THE EFFECT OF BOARD CAPITAL DEVELOPMENT ON INNOVATION PERFORMANCE OF HIGH-TECH ENTERPRISES IN SHANDONG PROVINCE, CHINA

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Management

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Declaration

I, Wang Fei (Student ID# 6319200025), hereby certify that the work embodied in this dissertation entitled "The Effect of Board Capital Development on Innovation Performance of High-Tech Enterprises in Shandong Province, China" is result of original research and has not been submitted for a higher degree to any other university or institution.

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May 19th, 2024

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Abstract

Title	:	The Effect of Board Capital Development on Innovation Performance of High-Tech Enterprises in Shandong Province, China
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This study had the following objectives: 1) To determine the factors of board capital investment that influence the technological innovation performance of high-tech enterprises; 2) To investigate the relationship between board capital, technological innovation resources, and the quality level for technological innovation strategies in high-tech enterprises; and 3) To examine how technological innovation resources and the quality of technological innovation strategy impact technological innovation performance. A total of 450 respondents were given questionnaires using a quantitative research method, and 401 valid responses were received, resulting in a validity rate of 89.11%. The sample population was comprised of members of the board of high-tech enterprises in Shandong province. A structural equation modeling (SEM) was utilized, and confirmatory factor analysis (CFA) was conducted to test the hypotheses.

The findings indicated variable relationships were impacted by the following: 1) The Board Human Capital (BHC), Board Social Capital (BSC), and Board Institutional Capital (BIC) significantly influence the innovation performance of high-tech enterprises; 2) The level of human capital of the board of directors has a significant positive impact on resource acquisition (Est.=0.131, $p<0.001$) and the quality of strategic decisions (Est.=0.551, $p<0.001$). However, the level of social capital of the board of directors does not significantly impact resource acquisition (Est.=0.094,

p=0.137); however, it does have a positive impact on the quality of strategic decisions (Est.=0.519, p<0.001). The institutional capital of the board of directors does not have a significant positive impact on resource acquisition (Est.=0.075, p=0.183), but it does have a positive effect on the quality of technological innovation strategic decisions (Est.=0.186, p<0.001); 3) The acquisition of technological innovation resources has a significant positive effect on technological innovation performance (Est.=0.5269, p<0.001). Similarly, the quality of technological innovation strategic decision-making significantly positively affects technological innovation performance (Est.=0.513, p<0.001).

Keywords: board capital, technological innovation resources, technological innovation strategy, performance, Shandong

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CHAPTER 1
INTRODUCTION

1.1 Background of the Study

The international ecological environment has deteriorated due to global epidemics, Sino-US trade friction, and Russia-Ukraine conflicts in military actions. Social development faces new challenges with economic issues and political contradictions, especially in developing countries. Some scholars have pointed out that only through transforming the social production mode and changing the essential economic structure can countries embark on sound economic development. China has put forward "high-quality development," which involves not only national policies at the macro level and industrial layout at the mid-level but also enterprise strategies at the micro level. As a micro entity of economic society, the development of enterprises has a core impact on achieving high-quality economic development of the entire community. High-quality products require enterprises to transform from extensive development to quality-efficiency-based sustainable development and shape a more competitive high-quality development paradigm (Fama & Jensen, 2019). The Chinese government has proposed that "to enhance the technological innovation capability of enterprises and to guide them to speed up the investment in technological innovation is an important means to achieve the goal of high-quality economic development."

Since technological innovation has been elevated to the national strategy, China has formulated many policies to support the development of innovation entities. High-Tech Enterprises (HTE) that integrate technology, knowledge and talents and take innovation as the core task are the critical support objects. The Chinese government departments have formulated and implemented supportive policies to provide favorable development conditions for High-Tech Enterprises. Under the guidance and support of policies, China's High-Tech Enterprises have achieved rapid development with the number of High-Tech Enterprises increasing and their position in China's national economy continuously improving (Feng et al., 2022). Statistics show that in 2020, the number of High-Tech Enterprises in China increased by 24%, achieving operating

revenue of 51.3 trillion Yuan, an increase of 13.8%. Total industrial output value was 37.8 trillion Yuan, an increase of 16.6%; Total profit was 3.8 trillion Yuan, an increase of 20.1%.

The rapid development of high-tech enterprises in China, according to the data provided by the National Bureau of Statistics of China and the Statistics Bureau of Shandong Province, China, uses the indicator of the economic value-added ratio of high-tech enterprises as an essential measure of the level of high-tech development. According to the relevant data compilation, although the high-tech enterprises in Shandong Province are developing rapidly and the number of enterprises is increasing (see Figure 1.1), the indicator of the economic value-added ratio of high-tech enterprises is always lower than the level of China from 2018 to 2022 (see Figure 1.2). The overall trend of economic value added by high-tech enterprises is increasing. Therefore, the development of high-tech enterprises in Shandong Province needs to be further improved, and a critical development component of high-tech enterprises is innovation performance. The study of the innovation performance of high-tech enterprises has become a hot research topic, which is of great significance. High-tech enterprises in China include new-generation information technology manufacturing enterprises, new energy and materials enterprises, high-end equipment enterprises, and artificial intelligence enterprises. Among them, the economic value added by high-tech enterprises is the Chinese government's measure of the development status of each type of enterprise. The high-tech industry in Shandong Province has been developing rapidly. The economic value added by high-tech enterprises has been growing, which has become a vital development object in Shandong Province (see Figure 1.3). As the most populous province of China, the area of science and technology innovation, and the region of GNP, Shandong Province plays an essential role as a fulcrum in the high-quality development of China's economy. Therefore, the research related to the development of high-tech enterprises in Shandong province has a vital demonstration role for the development of Shandong province and the development of high-tech enterprises in China.

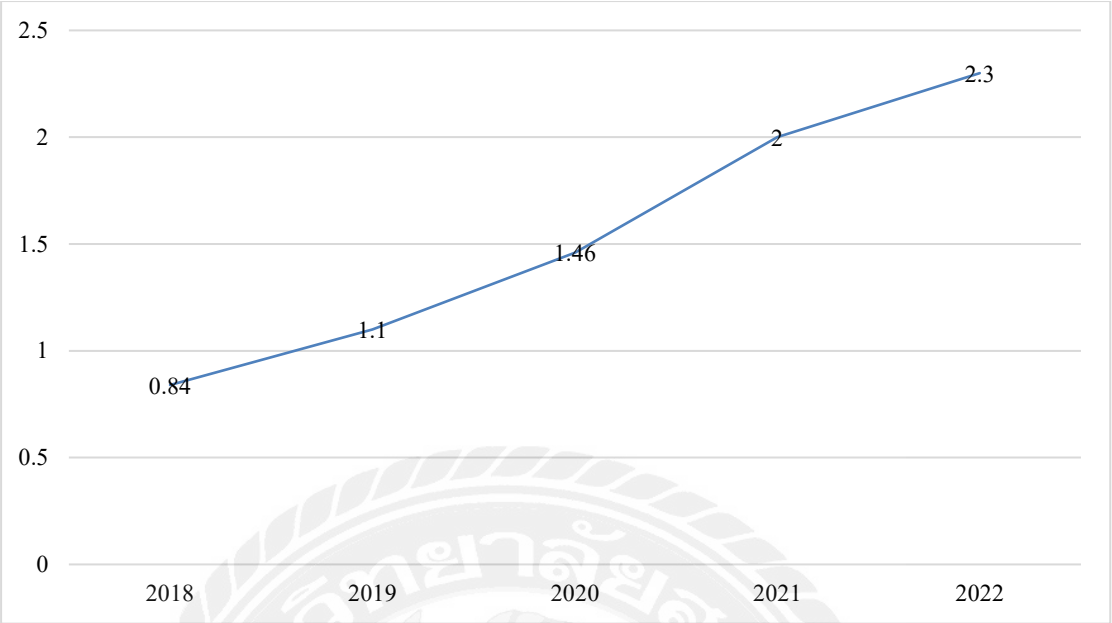

Figure 1.1 Number of high-tech enterprises in Shandong Province in 2018-2022 (Unit: 10,000) (http://tjj.shandong.gov.cn/)

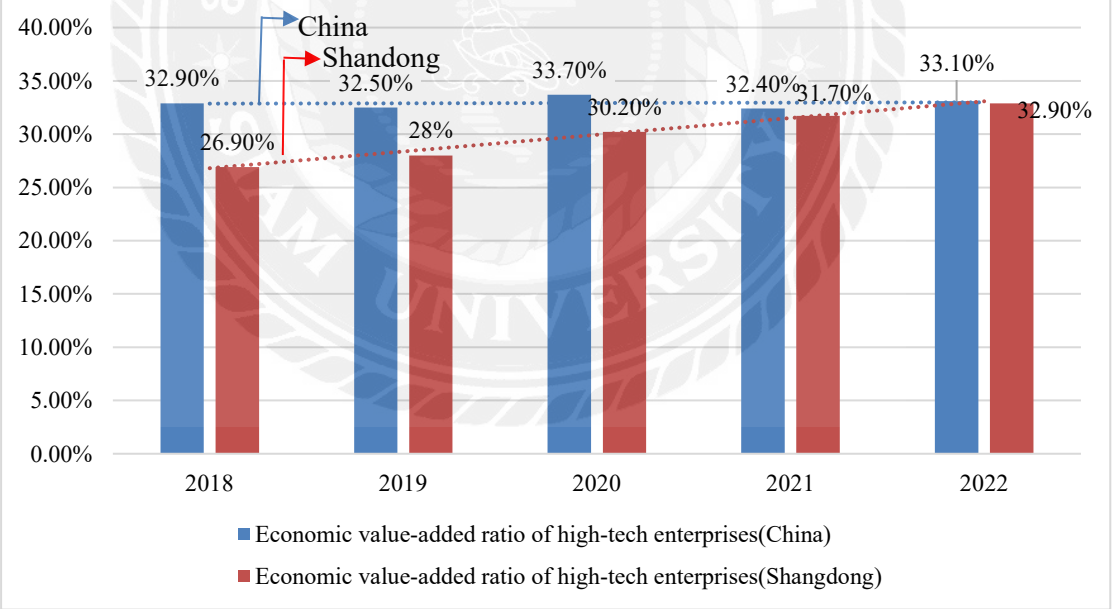

Figure 1.2 Current status of economic value-added ratio of high-tech enterprises in China, 2018-2022 (http://tjj.shandong.gov.cn/, http://www.stats.gov.cn/sj/tjgb/ndtjgb/)

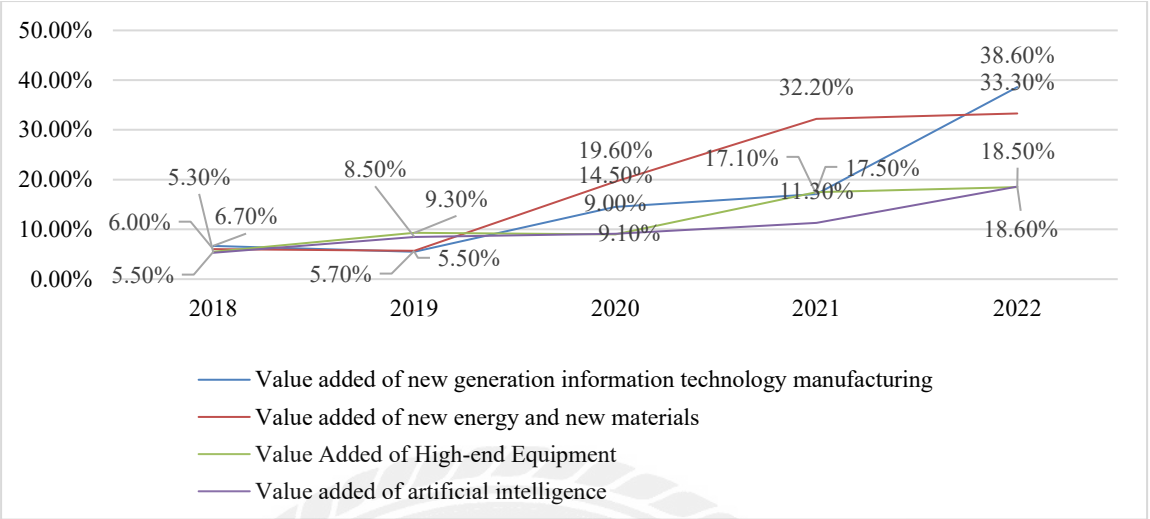

Figure 1.3 Classification and economic value added of high-tech enterprises in Shandong Province in 2018-2022 (http://tjj.shandong.gov.cn/)

China's high-tech industry has developed rapidly in the past decade but also faces serious problems. According to statistics, the average lifespan of High-Tech Enterprises is only 2.9 years, with 80% of five-year existence and 95% of 10 years. The main reason is that the technological innovation performance of Chinese High-Tech Enterprises still needs to improve. The United States and Japan account for up to 90 % of patents in high-tech fields worldwide. The remaining 10% is left to the rest of the countries, including China. However, the average annual patent usage fee of High-Tech Enterprises is relatively high in China, as high as 20% of operating revenue. Compared with the 30% profit margin of US high-tech products, the profit margin of China's high-tech products is only 10%. In addition, the transformation of traditional industries with high technology still follows external change (Damschroder et al., 2019). China's critical technological equipment is relatively backward, and it needs to rely on external technologies to a large extent. More than 60% of the equipment investment depends on imports, while the equipment investment accounts for about 40% of the fixed asset investment.

Economic globalization is spreading at a high speed, making the market competition increasingly fierce. High-tech enterprises must enhance their strength to improve their market position continuously (Meyer & Rowan, 2018). Compared with the enterprises of developed countries, China's High-Tech Enterprises have a long way

to go. The competitiveness of Chinese High-Tech Enterprises could be higher, especially in the high-tech field. The current market trend prompts China to realize that to occupy the market is bound to innovate technologies. Despite the rapid development of technological innovation and the increasing input and output of creation, the quality of China's innovative technologies remains to be evaluated. How to raise the technical innovation level of Chinese enterprises and promote high-quality development driven by innovation is a significant issue that needs to be solved urgently and studied further.

Many internal and external factors affect technological innovation. The Board of Directors is the core of corporate governance. It plays a key role and fundamentally affects the formulation of enterprise innovation strategy. The human and social capital of Board members includes their educational level, industrial experience, professional competence, social relations, etc. Regarding technological innovation, the existing studies have pointed out that innovative activities are often risky (Grant, 2019). If the enterprise cannot define the market and its trend, it may lead to innovation failure.

Moreover, innovation requires a lot of funds and human resources, and the input-output ratio still needs to be discovered. The critical role of the Board of Directors is to guide enterprises and grasp the market rules, which depend on the human capital of Board members. Board capital can provide resources for innovative activities, including funds from financial and political backgrounds and technical support and relationship resources brought by chain directors (Bendig et al., 2020).

The social network established by Board members can help enterprises acquire essential resources and complementary technologies in the innovation process, as well as the legitimacy guarantee of new products, technologies, markets, etc. The relationship resources of the chain directors can help enterprises obtain frontier market information and scarce resources, reduce the uncertainty of innovation policies, and promote the formulation and implementation of innovation policies. According to the Resources Dependence Theory, the survival and development of enterprises rely on the effective integration and coordination of internal resources. Correctly matching internal resources can help enterprises reduce their dependence on the external environment and transaction costs and effectively manage uncertainties. The Board of Directors is the provider of enterprise resources, and its members are the providers of Board resources.

The expertise, reputation, political connection, and relationship resources of Board members all influence the enterprise.

Shandong Province, a province with a large population, significant science and technology innovation, and a high GDP, plays an essential supporting role in the high-quality development of China's economy. In 2019, according to the policy planning of the central government of China, Shandong Province set up demonstration zones of "Rejuvenating Shandong with Science and Technology" to attract many High-Tech Enterprises into Shandong. During the construction of the Demonstration Zones, Shandong Province has provided preferential policies, including land policies, financial policies, technological innovation subsidy policies, etc. The high-tech industry in Shandong Province is representative and demonstrative within China. Since Board capital is significant for High-Tech Enterprises, its impact on the innovation performance of Shandong High-Tech Enterprises should be researched deeply.

(1) Board Governance is the Institutional Guarantee for High-Tech Enterprises to Obtain and Maintain Competitiveness.

Board governance is the core of corporate governance (Huse, 2005). The theme of corporate governance is to control and supervise the behavior of managers, and the ultimate goal is to ensure the value of enterprises. As the brain of an enterprise, the Board of Directors serves as the connecting hub between shareholders and managers. It is entrusted by shareholders to control and supervise the general manager to protect stakeholders' interests, including shareholders. Board governance is the critical element of corporate governance and an institutional guarantee for enterprises to obtain and maintain competitiveness. Its efficiency determines the competitive position of an enterprise and is closely related to its competitive advantage (Leblanc & Schwartz, 2007). If the efficiency of Board governance is high, the enterprise will retain its competitive advantage.

(2) The Effectiveness of Board Governance in Chinese High-Tech Enterprises Could be Higher.

The compliance of Board governance of High-Tech Enterprises has been significantly improved (Oxelheim & Randøy, 2003). Since the reform and opening up,

China has established and improved its modern enterprise system based on the advanced experience of developed countries in Europe and the United States by issuing relevant laws and regulations. In particular, the Board governance system is improving, and Board composition, scale, etc., are regulated in detail. Board governance performance of High-Tech Enterprises still needs to improve. During the construction of "China National-level High-Tech Demonstration Zones" in Shandong Province, the low Board governance effectiveness of High-Tech Enterprises is particularly prominent, which is the main reason for the research of this paper.

(3) Features of Board Governance of High-Tech Enterprises

Due to the unique features of High-Tech Enterprises, the relationship between Board capital and Board governance under senior executive incentive has its characteristics. Compared with Board physical capital, Board intellectual capital is more critical to the performance of Board governance (Woolcock & Narayan, 2000). Founders of High-Tech Enterprises enjoy higher intellectual capital. The level of intellectual capital and incentive of High-Tech Enterprises is higher than that of ordinary enterprises. The impact of Board capital on Board governance performance is also different.

From the above analysis, this study concludes that Board capital is a crucial pre-factor for enterprises' innovation-driven high-quality development and is of great significance for the innovation performance of High-Tech Enterprises. As the core of the corporate governance structure, the Board of Directors is to make strategic decisions on technology innovation; Board Capital (BC) is the foundation for the effective functioning of Board decisions (Tihanyi et al., 2014). Therefore, it is necessary to study the performance mechanism by which Board capital affects the technological innovation of High-Tech Enterprises. As an essential demonstration zone for developing high-tech industries in China, Shandong Province is critical to enhancing the role of Board capital in enterprise innovation performance.

1.2 Research Questions

Firstly, from the perspective of principal-agent theory, the study of the impact of Board capital on the innovation performance of High-Tech Enterprises can explore the incentive effect of Board capital investment on the innovation behavior and performance of High-Tech Enterprises. According to the principal-agent theory, the owner (principal) entrusts the management power to the manager (agent), and the manager needs to create benefits for the principal. However, due to information asymmetry and conflicts of interest, the agent may pursue personal interests rather than the principal's, leading to agency problems. In High-Tech Enterprises, these problems may affect Board capital investment decisions and the innovation performance of the enterprise. As an institution representing all shareholders, the Board of Directors should utilize its capital investment role to drive innovation activities and improve the performance of the enterprise. However, if Board members face agency issues, they may choose to pursue their interests rather than the interests of shareholders, which may lead to inefficient Board capital investment and negative impacts on innovation performance (McWilliams & Siegel, 2000).

Therefore, from the perspective of principal-agent theory, the research on the impact of Board capital investment on the innovation performance of High-Tech Enterprises can provide a deeper understanding of the factors of Board members' interests. It advises on improving Board governance structure and strengthening supervision mechanisms to ensure the positive effect of Board capital investment on enterprise innovation performance.

Secondly, from the perspective of resources dependence theory, studying the impact of Board capital on the innovation performance of High-Tech Enterprises can explore the impact of Board capital investment on acquiring external resources and realizing innovation. According to the theory of resource dependence, enterprises rely on external resources to survive and develop; the Board of Directors, one of the corporate governance institutions, can provide more resources through capital investment and help enterprises realize innovation. In High-Tech Enterprises, innovation is crucial, requiring enterprises to own sufficient resources and capabilities. In addition, Board members can also use their social resources and relations to introduce

more external resources to enterprises and accelerate their innovation process (Bendig et al., 2020).

However, if Board members lack the necessary resources and capabilities, they may be unable to provide sufficient capital investment and other resources for enterprises, which may affect the innovation performance. Therefore, from the perspective of resources dependence theory, the research on the impact of Board capital investment on the innovation performance of High-Tech Enterprises can provide a deeper understanding of the resources and abilities of Board members and then propose suggestions for improving Board talents selection and strengthening Board external connections to ensure the positive effect of Board capital investment on enterprise innovation performance.

Thirdly, from the perspective of upper echelon theory, the research on the impact of Board capital on the innovation performance of High-Tech Enterprises can focus on the relationship between the high-level echelon background of Board members and the innovation performance of enterprises. According to the upper echelons theory, the top talents are more competent and possess rich experiences, and they can create more value. In the Board of Directors, the principal skills have richer resources and expertise. They can provide better strategies and guidance, and thereby promote the innovation performance of the enterprise. In High-Tech Enterprises, it is necessary to possess high technical capabilities and experience due to the complexity and uncertainty of technological innovation. The background of Board members may have a significant impact on the innovation performance of the enterprise. While studying the impact of Board capital investment on the innovation performance of High-Tech Enterprises (Fama & Jensen, 2019), it is essential to consider the high-level echelon background of Board members and analyze their impact on enterprise innovation performance. It is also necessary to explore how to enrich the knowledge of Board members and how to better utilize the capabilities and experience of top talents in corporate governance to enhance the innovation performance of the enterprise.

In summary, the main research questions include:

(1) What Factors of Board Capital Affect the Innovation Performance of High-Tech Enterprises?

(2) Does Board Capital Affect the Technological Innovation Resources and Quality of the Technological Innovation Strategy of High-Tech Enterprises?

(3) Do Technological Innovation Resources and Quality of Technological Innovation Strategy Affect Technological Innovation Performance in High-Tech Enterprises?

1.3 Research Objectives

This research aims to investigate and analyze the relationship between Board capital investment and the innovation performance of High-Tech Enterprises in Shandong, China. The study aims to explore how Board capital investment affects the innovation activities of High-Tech Enterprises and to conduct in-depth research on the mechanism by which Board capital investment affects innovation performance. The study provides recommendations for improving investment strategies to enhance innovation performance. The main objectives of this study are as follows:

(1) To Find out the Factors of Board Capital Investment on the Technological Innovation Performance of High-Tech Enterprises.

(2) To Explore the Effects Between Board Capital and Technological Innovati on Resources, and the Quality of Technological Innovation Strategy of High-Tech Ent erprises.

(3) To Explore how Technological Innovation Resources and the Quality of Technological Innovation Strategy Affect Technological Innovation Performance.

1.4 Significance of the Study

It is both theoretically and practically important to investigate the mechanism of Board capital on the technological innovation performance of high-tech enterprises.

1.4.1 Theoretical Significance

(1) Enrich Theoretical Research on the Antecedents of Technological Innovation Performance.

The research on the antecedents of technological innovation performance is a crucial and hot issue in innovation management. Previously, scholars mainly studied from the two perspectives of technological innovation resources input and technical innovation ability. The variables such as technological innovation capital investment, government capital investment, enterprise technological innovation talents, enterprise resources integration, technology absorption, transformation, etc., are selected to study their impact on technological innovation performance. Fewer scholars explored corporate cognition and the relationship between corporate governance factors and technological innovation performance, and significantly more infrequent in the study of the impact of the Board of Directors on technological innovation performance (Simon, 2021). Therefore, this study chooses Board capital as the antecedent variable of technological innovation performance, explores the influence and mechanism of Board capital on the technological innovation performance of High-Tech Enterprises, and enriches the theoretical research on the antecedents of technological innovation performance.

