate R&D Investment - Empirical Evidence from Science and Technology-based SMEs]. *Journal of Guizhou University of Finance and Economics*, (1), 94-100.
- Guo, M. C. (2016). *A study of the moderating effect of executive team heterogeneity on the relationship between R&D investment and firm performance* [Master's thesis]. Jilin Caijing University.
- Hambrick, D. C. (1994). Top management groups: a conceptual integration and reconsideration of the "team" label. *Research in Organizational Behavior*, 16, 171-213.
- Hambrick, D. C. (2010). Guest editor's introduction: putting top managers back in the strategy picture. *Strategic Management Journal*, 10, 5-15.
- Hambrick, D. C., & Mason, P. A. (1984). Upper echelons: the organization as a reflection of its top managers. *The Academy of Management Review*, 9(2), 193-206.
- Han, L. (2022). *A study on the relationship between cost stickiness, R&D investment and firm performance in automotive parts manufacturing industry* [Master's thesis]. Nanjing University of Information Engineering.
- Han, X. F. & Dong, M. F. (2018). 研发投入对企业绩效影响的门槛效应 [Threshold effect of R&D investment on firm performance]. *Journal of Beijing Institute of Technology: social science edition*, 20(2), 95-101.
- Hao, H. L. (2014). *A study on the impact of executive team characteristics and executive incentives on corporate R&D investment in listed companies* [Master's thesis]. Xi'an University of Science and Technology
- Hao, J. (2022). *Evaluation of the Effectiveness and Performance Enhancement of the "Combination of Party Secretary and Chairman" in State-Owned Enterprises* [Doctoral thesis]. Beijing Jiaotong University
- Hartmann, G. C., Myers, M. B., & Rosenbloom, R. S. (2006). Planning your firm's R&D investment. *Research Technology Management*, 49(2), 25-36.
- Hou, X. Y. (2022). *A study of the impact of executive team heterogeneity on innovation performance of technology-based firms* [Master's thesis]. Tianjin Normal University
- Hu, X. Y. (2008). *案例研究的理论与实例* [Theory and examples of case study research]. Nanjing Normal University Press.
- Huang, Y., Yang, N. D., & Zhang, C. L. (2011). 高层管理团队异质性对企业绩效的影响研究——以股权集中度为调节变量 [A study on the impact of top management team heterogeneity on firm performance with equity concentration as a moderating variable].

- Management Review*, 23(11), 120-125.
- Jehn, K. A., Chadwick, C., & Thatcher, S. M. B. (1997). To agree or not to agree: the effects of value congruence, individual demographic dissimilarity, and conflict on workgroup outcomes. *International Journal of Conflict Management*, 8(4), 287–305.
- Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, 3(4), 305–360.
- Jensen, M., & Zajac, E. J. (2004). Corporate elites and corporate strategy: how demographic preferences and structural position shape the scope of the firm. *Strategic Management Journal*, 25(6), 507–524.
- Kang, Y. L., Huang, W. L., & Chen, K. J. (2011). 高管特征对研发投入的影响——基于高技术产业的实证分析 [The impact of executive characteristics on R&D investment - an empirical analysis based on high-tech industries]. *Science and Technology Progress and Countermeasures*, 28(8), 147–151.
- Katz, R. (1982). The effects of group longevity on project communication and performance. *Administrative Science Quarterly*, 27(1), 81–104.
- Kilduff, M., & Mehra, A. A. (2000). Top management-team diversity and firm performance: examining the role of cognitions. *Organization Science*, 11(1), 21–34.
- Knight, D., Pearce, C. L., Smith, K. G., Olian, J. D., & Flood, P. (1999). Top management team diversity, group process, and strategic consensus. *Strategic Management Journal*, 20(5), 445–465.
- Krishnan, H. A., Miller, A., & Judge, W. Q. (1997). Diversification and top management team complementarity: is performance improved by merging similar or dissimilar teams? *Strategic Management Journal*, 18(5), 361–374.
- Kur, E. (1996). The faces model of high performing team development. *Management Development Review*, 17(1), 32–41.
- Laffont, J. J., & Martimort, D. (2009). *The theory of incentives: the principal-agent model*. World Press.
- Laszlo Tihanyi., A. Ell., C. M. Daily., Dan R. Dalton. (2000). Composition of the top management team and firm international diversification. *Journal of Management*. 26(6), 1157-1177.
- Lee, C., Park, G., Marhold, K., & Kang, J. (2017). Top management team's innovation-related characteristics and the firm's explorative R&D: an analysis based on patent data. *Scientometrics*, 111, 639–663.
- Lee, I. H., & Marvel, M. R. (2009). *The moderating effects of home region orientation on R&D investment and international SME performance: lessons from Korea*. Social Science Electronic Publishing.
- Lenderman, J. (1996). *The strategic leader: born or made*. U.S. Army War College Press.
- Li, H.J., Sun, Y., & Ren, L. (2017). 新能源上市公司绿色技术创新绩效研究 [Research on green technology innovation performance of new energy listed companies]. *Science and Technology Management Research*, 37(21), 240-246.
- Li, J. J. (2019). *An empirical study on the impact of executive background characteristics on corporate innovation investment in GEM listed companies* [Master's thesis]. Southwest University of Finance and Economics.
- Li, J. Y. (2018). 研发投入规模与企业绩效——基于中国高新技术企业的半参数回归分析 [R&D Investment Scale and Firm Performance-Semi-parametric Regression Analysis Based on Chinese High-Tech Enterprises]. *Inner Mongolia Science and Economy*, (2), 26-29.
- Li, K. X. (2022). *The Impact of Executive Heterogeneity on Firm Performance - Based on the Mediating Role of CSR* [Master's thesis]. Zhejiang University.
- Li, M. (2022). *R&D investment persistence, executives' educational background and firms'*

- innovation performance* [Master's thesis]. Shandong Construciong University.
- Li, Q. M. (2021). A study of the relationship between executive team heterogeneity, internal control quality and firm performance [Master's thesis]. Xi'an University of Architecture and Technology
- Li, W. W., Hao, M. Y., & Gu, X. (2023). 高管团队断裂带对企业绩效的影响——基于 Meta 分析的检验 [The effect of executive team fracture zones on firm performance - a test based on Meta-analysis]. *Management Engineer*, (2), 28–35.
- Li, Y. (2021). *Study on the Impact of Pientzhuang Management Team Characteristics on Cash Dividend Policy* [Master's thesis]. Jilin University
- Li, Y. (2023). 高管团队特征与企业绩效关系研究——基于中小板上市公司的经验证据 [Research on the relationship between executive team characteristics and corporate performance-Empirical evidence based on small and medium-sized listed companies]. *Continental Bridge Perspectives*, (2), 109-111.
- Lichtenthaler, U. (2016). Absorptive capacity and firm performance: an integrative framework of benefits and downsides. *Technology Analysis & Strategic Management*, 28(6), 664–676.
- Lin, M. F., & Ma, J. (2021). 高管团队人口背景特征与企业创新强度——基于广东省上市公司的研究 [A study of the demographic background characteristics of executive team and the innovation intensity of firms based on listed companies in Guangdong Province]. *National Circulation Economy*, (23), 90–92.
- Liu, J. Y., Xu, H. W., & Li, M. D. (2022). 高管团队海外背景、研发投入与企业绩效 [Overseas background, R&D investment and corporate performance of executive teams]. *Friends of Accounting*, (17), 104–110.
- Liu, P., & Wu, A. K. (2022). 高管团队异质性与企业成长性——动态能力的中介效应 [Executive team heterogeneity and firm growth - the mediating effect of dynamic capabilities]. *East China Economic Management*, 36(11), 117–128.
- Liu, R. (2022). *Research on the effect and mechanism of environmental responsibility on corporate performance of Chinese steel companies*. [Doctorate's thesis]. University of Science and Technology Beijing.
- Liu, X., & Wang, Y. L. (2018). 开放式创新视角下企业技术创新投入与企业绩效的实证研究 [An empirical study on enterprise technological innovation investment and enterprise performance under the perspective of open innovation N]. *Journal of Humanities and Social Sciences of Nanyang Normal University*, 38(1), 120-124.
- Liu, Y. G., & Liu, W. (2007). 我国上市公司的高管任期与 R&D 支出 [Executive tenure and R&D expenditures of listed companies in China]. *Management World*, 23(1), 128–136.