(2) Enrich Theoretical Research on the Paths of Board Governance Efficiency.

The Board of Directors is the "hub" connecting shareholders and managers, the ultimate controller and decision maker of the enterprise, and the core of enterprise governance. Its governance efficiency is directly related to the level of enterprise performance. The theoretical studies on the paths of Board governance efficiency are fruitful. However, the majority is from the perspective of Board structure, focusing on the relationship between Board structure and governance efficiency and approaches to Board governance efficiency. This paper breaks the constraints of structural analysis. From the cognitive behavior of the Board of Directors, it selects and analyzes Board capital that reflects Board governance ability as the pre-factor, the acquisition of technological innovation resources that reflect the Board's behavioral performance, and the quality of technological innovation strategy that reflects the Board's strategic

performance. Through the theoretical analysis and empirical research, the impact of Board capital on acquiring technological innovation resources and the quality of the technological innovation strategy of High-Tech Enterprises is explored (Aguilera & Jackson, 2003). From the perspective of Board capital, this paper aims to explore the ways to acquire technological innovation resources and improve the quality of the technological innovation strategy of High-Tech Enterprises. It provides new directions for the theoretical research on Board governance efficiency.

(3) Improve Board Capital Theory.

The research on Board capital theory is quite mature. The human capital of the board and Board social capital are the standard divisions in analyzing Board capital dimensions, and the single size is studied in isolation from a static perspective. Through analyzing the essence of Board capital, this paper explores new dimensions of Board capital to make the research more comprehensive. Based on the measurements of Board capital composition and from the perspective of dynamic collaboration (Anderson & Reeb, 2003), this paper expounds upon the relationship between the dimensions and the multidimensional collaborative mechanism of Board capital to make up for the existing static and isolated research and improve the theoretical system of Board capital. Meanwhile, following the scientific scale development program, this paper develops Board capital measurement tools, establishes a Board capital synergy measurement model, and lays a solid foundation for empirical research on Board capital.

1.4.2 Practical Significance

(1) It is Critical to Enhance the Technical Innovation Performance of High-Tech Enterprises.

With the short life cycle of high-tech products and the increasingly severe market competition, a higher level of technological innovation is necessary. The continuous improvement of technological innovation level depends on higher technological innovation performance. Board capital is essential to the strategy and acquiring technological innovation resources (La Porta et al., 2000). This paper aims to enhance enterprises' cognition and perception of the relationship between Board capital and technological innovation performance and then propose feasible countermeasures

to improve High-Tech Enterprises' technological innovation performance from the perspective of Board capital.

(2) It is Realistic to Increase the Quality of High-Tech Enterprises' Technical Innovation Strategy.

The Board of Directors is responsible for making strategies and controlling implementation, and the effective implementation of its design is the prerequisite and condition to ensure the development of enterprises. In theory, the effective use of Board capital is relevant to the function of each link and ultimately affects the quality of strategies. Based on the idea of the strategic process, this paper discusses the influence of Board capital on the quality of technological innovation strategies of High-Tech Enterprises through theoretical analysis and empirical research. It explores ways to improve strategy quality from the Board capital perspective. This study is of great significance for High-Tech Enterprises to formulate high-quality strategies.

(3) It is Realistic to Boost the Acquisition of Technological Innovation Resources for High-Tech Enterprises.

The Board of Directors, as the valve for the organization to contact the outside world, plays a crucial role in obtaining external resources. Board capital is the foundation for the Board to fulfill its resources provision function. Based on the theory of Board capital and resource dependence, this paper explores the influence of Board capital on resource acquisition through theoretical analysis and empirical research. It is expected to find effective methods to supplement resource acquisition from the perspective of Board capital. This study is of great significance for the technological innovation resources for High-Tech Enterprises (Meyer & Rowan, 2018).

(4) It is Extremely Valuable to Assist in the Development and Operation of Board Capital for High-Tech Enterprises.

Most enterprises have realized the importance of Board capital in the Board construction process. However, accumulating Board capital and utilizing it effectively remains challenging for High-Tech Enterprises. Through the analysis of the composition dimensions of Board capital and the intrinsic value creation mechanism of each size, this paper clearly distinguishes the different roles and value creation

approaches of each measurement of Board capital, which helps High-Tech Enterprises understand the path of Board capital and has guiding value for the formation and operation of Board capital of High-Tech Enterprises (Gold et al., 2001).

1.5 Scope of the Study

This paper researches five aspects: Board capital, technological innovation resources, quality of technological innovation strategy, and technical innovation performance.

(1) The research on the impact of Board capital on the innovation performance of Shandong High-Tech Enterprises to explore the mechanism and pathway of Board capital investment on the innovation performance of enterprises. It aims to deepen the understanding of the relationship between Board capital investment and enterprise innovation performance, promote enterprise governance, improve enterprise innovation performance, and provide theoretical and practical guidance for the sustainable development of High-Tech Enterprises. Shandong High-Tech Enterprises are selected as research samples. Relevant data and indicators, including financial data, corporate governance structure, capital investment of Board members, the background of upper echelons, etc., are collected and analyzed to reveal the relationship between Board capital investment and enterprise innovation performance. The selection of research samples has considered enterprise size, industry type, innovation level, etc., to ensure the reliability and effectiveness of the research results.

(2) According to government statistics in 2021, there are 23,345 high-tech enterprises in Shandong Province. Research data collection includes educational background, work experience, professional field, social relations, etc., of Board members. Through data analysis, the research can gain a more comprehensive understanding of the impact of Board capital on the technological innovation performance of High-Tech Enterprises.

1.6 Research Methods

During the research, quantitative methods are used to determine the variables. The quantitative research method is to collect, analyze, and make statistics on the sample data to obtain the quantitative relationship between the data and to explain and predict the phenomena.

Structural Equation Modeling (SEM) is a common statistical analysis method that can be used to explore the causal relationship and influence mechanism among multiple variables. In the study of the influence of Board capital on the innovation performance of Shandong High-Tech Enterprises, SEM will be used to construct models, test hypotheses and analyze results. SEM is also used to explore the direct and indirect impact of Board capital on the innovation performance of enterprises. The SEM method is effective, and it can establish a complex relationship model among multiple variables and effectively reveal the influence mechanism and mode of action among variables.

1.7 Expected Results

The research is expected to explore the mechanism and path of the influence of Board capital on the innovation performance of enterprises and to put forward feasible suggestions for improvement. Specifically, the research is expected to achieve the following goals:

(1) Through a systematic literature review, to gain a deeper understanding of the research status and frontier of Board capital, high-tech enterprise innovation, and Board capital on enterprise innovation performance; to provide academic support for High-Tech Enterprises innovation performance improvement; to explore the role of Board capital on innovation performance of High-Tech Enterprises, and to provide suggestions and measures for innovation development of High-Tech Enterprises in the future.

(2) To get the influence mechanism and path of Board capital on the innovation performance of High-Tech Enterprises; to explore the role of Board capital in enterprise

innovation and to verify the research hypotheses. The results can also be applied to other High-Tech Enterprises.

(3) To promote enterprise innovation and development, to optimize Board structure and investment strategies, and to improve the competitiveness and long-term value of the enterprises. Achieving the above goals is expected to provide a scientific basis for the management and design of Shandong High-Tech Enterprises and support their sustainable development and competitiveness in the global market. The research on Board capital can serve as the foundation for future researchers.

1.8 Contributions of the Study

Through literature review and relevant theoretical analysis, it is found that more research on the Board capital of High-Tech Enterprises is needed. For High-Tech Enterprises, Board capital is essential for improving the development and performance of high-tech innovation. The main contributions of this study are:

Firstly, this study explores the impact of Board capital on corporate innovation performance from the perspective of principal-agent theory and resources-dependence theory, providing new concepts for theoretical research in related fields. This paper emphasizes the importance of Board capital and the critical role of the Board's collective wisdom and synergy effect on enterprise innovation performance. By introducing two intermediary variables, namely technological innovation resources and the quality of technological innovation strategy, the influence mechanism of Board capital on corporate innovation performance is revealed, and the research results in related fields are enriched. In the empirical analysis, SEM is used to systematically investigate the relationship between variables and verified by statistical methods, which provides a reference for the research in related fields and deepens the understanding and application of Board capital.

Secondly, the research uses the Structural Equation Model (SEM), which can simultaneously consider the relationship between multiple variables and conduct quantitative analysis and verification. SEM is used to verify the reasonable degree of the model, determine the relationship among Board capital, technology innovation

resources, technology innovation strategy quality, and technology innovation performance, and further infer the reliability and effectiveness of the research results. The methodological contribution of this study lies in providing a feasible approach for similar problems and implications for research methods.

Thirdly, the empirical analysis of high-tech enterprise samples in the Shandong region is carried out in this study, which verifies the relationship among Board capital, technological innovation resources, and technological innovation strategy quality, providing specific guidance for the actual operation and management of enterprises. It provides a feasible research method and framework for evaluating the impact of Board capital on technological innovation performance. As a standard analytical tool, SEM can be applied to other fields. This study puts forward suggestions to improve the effects of Board capital on enterprise innovation performance, such as optimizing Board structure and investment decisions, improving the quality of technological innovation resources and strategies, etc., which has specific application value and policy reference significance.

1.9 Definition of Key Terms

Term	Definition
Board Capital	Board capital refers to the resources of knowledge, skills, experience, contacts, and credibility possessed by Board members, as well as the ability to integrate and utilize these resources. The concept of Board capital is enriched along with its practical application, including the professional background, diversity, independence, etc., of Board members.
Human Capital of Board (HCB)	The human capital of the Board of Directors refers to the comprehensive abilities of Board members in terms of personal skills, knowledge, experience, and network resources that can create value for the enterprise.
Social Capital of Board (SCB)	The social capital of the Board of Directors refers to the social resources and relationships of Board members, including personal social status, reputation, interpersonal relations, social skills, industry experience, etc. The social capital of the Board has a positive impact on enterprises in improving the social image and reputation, expanding the market influence, and promoting strategies.

Term	Definition
Institutional Capital of Board (ICB)	Institutional capital of the Board of Directors refers to the resources and capabilities of institutions of Board members, including internal and external institutional capital of the company. Internal institutional capital mainly includes the departments branches, and subsidiaries represented by the senior management and Board members. In contrast, external institutional capital consists of the industry associations, professional organizations, and government agencies where the company is located.
Technological Innovation Resources (TIR)	Technological innovation resources refer to all kinds of resources required in technological innovation activities, including human resources, financial resources, information resources, material resources, etc.
Quality of Technological Innovation Strategy (QTIS)	The quality of technological innovation strategy refers to the strategy quality of enterprise technological innovation, and it usually depends on whether the system is scientific, forward-looking, rational, or feasible.
Technological Innovation Performance (TIP)	Technological innovation performance refers to the increase in commercial profits and market share obtained by enterprises through technological innovation and the impact of technological achievements on enterprise performance.
Principal-Agent Theory	Berle and Means first proposed the principal-agent theory in The Modern Corporation and Private Property in 1933 (Kline et al., 1933). According to this theory, a company's separation of ownership and control leads to agency issues between owners (i.e., shareholders) and operators (i.e., management).
Resources Dependence Theory	Resources dependence theory is an essential branch of organization theory. It holds that organizations are composed of resources, and the acquisition, utilization, and management of resources are crucial to the survival and development of organizations.
Upper Echelons Theory	Upper echelons theory states that the capabilities of team members are different. If all members are treated as equals, low-ability members will drag down and reduce the team's overall performance.
High-tech Enterprises	High-Tech Enterprises refer to enterprises in the national economy that focus on modern high technology, rely on scientific and technological innovation and knowledge capital, and continuously introduce research, develop, transform, and apply advanced scientific and technical achievements. The definition of High-Tech Enterprises may vary slightly in different countries and regions. High-tech enterprises in China include new-generation information technology manufacturing enterprises, new energy and materials enterprises, High-end equipment enterprises, and Artificial Intelligence enterprises.

1.10 Dissertation Structure

This research is divided into five chapters.

Chapter One: Research Introduction. It includes research background, significance, objectives, scope, an explanation of methods, survey scope, and expected effects. It defines the research's core concepts and critical terms and proposes a research framework.

Chapter Two: Literature Review. It reviews the literature on Board capital, technological innovation resources, strategy quality, and innovation performance, including related research, content, dimension, etc. Meanwhile, it sorts out the relationship between each variable based on principal-agent theory, resources dependence theory, and upper echelons theory.

Chapter Three: Research Methods. It clarifies the relationship among variables such as Board capital, technological innovation resources, strategy quality, and innovation performance. It proposes hypotheses, constructs conceptual models, determines research methods, and tests measurement tools' reliability and validity to improve them.

Chapter Four: Research Conclusion. Firstly, the questionnaire design and preliminary survey are based on the classical scale, and the questionnaire is verified and revised. Secondly, a questionnaire survey is conducted to collect data. Thirdly, data is analyzed. With SEM, validation analysis is made on the hypotheses among variables, and the correlation between variables is determined to conclude.

Chapter Five: Discussion. Based on the analysis, theory, and practice are combined to put forward countermeasures and suggestions for the problems, providing a reference basis for high-tech enterprises in Shandong Province to use corporate Board capital reasonably.

CHAPTER 2
LITERATURE REVIEWS

This Chapter Includes 8 Parts, Which are as Follows:

2.1 Fundamental Theories

2.2 Board Capital

2.3 Technology Innovation Resources

2.4 Quality of Technological Innovation Strategy

2.5 Technological Innovation Performance

2.6 Related Literature

2.7 Conceptual Framework

2.8 Conclusion

2.1 Fundamental Theories

Research on Board capital and firm TIP has been proposed as early as the late 20th century. In the research, education, experience, skills, and knowledge of Board members can be components of Board capital that positively affect corporate performance. Board members with a technical background or who have worked in high-tech companies have an essential role in promoting corporate technological innovation. Firms with higher Board capital have higher performance in terms of technological innovation. On the other hand, with the development of the economy and the emergence of new technologies, the research on Board capital and firm TIP has been intensified. For example, Westphal & Zajac (1995) define Board capital as the education, experience, skills, and knowledge of Board members (Westphal & Zajac, 1995), propose the concept of a "strategic board," in which the professional background and experience of Board members can be used to determine the performance of the Board. Damanpour (1991), one of the first scholars to study TIP, proposed the "TIP evaluation model" and defined TIP as the contribution of technological innovation to firm performance (Damanpour, 1991). The relationship between Board capital and solid TIP is a complex research area requiring consideration of multiple factors. However, many studies have shown that there is an effect of Board capital and firm TIP. Therefore, the

main content of this research literature review is the effect of Board capital on the Human capital of the board (Demsetz & Lehn, 2020), Board social capital, and ICB on firm TIR and the quality of healthy technological innovation strategy decisions.

These Foundational Theories are as Follows:

2.1.1 Principal-Agent Theory

2.1.2 Resources Dependence Theory

2.1.3 Higher Order Echelon Theory

2.1.1 Principal-agent theory

The principal-agent theory is a fundamental theory of corporate governance (Audretsch et al., 2009). It is currently the mainstream theory used in Board governance, dating back to the late 1960s to early 1970s. Early scholars focused on asymmetric game theory and proposed that asymmetric information is the basis for creating principal-agent problems. The information asymmetry leads to costs and issues such as adverse selection and moral hazard.

The principal-agent theory refers to an agency relationship between the owner and the management of a company under the modern corporate system. The owners entrust the control to manage the company's affairs. Due to the agency relationship, the management can, to a certain extent, pursue personal interests at the expense of the company's claims, which creates an agency problem. The core of the principal-agent theory is to study how to solve the agency problem and maximize the company's interests through effective mechanism design and regulatory measures. The specific connotation of the principal-agent theory refers to the following: one or more actors (i.e., authorizers and employers) hire some other actors (i.e., authorized and employed) to perform services, give the approved or certain power, require them to meet specific targets and pay them corresponding rewards according to their performance (Demsetz & Lehn, 2020). Agency relationships are formed in the context of information asymmetry and conflicting interests, where the interests of management and company owners may conflict, and administration may pursue personal interests in managing the company on behalf of the owners. The resolution of agency problems requires the design of a series of mechanisms, including incentive mechanisms, regulatory

mechanisms, and information disclosure mechanisms, to ensure that management acts in the interests of the company. Delegated agency theory occupies an important position in management and organization theory, which can help companies solve agency problems and guide the design of corporate governance structure, management performance evaluation, and incentive system design (Demsetz & Lehn, 2020),

The main mechanisms of the principal-agent theory include the incentive, regulatory, and information disclosure mechanisms. An incentive mechanism refers to the design of contracts or incentive programs to align the interests of agents with those of principals to maximize the interests of principals. Incentive mechanisms usually include stock options, salary incentives, bonus incentives, etc. These mechanisms can motivate agents to work hard and thus improve corporate performance. Supervisory agencies monitor agents' behavior to ensure their actions align with the principal's interests. Supervisory mechanisms can be achieved through internal and external supervision. Internal regulation includes the principal's internal control and audit system, etc. External law includes government regulation and stock exchange regulation, etc. The information disclosure mechanism refers to disclosing information about the company's operation and financial status to enhance the principal's right to know in the agency relationship (Kolk, 2007). The information disclosure mechanism can be realized through annual reports, financial reports, announcements, etc. Disclosing such information can improve market transparency and investor protection, which is conducive to reducing agency costs and improving the quality of corporate governance.

The American economists Berle and Means (1932) argue that companies face two practical situations in operation and management, One is that there is an actual demand for professional managers in business operations. When the overall scale of the enterprise reaches a certain level, the governance structure, business structure, and production structure tend to be more and more complex (Berle & Means, 1932). The difficulty of operation and management increases, and there is a higher demand for enterprise managers' knowledge, professional skills, and management skills. Hence, the need for experienced managers arises. The other situation is that it is difficult for business owners to be competent in investment attraction and operation management

simultaneously. With the development of the enterprise, an essential task of the original investors of the enterprise is to attract investment, which inevitably distracts the time and energy of the enterprise owners and makes it difficult to improve the efficiency of the enterprise operation. Therefore, a new management concept is proposed, which suggests that the ownership and operation of the enterprise should be separated. The owner should hire a professional manager from outside to take charge of the daily operation and management of the enterprise, thus creating a principal-agent relationship (Hellmann & Puri, 2002).

The principal-agent problem in modern enterprises is mainly manifested in the employment relationship between shareholders and top managers. Shareholders, as owners of the firm, allocate the right to run the firm to the senior management team through explicit and implicit contracts, and the senior management team receives compensation based on business performance. For most listed companies, the principal-agent problem occurs in two contexts. One is that shareholders hire Board members as senior corporate managers; the other is that the Board hires the executive team as decision executors. This separation of ownership and control is highly likely to cause stakeholders to have different demands, pursue other goals, and plan the development of the enterprise differently (Boukouras, 2011). The enterprise owner tends to maximize capital interests and achieve the enterprise's sustainable development.

In contrast, the controller tends to care more about his interests and effectively guarantees the maximization of personal or team interests. So the owner must take specific measures against the controller to avoid such risks (Shane & Venkataraman, 2000). When ownership and control are separated, the Board of Directors must perform its supervisory function to prevent executives from surrendering the company's interests and pursuing their interests. Within the framework of principal-agent theory, the Board of Directors, as the pivot of corporate governance, is responsible for the interests of all shareholders. In addition, the Board of Directors is obliged to circumvent opportunistic decisions by management through the formulation and implementation of decisions and to guarantee more standardized managerial behavior by performing its supervisory function.

The Board of Directors entrusts the manager to operate and manage the enterprise. The Board of Directors is the principal, and the manager is the trustee. There is an inevitable divergence of interests and information asymmetry between the two. Based on the view of a rational economic man, the goal of managers is to maximize their interests, and the purpose of shareholders is to maximize the interests of shareholders, and there are divergent interests between them (Merton, 2017). The inconsistency of the two goals diverges the goals, and the information asymmetry provides opportunities for managers to seek personal benefits. Therefore, managers may act opportunistically to maximize their interests and thus harm shareholders' interests. The depth and breadth of Board capital affect the depth, scope, and effectiveness of its access to information. This further involves the degree of information asymmetry between the Board of Directors and the managerial layer, enhancing the effectiveness of Board supervision. Executive compensation incentives and executive equity incentives can reduce the divergence of interests between the two, improve the degree of alignment of their goals, reduce the probability of opportunistic behavior at the managerial level, and thus enhance the effectiveness of Board supervision.

2.1.2 Resources Dependence Theory

Resources dependence theory (Pfeffer & Salancik, 2011), one of the most influential organizational and phenomena-driven theories, was formally introduced by Pfeffer & Salancik. Resources dependency theory originated from the Tennessee Valley Authority (TVA) and the grassroots, which proposed a "shared choice" process for designing the balance of power among organizations. Pimden Hertog et al. (2010) identified three types of inter-organizational partnerships: alliance, deliberation, and shared choice (Pimden Hertog et al., 2010), and proposed a comprehensive model of organizational power dependence. The ultimate inspiration for the resources dependency theory came from the affirmative action movement in the United States in the late 1960s and early 1970s. The U.S. Congress enacted laws requiring businesses to give women and minorities preferential treatment in education and work to protect them from discrimination in hiring and employment (Bhyrovabhotla, 2012). However, organizations reacted differently to this political pressure. To address this phenomenon,

which was established but could not rationally be explained, (Pfeffer & Salancik, 2011) Pfeffer and Salancik attempted to develop a new approach to explain it, and resources dependency theory emerged.

The theory suggests that organizations or firms exist because they need resources to survive and grow, and these resources may not be available internally through themselves and therefore need to be obtained through interaction with the external environment. These resources include material resources (e.g., capital, raw materials, etc.), human resources (e.g., employees, managers, etc.), and information resources (e.g., technology, market information, etc.). Therefore, resources dependence theory suggests that the success of organizations or firms depends on how they manage and utilize these resources and establish good relationships with the external environment to obtain the necessary resources (de Jong & den Hartog, 2010).

Resources dependency theory assumes that organizations have a dependent role in the external environment and have open qualities. On the one hand, the organization is influenced by external environmental factors. On the other hand, the external environment can constrain the organization's behavior through its association with the organization. In this framework, organizations need to reduce their dependence on the background to reduce the harm caused by environmental uncertainty. Companies can deal with external environmental resource constraints through adaptation or circumvention. Organizational compliance is one form of adaptation strategy. However, corporate compliance can also lead to a loss of administrative autonomy. An avoidance strategy is an attempt by an organization to reduce its dependence on external forces and to increase its control over external organizations (Hodgkinson & Wright, 2002).

One of the characteristics of resources dependence theory is that analyzing how organizations change their environment through mergers, coalitions, lobbying, or governance shows that organizations are no longer actors that adapt to their environment but that they have to make the environment adapt to them. The core assumption is that organizations need to acquire resources from the environment to survive. No organization is self-sufficient in resources but must exchange them with the environment. The basic ideas of resources dependence theory are: (1) many resources are not self-sufficient, and organizations must depend on some resources to survive; (2)

the resources that organizations depend on originate from the environment in which they live; (3) this environment contains other organizations to a large extent; (4) the resources that an organization needs may be in the hands of other organizations; (5) independent organizations in the environment are interdependent; (6) resources are the basis of power; (7) power is directly related to resources dependence - the power of organization A over organization B is equal to the degree of dependence of organization B on the resources held by organization A; and (8) power is an interactive, situational and potential interaction.

The theoretical mechanisms of resource dependence theory can be explained in two ways: external dependence and internal coordination. From the external dependence mechanism perspective, resources dependence theory believes that organizations must rely on external resources to survive and grow. In the face of changes and uncertainties in the external environment, organizations need to adapt to the external environment and acquire necessary resources through interaction with the external environment. Organizations will achieve external resources by establishing strategic alliances, developing multi-level supplier relationships, etc. In addition, organizations need to monitor and analyze the external environment and adjust their strategies to adapt to external environment changes promptly. In terms of the internal coordination mechanism, the organization needs to carry out internal coordination to utilize resources effectively after acquiring external resources. Internal coordination includes the integration, coordination, allocation and optimal utilization of resources. Organizations must establish effective internal communication channels and collaboration mechanisms to ensure that resources can be allocated and utilized correctly (Alavi & Leidner, 2001). In addition, organizations need to develop sound resource management systems and evaluation mechanisms and establish incentive mechanisms to encourage employees to fully use their resources advantages and create more excellent value for the organization. The organization must acquire the necessary resources by interacting with the external environment and establish effective coordination mechanisms internally to achieve the effective use of resources and the organization's long-term success.

The theory suggests that in a corporate governance structure, Board of Directors is designed to provide the firm with resources to identify and manage environmental uncertainties. Therefore, firms can select outside directors from relevant institutions with a high degree of dependence. For example, when a firm lacks capital, it can choose to have executives from financial institutions as outside directors and use the resources brought by them to help the firm grow better. Focusing on the enterprise level, established studies show that the Board of Directors is an essential supplier of resources to the enterprise (Teece, 2012). It can provide expertise, industry experience and management advice to help the enterprise obtain important related resources and communication paths from external stakeholders and to help the enterprise develop a reasonable strategy and get corresponding performance. In addition, Board members can be further divided into external and internal directors. Companies often hope to hire external directors to obtain external resources to increase the accuracy of corporate industry judgment and enhance the effectiveness of corporate strategies, such as corporate innovation strategies.

2.1.3 Higher Order Echelon Theory

Upper echelon theory was first developed by Donald Hambrick and Phylis Mason. In 1984, they published their article "Upper Echelons: The Organization as a Reflection of Its Top Managers" in the Academy of Management Review, laying the foundation for the top echelon theory. The core idea of the upper echelon theory is that the characteristics of its senior managers influence a company's decisions and performance.

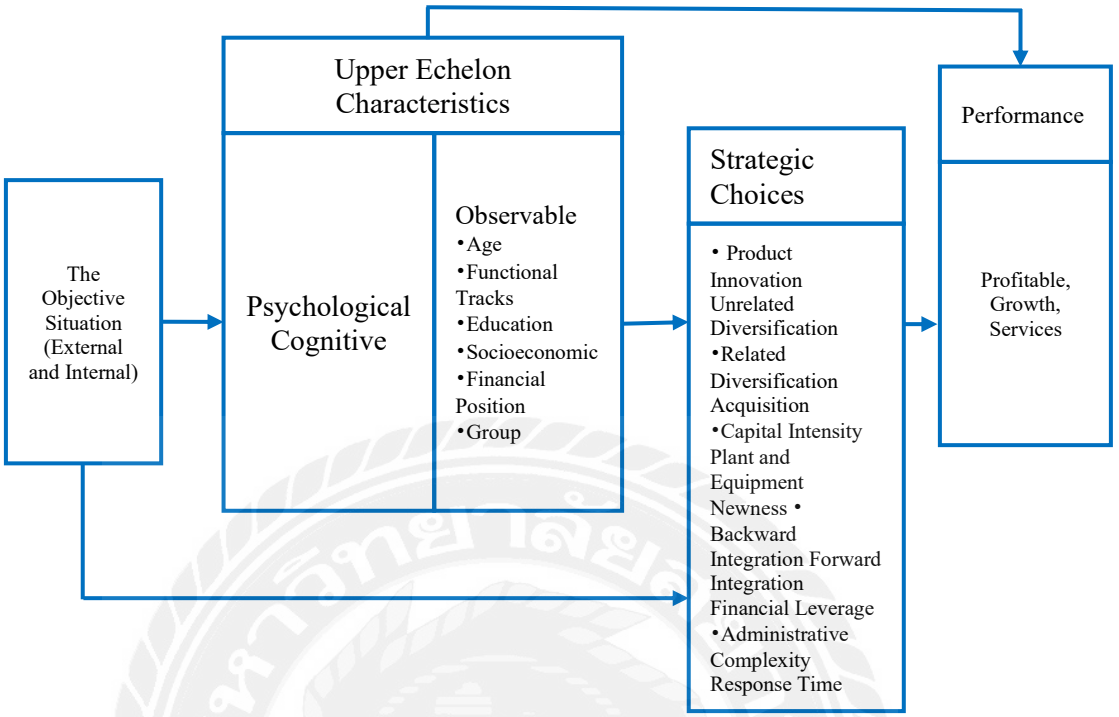

Figure 2.1 An Upper Echelons Perspective of Organizations (Hambrick and Mason,1984)

Hambrick and Mason (1984) argue that in the face of a complex external environment, the decision-makers are limited because of their limited rationality and the multi-objective and multi-constrained decision environment. The decision-makers are unable to find the optimal decision through traditional optimization methods. The final decision depends more on behavioral factors, including cognitive bias, prior experience and the values of the decision-makers (Hambrick & Mason, 1984). Based on the in-depth consideration of the corporate decision-making process in complex environments, Hambrick (2007) supplemented and improved the boundary conditions of top-echelon theory and proposed two key situational factors affecting the relationship between management characteristics and corporate decision-making: management's discretion and job demand. When a company's management faces a decision environment with high choice or job demands, its decision-making process will fall into a "weak context" with ambiguous situational characteristics (Hambrick, 2007). In this "weak context," it is difficult for external factors to regulate the decision-making process of the company's management, and the basis of management's decision-making at this time is more oriented to its behavioral factors rather than the actual external

environmental characteristics. Therefore, empirical evidence of the influence of management's behavioral factors on corporate decision-making is more likely to be found in high discretionary and job requirement contexts.

After introducing the top-echelon theoretical framework, many studies began to validate the impact of top management and its team characteristics on the organization. In recent years, more attention has been paid to the effects of top management and team characteristics on organizational outcomes. Examples include age, managerial tenure, education level and several complex psychological variables. These principal management characteristics can affect corporate strategy, performance and innovation.

(1) Organizational Strategy

The more experienced the CEO, the more likely they are to use tacit knowledge in strategic decision-making; the younger and more experienced the top management, the more likely the organization is to adopt an internationalization strategy; the tenure of top management and the firm's adoption of an internationalization strategy has an inverted U-shaped relationship (Tanikawa & Jung, 2018), with the likelihood of the firm adopting an internationalization strategy increasing with the tenure of top management and decreasing beyond a given assignment. The possibility of internationalization increases with the selection of top management and falls beyond a given position. The younger the average age of the whole management team, the shorter the average tenure. The higher the age diversity, tenure diversity, intermediate education level and educational background diversity, the higher the likelihood of strategic change. The higher the percentage of top management team members with foreign experience, the more likely the company is to adopt an international diversification strategy (Kiessling & Harvey, 2006).

(2) Organizational Performance

The younger the age, the longer the tenure, the higher the level of education, and the more functional experience of senior managers, the higher the performance of the organization in which they work. The Big Five personalities of top executives (openness, commitment, extroversion, agreeableness and emotional stability) contribute to organizational performance. The CEO's leadership charisma also predicts organizational performance (Waldman et al., 2006). Both the cohesiveness and social

integration of the top management team contribute to organizational performance (Hogg & Terry, 2000).

(3) Organizational Innovation

The higher the level of education and the longer the tenure of top management, the higher the level of organizational innovation. Top management's openness to change also promotes corporate innovation. The larger the size of the entire management team, the higher the team diversity (e.g., functional background diversity), The higher the average education level and the lower the team's average age, the higher the degree of organizational innovation. To explain the role of top management and top management teams, scholars have tested some possible important mediating mechanisms based on relevant theories. Firms with women as CEOs are more market-oriented and consequently have better financial performance. Strategic flexibility mediates the relationship between top management's Big Five personality and organizational performance: top management's emotional stability, agreeableness, extroversion and openness improve organizational performance by increasing the flexibility of organizational strategy, while top management's diligence reduces organizational performance by decreasing the flexibility of corporate design (Dimov & Shepherd, 2005).

The Board of Directors is part of the top management. The higher echelon theory equally applies to board-level research. Board members' demographic characteristics, knowledge levels and cognitive frameworks can also affect corporate performance. Different Board member traits can influence their analysis and judgment of strategy and interfere with their choice of corporate development goals, resulting in different strategic decision directions at the executive level (Papke-Shields & Malhotra, 2000). It is worth noting that the higher echelon theory also emphasizes the interaction of situational factors. For example, contextual factors such as industry and region can interfere with the performance of individual traits at the executive level. The Board capital studied in this research is an essential element of management team traits. Innovation decisions are part of corporate strategy. High-quality development is a necessary manifestation of corporate performance and contextual factors such as the degree of industry competition influence Board's role.

2.2 Board Capital

2.2. 1 Board Capital Concept

The functions of the Board of Directors are rich. From the perspective of resource dependence, the Board of Directors provides corporate resources. It can advise and consult on developing and implementing corporate strategies and create a channel between the company and external resources (Bear et al., 2010). Nahapiet and Ghoshal (1998) point out that the knowledge, work experience, and expertise of Board members can contribute to the firm's performance (Nahapiet & Ghoshal, 1998), and the related resources established by Board members can also effectively contribute to the firm's development (Bapuji & Crossan, 2005).

Hillman and Dalziel (2003) suggest that the role of the Board of Directors as a defender of the interests of the firm's shareholders provides the firm with critical resources. Following their definition, subsequent research further suggests that Board social capital consists of internal and external social capitals, which are fundamentally different and thus provide additional forms of social capital to the firm (Hillman & Dalziel, 2003). Internal Board social capital refers to the social capital that Board members bring to the company through their connections with each other and with internal members of the company. In contrast, the social network resources that Board members bring to the company through their relationships with social people outside the company are referred to as external Board social capital. These two types of Board social capital have different characteristics and bring additional social resources to the company.

The relationship between them is a mutual constraint, i.e., when the Board has more internal social capital, it is less likely to have more external social capital, and vice versa. The concept of Board capital has many theoretical and practical implications (Bart & Turel, 2010). First, it scientifically defines the role of the Board of Directors as a resources provider and establishes the evaluation indexes of the Board; second, it changes the previous study of the internal characteristics of the Board of Directors to the external resources provided by the human and SCB; third, the concept of Board capital guides the company to change the appearance of the Board's characteristics and

structure, and to hire outside directors as resources providers according to its need for external resources. The mechanism by which increased levels of Board capital can help improve corporate investment efficiency lies in the monitoring and resources effects.

Moreover, the Human capital of the board and the Board's social capital are interdependent relationships and cannot exist in isolation (Bapuji & Crossan, 2005). A model is reconstructed to measure Board capital attributes and divide them into two dimensions, breadth and depth, as shown in Figure 2.2. Heterogeneity refers to the directors' age, tenure, education level, and work background. The chain of directors constitutes the breadth of Board capital. The depth of Board capital refers to the depth of directors' work experience in the present and primary sectors in which they work, and the depth of chain directorship and background embedded in the company's current industry. On this basis, scholars have conducted more in-depth studies, and the results show that Board heterogeneity positively contributes to large shareholders' shelling behavior; however, the width and depth of Board capital can enhance corporate risk-taking ability.

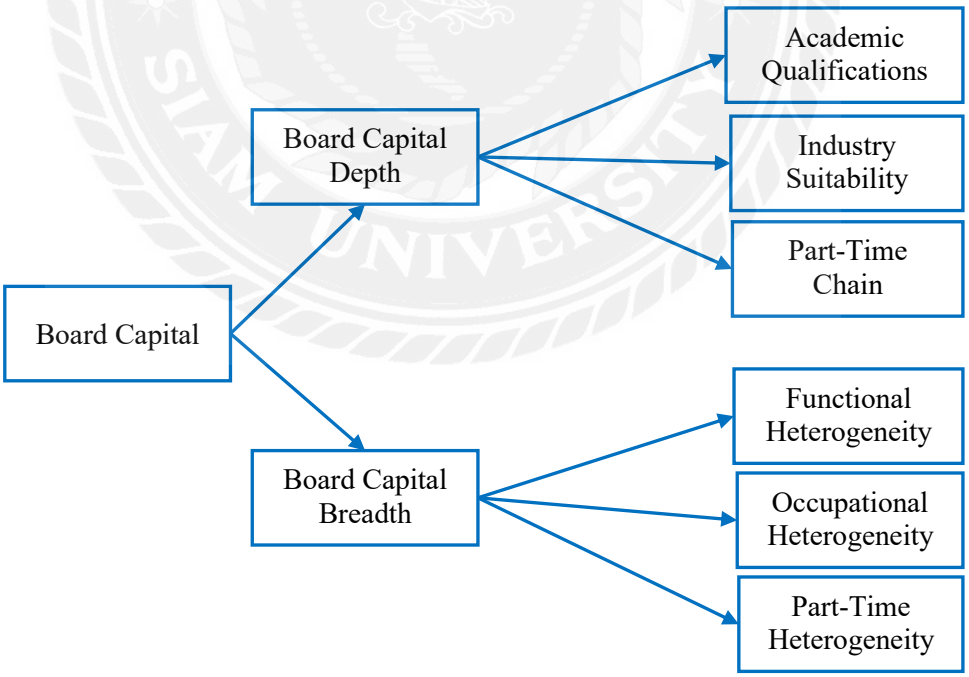

Figure 2.2 Board Capital Model (Hillman et al., 2019)

The impact of Board capital on firm performance and value is mainly through four main mediating variables: strategic change, competitive behavior, innovation, and Board effectiveness. Board capital provides essential resources of knowledge, skills, advice, and recommendations for strategic change and strategic decision-making in the firm. Boards do not directly influence organizational performance and strategic outcomes. By sharing their experience and knowledge, Boards provide sound management judgment and advice on significant issues to monitor and improve major corporate decisions. To some extent, the Board acts as a "gatekeeper" to the company's major strategic decisions, with guardianship responsibilities related to strategic change and essential resource allocation decisions. The Board of Directors influences strategic decisions through human and social capital, linking directors' education, competence, and professional experience to the company's strategic decisions (Hillman et al., 2019). For example, the strategic background of a Board member's social network determines his contribution and ability to make strategic decisions for the company. Companies that hire directors from industries of the same environment and background as the company's operations facilitate the ability of directors to consult and advise. The different backgrounds of Board members can create different biases and trends in the company's strategic decision-making.

Based on the resources dependence theory, the Board is an essential provider of corporate resources and significantly affects corporate development. Board capital can be classified into human and social capital based on the type of resources. Board capital width and depth are critical dimensions to measure capital characteristics, distinguish Board capital differences among firms, and better explain the impact of heterogeneity of Board capital allocation on firms. In addition, Board capital does not directly contribute to firm performance but plays a role in healthy development through mediating variables such as strategic decisions (Hillman & Keim, 2001).

2.2.2 Connotation of Board Capital

From the late 1960s to the early 1980s, scholars studied the theory of Board governance based on practice. In the late 1980s, the theory of Board governance was formed. Since then, scholars have conducted many empirical studies on it based on the advanced Board governance theory. As the concept of corporate governance has been

deepened and improved, its meaning has been gradually enriched and expanded (Nahapiet & Ghoshal, 1998). In the early stage of Board capital, the main focus was on Board members' financial and economic backgrounds, i.e., the economic capital. This kind of capital focuses on Board members' investment and financial experience and their reputation and connections in the market (Davidsson & Honig, 2003). As it evolved, the concept of Board capital gradually expanded to social capital, i.e., the social relationships and networks of Board members. Social capital can help Board members access more business opportunities and information, enabling them to better serve the company's and its shareholders' interests. With the rise of the knowledge-based economy, intellectual capital has also become an essential component of Board capital. Intellectual capital focuses on Board members' expertise, skills, and experience, which can help Board members better understand the company's strategy and business and provide better advice and guidance. The modern management philosophy has changed, and human capital is becoming an essential element of Board capital. Human capital focuses on the talent and organizational capabilities of Board members, and this capital can help Board members better lead and manage the company's employees to achieve long-term company success.

Board capital refers to the various resources and capabilities they possess, including but not limited to economic, social, intellectual, and human capital (Brush et al., 2001). These capitals are essential for Board members to manage the company and are essential indicators of the Board's ability and value.

Economic capital refers to the wealth, investment, and equity Board members own. Through this capital, Board members can provide support for financing, investment, and mergers and acquisitions to enhance the strength and competitiveness of the company. Social capital refers to the social relationships and networks that Board members possess (Meyer & Rowan, 2018). These relationships can support the company to access government and industry resources, expand partners, and enhance brand images. Intellectual capital refers to Board members' expertise, skills, and experience. The knowledge and skills can guide and support the company in strategic planning, risk management, and business operations. Human capital refers to the talent and organizational capabilities of Board members. These competencies can support the

company in the areas of leadership, team building, and talent development. The various capitals of Board members not only influence the Board's decision-making and execution capabilities but also significantly affect the company's strategic planning and business development. Therefore, the Board of Directors must continuously improve capital accumulation to serve the company's and its shareholders' interests (DiMaggio & Powell, 2000).

Before exploring the meaning of Board capital, it should be clarified that it is a particular form owned by the Board of Directors, but its capital properties have stayed the same. The concept of "capital" should have three intrinsic properties: First, capital comes from a prepaid investment. Board capital is an intellectual asset created by the intellectual activity of Board members through acquiring knowledge and establishing valuable network relationships (Ghoshal, 2005). It is the result of a prepaid investment. Based on the capital owned, the Board of Directors can help the company reduce its dependence on the environment, establish and maintain a competitive advantage, and create value through strategic decision-making, resource provision, and effective performance of supervisory and control functions—third, clear ownership of capital. Board capital is dependent on the individual capital of Board members. Through the practical collision of different elements, the Board's productivity as a whole is formed after integration, and the ownership of Board capital is vested in the Board.

Based on the above analysis, this study defines Board capital as intellectual capital owned or controlled by the Board of Directors. It can enhance the effectiveness of the Board's functions (Grant, 2019). It is formed by the intellectual activities of Board members such as knowledge acquisition, innovation, and valuable relationships.

Essence and phenomenon are categories that reveal the interrelationship between the external and internal connections of objective things. Board capital is manifested externally in the various knowledge and skills of Board members and the mechanisms, management models, and relationships with external parties in the operation of the entire team (Austin et al., 2006). The essence of the Board capital is the fundamental nature of the Board capital and the inner connection between the essential elements that make up the Board capital.

Board capital is a particular form of capital owned by the Board of Directors, which has the essential characteristics of intangibility, integration, durability, and path dependence that are necessary for the organization's intellectual capital. Firstly, Board capital consists of intangible assets of knowledge, ability, experience of Board members, the organizational system of the Board, and social network relations; secondly, Board capital is not a simple sum or average of all individual-level capital, but the interaction effects between different individual capital and organizational task allocation, and between different individual capitals and organizational culture. Thirdly, Board capital can be used infinitely. Through continuous intermingling and sharing, it can be amplified and deepened to create new capital, making Board capital more prosperous and increasing the value of the enterprise, which has the characteristic of durability. Finally, forming Board capital requires unique organizational conditions (Dane & Pratt, 2007), making Board capital highly path-dependent. Based on the above analysis, it is clear that Board capital has the property of organizational intellectual capital.

Board capital has the attribute of intellectual capital, but whether this attribute is the essential attribute of Board capital needs to be further judged (Henderson & Fredrickson, 2001). In determining whether an attribute is an essential attribute of a particular class of things, two aspects must be considered: first, whether the attribute is a common attribute of all things of that class; second, whether the attribute is a stable attribute of the class of things at all times and under all circumstances. If both conditions are met, the attribute becomes an essential one.

First, it can be affirmed that the organizational intellectual capital of Board capital is a common attribute of the capital owned by the Board of Directors in any model. The models currently used by the Board are the single-tier and two-tier models. In the single-tier model, only the shareholders' meeting and the Board of Directors are included in the governance structure, and there is no supervisory Board. The main difference between the two-tier and single-tier models is a supervisory Board, which manages and supervises the Board of Directors. Both Board models create a complete chain of principal-agent relationships from the owner to the manager. The development of the Board of Directors can be divided into three stages according to the changes in

organizational characteristics during the development of the Board of Directors: the stage of insider control, the stage of predominantly independent directors, and the stage of committee system of the Board of Directors. Board capital reflects the attributes of intellectual capital in the Board development process, whether in the insider control stage, the independent director-dominated stage, or the committee system of the Board stage.

2.2.3 Board Capital Classification

The personal knowledge, business experience, and social network of Board members can drive a company's financial performance (Eisenhardt & Graebner, 2007). Board capital is condensed in a combination of personal knowledge, work experience, and social connections. Board human and social capital are distinguished in the classification and measurement of Board capital.

(1) Board Capital, Human Capital, and Social Capital

According to the study of human and social capital, the Human capital of a board is defined as a Board member's knowledge, work experience, and other resources. In contrast, social capital refers to Board members' resources due to social networks, etc. Both the human capital and the social capital are resources of Board members that affect the company's strategic decisions. Human capital refers to the knowledge, skills, and experience of Board members and their positions, reputation, and networks within the company (Cornforth, 2001). This capital can be increased through training, education, and experience and usually requires time and effort. Social capital, on the other hand, refers to the relationships and connections Board members have with external organizations and individuals. These connections may include business partnerships, social networks, government relationships, industry associations, etc. This capital is often built on trust, reciprocity, and interaction and can help Board members gain a broader perspective and information to perform their roles better. An effective Board usually requires both human capital and social capital. Human capital can provide expertise and management skills, while social capital can provide broader resources and support for the company. Combining these two types of capital can make Board members more influential and thus carry out their responsibilities and bring success to the company.

(2) Board Capital Width and Depth

In practice, Board members' human and social capitals are complementary and challenging. Taking the study as an example, Board members who have worked in the financial industry can use their financial expertise to benefit the company and facilitate the company through their social connections within and outside the financial industry (Berezinets et al., 2016). Based on Board capital concept, Board capital is further divided into Board capital breadth and Board capital depth. The Board members' heterogeneity measures Board capital breadth in terms of their professional experience, functional background, and external industry ties. In contrast, Board capital depth is measured from the perspective of Board members' embeddedness in the industry. The division of Board capital into Board capital width and depth fully considers the interdependence of Board members' human and social capital and measures Board capital from a new perspective.

Board capital breadth refers to members' diverse backgrounds and experiences, such as industry, discipline, and cultural and geographic backgrounds (Crossan & Apaydin, 2010). When Board members come from different fields and cultural backgrounds, their perspectives and knowledge can bring a broader range of ideas and solutions to the company. Board capital depth, on the other hand, refers to how well Board members know the company and the industry. This includes their knowledge of the company's strategic, financial, operational, and risk management, as well as their understanding of the industry in which the company operates. Board members' depth of capital can help them better assess the company's performance and future direction and provide constructive advice and recommendations.

(3) Board Capital Integration

Some scholars have also measured Board capital as a whole, using the ranking method to rank the three indicators of educational background, work experience, and social connections, which are used to measure Board capital and explore its impact on corporate R&D investment (Lee & Choi, 2003). A weighted average of Board members' capital can be used to calculate the overall level of Board capital. In this approach, the capital of Board members can be weighted according to their contributions to reflect their importance in corporate decision-making and performance.

Board capital includes the capital of Board members in terms of expertise, skills, experience, contacts, and relationships. Board members' capital can be assessed through surveys, interviews (Zhao et al., 2015), and data analysis, including factors such as education, work experience, industry background, geographic background, gender, and age. Board members' capital can also be weighted differently based on their contributions to reflect their importance in the company's decision-making and performance. This can be achieved using different weighting methods, such as equal weighting, experience weighting, and professional weighting. In this way, the overall level of Board capital can be calculated. This can help us better understand the quality and level of Board capital and its impact on company performance.