- Liu, Y. Y., Liu, J., & Liu, S. (2022). 高管团队职能背景异质性对企业绿色创新的影响研究 [A study on the impact of heterogeneity of executive team's functional background on corporate green innovation]. *Journal of Natural Sciences of Hunan Normal University*, 45(6), 62–69.
- Liu, Z. N. (2022). *The effect of executive team heterogeneity on firms' R&D investment* [Master's thesis]. Shandong Caijing University.
- Lu, Z. (2021). *China Medical Device Industry Development Report Status and Outlook of the 14th Five-Year Plan*. China Health Media Group.
- Luo, P., & Ge, Y. H. (2018). 权力分布视角下的高管团队异质性与企业创新绩效 [Executive team heterogeneity and corporate innovation performance under the power distribution perspective]. *China Human Resource Development*, 35(2), 41-49.
- Luo, Z. Y., Tang, L. L., & Chang, C. (2013). 高管团队人力资本、激励机制与企业研发投入 [Human capital, incentives and corporate R&D investment of executive teams]. *Journal of Soochow University (Philosophy and Social Science Edition)*, 34(1), 123–131.

- Ma, C. F. (2006). 高层管理团队是组织绩效提升的关键 [Top management team is the key to organizational performance improvement]. *Management Insight*, (2), 14–15.
- Ma, H. L. (2017). 企业高管背景特征与企业创新关系研究 [Research on the relationship between background characteristics of corporate executives and corporate innovation]. *Jiangsu Science and Technology Information*, 34(21), 30–31.
- Ma, J. J., & Ji, C.Y. (2023). 上市公司研发投入与公司绩效研究——以 A 股上市公司为例 [Research on R&D investment and company performance of listed companies--Taking A-share listed companies as an example]. *International Business Accounting*, (2), 18–22.
- Ma, L., & Wang, L. (2023). 俄乌冲突对国际贸易格局的影响及中国应对之策 [Impact of Russia-Ukraine conflict on international trade pattern and China's response]. *Price Monthly*, (5), 50–55.
- Ma, Y. Z. (2017). 企业文化对高层管理团队的影响 [The Impact of corporate culture on top management teams]. *Global Market Information Herald*, (29), 121.
- McCurtain, S., Flood, P. C., Ramamoorthy, N., West, M. A., & Dawson, J. F. (2010). The top management team, reflexivity, knowledge sharing and new product performance: a study of the Irish software industry. *Creativity and Innovation Management*, 19(3), 219–232.
- Mao, L. C., & Lou, F. F. (2016). 高管团队特征对企业战略选择影响评述 [A review of the impact of executive team characteristics on corporate strategic choice]. *Contemporary Economics*, 33(34), 113–115.
- Marshall, C. D., & Rossman, G. B. (2014). *Designing qualitative research*. Sage publications.
- McCain, B., E., O'Reilly, C., A., & Pfeffer, J. (1982). The effects of departmental demography on turnover. *Academy of Management Proceedings*, 1982(1), 235–239.
- Mei, Q., & Xu, S. N. (2012). 高层管理团队异质性、团队冲突和创业绩效的关系研究——以冲突管理为调节变量 [The relationship between top management team heterogeneity, team conflict and entrepreneurial performance with conflict management as a moderating variable]. *Economic and Management Research*, (6), 94–103.
- Miao, M. (2020). 煤炭企业高管团队异质性与财务绩效关系研究——以盈余管理为调节变量 [A study on the relationship between executive team heterogeneity and financial performance in coal enterprises--with surplus management as a moderating variable]. *Coal Economic Research*, (3), 66–72.
- Mikulay, S., Neuman, G., & Finkelstein, L. (2001). Counterproductive workplace behaviors. *Genetic Social & General Psychology Monographs*, 127(3), 279–300.
- Mooney, A. C., & Sonnenfeld, J. (2001). Exploring antecedents to top management team conflict: the importance of behavioral integration. *Academy of Management Annual Meeting Proceedings*, 2001(1), 11–16.
- Murray, A. I. (1989). Top management group heterogeneity and firm performance. *Strategic Management Journal*, 10(S1), 125–141.
- Nahavandi, A. (2015). *The Art and Science of Leadership*. Pearson.
- Nemeth, C. J., & Kwan, J. L. (2006). Minority influence, divergent thinking, and detection of correct solutions. *Journal of Applied Social Psychology*, 17 (9), 788–799.
- O'Mahony, M., & Vecchi, M. (2009). R&D, knowledge spillovers and company productivity performance. *Research Policy*, 38(1), 35–44.
- Patton, M. Q. (1990). *Qualitative evaluation and research methods*. Sage Publications.
- Pelled, L. H. (1996). Demographic diversity, conflict, and work group outcomes: an intervening process theory. *Organization Science*, 7(6), 615–631.
- Peng, H. X., & Mao, X. S. (2017). 政府创新补贴、公司高管背景与研发投入——来自我国高科技行业的经验证据 [Government innovation subsidies, firm executive background and R&D investment - Empirical evidence from China's high-tech industry]. *Finance and Trade Economics*, 38(3), 147–160.

- Pratt, J. W., & Zeckhauser, R. J. (1985). *Principals and agents: the structure of business*. Harvard Business Review.
- Reger, R. K. (1997). Strategic Leadership: Top executives and their effects on organizations. *The Academy of Management Review*, 22(3), 802–805.
- Reinganum, J. F. (1981). Dynamic games of innovation. *Journal of Economic Theory*, 25(1), 21–41.
- Richard, O. C., & Shelor, R. M. (2002). Linking top management team age heterogeneity to firm performance: Juxtaposing two mid-range theories. *International Journal of Human Resource Management*, 13(6), 958–974.
- Ross, S. A. (1973). The Economic Theory of Agency: The Principal's problem. *American Economic Review*, 63(2), 134–139.
- Round, M. L. K. (1978). Research and product innovation in Australian manufacturing industries. *Journal of Industrial Economics*, 27(1), 1–12.
- Shank, M. E., Zeithmlal, C. P., Blackburn, R. S., & Boyton, A. C. (1988). Predictors of top management team environmental perception accuracy: a model and propositions. *Academy of Management Annual Meeting Proceedings*, 1988(1), 37–41.
- Sheng, M. Q., & Long, H. H. (2023). 人才强国战略视角下高管团队异质性与企业全要素生产率的关系研究 [A study on the relationship between executive team heterogeneity and corporate total factor productivity under the perspective of the strategy of strengthening the country with talents]. *Journal of Huaibei Normal University (Philosophy and Social Science Edition)*, 44(2), 74–82.
- Sheng, Y. H., & Lu, L. (2016). R&D 投入与企业绩效的倒 N 型关系研究 [A study on the inverted N-shaped relationship between R&D investment and firm performance]. *Nanjing Social Science*, (1), 32–38.
- Simons, T., Pelled, L. H., & Smith, K. A. (1999). Making use of difference: diversity, debate, and decision comprehensiveness in top management teams. *Academy of Management Journal*, 42(6), 662–673.
- Smith, K. G., Smith, K. A., Olman, J. D., Sims, H. P., O'Bannon, D. P., & Scully, J. A. (1994). Top management team demography and process: the role of social integration and communication. *Administrative Science Quarterly*, 39(3), 412–438.
- Smith, P. B., Dugan, S., & Trompenaars, F. (1996). National culture and the values of organizational employees: a dimensional analysis across 43 nations. *Journal of cross-cultural psychology*, 27(2), 231–264.
- Sun, H. M., Yao, Z. H., & Yan, J. S. (2006). 高管团队人口统计特征对纺织和信息技术公司经营绩效的影响 [The effect of executive team demographic characteristics on business performance of textile and information technology firms]. *Nankai Management Review*, 9(6), 61–67.
- Sutcliffe, K. M. (1994). What executives notice: accurate perceptions in top management teams. *Academy of Management Journal*, 37(5), 1360–1378.
- Tong, J. D., & Ju, X. (2022). 构建更高水平开放型经济新体制的国际战略形势思考 [Reflections on the international strategic situation of constructing a new open economic system at a higher level] *International Economic Cooperation*, (6), 4–13.
- Torchia, M., Andrea Calabrò, & Huse, M. (2011). Women directors on corporate boards: from tokenism to critical mass. *Journal of Business Ethics*, 102, 299–317.