Table 2.1 Classification and Measurement of Board Capital

Scholars	Board Capital Classification	Measurement
DiMaggio & Powell, 1983	**The Human Capital of the Board**	**A general term for all Board members' expertise, experience, knowledge, reputation, and skills.**
	Board Social Capital	Embedded in the network of relationships owned by the directors available in the present. **The sum of it and potential resources.**
Vandenbroucke et al., 2014	**The Human Capital of the Board**	Independent directors bring skills, knowledge, and perspectives to the Board.
	Board Social Capital	Distinguish between internal social capital and external social capital
Bertrand & Mullainathan, 2003	**The Human Capital of the Board**	Board expertise and education level
	Board Relationship Capital	Board members' connections to other organizations and the number of chain directorships
Choo Huang et al., 2007	**Board Capital Width**	Functional background heterogeneity, occupational background heterogeneity, part-time industry heterogeneity
	Board Capital Depth	Degree of industry occupational embeddedness, degree of industry chain embeddedness
Loughran &	**Board Capital Overall**	Four attributes possessed by Board

Scholars	Board Capital Classification	Measurement
Mcdonald, 2011		members, including skills, experience, product, supply market, specific knowledge, and reputation
Fama, 2021	**Board Capital Richness**	the capital occupational richness and Board capital part-time richness.
	Board Capital In-depth	It is fitted by the past career experience of Board members in the industry, the outside director's current job, and the outside director's part-time job.
Demsetz & Lehn, 2020	**Board Capital Overall**	Educational background, work experience, and social connections

2.2.4 Three-Dimensional Structure and Interaction Mechanism of Board Capital

(1) Three-Dimensional Structure of Board Capital

The essence of Board capital is organizational intellectual capital, The study of Board capital structure can be carried out concerning the theoretical framework of organizational intellectual capital structure. There are several perspectives on the dimensions of the components of organizational intellectual capital: the two-factor structure perspective of Kim & Cannella, (2008), the three-factor structure perspective of Manna et al. (2016), and the four-factor structure perspective of Chebbi & Ammer (2022), as shown in Table 2.2.

Table 2.2 Board Capital Composition Dimensions

Scholars	Dimension	Viewpoints
Kim & Cannella, (2008)	Two-Factor Structural View	Intellectual capital is divided into institutional capital and human capital by the ability to think actively and further divided into institutional capital, which enhances the efficiency of internal operations, and relational capital, which interacts with the outside world, by the distinction between internal and external.
Manna et al.(2016),	Three-Factor Structural View	Intellectual capital is divided into social, human, and institutional capital according to value creation paths. Human capital mainly includes the knowledge, ability, experience, and skills of members within the organization; social capital is mainly reflected in the internal and external

Scholars	Dimension	Viewpoints
		relationship network of the organization; institutional capital is a set of unique processes and procedures gradually formed during the operation of the organization, including the organizational structure, code of conduct information system, etc.
Chebbi & Ammer, (2022)	Four-Factor Structural View	Based on the knowledge scorecard framework, it is proposed that intellectual capital consists of four aspects: human capital, institutional capital, relational capital, and process capital. Among them, human capital includes the knowledge, skills, and experience of the organization's employees and managers; process capital includes workflow and expertise; institutional capital includes information technology and organizational thinking; and relational capital includes the actual and potential resources embedded in personal and organizational network relationships.

Although scholars have different views on the constituent dimensions of intellectual capital, most researchers believe that human capital is an essential constituent dimension of intellectual capital. The internal and external environment of the organization influences social capital (relational capital) (Filatotchev & Nakajima, 2010). It is highly volatile and fluid, unlike the stable characteristics of institutional capital, so it cannot be classified into the category of institutional capital. Process capital is the essential content of the organization's operation and internal management. It fundamentally occupies a central position in the organization's operation and has a supportive role to be classified as institutional capital. Therefore, this study agrees with the three-factor view of organizational intellectual capital: human capital, institutional capital, and social capital.

The existing research on Board capital generally assumes that there are only two dimensions of Board capital: Human capital of the board and Board social capital. From the three-dimensional view of intellectual capital, it is evident that identifying Board capital as two dimensions is comprehensible. Institutional capital is an organizational force endogenously generated by the Board of Directors (Fama, 2021), directly reflecting the Board's competitive ability to integrate various resources and bring systemic efficiency into play. This ability can be accumulated. As an organization, institutional capital is also an indispensable and significant factor for the Board of directors.

Therefore, this study proposes a three-dimensional structure of Board capital: Human capital of board (CHB), Board social capital (BSC), and Board institutional capital (BIC) (Feng et al., 2022).

The three dimensions of Board capital are an organic whole, and they are interdependent and interactive with each other, with synergistic functions and effectiveness. Human capital is the core of Board capital performance. The higher the stock of human capital, the higher the Board's working ability and efficiency, and thus the higher the value it embodies. The SCB is an important way for the Board of Directors to realize value creation. It is the environmental condition for Board capital performance. The Board's social relationships unite all stakeholders into an organically connected whole, creating strong ties. Relevant relationships provide the basis for network members to trust each other, convey influence and trust, effectively fill internal gaps between relationship partners, improve internal organizational cohesion and organizational effectiveness, and are the guarantee for the formation of actual Board performance. Institutional capital is the "infrastructure" or "knowledge platform" that supports the creation of wealth by human and social capital. It is the key to the performance of Board capital, providing a bridge and a tool for Board human and social capitals to function, but also created by Board social capital (Chiu et al., 2006). It provides a stable work environment where Board members are interested in and aware of their mission. The Board can function in a safe, orderly, and high-quality manner, providing a platform for members to work and interact.

Based on the above analysis, human capital is the core of Board capital and plays a leading role in creating value for Board capital. Social capital is an essential guarantee for Board capital performance, plays a catalytic role in the operation of Board capital, and is a decisive factor in the transformation of Board capital into Board performance. Institutional capital is the primary platform for Board capital performance, creates conditions for the optimal use of human capital and social capital, and cooperates with human capital and social capital to create value. The three-dimensional synergy of Board capital contributes to the improvement of Board performance. Accordingly, the research proposes a three-dimensional structural framework of Board capital, as shown in Figure 2.3.

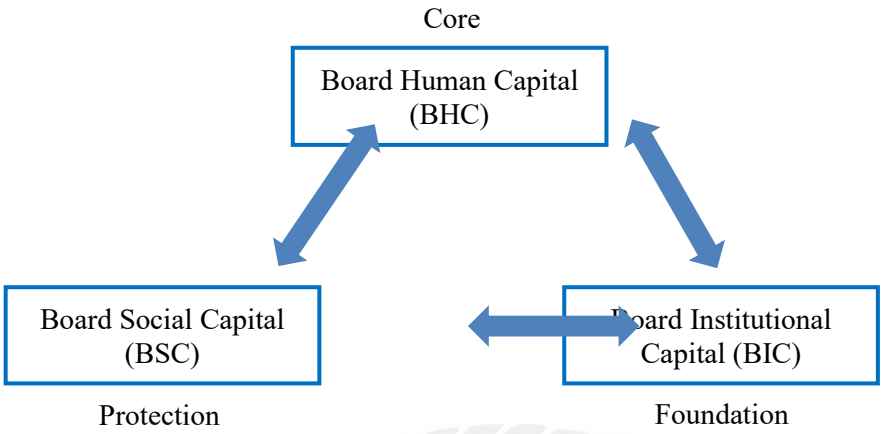

Figure 2.3 Structure Framework of Board Capital (Leitch et al., 2012)

(2) Board Capital Three-Dimensional Synergistic Interaction Mechanism

The Board capital system comprises three subsystems: human capital, social capital, and institutional capital. Each subsystem contains several elements (Leitch et al., 2012). The three subsystems of Board capital do not act in isolation but interact and cooperate to promote the Board's governance performance. The Board capital system is open and non-linear in structure and operation, non-equilibrium, dynamic, and highly complex.

A board capital system is an open system containing many elements. Different organizations need to identify the critical elements of their Board capital to obtain a sustainable competitive advantage, improve their governance performance, and continuously input material, energy, and information into the Board capital system so that the Board capital system can make adaptive adjustments. The Board capital required by the organization is formed through action and accumulation.

The board capital system is a non-equilibrium system. Non-equilibrium is relative to equilibrium, in which the system neither communicates with the environment nor does the state variable change over time. The knowledge, health, and competence of Board members are constantly changing, and so is the relationship between the Board and external organizations. The board's incentives, constraints, practices and culture are dynamically evolving. Therefore, the Board capital system is a non-equilibrium system.

Compared with linear interaction, the essential feature of non-linear interaction is its coherence (Anderson et al., 2004). The interaction between the elements of the

three-dimensional system of Board capital is not simply quantitatively superimposed but mutually constrained and coupled to form a holistic effect that is entirely different from the parts as a whole. Non-linearity plays a prominent role in the evolution of the Board capital system, and this non-linearity is an intrinsic motivation for the formation of an orderly structure and complexity of the system.

Synergy is a relationship in which the elements that make up a system promote each other, coordinate, and grow together during the development and operation of the system. The interdependence and interaction among the three dimensions of Board capital make them have synergistic functions and effectiveness. The three-dimensional synergy of Board capital is forming synergy of Board capital in three dimensions. Human capital is the essential production factor of Board operation and is the core of Board capital performance. The social capital is the primary way of Board operation and the environmental condition for the realization of Board capital performance. The institutional capital is the "infrastructure" or "knowledge platform" that supports the Board's operation and is the key to the performance of the Board's capital.

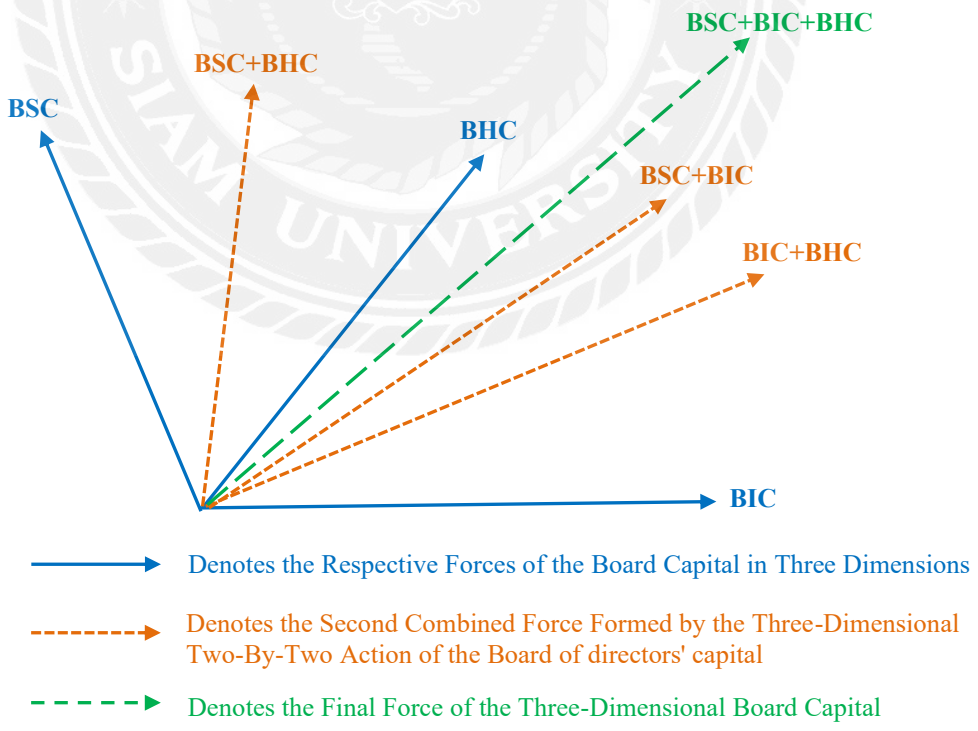

Figure 2.4 Three-dimensional collaborative process of Board capital (Dorigo et al., 1996)

The three dimensions of Board capital act two by two and then act again to form the final synergy, which is the process of close cooperation between the three

dimensions of Board capital and evolving to a higher level. The interaction of Human capital of board (CHB), Social Capital (BSC), and Institutional Capital (BIC) can form a structured social capital that relies on human capital, as shown in Figure 2.4 (Dorigo et al., 1996). This is reflected in the various institutional and human factors contributing to good relations between the Board and the social network members (Damschroder et al., 2019). These factors are the interaction between the overall operating environment of the Board of Directors, the contacts between the Board of Directors and the outside world, the quality of the Board members, and other factors whose value depends not only on the level of knowledge, experience, and competence of Board members but also on the organizational culture of the Board and the various internal systems (Hopkins et al., 2007), etc. The optimal organization of Board capital in three dimensions constitutes a synergy that needs to be repeated several times and is the result of many interactions. It is possible that one of the dimensions occupies a central position or that two dimensions work together to produce the effect. The optimized and integrated Board capital often forms a Board capital synergy so that the synergistic effect of Board capital dimensions after the synergy is much greater than the effects of the single dimensions before the synergy. Board performance is usually the result of the synergy of the three dimensions of Board capital and their optimal integration.

2.2.5 Operating Mechanism of Board Capital

The primary operational mechanisms of Board capital include identifying, assessing, integrating, managing, utilizing, leveraging, renewing, and developing various capitals of Board members. The practical implementation of these mechanisms can help the Board to fulfill its roles and responsibilities better.

The various capitals of Board members (expertise, skills, experience, and contacts) need to be identified and evaluated. This can be done by considering each Board member's background, experience, and expertise. Assessing the capital of Board members can help identify Board competencies and how these resources can be leveraged to contribute to the company's success: Board capital integration and management mechanisms. The various capitals of Board members need to be integrated and managed to ensure they are appropriately applied to the company's decisions and strategies (Bertrand & Mullainathan, 2003). This can be accomplished through effective

Board organization and management, including identifying appropriate committees and groups and ensuring the exchange of information and ideas among Board members.

The various capitals of Board members must be leveraged and utilized to move the company forward. This can be achieved by ensuring that Board members can participate best in the company's decision-making and strategy development. In addition, trust and cooperation among Board members are crucial to achieving capital utilization and leverage: Board capital renewal and development mechanisms (Demsetz & Lehn, 2020). Board members' capital must be updated and developed to keep pace with the changing business environment and market competition. This can be achieved by providing training and development opportunities, recruiting new Board members, and ensuring that their knowledge and skills are aligned with the company's strategic direction (Christa Leigh Catchings et al., 2005).

Different theoretical perspectives explain the functions of the Board of Directors differently (Fama & Jensen, 2021). Board of directors's theories have developed along the path of management control theory, legal theory, agency theory, resources dependence theory, and stewardship theory. Considering that it may be one-sided to understand Board functions based on one single theory, scholars currently mainly use agency theory with resources dependence theory and stewardship theory as the mainstream theories (Luthans, 2002). Therefore, this study considers the Board has responsibilities and tasks that it should perform, and the Board's functions include the supervisory function and strategic function.

According to stewardship and resources dependency theories, the Board of Directors is closely related to the company through direct participation and indirect influence. The Board of Directors and the top management are not just in a principal-agent relationship but share the same goals and work together to enhance corporate value (Uman & Smith, 2013). The Board of Directors provides management with the resources needed for corporate development and participates directly in formulating corporate strategic decisions. Management acts as a steward of corporate resources and strives for corporate goals to maximize the interests of shareholders. The Board of Directors is directly involved in formulating corporate strategic decisions, including short-term corporate goals, medium- and long-term strategic plans, corporate vision and

mission, and implementation of strategic goals. Based on the resources dependency theory, the enterprise's strategic decisions depend on Board human and social capital (Murray et al., 2017). The Board of Directors indirectly influences the formulation and implementation of corporate strategic decisions by increasing the frequency of communication between the company and the external environment, increasing the channels and ways to obtain information, and grasping the corporate direction more precisely (Byun et al., 2017).

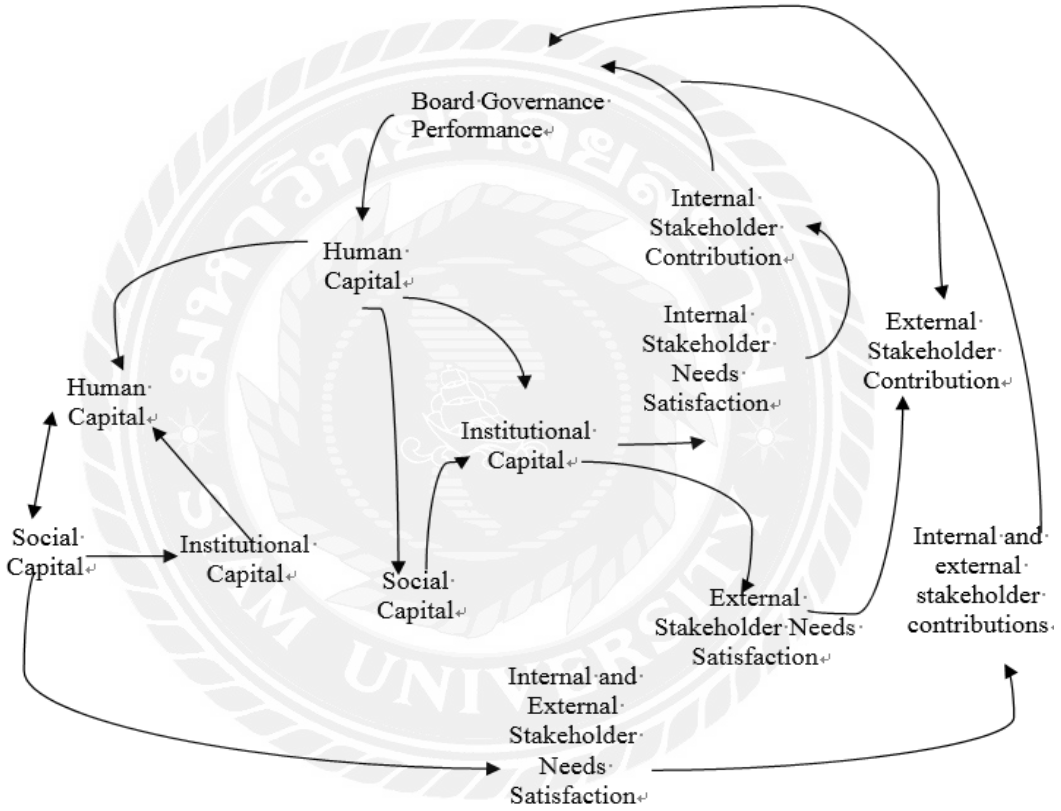

Figure 2.5 Three-Dimensional Collaborative Value Creation Path of Board Capital (Garas & ElMassah, 2018)

The Board of Directors is the one who makes and executes the strategy of the company. A survey of Board responsibilities has found that about 67% of directors believe the Board makes strategic decisions, and about 8% believe it is only involved in making strategic decisions for the company. It is also found that 3/4 of the directors believe the Board determines the company's vision, mission, strategy, and bylaws. The improvement of Board governance performance is a driver of the three-dimensional synergy of Board capital, and the key to this goal is the role of internal and external

stakeholders of the Board. Internal Board stakeholders are the internal members of the Board (Garas & ElMassah, 2018). External Board stakeholders include supply chain partners, collaborative and competitive partners, members of social value network relationships, etc. Board governance performance depends on the extent to which these two types of stakeholders contribute to the Board, so meeting their reasonable demands and increasing their satisfaction is the key to motivating these two types of stakeholders to do their best for the Board. The path of Board capital three-dimensional synergy to improve board governance performance is shown in Figure 2.5.

2.3 Relevant Research on Technological Innovation Resources

2.3.1 Definition and Development of Technological Innovation Resources

(1) Definition of Technological Innovation Resources

For the resources required for technological innovation, there is no unified definition. The trichotomy of enterprise TIR, i.e., the components of knowledge resources, technology resources, and financial resources, is widely accepted by academics.

For high-tech enterprises' technological innovation activities, timely and accurate information determines the lifeline of technological innovation and runs through the whole innovation process; technological innovation information is crucial for high-tech enterprises' technological innovation process. Market, technology, and policy are necessary for technological innovation activities, which largely determine whether the enterprise's technological innovation can be carried out smoothly (Cohen & Levinthal, 2018). The market information includes information on the economic environment and market demand environment, explicit or implicit information on the existence of the market, information on the unstable change of customer preferences, information on the supply of production factors by suppliers, and information on peer competitors. Technical information focuses on cutting-edge technology and patent literature, technical standards, technical achievements, the development stage of existing technologies, the feasibility of technological innovation, the current status and prospects of new technologies, new processes, new products, the competitiveness of

technologies, and other information about the current status and future trends of technology (Myers, 2019). The policy information mainly includes national innovation policy, industrial policy, intellectual property policy, tax policy, foreign trade policy, financial policy, price policy, environmental protection policy, and other related policies.

The development process of science and technology inevitably includes the production and transfer of knowledge (Grant, 2019). The importance of knowledge to technological innovation activities is self-evident. Along with the significant increase in the stock of scientific knowledge in the 20th century and the rapid increase in industrial research and development, explicit knowledge and tacit knowledge go hand in hand to promote technological innovation for enterprise technological innovation. The importance of knowledge production, transfer, and usage for technological innovation is increasing daily. Numerous studies in technological innovation have confirmed this conclusion. The knowledge required by high-tech enterprises for technological innovation includes market development knowledge, technology research and development knowledge, and innovation management knowledge of new products (Morgan & Hunt, 2020). Among them, market development knowledge is the market segmentation and expansion adopted by enterprises to meet the diversified needs of consumers. Technology research and development knowledge is the knowledge of a company to carry out technology or product innovation areas and thus draw on detailed research and development technologies. Innovation management knowledge is the management knowledge of the company in considering how to establish executable system management (Chen et al., 2022).

The process of technological innovation requires capital to support development. Funds required for technological innovation activities of high-tech enterprises include funds required for R&D and funds required for non-R&D (Lockett & Wright, 2005). R&D funds focus on the enterprise's expenditure on technology research and development as well as the input funds related to the purchase of equipment, raw materials, test fees, trial production, energy, transportation, site fees, and labor costs. The non-R&D funds refer to the introduction of patents, the costs of technological innovation activities other than the R&D part, technology introduction

costs, technology transformation costs, and digestion and absorption costs (Latour, 2022).

The definition of resource acquisition can be understood from different perspectives. From the evaluation perspective, it can be divided into the efficiency perspective and the effectiveness perspective. The efficiency perspective stands on the efficiency of enterprises in acquiring valuable resources, and the effectiveness perspective focuses on whether these resources can be acquired by enterprises and whether they can bring temporary or long-term competitive advantages to enterprises. Based on the specificity and significance of resources acquisition in the context of technological innovation, this study selects the resources acquisition outcome perspective to examine the relationship between Board capital and TIP and the resources acquisition outcome of technology start-ups (Chen et al., 2022). Regarding resource acquisition channels, internal accumulation of resources and external acquisition of resources are the two main ways of resource acquisition. From the beginning of a firm, various resources are accumulated through continuous development and embedded within the firm (Paauwe, 2020). However, the demand for resources for technological innovation can no longer be satisfied by the internal accumulation of resources. Companies relying only on their internal resources to develop innovation can hardly have a place in the current market competition. To sustain innovation and development, enterprises must use external resources. Therefore, the resource acquisition referred to in this study is external acquisition. Based on this, this study defines resources acquisition of technological innovation (Morgan & Hunt, 2020) as the result of acquiring resources required for technological innovation from the external environment, i.e., whether sufficient resources required for technological innovation can be obtained from external sources promptly (Latour, 2022).

(2) Development of Technological Innovation Resources

Technological innovation resources refer to various resources that enterprises need to achieve technological innovation, such as talents, capital, technology, equipment, information, etc. These resources play an essential role in the technological innovation process of enterprises and affect their technological innovation capability and competitiveness. The research and development history of TIR has gradually

shifted from the theoretical level to the practical level and has explored and established a system of technological innovation resources management to promote the innovation and development of enterprises.

Table 2.3 Development Process of TIR

Year	Development Process
Formative Stage of Resources Concept (the 1960s-70s)	They were defining and conceptualizing TIR at the theoretical level. Economists began to recognize the importance of technological innovation to the competitiveness of firms and began to study the factors influencing technological innovation, such as patents, technical talent, and R&D investment.
The Exploratory Phase of Technology Innovation Resources Management (the 1980s-1990s)	Enterprises began to realize the importance of technology innovation resources and started to establish and improve the technology innovation resources management system. The main task of this stage was to study how to effectively manage technology innovation resources, including the formulation of technology strategy, construction of organization, talent training, knowledge management, etc.
Open and Cooperative Stage of TIR (Early 21st Century to Present)	With the intensification of globalization and the rapid development of information technology, the openness and cooperation of TIR have become a hot research topic. In this stage, enterprises adopt more open strategies to cooperate and share TIR with other enterprises, research institutions, government departments, etc. The main task of this stage is to study how to promote the sharing and cooperation of TIR to realize the synergistic effect of technological innovation.

2.3.2 Elements of Technological Innovation Resources

The elements of TIR are interrelated and interactive, and enterprises need to reasonably allocate and manage these elements to realize the smooth implementation of technological innovation and ultimately achieve enterprises' development and competitive advantage (Chen et al., 2022). First, talent, capital, technology, intellectual property, and other elements are interdependent and mutually supportive, and one is indispensable without the other. For example, enterprises need technical R&D personnel to carry out technological innovation; at the same time, they need to invest capital to support R&D activities and have relevant technology and intellectual property rights to protect and return technological innovation results. Therefore, enterprises need to consider the ratios and inputs of various elements to realize the smooth implementation of technological innovation (Ostrom, 2000). Secondly, a synergy and influence relationship exists between technological innovation resources elements. For example, the ability and quality of talents will affect the direction and results of

technological innovation; the amount and efficiency of capital use will affect the progress and results of technological research and development; the protection and application of intellectual property rights will affect the returns and commercialization effects of technological innovation (Alonso Alvarez, 2015). Therefore, enterprises must comprehensively consider the synergy and influence relationship among various elements to achieve the optimal technological innovation effect. Finally, reasonably allocating and managing technological innovation resources elements requires establishing an effective technological innovation management mechanism and organizational system. Enterprises need to establish scientific R&D management systems, project management systems, knowledge management systems, etc., to ensure the smooth implementation of technological innovation and effective management and application of results. At the same time, enterprises need to strengthen contact and communication with the market, understand the market demand deeply, promote the transformation of technological innovation to the market direction, and improve the commercialization and marketing of technological innovation(Alonso Alvarez, 2015).

Table 2.4 Technology Innovation Resources Elements and Main Content

Elements	Content
Talent Elements	**Talent is the core element of technological innovation, including technology developers, engineers, scientists, and other talents with relevant technical skills and innovation capabilities.**
Funding Elements	**Capital is the basic element of technological innovation, and enterprises need to invest a lot of money to support activities in technology research and development, equipment renewal, marketing, etc.**
Intellectual Property Elements	**Intellectual property rights guarantee and reward technological innovation, and enterprises need to protect and manage technological innovation results by employing patents, trademarks, copyrights, etc.**
Technical Elements	**Technology is the core element of technological innovation, and companies need to have advanced technology, processes and equipment, and other resources to support them.**
Management Elements	**Scientific technology innovation management guarantees technology innovation, and enterprises need to establish an effective technology innovation management mechanism, including R&D organization, project management, knowledge management, and other aspects.**

Elements	Content
Market Elements	**The market is the home of technological innovation, and companies need to have an in-depth understanding of market demand and conduct marketing and promotional activities to ensure the commercialization and marketability of technological innovation.**

2.4 Relevant Research on the Quality of Technological Innovation Strategy

2.4.1 Definition of Quality of Technological Innovation Strategy

The main issues considered in the strategic decision of technological innovation include market positioning of technological innovation, the timing of innovation realization, selection of technological innovation object, technological innovation path, technological innovation mode, and resources investment intensity. According to the current research, the technological innovation decision involved in the Board of Directors mainly includes three aspects: technological innovation path decision, technological innovation mode decision, and technological innovation investment intensity decision (Zhou et al., 2019).

Technology innovation path decision is mainly analyzed on how to carry out technological innovation (Luo & Tung, 2007). When carrying out technological innovation, high-tech enterprises first need to clarify their concept; scientific innovation concepts can not only bring benefits to the enterprise but also need to meet the long-term development strategy of the enterprise. According to the different technological innovation magnitudes, the technological innovation path can be divided into, exploratory innovation path, utilization innovation path, technology track, innovation target, technology base, target customers, and market level. (Amit & Schoemaker, 2021).

The technological innovation model is an integral part of enterprise technology innovation strategy and is the organizational strategy of enterprise technology innovation activities (Amit & Schoemaker, 2021). According to the participants, technological innovation modes can be divided into three categories: autonomous, collaborative, and imitation. The three innovation modes, namely, autonomous innovation mode, cooperative innovation mode, and imitation innovation mode (Martin

& Salomon, 2003), differ in terms of technology sources and acquisition channels, technology and market positioning, technology development cycle, and cost. Technology innovation investment decision involves selecting technology innovation investment projects. R&D investment is divided into two types research-based technology innovation investment and development-based technology innovation investment. The two investments differ in terms of innovation purpose, investment accounting treatment, investment risk, return, etc. In the same technological innovation strategy decision problem, the nature of different decision options or countermeasures are very different, and even some characteristics are opposite, i.e., the options are mutually exclusive. In addition, it is complicated for the same enterprise to carry out multiple innovations simultaneously due to its limited resources and capabilities. Therefore, choosing a technological innovation strategy for an enterprise is a selection process—a particular innovation strategy adopted by an enterprise results from a comprehensive set of choices (Kohli & Jaworski, 2019).

The correctness of technology innovation strategy selection is related to the efficiency of enterprise resource utilization, organizational operation efficiency, enterprise's technological innovation ability, and the adaptability of the external environment (Nelson, 2020), which significantly affect technology innovation performance. Scholars have different views on evaluating the goodness of a strategic decision. There are two kinds of definitions on the connotation of strategic decision: outcome view and process view. The outcome view of strategic decision believes that the ultimate goal of strategic decision is to maximize the utility of the decision, and the decision that can achieve this goal is a high-quality decision. Otherwise, it is a low-quality decision (Kohli & Jaworski, 2019). However, this view needs to be applied in a simple and stable environment with clear objectives of the decision problem, and the decisions in practice often need to meet these assumptions. The process perspective views strategic decision-making as a process in which decision-makers weigh outcomes against various uncertainties based on their preferences and judgments (Graebner & Eisenhardt, 2004). A rational decision-making process often leads to more qualitative decision outcomes. What the environment decision-makers face in technology innovation strategy is uncertain and complex, and the decision-making problems are often complex. Since there is no uniform standard of value orientation between

decision-makers and evaluators, it is difficult to use the outcome perspective to measure the quality of decision-making in practice, and even the "right decision result" may not be found. This study defines the quality of technological innovation strategy as the degree to which technology innovation strategy is compatible with the enterprise's internal conditions and external environment.

2.4.2 Development of the Quality of Technological Innovation Strategy

Technological innovation strategy is the overall goal and essential deployment of technological innovation established by a country, region, or organization based on the correct analysis of its internal conditions and external environment, intending to gain a competitive advantage (Nelson, 2020). It includes both macro and micro levels. The former involves the significant issues of technological innovation of a country or region, and the latter involves the significant issues of technological innovation of an organization such as an enterprise. With the advent of a knowledge-based economy, technology innovation strategy has become the core of the overall enterprise strategy (Zott & Amit, 2010). Technological innovation strategy is the significant decision of an enterprise to gain a competitive advantage and achieve innovation goals, usually involving the acquisition, upgrading, and utilization of technology, especially regarding enterprise research and development. The most fundamental goal of corporate technological innovation is to gain a competitive advantage for the company and improve its profitability. This includes, but is not limited to, increases in sales or improvements in product performance, nor is it limited to the issue of new products or services, but more importantly, to change the competitive position and establish a core competitive advantage (Grant, 2019).

Technological innovation strategies are classified into different types according to different classification criteria. The technological innovation strategies of enterprises are classified into technology-leading strategies and technology-following strategies according to the desired technological competitive position of enterprises (Grant, 2021). According to the different ways of enterprise behavior, the enterprise technology innovation strategy can be divided into offensive, defensive, and cut-in. According to the different technology sources, enterprise technology innovation strategy can be

divided into independent innovation, imitation innovation, and collaborative innovation (see Table 2.5).

Table 2.5 Types of Technology Innovation Strategies

Classification Criteria	Type
Differences in the Competitive Position of Technology Desired by Companies	**Technology-Leading Strategy, Technology-Following Strategy**
Differences in the Way Companies Behave	**Offensive Strategy, Defensive Strategy, Cut-Through Strategy**
Differences in technology sources	**Autonomous Innovation Strategy, Imitation Innovation Strategy, and Cooperative Innovation Strategy.**

With the rapid progress of science and technology, in the fierce market competition, the product's life cycle is significantly shortened, and the situation that a new product can survive for decades has been broken; new products are constantly emerging, and enterprises may be eliminated from the market if they do not adopt technological innovation (Grant, 2021). Bad innovation caused by the mistake of innovation strategy selection may also accelerate the process of enterprise demise. Therefore, choosing a technological innovation strategy that aligns with this enterprise's reality is necessary. The choice of technological innovation strategy is closely related to the market position sought by the enterprise. Market-leading and market-following are the most fundamental strategic modes in technological innovation strategy, which are representative and essential in strategic choice (Moraes et al., 2010).

2.4.3 The Role of the Quality of Technological Innovation Strategy

The QTIS refers to the accuracy, comprehensiveness, and effectiveness of the decisions made by decision-makers when a firm is developing its technology innovation strategy. This decision quality is essential to implementing a firm's technology innovation strategy and performance. High-quality technology innovation strategy decisions can ensure enterprises develop technology innovation strategies suitable for themselves (Prahalad & Hamel, 2019), thus improving their technological innovation capability and competitiveness. On the contrary, low-quality technology innovation strategy decisions may lead to inappropriate or infeasible technology innovation

strategies, thus wasting the enterprise's resources and time and reducing the enterprise's competitiveness. The impact on firm performance is different when firms adopt different innovation strategies (Tavassoli & Karlsson, 2015). In addition, the implementation and execution of innovation strategies also affect the performance of firms. Decision makers' information processing ability and knowledge-sharing ability can affect firm performance. While developing technology innovation strategies, decision-makers should fully consider the heterogeneity and information-processing capabilities of the executive team (Dziak et al., 2019).

Second, high-quality technology innovation strategy decisions can improve a firm's performance. This is because the implementation and performance of a firm's technology innovation strategy are the results of decision-making. In implementing technology innovation strategies (Robert et al., 2020), if decision-makers can make accurate, comprehensive, and practical decisions, then firms can make better use of resources and opportunities to improve technology innovation performance. High-quality technology innovation strategy decisions can promote the long-term development of enterprises. Technology innovation strategy is the foundation and driving force for the long-term development of enterprises. Only after decision-makers make high-quality technology innovation strategies can enterprises grow steadily, adapt to market changes, and cope with fierce competition. While formulating technological innovation strategies, enterprises should pay attention to improving decision quality (Wiklund & Shepherd, 2003), fully consider various factors and risks, and ensure the accuracy and feasibility of technological innovation strategies to improve enterprises' competitiveness and long-term development.

Board capital is essential to the QTIS decisions. The Board of Directors is the company's highest decision-making body and is responsible for formulating the company's development strategy and management policy (Ireland, 2022). There is a significant positive relationship between Board capital and the QTIS decisions. Board capital refers to Board members' resources in terms of experience, knowledge, skills, and connections, which can provide valuable information and suggestions for technology innovation strategy decision-making and thus improve the quality of decision-making (Tasavori et al., 2018). In addition, Board capital can also help in

strategic direction, resource allocation, and market insight to further improve the quality of decision-making in technology innovation strategy. Board capital can also avoid financial losses and reputation damages caused by improper decisions on technology innovation strategy by monitoring and controlling the company's technology innovation strategy decisions. The experience, knowledge, and skills of Board members can help companies identify and manage the risks and challenges in implementing technology innovation strategies, ensuring that companies can move forward soundly in implementing technology innovation strategies (van de Vrande et al., 2019).

Therefore, enterprises need to pay attention to the role of Board capital, especially in making technological innovation strategy decisions, and use Board members' knowledge (Hekkert et al., 2007), experience, and skills to ensure the QTIS decisions. At the same time, enterprises should focus on the training and development of Board members to improve the level and quality of Board capital to better support the implementation and long-term development of their technological innovation strategies.

2.4.4 Important Factors Affecting the Quality of Technological Innovation Strategy Decisions

Technological innovation strategy is an important decision for enterprise development, and its quality directly affects the innovation ability and competitiveness of the enterprise. The factors affecting the QTIS are complex, among which external environment factors, internal resources factors, organizational culture factors, and organizational decision factors are all essential (Albino et al., 2015).

(1) External Environmental Factors

The influence of the external environment on the strategic decision of enterprise technology innovation is objective. It includes market demand, competition, policies, and regulations (Albino et al., 2015). Enterprises need to understand and analyze the changes in the external environment and make adaptive technology innovation strategy decisions. Market demand is one of the essential bases for enterprises to develop technology innovation strategies. Enterprises need to understand the changing market demand, analyze the variability and uncertainty of market demand, and make adaptive technology innovation strategy decisions. Competition is an essential background for

the formulation of technological innovation strategy (Williamson, 2020). Enterprises need to understand competitors' technological levels and innovation direction, analyze the changes in the competitive environment, and make technological innovation strategy decisions with competitive advantages. Policies and regulations also have an important influence on enterprise technology innovation strategy decisions. Policies and regulations will affect the technological innovation environment of enterprises, and enterprises need to understand the changes in policies and regulations in time to make corresponding technological innovation strategic decisions. The development of science and technology is one of the essential backgrounds for the strategic decision of technology innovation (Ooi et al., 2017). Enterprises need to understand the latest science and technology development and trends, analyze the direction and laws of science and technology innovation, and make forward-looking and innovative technology innovation strategy decisions. The influence of the social environment on the strategic decision of enterprise technology innovation cannot be ignored (Chen, 2014). Changes in the social environment will affect the technological innovation of enterprises, and enterprises need to understand the changes in the social environment and make technological innovation strategic decisions that meet the expectations and responsibilities of society. The influence of external environmental factors is multifaceted, and enterprises must consider and analyze them comprehensively to make innovation decisions (Byun et al., 2017).

(2) Internal Resources Factors

The influence of the internal resources of the enterprise on the strategic decision of technological innovation is also significant. It includes human resources, financial resources, technical resources, and others. Enterprises need to consider their resource conditions when making technology innovation strategy decisions and make reasonable decision plans (Schot & Geels, 2008). An enterprise's human resources are one of the critical elements in implementing a technological innovation strategy. A high-quality and innovative talent team is the basis for enterprises to develop and implement technology innovation strategies. Therefore, enterprises need to have the ability to effectively manage and cultivate human resources to provide sufficient talent support for technological innovation. Financial resources are the fundamental guarantee for innovation. Enterprises need sufficient funds to support the development and

implementation of technological innovation. Therefore, enterprises need to reasonably plan the allocation of financial resources, improve the effective use of funds, and provide sufficient financial support. Technology resources are an essential foundation for technological innovation. Enterprises need the ability and strength of technology research (Byun et al., 2017) and development and continuously improve the technology level and technical capability. Enterprises also need to manage technical resources reasonably to provide reliable technical support for technological innovation. Organizational resources are essential for enterprises to develop and implement technology innovation strategies (Habbershon et al., 2003). Enterprises need a flexible organizational structure and management mechanism to provide adequate organizational guarantees for innovation. Enterprises also need to reasonably plan the allocation of organizational resources and improve the efficiency and effectiveness of organizational resources (Grant, 2021). Knowledge resources are essential to support technological innovation. Enterprises must have rich knowledge reserves and intellectual property rights, actively carry out knowledge management and knowledge innovation, and provide reliable knowledge support for technological innovation. The influence of the internal resources of enterprises on the strategic decision of technological innovation is multifaceted. Enterprises need to plan and manage internal resources reasonably, improve internal resources' efficiency and utilization rate, and provide comprehensive resource guarantees for technological innovation (Grant, 2021).

(3) Organizational Culture Factors

Organizational culture is the core values and code of conduct within an enterprise. The organizational culture of an enterprise has an important influence on the development and implementation of technological innovation strategy decisions. Enterprises must establish an excellent organizational culture to create an environment and atmosphere supporting technological innovation. Innovation culture refers to employees' attitudes, values, and behavioral habits toward innovation. Innovation culture encourages employees to try new things and constantly pursue innovation and improvement, thus promoting the development and growth of the enterprise. Enterprises must actively establish an innovation culture, advocate employees' innovation consciousness and spirit, and provide an excellent cultural environment for technological innovation. A learning organization is an enterprise that can continuously

learn and improve its competitiveness and adaptability. A learning organization can absorb external knowledge and technology and innovate and develop. Enterprises must establish a learning organization to continuously absorb new knowledge and technology and provide a quality learning environment for technological innovation (Calantone et al., 2002). Incentive mechanism refers to the various incentives enterprises provide for employees, including salary incentives, promotion opportunities, training opportunities, etc. A suitable incentive mechanism can improve the enthusiasm and creativity of employees and encourage them to keep exploring technological innovation. Enterprises need to establish a perfect incentive mechanism to provide strong incentive support for technological innovation. Leadership style refers to the personal style and management philosophy embodied by the leader of an enterprise in management (Grant, 2021). Leaders should have a sense of innovation and the ability to innovate and encourage employees to innovate. Companies must establish an upbeat leadership style to stimulate employees' innovation potential and promote technological innovation development. The influence of organizational culture on strategic decision-making of technological innovation is also multifaceted. Enterprises must establish an innovative and learning organizational culture, provide good incentives and leadership styles, and provide a comprehensive cultural guarantee for technological innovation (Zhou et al., 2019).

(4) Managerial Decision-Making Factors

The decision-making ability and style of enterprise managers have a decisive influence on the QTIS. Enterprises must cultivate managers with innovative spirits and decision-making abilities and adopt scientific and reasonable decision-making methods and tools (Amit & Schoemaker, 2021). Setting clear decision-making goals is very important for developing technology innovation strategies. Managers must identify technological innovation goals, such as launching new products, increasing productivity, improving marketing, etc., to develop appropriate technological innovation strategies and action plans. Managers must collect and analyze information about technology, markets, and competitors. By gaining insight into industry and market trends, as well as the technological developments of competitors, managers can develop more accurate technology innovation strategies (Laursen & Salter, 2006). Technological innovation involves a high degree of uncertainty and risk. Therefore,

managers should assess the potential risks and develop corresponding risk management plans. Managers must choose the appropriate technology innovation strategy based on the company's strengths and market demand (Mintzberg, 2020). They should analyze the costs and benefits of technological innovation and develop appropriate technological innovation strategies and implementation plans. Managers need to communicate effectively to ensure that all departments and employees of the company understand and support the technology innovation strategy. Effective communication can lead to the smooth implementation of a company's technology innovation strategy, thus improving the quality of technology innovation decisions. Managerial decision-making factors are crucial to the impact of technology innovation strategy decisions (Mintzberg, 2020). Managers need to set clear decision goals, actively collect information, analyze decision risks, select appropriate technology innovation strategies, and communicate and coordinate effectively to improve the quality of technology innovation decisions (Van Riel et al., 2004).

(5) Technology Innovation Capability Factor

Technological innovation capability is the source of enterprise core competitiveness. Enterprises need to improve their technological innovation capability and strengthen it to provide strong support for technological innovation strategy decisions (Mintzberg, 2020). Technological resources include talents, technical equipment, research and development budget, etc. Enterprises with advanced technological resources can improve QTIS decisions and are more likely to implement technological innovation strategies successfully (Li & Liu, 2005). Technology R&D capability is the basis for technological innovation in enterprises. Companies need good technological R&D capabilities, including optimization of R&D processes, innovative development methods, and teamwork capabilities. These factors can improve the quality of technology innovation strategy and improve the competitiveness of enterprises. Technological innovation culture is an essential reflection of an enterprise's technological innovation capability. The technology innovation culture includes the enterprise's innovation atmosphere, culture construction, and innovation incentive mechanism. Enterprises must establish a culture that encourages employees to develop new ideas and practices to succeed in technological innovation (Fama & Jensen, 2021). Companies must have good strategic planning capabilities, including developing

strategies, managing technology innovation, and implementing technology innovation plans. These capabilities can help companies make accurate and feasible decisions regarding technological innovation, thereby improving the quality of strategic decisions. Technological innovation involves high uncertainty and risks, and enterprises need good technological innovation risk management capabilities, including formulating risk management strategies, identifying and assessing potential risks, and formulating risk response measures (Adebayo et al., 2023). These capabilities can help enterprises reduce risks in technological innovation and improve QTIS decisions. Technological innovation capabilities have an essential impact on QTIS decisions. Enterprises need to improve their technological innovation capabilities actively (Myers, 2019).

To sum up, many factors affect the QTIS decision-making, which need to be considered comprehensively. Enterprises need to continuously summarize and experience in practice and improve their technology innovation strategy decision-making system to lay a solid foundation for the long-term development of enterprises.

2.5 Relevant Research on Technological Innovation Performance

2.5.1 Technological Innovation Performance Connotation

The famous American management scientist Drucker introduced the concept of "innovation" in management. According to Drucker, innovation includes technological innovation and social innovation (Lee, 2008). Technological innovation is the application of natural objects in nature to new fields and innovation in economic value. In contrast, social innovation is the innovation of management institutions, methods, or means to achieve more excellent value in allocating resources in society and the economy.

The connotation of technological innovation includes the following four aspects: firstly, technological innovation combines economic activities with specialized activities to transform technological inventions into new products and new production methods (Adebayo et al., 2023). The basis of this transformation process is knowledge, which is different from pure technical activities and pure economic activities, and

technological innovation is the unification of technology and economic activities. Secondly, technological innovation takes enterprises as the main body, and in the current economic context, enterprises take technological innovation as their primary function. Thirdly, enterprises learn, select, and apply knowledge through technological innovation, and they can obtain new technologies, new techniques, new production methods, and new business management modes in the process of technological innovation, and also get new products of high quality (Woolcock & Narayan, 2000). Fourthly, technological innovation is a comprehensive and complex activity consisting of multiple interacting elements, including a series of actions from technology development, product manufacturing, and marketing to after-sales service.

A high-tech enterprise is one that produces high-tech products and provides high-tech services with high technology. It is also an enterprise entity with the spirit of pursuing innovation, rapid market response-ability, and flexible R & D mechanism of high-tech products (Demsetz & Lehn, 2020). The level of TIP is closely related to scientific and technical progress and social development and has become a research hot spot in academia in recent years. Scholars have explored the connotation of TIP based on different research perspectives. Some scholars have defined the concept of TIP from the perspective of technological innovation (Fama & Jensen, 2021).

The TIP of enterprises is reflected in the input and output of enterprise science and technology innovation, which generally refers to the results of enterprise science and technology. Hagedoorn (2003) points out that TIP is the net output of products enterprises achieve through technological innovation activities, specifically expressed as new products, new patented technologies, new processes, or new equipment.

Based on the research on the connotation of TIP from the perspective of technological innovation output, some scholars believe that TIP should include not only the direct output of innovation inputs but also the benefits brought to enterprises by the direct output (Fama & Jensen, 2021). The technological innovation activities of enterprises bring economic benefits to enterprises and improve their market competitiveness, so technical innovation performance should include increasing enterprise value brought by technological innovation activities. TIP should consist of not only the direct output of enterprise technological innovation inputs (Cohen &

Levinthal, 2018), new product sales revenue, improvement of market competitiveness, and increase of enterprise value and other economic benefits, but also the contribution of technological innovation to society, such as environmental protection, rational use of resources and alleviation of employment pressure, which should be green, sustainable and contributing to economic benefits (Byun et al., 2017).