- Urs, S., Daellenbach, Anne, M., McCarthy, Timothy, S., & Schoenecker. (1999). Commitment to innovation: the impact of top management team characteristics. *R&D Management*, 29(3):199–208.
- Vanderpal, G. A. (2017). *Impact of R&D expenses and corporate financial performance*. Social Science Electronic Publishing.

- Venkatraman, N., & Ramanujam, V. (1986). Measurement of business performance in strategy research: a comparison of approaches. *The Academy of Management Review*, 11(4), 801–814.
- Wang, H. P. (2011). *A study of the impact of executive team background characteristics on corporate investment* [Master's thesis]. Zhejiang Caijing University.
- Wang, J., Li, M., & Zhao, L. L. (2023). R&D 投入持续性、高管教育背景与企业创新绩效——基于 A 股上市公司的实证研究 [R&D investment continuity, executives' educational background and corporate innovation performance - an empirical study based on A-share listed companies]. *Operation and Management*, (3), 32–39.
- Wang, J. L., & Li, C. F. (2007). 高管人力资本、高管报酬和公司绩效关系的实证研究——以中部地区上市公司为例 [An empirical study on the relationship between executive human capital, executive compensation and firm performance--a case of listed companies in central China]. *Economic Management*, 33(24), 33–38.
- Wang, J. T., & Zhang, Y. (2023). 财务柔性、高管团队背景特征对企业风险承担水平影响研究 [A study on the influence of financial flexibility and background characteristics of executive team on corporate risk-taking level]. *Journal of Southwest University (Natural Science Edition)*, 45(5), 134–144.
- Wang, L. C. (2022). *A Study of Generational Inheritance, Changes in Governance Structure and Corporate Performance* [Master's thesis]. Hefei University of Technology.
- Wang, L. L., Han, D. Q., & Zhang, C.K. (2021). 中小板公司股权集中度、研发投入与公司绩效 [Shareholding concentration, R&D investment and firm performance in small and medium-sized companies]. *Friends of Accounting*, (3), 117–123.
- Wang, M. L. (2020). *A study of the effect of heterogeneity of executive team's occupational background on R&D investment* [Master's thesis]. Lanzhou Caijing University.
- Wang, Q., & Zhou, Z. J. (2015). 女性高管与 R&D 投入:中国的经验证据 [Female executives and R&D investment: empirical evidence from China]. *Management world*, 31(3), 178–179.
- Wang, S. C., Chen, J., & Zhao, Z. W. (2022). 生物科技公司竞争战略与创新发展对策 [Competitive strategy and innovation development countermeasures of Biotech companies]. *Pharmaceutical Biotechnology*, 29(5), 441–447.
- Wang, W., Jing, N., & Zhang, P. F. (2016). CEO 背景特征,研发投入与企业价值研究——以高新技术企业为研究对象 [CEO Background Characteristics, Research on R&D Investment and Firm Value - A Study on High-Tech Enterprises]. *Friends of Accounting*, (5), 33-37.
- Wang, W. H., Zhang, Z., & Huang, Q. (2014). 基于高管团队人力资本调节作用的研发投入与企业绩效关系研究 [A study on the relationship between R&D investment and firm performance based on the moderating role of executive team's human capital]. *China Science and Technology Forum*, (6), 115-120.
- Wang, W. J., & Li, J. (2015). 企业高层管理团队研究综述 [A Review of Research on Corporate Top Management Teams]. *Journal of Yanbian University (Social Science Edition)*, 48(5), 122–130.
- Wang, X. W., & Wu, Y. W. (2019). TMT 背景特征,研发投入与企业价值 [TMT background characteristics investment and firm value]. *Journal of Northeast Agricultural University: social science edition*, 17(6), 10–20.
- Wang, Y. M., Wang, Y. L., & Cheng, H. D. (2015). 高管团队异质性、战略双元与企业绩效 [Executive team heterogeneity, strategic duality and firm performance]. *Research Management*, 36(11), 89–97.
- Weber, E. U., & Hsee, C. (1998). Cross-cultural differences in risk perception, but cross-

- cultural similarities in attitudes towards perceived risk. *Management Science*, 44(9), 1205–1217.