2.5.2 Evaluation Study of Technological Innovation Performance

The quality of technical innovation output of firms, and patents are subject to severe requirements and are widely available (Kohli & Jaworski, 2019). The number of patents is a good measure of technical output performance and has a high accuracy in measuring. Subsequently, most scholars have adopted the patent output index to measure enterprises' technological innovation output (Ahmad et al., 2020). The number of patents filed by enterprises reflects the level of technological innovation output of enterprises. For measuring technological innovation output performance, use the number of new goods indicator. The number of patents and new goods cannot reflect the economic rewards of technical innovation. New product sales revenue, market share, and success rate are included to strengthen the TIP index system. (Adebayo et al., 2023).

The fuzzy comprehensive evaluation method has the advantages of clear thinking, precise results, and strong systematicity, which is suitable for solving the problem of multi-level and multi-indicator TIP evaluation. When analyzing the TIP of enterprises, the fuzzy comprehensive evaluation model is used to construct the index system for evaluating the TIP of enterprises, and the "maximum affiliation" method is used to assess the merits of the TIP of enterprises (Demsetz & Lehn, 2020). The study has pointed out that the gray fuzzy clustering method considers the advantages of single fuzzy evaluation, principal component analysis, and factor analysis and can be applied to assessing enterprise innovation performance. The gray undefined clustering method is used to evaluate the TIP of technology-based enterprises.

2.5.3 Factors Influencing the Technological Innovation Performance

Research scholars have studied the factors influencing TIP more deeply, forming a wealth of research results (Byun et al., 2017). The technical innovation process of enterprises is composed of multiple links and stages. The process of technological innovation of different enterprises, despite specific differences, runs through a logical development procedure, i.e., from Input-R&D-manufacturing-sales-output. Therefore, research on the factors of the technological innovation process mainly focuses on technological innovation input capacity, technological R&D capacity, technological transformation capacity, etc. Highly qualified personnel help to utilize technology entirely, and they examine 33 industries and find that technical personnel have a significant positive effect on new product sales revenue (Hall, 2013).

Hall (2013) investigated data from various sectors of the Italian manufacturing industry and found that R&D capital investment positively affects firms' innovation performance. Technological R&D capabilities can only guarantee the front end of the innovation process (Hall, 2013); the ability to achieve actual TIP depends on the firm's ability to transform R&D results into technical transformation capabilities that meet market needs and design requirements and enable the production of innovative products in batches. Vorhies & Morgan (2005) empirically analyzed 376 U.S. firms and found that marketing capabilities positively affected new product development and market performance (Vorhies & Morgan, 2005). Many scholars focus on organizational factors and consider firm size, technology innovation strategy, firm executive team characteristics, and corporate culture as key influencing factors of technology innovation performance. After analyzing the relationship between competition, monopoly, and innovators, Schumpeter found that large-scale cartels have a large enough platform and capacity to carry out technological innovation activities. At the same time, in a perfectly competitive market, small firms need more financial support and thus are not conducive to technological innovation.

2.5.4 Studies Related to Technological Innovation Performance

Regarding the definition of the connotation of TIP, scholars mostly take the perspective of results and consider TIP as a measure of the impact of technological innovation activities of enterprises on themselves and society, including three categories technical performance, economic performance, and social performance (Mintzberg, 2020). Technology innovation performance evaluation has been widely explored in technology innovation management research. However, due to the complexity of the technological innovation process and the diversity of innovation results, there is no unified evaluation system of TIP at this stage. Research on the index system of TIP evaluation has formed the index system of innovation output such as the number of patents applied by enterprises (Eisenhardt, 2020), the number of new products, the sales revenue of new products, the market share of new products, and the success rate of innovative products; many quantitative analysis tools have been used by scholars in the evaluation of TIP of enterprises, such as hierarchical analysis method, multi-level fuzzy comprehensive evaluation method, and artificial neural network model (Eisenhardt, 2020; Latour, 2022).

2.6 Related Literature

2.6.1 Board Capital and Corporate Development

According to resources dependence theory, a company is in an open environment system. It cannot be self-sufficient in acquiring all the resources required for its survival and development, such as finance, information, and material resources. These resources are in the hands of external organizations. In order to obtain the relevant resources to ensure their survival and development (Christa Leigh Catchings et al., 2005), enterprises must interact with the external organizations that possess the resources. The actions that enterprises can take include strategic alliances, mergers, acquisitions, and Board relations. Board relations are a convenient and low-cost way to obtain resources (Fama & Jensen, 2021). The Board of Directors, the highest decision-making level of the company, is responsible for monitoring the behavior of management in order to reduce agency costs, and it has the responsibility to consider essential

projects of the company (Lai et al., 2012). It should use its social resources for the development of the company. The board of directors forms board relation capital by building relationships with external organizations (other companies, government, and financial institutions) to help the company access relevant resources. Board relation capital can bring resources to the company in four areas (Murray et al., 2017):

First, it establishes a channel of communication with external organizations for the enterprise. By establishing relationships with other companies through a chain of directors, the Board of Directors facilitates the dissemination of information among companies (Byun et al., 2017), enhances the ability to monitor the corporate environment, and obtains information related to the management of other companies, which helps to make strategic (Myers, 2019) decisions and improve the performance of the company.

Second, it helps companies prioritize access to critical external resources. The relationship between the Board of Directors and external organizations allows companies to access favorable essential resources (Morgan & Hunt, 2020). Companies with government background directors are more likely to obtain policy resources such as tax breaks and government subsidies, which help improve corporate performance. Firms with directors from financial backgrounds have easier access to financial resources.

Third, it provides legitimacy support for the company. The social status of Board members in other companies, government departments, and financial institutions sends a positive signal to the outside world (Coleman, 2000). It represents a guarantee of corporate value provided by the Board to other organizations and individuals, enhancing external recognition of the company. A Board of Directors with relation to relevant companies can provide advice and counsel more effectively and have ample information to support the decision-making process through relationship capital (Fama & Jensen, 2021).

Due to the asymmetry of dependency relationships between organizations, organizations with relevant resources can gain relative power in the dependent relationships and influence other organizations (Christa Leigh Catchings et al., 2005). While acquiring relevant resources through the Board of Directors' relationship capital,

the company also provides a channel for external organizations to exert control over the company. The higher the dependence on resources, the greater the ability of the external organization with the resources to exert influence on it. In China's extraordinary transition economy, where institutional arrangements are still being established, relational capital is essential in securing external resources to ensure corporate survival and promote corporate development.

2.6.2 The Impact of Board Capital on Technological Innovation Resources

(1) Impact of the Human Capital of the Board on Technological Innovation Resources

Cognition is the most important psychological condition for successful resource acquisition behavior (van Riel et al., 2004). It plays a unique and essential role in resource identification, resource acquisition path selection, and interaction with the resource provider. The different levels of Human capital of the board indicate that there are differences among Board members in terms of knowledge level, personal quality, ability level, and experience accumulation (Mintzberg, 2020). These differences can trigger differences in the overall cognitive level of the Board of Directors to the extent that they have an impact on the effect of technological innovation resources acquisition (Kogan et al., 2017).

In the process of TIR, the higher the knowledge level of Board members, the more accurate the understanding and judgment of resource acquisition, and correspondingly (McMullen & Shepherd, 2006), the higher the degree of effective resource acquisition. The technical knowledge and market knowledge of Board members can have a more comprehensive understanding (Eisenhardt, 2020) and judgment of the channels and ways of knowledge acquisition and the positive impact of acquiring technological innovation knowledge resources required by enterprises. In addition, the level of knowledge positively affects the complexity of cognitive schema (Latour, 2022). The more knowledgeable Board members are, the more complex the cognitive schema is. The board can make a comprehensive, reasonable, and objective judgment on each feedback from the resources-providing subject and accordingly construct the strategy for the subsequent resources acquisition behavior in a purposeful and step-by-step manner. Competence plays an essential role in resource acquisition,

and many companies face the dilemma of having a heart but not a mind because they cannot acquire and discern resources (Chen et al., 2022). The sharper the sensory, perceptual, and attentional abilities of Board members, the more motivated they are to interact with multiple stimuli from the external information environment or information sources, including information acquisition selection and optimization, and consequently to establish intentions. The Board of Directors is motivated to acquire information resources about the economic environment and market needs. The stronger the memory and thinking ability of Board members, the more they can reproduce the process of acquiring resources, get feedback from the process of behavior, monitor and adjust individual resources behavior, and take corrective measures (Fama & Jensen, 2021).

The stronger the thinking ability of the Board members, the more they will make longitudinal considerations in resource acquisition behavior in terms of future resource selection and usage (Byun et al., 2017). Furthermore, they will construct strategies for the subsequent resource acquisition behavior. Resources acquisition behavior is not only dependent on knowledge and ability (Myers, 2019) but also on acquired behavior closely related to past experiences. People are more likely to perceive familiar things than strange things, and experience can reduce the cognitive load of the mental object and achieve satisfactory results. Experienced managers have a range of skills in resource acquisition, such as skills in identifying needed resources, negotiation skills (Kandemir, 2006), and skills in integrating and allocating resources, which facilitate the Board's identification of resources required for technological innovation, flexibility in the way resources are acquired, and improvement in the effectiveness of resources cognitive interaction processes. Experience enables people to focus on familiar things and ignore unfamiliar objects, positively influencing constancy and comprehension in the subject's resource acquisition process. Emotions profoundly affect cognitive functions and are an important influence on resource acquisition (van Riel et al., 2004). Optimistic feelings can enhance the subjective motivation of Board members' resource acquisition behavior, improve their attitudes, and enhance their engagement in resource acquisition and facilitating technological innovation. In addition, optimistic work attitudes generate lower work stress, reduce anxiety depletion of cognitive resources needed for working memory and executive functions, and alleviate insufficient mental

resources available (Kogan et al., 2017) to address resources-providing subjects' selection and interaction for proper and timely information source selection behavior.

(2) Impact of Board Social Capital on Technological Innovation Resources

There are two ways of acquiring resources for enterprise technology innovation: an economic transaction and a social transaction. Board structure-dimensional social capital, relationship-dimensional social capital, and cognitive-dimensional social capital are the basis of social commerce. They not only influence the access channel of resources (Eisenhardt, 2020) but also interact with the effect of influencing the resource-providing subject, which has an impact on the quantity and quality of resource acquisition. Board structure dimensional social capital is an important influencing factor for TIR, among which (Cancela et al., 2020), the size of the Board social capital network can effectively broaden the communication channels with other subjects of the social network (Ghoshal, 2005; Jackling & Johl, 2009), save a lot of time and search costs, and enhance enterprises' access to technology innovation information resources. The greater the number of Board of Directors connected network members, the broader the channels of extensive relationships that provide enterprises with connections to resource subjects (Jackling & Johl, 2009), and the easier it is for enterprises to access various necessary TIR. In addition, the density of the Board's social capital network can increase the resources exchange's depth, breadth, and efficiency.

In the process of interaction with resource providers, some inevitable conflicts and misunderstandings affect the effectiveness of resource transfer. The Board of Directors' cognitive dimensional social capital can facilitate efficient communication (Post & Byron, 2015), avoid unnecessary misunderstanding (Nicholson & Kiel, 2004), and promote the transfer of TIR. From the perspective of a common language, using a common language between the Board and the network members can improve the Board's ability to reach others and their knowledge, avoiding their alienation and hindering the Board's access to knowledge due to differences in language and rules. From the perspective of shared vision and values (Marquis et al., 2007), whether or not social network members share a common vision also affects cooperation and the development and maintenance of relationships. A shared vision between the Board and

social network members can facilitate efficient communication and more opportunities to exchange information and resources freely.

(3) Impact of Board Institutional Capital on Technological Innovation Resources

Due to the multiple objectives of technology innovation resources acquisition, the uncertainty of the internal and external environment, and the dynamic nature of time, the investment of technology innovation resources for the Board of Directors is often beyond the scope of individual capabilities, which requires cooperation among Board members. Collaborative resource acquisition behaviors such as information exchange, brainstorming (Hamari et al., 2016), and consensus building among Board members can identify the demand for technology innovation resources more accurately. They can choose a more appropriate path for TIR while dealing with the technology innovation resource providers more efficiently. Institutional capital, such as incentives and constraints, practices and culture of Board, determines the way of thinking and action of Board members (Alonso Alvarez, 2015), which guarantees Board cooperation and plays an essential role in each stage of TIR.

Differences in the way of thinking of Board members can affect their views on resource acquisition. Contradictions and conflicts may arise among members in the process of technological innovation resources acquisition, creating a state of emotional discord among Board members and making it difficult to establish good cooperative relationships (Dorigo et al., 1996). Organizational routine behavior is regular, consistent, and systematic under the role of conventions, according to which each person has knowledge of others' behavior and serves as a basis for decision-making, providing instructions, and establishing a truce mechanism through procedures (Ahmad et al., 2020). The stable behavior brought by higher behavioral tacit understanding makes it easier for Board members to predict the behavior of other members, which facilitates the coordination of relations between them and can accelerate the common knowledge of resource acquisition. The easier it is to produce consistent behavior and increase the TIR in the stages of technological innovation resources demand identification (Hansen & Winther, 2011), technological innovation resources acquisition path selection, and interaction with technological innovation resources-

providing subjects, the more likely it is to generate consistent behavior and increase the efficiency of technology innovation resources acquisition.

A good Board culture is among the essential foundations for Board members to cooperate and share resources. In an uncertain environment, a high level of Board trust culture in which trust among Board members facilitates the effective formation of psycho-social self-control mechanisms among team members helps to enhance members' confidence and positive expectations of each other's behavior (Adebayo et al., 2023). In an open and inclusive Board culture environment, Board members will not feel embarrassed or rejected for offering different or pointed views. They will be encouraged to question current practices and share challenging opinions with others, contributing to the team's interest in increasing Board members' psychological security (Zhou et al., 2019). Members may be more willing to express their views without considering the possibility of rejection, thus increasing the willingness to share information about innovation strategies and approaches (Eisenhardt, 2020).

2.6.3 Board Capital Impact on Quality of Technological Innovation Strategy

(1) The Impact of the Human Capital of the Board on the Quality of the Technological Innovation Strategy

Strategic decision-making is a typical risky decision, and dual system theory has two kinds of information processing systems when judging risks: analytical and rational decision-making; and automated empirical decision-making (Amit & Schoemaker, 2021). The analytical and rational decision-making system requires consciousness, and the decision is made through logical rules and probability calculations, which is a cognitive decision-making process; the automated empirical decision-making system requires less consciousness (Cho & Hambrick, 2006), and the decision is made mainly through experience or connections between things, and emotions play an essential role. The knowledge, experience, competence, and inner qualities of Board members are the basis for cognitive and emotional decisions and are the key factors influencing the quality of strategic decisions (Kohli & Jaworski, 2019). The higher the knowledge level of Board members, the better the Board of Directors will understand the internal management of the company and the state of competition the company is in, the needs of customers and the capabilities of suppliers, as well as being able to make scientific

predictions about the current state of industry development and future development trends of the company, which helps the Board of Directors to identify the environment correctly, better combine technological innovation with the external environment, and adapt to the external market environment strategic path decisions (Lee & Lee, 2015). The more complex the overall knowledge structure of Board members, the more information they can receive from the object (Chen et al., 2022). The more comprehensive the understanding formed, the broader the scope of environmental information scanning and the higher the degree of interpretation of environmental information (Marquis et al., 2007). So the strategic model decisions can be adapted to the external environment.

The high risk and uncertainty of technological innovation activities place high demands on decision-makers' abilities (Geels, 2002). Board of Directors' decision-making ability, thinking ability, memory ability, and attention ability affect cognition in the strategic decision-making process and the quality of the decisions (Myers, 2019). A committee of directors with solid attention skills can perceive changes in the internal and external environments of the company, identify and discover market opportunities, search for practical information, and form correct judgments based on intuition or rationality of the information available. A Board of Directors with more vital rational cognitive ability has a broader vision and view (Chen et al., 2022). It can analyze and process more practical knowledge in strategy selection and formulation, thus making technological innovation strategies better suited to the company. The Board of Directors with more robust memory capacity, increased long-term memory knowledge, and increased capacity of working memory closely related to decision-making can enhance the Board's ability to handle ambiguous information, recall relevant information for effective coding and processing promptly, and make high-quality technology innovation strategy decisions (Latour, 2022).

The inner qualities of Board members lead to changes in emotional processing that profoundly affect various higher cognitive processes of the Board, including memory, judgment, and decision-making, which in turn affect the quality of strategic decisions. Positive work attitudes and behaviors cause decision-makers to experience positive emotions generated by the state of mind, emotions, and affective moods evoked

by the work object during the decision-making process. Positive emotions help to enhance the functioning of these areas of executive attention and working memory and enable high-quality decisions. Enterprising directors have higher cognitive needs because they prefer to trace their roots, think and process more about the advice from social networks (Waheed et al., 2019), overcome the mental framing effect, make strategic decisions on technological innovation more efficiently and comprehensively, and are more compatible with the internal conditions and external environment of the company.

(2) Impact of Board Social Capital on the Quality of Technological Innovation Strategy

In the face of a complex and changing business environment, it is difficult for an individual to be omniscient, even if he or she is outstanding, by combining the "real person" concept of finite rationality theory. Similarly, as a subsystem of the enterprise, the Board of Directors is also a "real person" compared to the whole external system (Carter et al., 2003). Therefore, dealing with unstructured and uncertain strategic decisions is difficult because Board members need help to grasp all the information. The Board of Directors and external stakeholders need to exchange information, integrate resources, and even make joint decisions to integrate the wisdom of all parties to compensate for Board members' lack of wisdom and experience. According to information decision theory, the basis of decision reliance is information (Nelson, 2020). Social connections help the Board obtain more information for strategic decisions. The larger the size of the Board's social network, the more help it gets from social network members. More social network members from different industries can provide entrepreneurs with new and heterogeneous information. The more adequately they scan the environment, the better they can make high-quality strategic decisions on technological innovation. In addition, the number of interactions between the Board and social network members (Sauerwald et al., 2014), the degree of closeness, and the duration of interactions can affect the quality of information. The more frequent and reciprocal the interaction between the Board and other network members, the higher the quality of the information resources, which contributes to the quality of the technological innovation strategy decisions (Grant, 2019).

The Board of Directors needs to interpret the information obtained from the environmental scan creatively, give it positive strategic meaning, and use it as a basis for forming strategic solutions. In addition to providing information resources and emotional support (Eisenhardt, 2020), social networks can provide advice. Members of social networks can draw on their expertise and experience in their fields to help Boards of Directors analyze cutting-edge market and technology trends and develop strategic responses. Board social capital helps the Board brainstorm (Hillman et al., 2007), obtain diversified decision-making suggestions, provide more alternatives, and comprehensively evaluate the decisions to ensure the quality of strategic decisions on technology innovation (Latour, 2022). Trust, obligations, and expectations in the Board's relational dimension of social capital influence the motivation and willingness of network members to provide advice.

Board social cognitive dimensions simplify members' understanding of group goals, drive members to behave in a manner consistent with organizational requirements, and contribute to the effectiveness of Board interactions with external stakeholders, which positively affects the quality of strategic decisions on corporate technology innovation.

(3) Impact of Board Institutional Capital on the Quality of Technological Innovation Strategy

Technological innovation strategic decisions are formed based on the interaction of multiple behaviors of Board members. During the enterprise's internal and external environmental scanning, environmental interpretation, and action phases, Board members must engage in team behavioral integration regarding cooperative behavior (Grant, 2019), information exchange, and joint decision-making. Institutional capital such as Board incentives and constraints mechanisms, practices, and culture serve as the basis for Board team behavioral integration and significantly affect the effectiveness of behavioral integration. A well-developed Board mechanism can improve the cohesiveness of the Board team and help the Board team to improve communication (Moraes et al., 2010).

Board of Directors can improve the QTIS decisions by overcoming the adverse effects of team politics (Goh, 2009). A scientific and reasonable Board incentive

mechanism can encourage Board members to give full play to their roles and form certain internal cohesion, increase the willingness to exchange information among themselves to bring enough and correct differential information for decision-making (Tavassoli & Karlsson, 2015), and enable Board to have a comprehensive and transparent knowledge of the technological innovation environment and improve the QTIS decision making. A sound Board of Directors' constraint mechanism can promote the internalization of collective goals into individual goals, which can strengthen Board members to harmonize personal goals with collective goals, make them become rational agents of collective goals, reduce the adverse effects brought by team politics, and improve the QTIS decision making. There are inevitably collisions in the Board decision-making process due to arguments over views and opinions or differences in value choices. These situations may lead to a state of emotional discord among Board members (Dziak et al., 2019). Emotional conflicts may also affect the cognitive ability among members. Team members may spend a lot of time and energy dealing with interpersonal relationships, which may also reduce the integration of Board team behavior. Practices can reconcile conflicts and contradictions among Board members, facilitating mutual communication and collaboration among them. Communication often enables executive team members to discuss issues face-to-face and effectively integrate multifaceted information resources, thereby improving the quality of strategic decisions.

2.6.4 Technological Innovation Resources Impact on the Quality of Technological Innovation Strategy

The key influencing factors of TIP are identified: the access to technical innovation strategic resources and the quality of technological innovation strategic decisions. These two influencing factors are not independent of each other. A high-quality innovation strategy requires compatibility with the external environment and internal resources capabilities (Robert et al., 2020). However, internal resources often constrain most firms from making innovation strategy decisions compatible with the external environment (Vandenbroucke et al., 2014). Studies have also shown that firms with a stable supply of core resources make higher-quality technology innovation strategy decisions than firms with a scarce collection of core resources.

In the following aspects: the quantity and QTIS information affect decision makers' prediction of external market demand and judgment of the market environment (McWilliams & Siegel, 2001). It is an important influencing factor in the QTIS decisions. The stronger the ability of enterprise technology innovation information acquisition, the higher the quality of technology innovation strategy information resources. It is essential to expand the scope of application of resources, and to enhance the flexibility of enterprise technology innovation strategy (Ireland, 2022). Significant technological innovation information can reduce the time for the Board to make technological innovation strategy decisions, strengthen the excitability of technological innovation strategy, and improve the flexibility of technological innovation strategy. Knowledge resources from external sources can alleviate the problem of the constraint of internal knowledge resources, improve the richness of technological innovation solutions (Nelson, 2020), optimize the conception of technological innovation strategy decisions, improve the speed of technological innovation strategy decisions, and promote enterprises to formulate high-quality technological innovation strategies (Grant, 2021).

Innovation strategy decision-making environment has a high degree of uncertainty and dynamics; if high-tech enterprises in the process of economic transactions obtain the trust of the counter-party (Wen, 2009), it is easy to fight for preferential payment methods, high-quality supply of raw materials, loyal customers, and understanding of competitors. The stronger the capital acquisition ability of high-tech enterprises, the more they can comprehensively compare the advantages and disadvantages of multiple medium solutions, and the greater the margin of choice of technological innovation strategy. The more capital acquired by high-tech enterprises in the process of innovation strategy decision (van de Vrande et al., 2019), the less the financial constraints on innovation strategy decision, and the more innovation strategy decision options are formed, which can improve the freedom of innovation strategy choice and improve the quality of innovation strategy decision (Albino et al., 2015).

2.6.5 The Relationship Between Board Capital and Technological Innovation Performance

(1) The Relationship Between Board Capital and Technological Innovation Performance

Research on the relationship between Board capital and firm innovation performance is scarce, and scholars have primarily conducted studies on the relationship between Board capital and strong innovation. Relevant studies have found that both the Human capital of the board and the Board's social capital influence corporate innovation (Chen, 2014) and the performance of corporate technological innovation. Work experience and social experience affect firms' ability to identify market opportunities and dominate the market with new products from innovative outputs (Hall, 2020), which can improve firm performance and ultimately increase value by increasing competitive advantage. The results of the empirical evidence conducted in different regions show that the Human capital of the board significantly affects the diffusion of technological innovation outcomes. In contrast to these views, it is argued that the Human capital of the board indirectly affects variables related to firm operating results by influencing firm innovation inputs (Ooi et al., 2017). Collecting relevant studies on the relationship between human capital and innovation technology performance at the country level and the firm level, it can be argued that there is a closer relationship between the Human capital of the board and TIP.

A composite indicator of a firm's human capital reflects the firm's knowledge, professionalism, and skills by synthesizing three indicators of employees' average years of work, average age, and average education. An empirical analysis of the relationship between the firm's human capital and technological performance shows that a firm's human capital could positively influence a firm's social capital (Grant, 2021), which in turn affects innovative technological performance (Demsetz & Lehn, 2020). Using two indicators of executive work experience and technical background to reflect administrative and human capital, the study finds that human organizational capital contributes to corporate patent output and further analyzes the impact of innovation inputs on innovation output, concluding that the efficiency of innovation output driven by executive human capital is higher than the efficiency of innovation output achieved

by innovation inputs (Tavassoli & Karlsson, 2015). Several scholars have explored the relationship between Board social capital and firm innovation performance from resources dependence theory but have obtained different conclusions. Board social capital also has a positive impact on the firm's innovation value performance (Cancela et al., 2020).

(2) Relationship Between Board Capital and Technological Innovation Performance

The problems of the current research on the relationship between Board capital and corporate technological innovation include the following: First, the research on the relationship between Board capital and corporate technological innovation has a single perspective (Jackling & Johl, 2009). Most studies have analyzed the relationship between Board capital and corporate technology innovation from one aspect of Board capital, such as education level, tenure, professional background, corporate relationship, government relationship, financial relationship, etc. (Waheed et al., 2019). Few studies have systematically analyzed the relationship between Board capital and corporate technology innovation from the perspective of Board capital as a whole, and the single philosophy of research has led to no consistent conclusion on the relationship between Board capital and corporate technology innovation (Vandenbroucke et al., 2014). Second, there needs to be more research on the relationship between Board capital and TIP. Currently, most scholars focus on the influence of Board capital on the degree of technological innovation investment. Fewer scholars study the relationship between the level of capital owned by the Board and the TIP of enterprises, and even fewer scholars study the influence mechanism of Board capital on the TIP of enterprises (Grant, 2021).

(3) Relationship Between Board Capital with Technological Innovation Performance Through Technological Innovation Resources

TIR behavior is one of the Board of Directors' main behaviors in the technology innovation process. The result of realizing Board capital value based on resource acquisition behavior is that high-tech enterprises can acquire sufficient technology innovation resources. By identifying key factors of TIP, technological innovation resources acquisition is the key influencing factor of the TIP of high-tech enterprises

(Grant, 2021). Accordingly, this study proposes the first path that Board capital affects the TIP of high-tech enterprises: through technological innovation resources acquisition. The specific analysis is as follows:

Regarding the relationship between Board capital and the acquisition of TIR, Board capital is a crucial contributor to the purchase of TIR (Lee & Bozeman, 2005). According to the previous analysis, Board capital is the basis of Board resources acquisition behavior (Chen et al., 2022). Identifying resources needed for technological innovation, selecting resource acquisition methods, and interacting with resource providers is essential. Regarding the interrelationship between Board capital, TIR, and technology innovation performance of high-tech enterprises, a high level of Board capital tends to acquire high-quality and timely technology innovation resources, which is conducive to improving technology innovation performance (Zhou et al., 2019). Therefore, this study suggests a path for Board capital to influence technology innovation performance by affecting access to technology innovation resources.

(4) Relationship Between Board Capital and Technological Innovation Performance Through the Quality of Technological Innovation Strategy Decisions

Technological innovation strategic decision-making behavior is another essential behavior of the Board in the process of technological innovation. The result of capital value realization of the Board based on technological innovation strategic decision-making behavior is the improvement of technological innovation strategic decision-making quality of high-tech enterprises (Raheja, 2005). By identifying critical factors of TIP, the quality of technological innovation and strategic decision-making are the key influencing factors of TIP of high-tech enterprises (Eisenhardt, 2020). Accordingly, this study proposes a second path for Board capital to influence the TIP of high-tech enterprises: through technological innovation.

Regarding the relationship between Board capital and the QTIS decisions, Board capital is crucial to the QTIS decisions. Board capital is the basis of strategic decision-making behavior (Morgan & Hunt, 2020). It plays a vital role in identifying, selecting, and processing information resources and the various decision-making stages in the technological innovation strategic decision-making process (Demsetz & Lehn, 2020). Regarding the relationship between technological innovation strategic decisions

and the TIP of high-tech enterprises, the quality of technological innovation strategic decisions catalyzes the TIP of high-tech enterprises. Technological innovation in high-tech enterprises is an ever-changing and complex continuous process (Christa et al. et al., 2005).

On the one hand, a technology innovation strategy can help enterprises clarify their market positioning and determine their technology innovation goals to be well prepared to meet the ever-changing technological development (Fama, 2021). On the other hand, technology innovation strategy also plays a role in unifying employees' perceptions and improving their unity. Having employees properly participate in the system's conception, formulation and implementation is conducive to generating comprehensive perceptions and rational behavior. It also stimulates the initiative, innovation, and participation of employees to a great extent, which in turn improves the efficiency of TIR of the company. In terms of the interrelationship between Board capital (Chebbi & Ammer, 2022), technology innovation strategy decision quality, and technology innovation performance of high-tech enterprises, a Board with more money helps to improve the QTIS (Jeon et al., 2006), and improvement of technology innovation strategy decision quality helps to enhance technology innovation performance. Therefore, this study suggests that the path of Board capital affecting innovation performance by influencing the rate of technological innovation strategy decisions is possible in reality (Loughran & Mcdonald, 2011).

(5) Quality of Technological Innovation Strategy Decisions Impact on Technological Innovation Performance

The QTIS significantly affects technology innovation performance. If the QTIS is high, firms are more likely to implement effective technology innovation plans and thus achieve better technology innovation performance (Mintzberg, 2020).

Firms with higher-quality technology innovation strategy decisions are more likely to choose the right technology innovation direction, invest resources in the most promising areas, and thus achieve better technology innovation performance (Lee & Lee, 2015). The QTIS affects the choice of technology innovation direction, one of the critical factors for the success of technology innovation. Specifically, the choice of technology innovation direction considers several factors, such as market demand,

competitors, technology trends, stretched resources, capabilities, etc. Suppose an enterprise's technological innovation strategy decision considers these factors and conducts scientific analysis and evaluation (Nelson, 2020). In that case, the chosen technological innovation direction is more likely to adapt to market demand, have a differentiated competitive advantage, meet the requirements of enterprise resources and capabilities (Iacob et al., 2012), etc., and improve TIP. On the contrary, if enterprises lack scientific analysis and evaluation while choosing technological innovation direction, blindly follow the trend, or pay too much attention to internal resources and technical capabilities, they may select technological innovation directions that are not suitable for market demand, lack competitive advantages, and cannot bring into play the benefits of enterprise resources and capabilities, which will reduce TIP. Therefore, the quality of the technological innovation strategy decision affects the choice of technological innovation direction (Simon, 2021), and the TIP is improved by choosing the appropriate technological innovation direction.

On the contrary, if there are problems in technology innovation strategy formulation, resource allocation, and team formation, it may lead to the lack of support for the decision of technology innovation input and thus reduce the technology innovation performance (Byun et al., 2017). Therefore, the quality of the technology innovation strategy decision affects the decision of technology innovation input. Through scientific analysis and evaluation, an appropriate technology innovation strategy is formulated, resources are reasonably allocated, and teams collaborate to improve the quality of technology innovation input decisions and improve technology innovation performance (Ooi et al., 2017).

Firms with higher-quality technology innovation strategy decisions are more likely to implement effective risk management programs, including risk assessment and risk management strategy development, to reduce technology innovation risks and improve technology innovation performance (Ireland, 2022). The QTIS significantly affects technology innovation risk management decisions. Specifically, high-quality technology innovation strategy decisions will help organizations better identify, assess, and manage risks in technology innovation (Robert et al., 2020). Technology innovation strategy decisions should include steps to determine possible risks that may arise. In

this process, the organization can identify the risks and challenges of technological innovation, such as the feasibility of technology implementation, changes in market demand, and the lack of resources investment. Second, high-quality technology innovation strategy decisions require corresponding risk management measures (Lumpkin & Dess, 2001). These measures may include budgetary control of technology development, composition and management of technology teams, and schedule and quality control of technology implementation. Finally, technology innovation strategy decisions also need to consider how to classify and deal with different types of risks. For example, for the uncertainty of technology implementation, the organization can reduce the risk by developing multiple scenarios; for the apprehension of market demand, the organization can reduce the risk by market research. Therefore, high-quality technology innovation strategy decisions can help organizations better manage risks in technology innovation, reduce the negative impact of risks on technology innovation performance, and increase the probability of successful technology innovation. The QTIS is essential to technology innovation performance. Companies must focus on improving the QTIS to achieve better performance (Grant, 2021).

Table 2.6 Scholars' Related Research

Variables	Scholars																		
	DiMaggio & Powell, 1983	Dorigo et al., 1996	Nahapiet & Ghoshal, 1998	Hillman & Dalziel, 2003	Graebner & Eisenhardt, 2004	Bapuji & Crossan, 2005	McMullen & Shepherd, 2006	Cho & Hambrick, 2006	Austin et al., 2006	Hopkins et al., 2007	Luo & Tung, 2007	Leitch et al., 2012	Cohen & Levinthal, 2018	Garas & ElMassah, 2018	Meyer & Rowan, 2018	Hillman et al., 2019	Prahalad & Hamel, 2019	Cancela et al., 2020	Feng et al., 2022
Capital of Board	●	●	○	●	○	○	●	●	○	●	●	●	●	●	●	●	●	●	●
HCB	●	●	●	●	●	●	●	●	●	●	○	●	●	●	●	●	●	●	●
SCB	●	●	○	●	○	○	●	●	○	●	●	●	●	●	●	●	●	●	●
ICB		●	○	●	○	○	●	●	○	●	●	●	●	●	○	●	●	●	●
TIR		○		●	●	●	●	○		○		○	●	●	○	●	●	○	
QTIS		○					○	●		●	●	○		●	○	●	●	●	●
TIP	●	●	●		●	●	○	○	●	○	○	○		●	●	●	○	○	

Note: ● indicates a high correlation, ○ indicates correlation exists, and unmarked indicates no correlation. Human capital of the Board (HCB), Social capital of the Board (SCB), Institutional capital of the Board (ICB), Technological innovation resources (TIR), Quality of technological innovation strategy (QTIS), Technological innovation performance (TIP).

2.7 Conceptual Framework

Board capital in this study consists of three dimensions: Human capital of the board, Board social capital, and Board institutional capital. The three dimensions complement each other in their roles and work in synergy. This study considers the personal effects of the three elements of Board capital on the acquisition of TIR and the QTIS decisions and the results of the synergy among the three elements on the purchase of TIR and the QTIS decisions.

Identifying the critical elements of the TIP of high-tech enterprises, the research is that technological innovation resources acquisition and technical innovation strategy decision quality are the intermediate influencing factors in the relationship between Board capital and high-tech enterprises. The influence paths of Board capital on high-tech enterprises' TIP can be considered: "Board capital - TIR acquisition - high-tech enterprises' TIP" and "Board capital - innovation strategy decision quality - high-tech enterprises' TIP." -Innovation strategy decision Quality-Technology innovation performance of high-tech enterprises." Based on the analysis of the internal operation of Board capital and its influence path on technology innovation performance, the following framework model of Board capital influence on technology innovation performance of high-tech enterprises is established, as seen in Table 2.6.

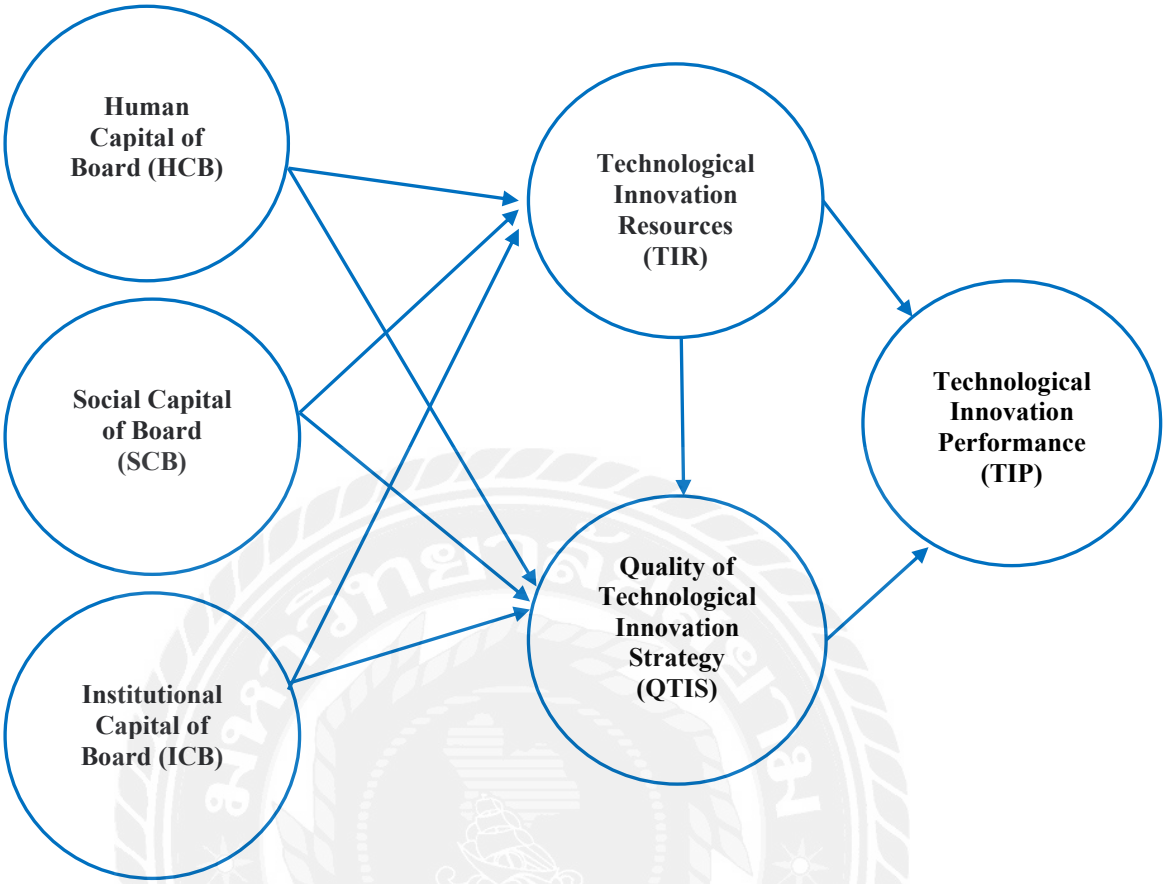

Figure 2.6 Conceptual Framework

The human capital of the board, social capital, and institutional capital constitute the three-dimensional structure of Board capital. The three dimensions are interactive, mutually reinforcing, and synergistic for value realization. Board capital structure refers to the level of each size and the synergistic relationship between the three dimensions, which will not be discussed here. The following analysis will focus on Board governance behavior and Board governance performance.

Board governance function is agreed upon in corporate governance; that is, Board governance function consists of three main aspects: control function, service function, and strategy function. Based on these three Board functions, Board behavior consists of strategic behavior, control behavior, and service behavior.

Control behavior is the Board's role in monitoring the management's behavior to protect the interests of shareholders and stakeholders. This theory is derived from the agency theory, which emphasizes that the responsibility for monitoring and controlling

the behavior of managers rests with the Board, which has the authority to appoint and dismiss the chief executives of the company, to appraise management and organizational performance results, to exercise strategic control, and to supervise management.

Service behavior, which refers to helping the company to obtain external resources (knowledge, information, capital, technology), is based on resources dependence theory, which emphasizes that the Board is responsible for forming essential links with the external environment and that it can respond to changes in the external environment based on the acquisition of crucial resources.

The strategic decision-making behavior of the Board is the highest decision-making body. The strategic function is the core work of the Board. The panel mainly makes the strategic decisions of the company of directors, and the main processes include active participation in the analysis of the strategic environment, identification of strategic proposals, and selection of strategic options. Based on the literature review and analysis of related studies, the final model of this study is proposed. The independent variables are the Human capital of the board, the Board's social capital, and the Board's institutional capital. The dependent variables are TIR, strategy decision quality, and technology innovation performance, as seen in Figure 2.6.

2.8 Conclusion

This study is based on the principal agent, resource dependence, and higher-order echelon theories by combining related research literature. At the same time, the definitions, connotations, measurement dimensions, influencing factors, associated studies of Board capital, technology innovation resources, strategy decision quality, and technology innovation performance are explained. Among them, Board capital includes Board human capital, Board social capital, and Board institutional capital.

Analyzing the three-dimensional structure of Board capital and the components of each dimension, it is concluded that Human capital of the board dimension consists of four elements of knowledge, skills, ability, and intrinsic quality; Board social capital includes three aspects of structural dimension, relationship dimension and cognitive

dimension; ICB has mechanism and practice, and culture ICB includes tool, tradition and culture. Secondly, the three-dimensional interaction relationship, synergistic process, and synergistic value creation path of Board capital are explored, and the three-dimensional synergistic mechanism of Board capital is proposed.

Two critical elements of the TIP of high-tech enterprises are identified: technological innovation resources acquisition and strategic decision quality. The role of the Board and its value creation in the technological innovation process of high-tech enterprises are analyzed by drawing on the SCP (Structure- Conduct- Performance) paradigm. The SCP paradigm belongs to the scope of industrial economics, specifically decomposed: S is Structure, C is Conduct, and P is Performance. The core idea of this paradigm is that the behavior of firms in a market is dominated by the structure of the industry (market structure), and the behavior of firms dominates the performance of firms operating in that market. Based on the above analysis, the SCP paradigm of capital structure, behavior, and implementation of the Board is proposed.

Two ways are proposed: Board capital influences technological innovation resources acquisition through resources acquisition behavior, and Board capital affects technological innovation strategic decision quality through strategic decision behavior. Through rigorous and logical reasoning, the research clarifies the role of Board capital on the TIP of high-tech enterprises. It constructs a framework model of Board capital affecting the TIP of high-tech enterprises. In conclusion, the literature review provides a comprehensive framework and theoretical foundation for studying Board capital and technological innovation implementation. It proposes relevant hypotheses to help future researchers further explore the factors and mechanisms influencing Board capital.

According to the SCP (structure- Conduct -performance) paradigm, the role of board capital in the technological innovation process of high-tech firms is decomposed into three aspects: structure, behavior, and performance. This process is similar to the S->C->P structure, and we will draw conclusions at the end of the analysis.

• Structure: In the SCP paradigm, structure refers to market structure or industry structure. From the perspective of board capital, structure refers to the composition, structure, and characteristics of the board, including members' background, experience, and expertise. The structure of the board of directors of a high-tech firm will have a

direct impact on the acquisition of technological innovation resources and the quality of strategic decisions. For example, board members with extensive experience and a wide network of relationships may be better able to access innovation resources and be able to provide strategic advice with greater depth and breadth.

- Conduct: Behavior refers to the specific actions and decisions taken by board members in practice. The behavior of the board of directors will have a direct impact on the technological innovation process of the enterprise. Behavioral factors include the degree of cooperation among board members, communication efficiency, and decision-making speed. Efficient board behavior can facilitate the acquisition of technological innovation resources and ensure that the formulated technological innovation strategy can be effectively implemented.

- Performance: Performance refers to the performance and results of a firm in the marketplace. In the context of technological innovation, performance can include indicators such as product innovation, market share growth, and revenue growth. The structure and behavior of board capital will directly affect the performance of the firm. Excellent board capital can help enterprises better respond to market changes and improve the success and efficiency of technological innovation, thus achieving superior performance.

After comprehensively analyzing the role of board capital in the technological innovation process of high-tech enterprises, we can conclude that the structure and behavior of board capital have an important impact on the acquisition of technological innovation resources and the quality of strategic decision-making, which in turn affects the performance of enterprises. Enterprises with excellent board capital tend to be able to acquire technological innovation resources more effectively, formulate more rational technological innovation strategies, and ultimately achieve better performance. Therefore, board capital plays a key role in the entire technological innovation process.

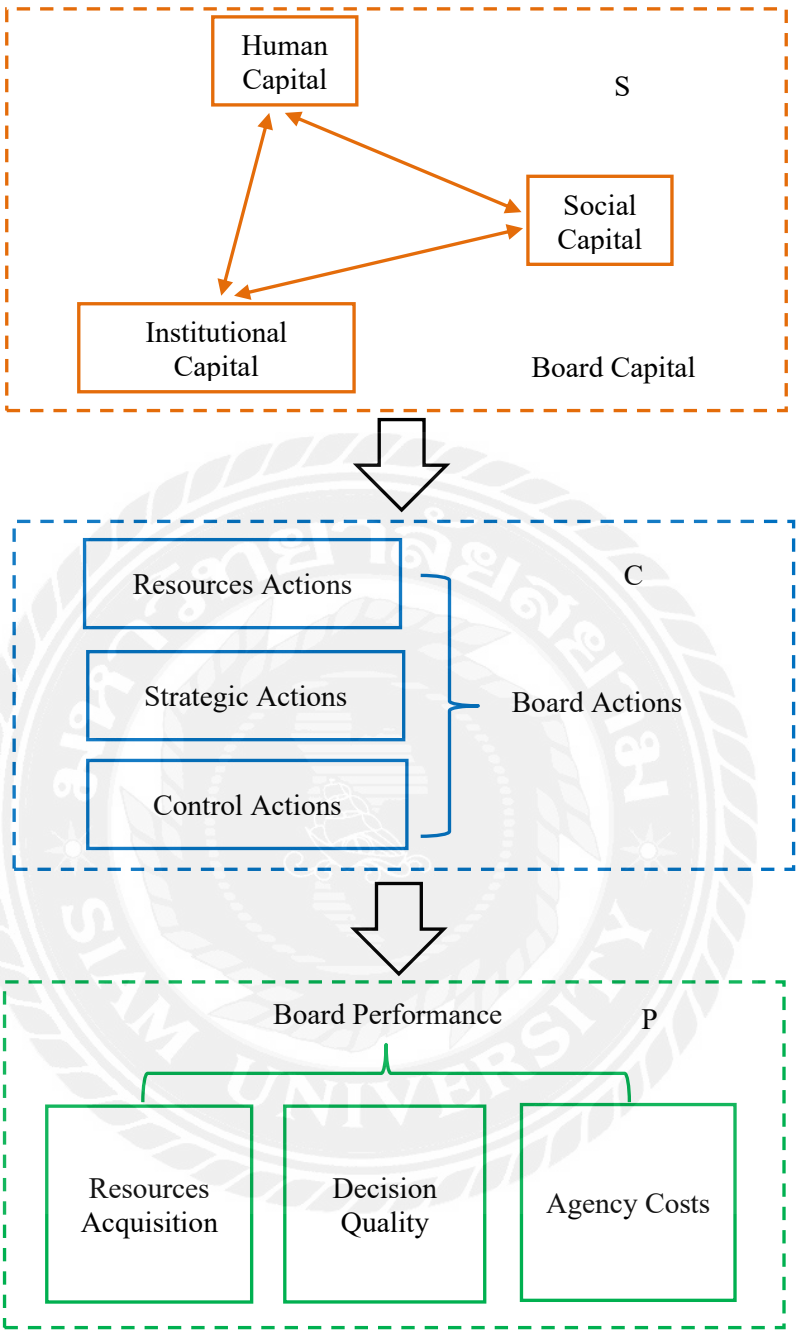

Figure 2.7 Structure - Conduct - Performance Framework of Board Capital

CHAPTER 3
RESEARCH METHODOLOGY

This Chapter is Divided into 9 Parts as Follows:

3.1 Research Design

3.2 Operationalization of Variables

3.3 Hypotheses

3.4 An Analytical Model

3.5 Population and Sampling Methods

3.6 Questionnaire Pretest

3.7 Item Analysis of the Quality of the Measurement Tool.

3.8 Statistical Method of Analysis

3.9 A Model of Board Capital for Innovation Performance of High-Tech Enterprises

3.1 Research Design

This study is a research on the influence of Board capital on the innovation performance of high-tech enterprises. Firstly, the research analyzes the relationship between human capital, social capital, and institutional capital of the Board and technological innovation resources acquisition by refining the content of technological innovation resources acquisition in three aspects: specialized innovation knowledge acquisition, capital acquisition, and information acquisition. Secondly, the research analyzes the relationship between human capital, social capital, and institutional capital of the Board and the quality of technological innovation strategic decisions by refining the content of technological innovation strategic decisions in three aspects: technical innovation model decisions, technological innovation path decisions, and technological innovation investment decisions. Again, the relationship between acquiring technology innovation resources, QTIS, and technology innovation performance is analyzed. Finally, the relationship between technological innovation resources acquisition and technological innovation strategic decision quality and the theoretical model of the study of the influence mechanism of Board capital on high-tech enterprises is constructed.