- Wei, L. Q., & Wang, Z. H. (2002). 我国上市公司高管特征与企业绩效的实证研究 [An empirical study of executive characteristics and corporate performance of listed companies in China]. *Nankai Management Review*, (4), 16–22.
- Wen, Z. L., Hou, T. J., & Zhang, L. (2005). 调节效应与中介效应的比较和应用 [Comparison and application of moderating and mediating effects]. *Psychological Journal*, (2), 268–274.
- Wiersema, M. F. (1992). Top management team demography and corporate strategic change. *Academy of Management Journal*, 35(1), 91–121.
- Wiersema, M. F., & Bird, A. (1993). Organizational demography in Japanese firms: group heterogeneity, individual dissimilarity, and top management team turnover. *Academy of Management Journal*, 36(5), 996–1025.
- Wu, B. H. (2018). 研发投入对企业绩效的影响研究 [Research on the impact of R&D investment on enterprise performance]. *China Business Journal*, (6), 89–90.
- Xu, J. C., & Wang, S. H. (2010). 核心高管特征与公司成长性关系研究——基于中国沪深两市上市公司数据的经验研究 [The relationship between core executives' characteristics and firm growth: an empirical study based on data from listed companies in Shanghai and Shenzhen, China]. *Economic Theory and Economic Management*, 30(6), 58–65.
- Xu, P. P. (2016). 研发投入与企业绩效的相关性研究——基于创业板制造企业数据的检验 [A study on the correlation between R&D investment and firm performance - a test based on data from GEM manufacturing firms]. *Innovation and Technology*, 16(12), 26–28.
- Xu, P. Y. (2023). *Environmental Regulation, Executive Team Heterogeneity and Financial Performance of Heavily Polluting Firms* [Master's thesis]. Hebei University of Economics and Business.
- Xu, Z. C., & Hou, J. C. (2019). 创新投入、竞争战略与企业绩效水平——基于中国制造业上市公司的实证分析 [Innovation investment, competitive strategy and firm performance level - An empirical analysis based on listed companies in China's manufacturing industry]. *Modern Finance and Economics (Journal of Tianjin University of Finance and Economics)*, (9), 56–68.
- Xue, Y., & Chen, Q. (2014). CEO 特征对 R&D 投入的影响——基于中国制造业上市公司的实证分析 [The impact of CEO characteristics on R&D investment - An empirical analysis based on listed companies in China's manufacturing industry]. *Journal of East China Normal University (Philosophy and Social Science Edition)*, 46(6), 129–138.
- Yang, D. (2022). *A Study of the Effect of Source Heterogeneity Debt on Firms' R&D Investment* [Master's thesis]. Xi'an University of Science and Technology.
- Yang, F., Li, P. Y., & Wu, X. H. & 吴晓晖. (2016). 两权分离、管理者背景特征和创新强度——基于创业板上市公司的经验证据 [Separation of powers, managerial background characteristics and innovation intensity - Empirical evidence based on GEM listed companies]. *Science and Technology Management Research*, 36(12), 5–10.
- Yang, X. P. (2021). *A study of the relationship between executive team characteristics, corporate social responsibility, and corporate value* [Master's thesis]. Southwest University of Finance and Economics.
- Yao, C, S. (2022). 基于委托代理理论的科技型企业核心技术人员股权激励研究 [Research on equity incentives for core technical personnel in technology-based enterprises based on principal-agent theory]. *China Market*, (30), 98–100.
- Ye, H. Y., & Chen, T. (2016). 高管团队特征对企业研发投入影响的研究——基于高管激

- 励的调节作用 [A study on the impact of executive team characteristics on firms' R&D investment - based on the moderating role of executive incentives]. *Technology and Innovation Management*, 37(2), 177–182.
- Yu, L., & Xu, M. (2023). 女性管理者对上市公司碳信息披露水平的实证研究 [An empirical study of female managers' influence on the level of carbon disclosure in listed companies]. *Modern Business*, (4), 165–168.
- Zenger, T. R., & Lawrence, B. S. (1989). Organizational Demography: The differential effects of age and tenure distributions on technical communication. *Academy of Management Journal*, 32(2), 353–376.
- Zhang, H., An, T. L. (2006). 中国上市公司董事会学历分布与公司绩效的实证分析 [An empirical analysis of board education distribution and firm performance in Chinese listed companies]. *Nanjing Social Science*, (1), 37–43.
- Zhang, H. B. (2006). *Research on Business Strategy of Chinese Medical Device Enterprises* [Master's thesis]. University of International Business and Economics.
- Zhang, P. (2005). *Research on the Relationship between Heterogeneity of Top Management Teams and Corporate Performance of Listed Companies in China* [Master's thesis]. South China University of Technology.
- Zhang, P. (2020). *An Empirical Study on the Effect of Joint Venture Capital Membership Heterogeneity on Corporate IPO Performance* [Master's thesis]. Xi'an University of Science and Technology.
- Zhang, X. P., & Shi, Q. (2020). 高阶理论研究综述：基于企业行为与作用机制视角 [A review of upper echelons theory research: based on the perspective of firm behaviour and action mechanism]. *Accounting Newsletter*, (10), 9–15.
- Zhang, Y. F. (2022). *A study on the relationship between executive team characteristics, marketing investment and corporate performance of New Third Board sports companies* [Master's thesis]. Wuhan Sports Institute.
- Zhang, Y. W. (2021). *Board Heterogeneity, Diversification Strategies, and Corporate Inefficient Investment* [Master's thesis]. Capital University of Economics and Business.
- Zhao, Y., Wang, N., & Zhang, L. Y. (2021). 科创企业研发投入对企业绩效的非线性影响——基于固定效应面板门槛模型的实证研究 [The nonlinear impact of R&D investment on firm performance of science and technology startups - an empirical study based on a fixed-effects panel threshold model]. *Industrial Technology Economics*, 40(1), 48–58.
- Zheng, Y. J., & Lu, S. (2015). 高管团队特征对企业 R&D 投资效率的影响研究——来自西部地区上市公司的经验证据 [A study on the impact of executive team characteristics on corporate R&D investment efficiency - Empirical evidence from listed companies in the western region]. *Finance and Accounting Monthly*, (17), 29–33.
- Zhong, X. L. (2020). *A study on the impact of executive team tenure on corporate performance* [Master's thesis]. South China University of Technology.
- Zhu, J. W., & Zhao Y. (2021). 高管团队职能异质性对创新绩效的影响机制——基于创业板企业的实证分析 [Mechanisms of executive team functional heterogeneity on innovation performance: an empirical analysis based on GEM firms]. *Journal of Henan Normal University (Philosophy and Social Science Edition)*, 48(5), 45–51.
- Zhu, M. Q., & Zhang, P. X (2018). 高管团队、企业创新与企业绩效——基于企业创新中介作用的实证研究 [Executive team, corporate innovation and corporate performance - An empirical study based on the mediating role of corporate innovation]. *Friends of Accounting*, (22), 64–71.
- Zhu, W. L., & Chen, X. (2017). 研发投入与企业绩效究竟呈什么关系?——来自国内研究

- 的动态分析 [What exactly is the relationship between R&D investment and firm performance?--A dynamic analysis from domestic studies]. *Management Modernization*, 37(3), 54–57.
- Zhu, W. P., & Lun, R. (2004). 高新技术企业科技投入与绩效相关性的实证分析 [An empirical analysis of the correlation between science and technology investment and performance of high-tech enterprises]. *Science and Technology Management Research*, 24(5), 7–9.
- Zhu, W. Y. (2016). *Research on the Impact of Executive Team Background Characteristics on Corporate Technological Innovation* [Master's thesis]. Nanjing Post and Communications University.
- Zhu, Z. L., & Wang, L. (2004). 上市公司经营者个性特征与公司绩效的相关性实证研究 [An empirical study on the correlation between personality traits of listed company managers and company performance]. *Financial Theory and Practice*, 25(2), 46–50.
- Zou, Q., Liu, J. H., Hong, K., & Luo, D. (2014). 科技型中小企业技术创新的对策研究 [Research on countermeasures for technological innovation of science and technology-based SMEs]. *Financial Education Research*, 27(2), 53-55.

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Other References

- China Food and Drug Administration. (2015). *Announcement on the China medical devices classification catalogue in Beijing*, China (Report No. 2017/104).
- China National Medical Products Administration. (2021). *China Medical Device Supervision and Administration Regulations in Beijing*, China (Report No. 2021/158).