The quantitative research method is used in this study. Questionnaires are identified based on the literature review, and questionnaires and relevant data are collected. The variables measured in this study are the Human capital of the board, Board social capital Board institutional capital, technology innovation resources access, QTIS, and technology innovation performance.

Most empirical studies on Board capital, TIR, and technology innovation performance have used questionnaires. If properly implemented, this method is the most common one for obtaining data for quantitative management research as it provides reliable and detailed first-hand data. The questionnaire design of this study is based on the premise that the design objectives are set. To make the content of the questionnaire more accurately reflect the actual situation of the company, the first part of the questionnaire is a basic overview of the respondent, the Board, and the company being surveyed. The second part investigates Board capital, technology innovation resources acquisition, technology innovation strategy decision quality, and enterprise technology innovation performance. Board capital is divided into three dimensions: Human capital of the board, Board social capital, and Board institutional capital, with 20 questions. There are six questions on acquiring technology innovation resources, six questions on QTIS, and four on enterprises' technology innovation performance. The total number of questions is 36.

3.2 Operationalization of Variables

3.2.1 Independent Variables

3.2.1.1 Human Capital of the Board

Board capital is an abstract idea that cannot be directly observed and can only be measured by scientific conceptual measurement models or methods based on understanding its theoretical conceptions. According to the difference in the intrinsic relationship between measurement indicators and theoretical concepts, conceptual measurement models can be divided into constitutive measurement models and reflective measurement models. Based on the literature review, this study classifies Board capital into three dimensions: human capital, social capital, and institutional

capital. The entries for Human capital of the board focus on four dimensions of Board knowledge, skills, abilities, and intrinsic qualities, comprising five items.

Table 3.1 HCB Measurement Item

Dimension	Measuring Item	NO.
Human Capital of Board (HCB)	1. Board members as a whole possess rich professional knowledge.	BHC1
	2. Board members as a whole can use communication skills to reach a consensus.	BHC2
	3. Board members as a whole can quickly identify the causes of problems and the appropriate solutions.	BHC3
	4. The board as a whole members have strong attention, thinking, and memory abilities.	BHC4
	5. Board members have optimistic attitudes to solve problems.	BHC5

3.2.1.2 Social Capital of Board

The existing research on Board capital measurement is mainly based on the constitutive measurement model, i.e., the constitutive indicators of various aspects of Board capital are selected, and the synthetic indicators of Board capital are formed using specific methods. While using the constitutive measurement model to measure Board capital, there are drawbacks such as difficulty in ensuring the consistency between theoretical concepts and variable measurements, conceptual ambiguity, and statistical imprecision, which may cause deviation of statistical results from the actual situation. The entries for Board social capital focus on three dimensions: structural dimensional social capital, relational dimensional social capital, and cognitive dimensional social capital, with a total of 6 items.

Table 3.2 SCB Measurement Items

Dimension	Measuring item	NO.
Social Capital of Board (SCB)	6. The Board of Directors is in contact with many customers, suppliers, enterprises, scientific research institutes, universities, technical intermediary organizations, governments, and financial institutions.	BSC1
	7. The Board of Directors frequently contacts customers, suppliers, enterprises, scientific research institutes, universities, technical intermediary organizations, governments, and financial institutions.	BSC2
	8. Mutual trust exists between the Board of Directors and customers, suppliers, enterprises, scientific research institutes, universities, technical intermediary organizations, governments, and financial institutions.	BSC3

Dimension	Measuring item	NO.
	9. Mutually beneficial cooperation exists between the Board of Directors and customers, suppliers, enterprises, scientific research institutes, universities, technical intermediary organizations, governments, and financial institutions.	BSC4
	10. The Board of Directors can communicate effectively with customers, suppliers, enterprises, scientific research institutes, universities, technical intermediary organizations, governments, and financial institutions due to the shared benefits.	BSC5
	11. Similar value orientation exists between the Board of Directors and customers, suppliers, enterprises, scientific research institutes, universities, technical intermediary organizations, governments, and financial institutions due to the shared benefits.	BSC6

3.2.1.3 Institutional Capital of the Board

In contrast, the reflective measurement model is closer to the positivist epistemological tradition, as the theoretical constructs represent the objective reality of the phenomenal world. The selected measurement indicators are the various external manifestations of this objective existence. This study uses the reflective measurement model to measure Board capital. The entries on Board institutional money are designed in three aspects: mechanism, practice, and culture, with six items in total.

Table 3.3 ICB Measurement Items

Dimension	Measuring Item	NO.
Institutional Capital of Board(ICB)	12. The material and spiritual incentive mechanisms of the Board of Directors are relatively complete and independent.	BIC1
	13. The systems of the Board of Directors and the audit committee are complete.	BIC2
	14. There is a clear procedure to follow in a specific task undertaken by the Board of Directors.	BIC3
	15. Board members have a good rapport with each other and understand each other's intentions quickly.	BIC4
	16. Board members trust each other.	BIC5
	17. The Board of Directors encourages its members to fully express their views in collective decision-making.	BIC6

3.2.2 Dependent Variables

3.2.2.1 Technological Innovation Resources

Currently, the scale of resource acquisition is mainly reflected in quantitative and qualitative characteristics of resource acquisition. The number of resources, i.e., the adequacy and quality of resources, can generally be operationalized as the timeliness, accuracy, usefulness, and cost-utility of information. Scholars in subsequent studies have invoked this idea, improved the characteristics of different resource types, and developed scales for different types of resource acquisition. In the study of social capital and resources acquisition, of technological innovation of resources-based enterprise executives, the investment of resources is divided into three dimensions: information resources acquisition, knowledge resources acquisition, and financial resources acquisition, which are measured in terms of the quantity and quality of different types of resources. In the study of social capital and knowledge creation of knowledge-based enterprises (Yli-Renko et al., 2002), the knowledge acquisition scale is designed regarding timeliness and adequacy of knowledge acquisition. Information acquisition is measured in terms of the degree of accuracy, usefulness, and timeliness of information in the relationship between entrepreneurial social capital and strategic decision quality. Drawing on the scales of scholars' empirical studies and relevant empirical studies, this study divides resources into three categories: information, knowledge, and capital. It measures technological innovation information acquisition in terms of the adequacy and aspect of information acquisition, technological innovation knowledge acquisition in terms of the accuracy and aspect of specialized innovation knowledge acquisition, and specialized innovation capital acquisition in terms of the low cost and adequacy of technological innovation capital acquisition. The final scale of technology resources acquisition is shown in Table 3.4.

Table 3.4 TIR Measurement Item

Dimension	Measuring Item	NO.
Technological Innovation Resources(TIR)	21. Enterprises can timely acquire information for technological innovation.	TIR1
	22. Enterprises can acquire sufficient information for technological innovation.	TIR2
	23. Enterprises can timely acquire knowledge for technological innovation.	TIR3

Dimension	Measuring Item	NO.
	24. Enterprises can acquire a large amount of knowledge for technological innovation.	TIR4
	25. Enterprises can timely acquire the funds for technological innovation.	TIR5
	26. Enterprises can acquire sufficient funds for technological innovation.	TIR6

3.2.2.2 Quality of Technological Innovation Strategy

For the evaluation of strategic decision quality, research scholars have proposed criteria: internal consistency, environmental consistency, adaptability, and degree of risks. Based on the strategic scale of strategic decision-making in the study, concerning relevant theoretical and empirical studies, this study evaluates two aspects of technological innovation path decision and technological innovation mode decision from the perspective of the adaptation of technological innovation strategy to the internal conditions and external environment of the enterprise. The internal conditions considered for technical innovation path decision include knowledge system structure, innovation personnel strength, and organizational learning ability; the external environment consists of the external market environment and external policy environment. The internal conditions considered in the decision of technology innovation mode include technology capability, network capability, and innovation results protection mechanism; the external environment considered consists of the market environment and policy environment. The internal conditions considered for technology innovation investment decisions are cash capacity and risk-bearing capacity; the external environment considered includes the market environment and policy environment, forming the quality scale of the technology innovation strategy decision, as shown in Table 3.5.

Table 3.5 QTIS Measurement Item

Dimension	Measuring item	NO.
Quality of technological innovation strategy (QTIS)	27. The technological innovation path of enterprises is consistent with internal conditions such as knowledge system structure, innovation personnel capability, and organizational learning ability.	DQ1
	28. The technological innovation path of enterprises is consistent with the external market and policy environments.	DQ2

Dimension	Measuring item	NO.
	29. The technological innovation mode of enterprises is consistent with their technical capability, network capability, and innovation protection mechanism.	DQ3
	30. The technological innovation mode of enterprises is consistent with the external market and policy environments.	DQ4
	31. The technological innovation investment mode of enterprises is consistent with the cash capacity and risk-bearing capacity.	DQ5
	32. Enterprises' technological innovation investment mode is consistent with the external policy and market environments.	DQ6

3.2.2.3 Technological Innovation Performance

TIP refers to some results that can be objectively measured and perceived as the direct output of technological innovation activities, which can be reflected by technical performance and economic performance. Technology performance is mainly formed in two movements: technology research and development and technology industrialization. The scientific and technological results obtained from research and development activities reflect the early technical value of technological innovation, mainly the results of the knowledge technology category. The number of patents granted for inventions is the direct innovation result of technology development activities, which is an international standard measurement index of technological innovation output. Industrialization completes all technical issues from technology development to trial production to meet production needs. The most crucial work is new products that can be produced. The number of new product development projects is the leading indicator to measure the success of technical output in the industrialization stage of technological innovation. Therefore, this study selects two hands to reflect the technological performance: the number of patents granted for inventions, and the number of new product projects developed. The ultimate purpose of technological innovation in high-tech enterprises is to use new products or technologies to improve business performance and obtain economic benefits. Therefore, this paper selects the financial indicators reflecting the operating performance to measure the economic performance. Total asset margin represents the overall profitability of all assets, including net assets and liabilities. It is used to evaluate the overall profitability of an

enterprise using all purchases, which is an important indicator to assess the operational efficiency of the enterprise's assets. Net cash flow from operations is the fundamental guarantee for sustainable business operation, which not only provides resources for expanding reproduction but also is a decisive factor for the strength of liquidity of an enterprise. By analyzing the cash flow status of an enterprise, it is possible to gain a more objective perspective on its operations and evaluate management performance. Since an enterprise's net operating cash flow index is affected by its size factor, this paper selects the cash-asset ratio of operational activities to measure its net operating cash flow. The final technology innovation performance scale is formed, as shown in Table 3.6.

Table 3.6 TIP Measurement Item

Dimension	Measuring Item	NO.
Technological Innovation Performance (TIP)	33. Compared with similar enterprises, the number of patents granted to enterprises is higher.	DQ1
	34. Compared with similar enterprises, the number of new product projects developed by enterprises is higher.	DQ2
	35. Compared with similar enterprises, the profit margin of the total assets of enterprises is higher.	DQ3
	36. Compared with similar enterprises, the cash assets of operating activities of enterprises are higher.	DQ4

3.2.3 Control Variables

By combining principal-agent theory, resources dependency theory, and higher echelon theory, the control variables of the study are proposed mainly based on the main characteristics of Board capital. These include the employee's age, gender, job position, years of experience, nature of the firm, and the number of Board members.

3.3 Hypotheses

The relationship between Board capital, technology innovation resources, technology innovation strategy decision quality, and technology innovation performance variables is proposed by combining principal-agent theory, resources dependence theory, and higher echelon theory. A conceptual model is constructed. The independent variables of Board capital in Board and ICB are proposed with technology

innovation strategy decision quality and technology innovation performance. The hypothesis of the relationship between Board capital variables of Human capital of the board, Board social capital, and Board institutional capital, and the quality variables of technological innovation, strategic decision-making, and TIP is proposed.

Therefore, the assumptions related to the conceptual model are summarized as follows:

Table 3.7 The Summary of the Hypothesis

NO.	Hypothesis
H1	The HCB of high-technology companies has a positive effect on TIR.
H2	The HCB of high-technology companies has a positive effect on QTIS.
H3	The SCB of high technology companies has a positive effect on TIR.
H4	The SCB of high-technology companies has a positive effect on QTIS.
H5	The ICB of high-technology companies has a positive effect on TIR.
H6	The ICB of high-technology companies has a positive effect on QTIS.
H7	The TIR of high technology companies has a positive effect on QTIS.
H8	The TIR of high-technology companies has a positive effect on TIP.
H9	The QTIS has a positive effect on TIP in high-technology companies.

3.4 An Analytical Model

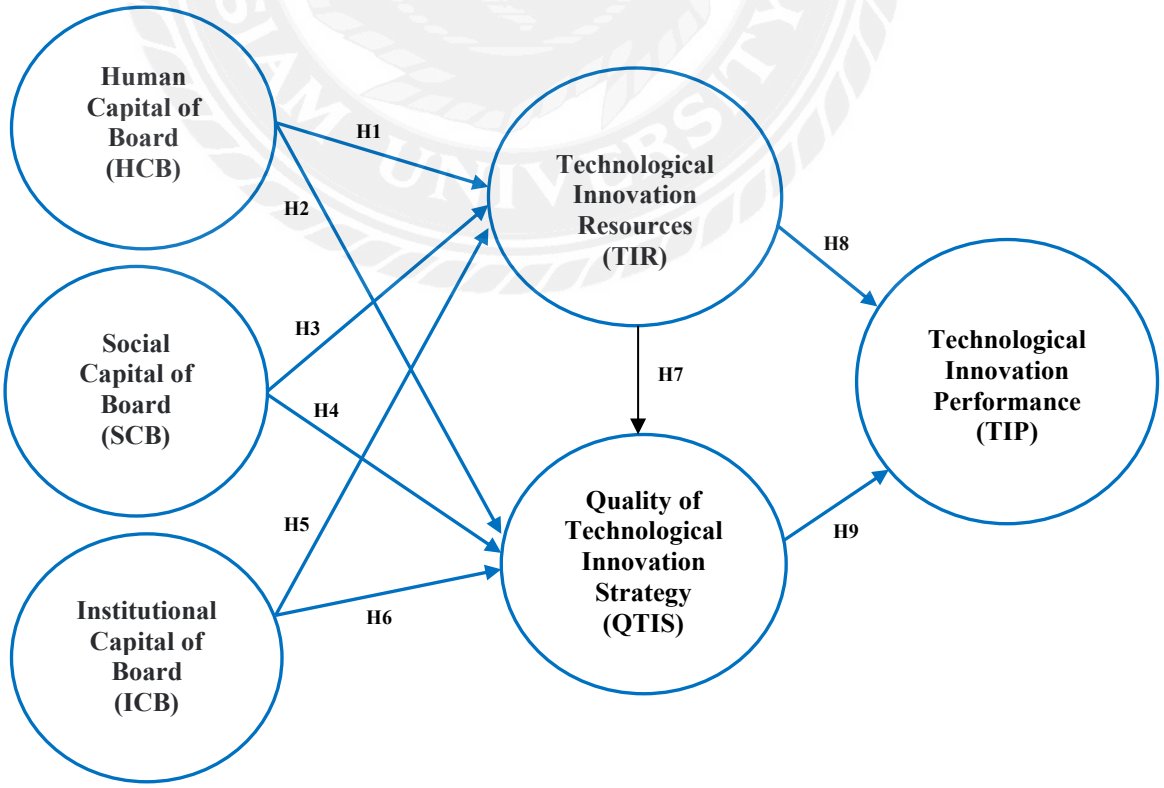

Figure 3.1 Conceptual Model

3.5 Population and Sampling Methods

The main content of this study is to investigate the influence of Board capital on the innovation performance of high-tech enterprises in Shandong Province (HUANG et al., 2021), which needs to clarify the research subjects and samples and to determine the research methods and indicators. It uses scientific analysis methods and statistical tools to obtain accurate and reliable conclusions.

The research object of this study is high-tech enterprises in Shandong province, which usually have certain advantages and strengths in technological innovation and high-end industries and are the leading forces in promoting local economic development, transformation, and upgrading. The primary research samples include high-tech enterprises in Shandong province, which can be obtained through industry associations, government agencies, commercial databases, etc. The sample selection is based on specific criteria and indicators, such as enterprise size, industry type, technological innovation capability, etc. The sample size is large enough to ensure the reliability and generalization of the research results. The sample size is determined by the research design, and the number of randomly selected samples is calculated according to the analysis using the random sampling survey method. According to government statistics, in 2021, there are 23,345 (http://tjj.shandong.gov.cn/) high-tech enterprises in Shandong Province.

Yamane (1974) adjusted the calculation formula to be more accurate by increasing the π = population variance from the Dichotomous Variable equal to 0.50 and z =z score at significance level β (where z = 1.96 at β = 0.05 and z = 2.56 at β = 0.01) as the following formula (Yamane Taro, 1974).

$$\mathrm{n} = \frac{(z)^2(\pi)(1-\pi)(N)}{(z)^2(\pi)(1-\pi) + (N)(e)^2}$$

After calculating the sample n=398.18

The main research methods include descriptive analysis, correlation analysis, structural equation modeling, and other ways to explore the effect of Board capital on innovation performance. The specific research methods are selected and designed according to the research questions, data types, and research objectives to ensure the

validity and reliability of the findings. The available data from the questionnaire are analyzed using the SPSS program to test the hypotheses.

3.6 Questionnaire Pretest

In this study, the questionnaire is pretested to ensure the validity and feasibility of the research instrument. The form of online method is used, and high-tech enterprises in Shandong Province are selected as the respondents to the survey.

The questionnaire is designed according to the research objectives. The range includes

- Basic personal information,
- The concept and role of Board capital,
- The perception and opinion of Board capital on corporate innovation performance.

The survey objects and samples need to be determined. Determine the high-tech enterprises in Shandong Province that need to be surveyed, and then randomly select a part of employees from these enterprises as sample subjects to ensure sample representativeness and validity—survey questionnaire distribution. The designed questionnaires are sent to the sample subjects online and must be filled out and returned within the specified time. Collect all questionnaire data, organize and analyze the data, analyze the reliability of the questionnaires, and ensure the validity and reliability of the research instrument.

The questionnaire pre-survey of the study on the impact of Board capital on the innovation performance of high-tech enterprises in Shandong Province can understand the respondents' perceptions and opinions on Board capital, further clarify the research questions, and guide the design and implementation of the subsequent study. The pre-survey can determine whether there are sample subjects who do not meet the research requirements or do not have valid data, adjust the sample in time, and improve the accuracy and reliability of the research data. The pre-survey can be used to understand the respondents' understanding and response to the questions and adjust the questionnaire design in time to ensure the accuracy and clarity of the questions. Pre-

survey is the first step of the study, which provides valuable guidance and preparation for the subsequent field survey and data analysis, thus improving the quality and credibility of the study.

3.7 Item Analysis of the Quality of the Measurement Tool

3.7.1 Validity Testing

Validity analysis refers to the study of the degree of accuracy of the scale measure expression to the measurement indicator. Validity analysis determines whether a research question effectively expresses conceptual information about a research variable or dimension, i.e., whether the research question design is reasonable or represents a variable appropriately. Validity refers to the degree to which a measurement instrument or tool can accurately measure the thing to be measured.

(1) Content Validity

Content validity, also known as face validity or logical validity, refers to the ability of the designed items to represent the content or topic to be measured. Content validity is often evaluated using logical analysis (expert method) and statistical analysis. Therefore, in this study, an expert panel is formed to assess the content validity of the questionnaire.

(2) Structural Validity

Structural validity refers to the degree of correspondence between a particular structure embodied in the measurement results and the measured values. The method used for structural validity analysis is factor analysis. It has been argued that the ideal way for validity analysis is to use factor analysis to measure the scale's structural validity or the entire questionnaire. The primary function of factor analysis is to extract some common factors from all the variables (questions) of the scale, each of which is highly correlated with a specific group of variables, and these common factors represent the basic structure of the scale. Factor analysis can be used to examine whether a questionnaire can measure a specific format the researcher has assumed when designing. In the results of factor analysis, the leading indicators to evaluate the structural validity are cumulative contribution, commonality, and factor loading. The

cumulative contribution rate reflects the incremental reality of the common factor to the scale or questionnaire. The commonness demonstrates the validity of the original variable explained by the common factor, and the factor loading reflects the correlation between the original variable and a common factor. It is an essential part of the research process to enhance the quality of the questionnaire and the value of the whole study.

(3) Logical Validity

The validity measure of the questionnaire is mainly adopted by the expert evaluation method, so an expert panel is formed, with the leading members being Liou-Yuan (Rajamangala University of Technology Thanyaburi, Associate Professor), Vuttichat Soonthonsmai (Rajamangala University of Technology Krungthep, Associate Professor), Jidapa Chollathanrattanapong (Siam University, Ph.D.), and Sarun Widtayakornbundit (Kasetsart University, Ph.D.).

Logical validity examines whether the items in a test or questionnaire make logical sense concerning the measured structure. The research questionnaire is based on social identity theory, social exchange theory, and organizational equity theory. Each item is evaluated to determine whether it makes logical sense about the structure being measured. Moreover, I will consult with experts in the field, review existing literature, and revise necessary items to ensure that they are logically related to the measured structure. Based on the expert panel evaluation, the consistency of each item in the test or questionnaire with the overall structure being measured is obtained by calculating objective congruence (IOC). A value of IOC between 0 and 1, with higher values indicating more substantial agreement between the item and the overall structure being measured. Items with IOC values above 0.50 generally have good unity, while items above 0.50 are considered very good.

3.7.2 Reliability Testing

Reliability refers to the reliability of the scale measurement results. The more repeatable and reliable the scale is, the less it is affected by the environment, such as time and place, and the more stable the testing results. The internal consistency and reliability of the scales are examined by examining Cronbach's alpha coefficient of each scale. It is necessary to judge the reliability and validity of the questionnaire based on

the pretest, and Cronbach's alpha is above 0.7 to meet the requirements of internal consistency and reliability.

Table 3.8 Cronbach's Alpha Coefficient Result

Variable		Number of Questions	Cronbach's Alpha
Board Capital	Human Capital of Board (HCB)	5	0.877
	Social Capital of Board (SCB)	6	0.892
	Institutional Capital of Board (ICB)	6	0.902
Technological Innovation Resources (TIR)	-	6	0.892
Quality of Technological Innovation Strategy (QTIS)	-	6	0.888
Technological Innovation Performance (TIP)	-	4	0.837

3.8 Statistical Method of Analysis

The data is analyzed by the SPSS program and AMOS to test the hypotheses of this paper. The statistical methods used in this study are as follows:

(1) Descriptive Statistical Analysis

Descriptive statistical analysis includes demographic description, analysis of means, analysis of variance, and median analysis. Descriptive statistical analysis methods can provide a preliminary understanding of the impact of Board capital on the innovation performance of high-tech enterprises and provide essential data and references for further research.

The relationship between Board capital and innovation performance is described by calculating the mean value of the two. The means of Board capital and innovation performance can be calculated separately and compared to understand their trends and differences. Quantile regression can describe the variation in the effect of Board capital on innovation performance at different quartiles. Board capital and innovation performance at different quartiles can be calculated separately, compared, and analyzed to understand their relationship.

(2) Implementation of Validation Factor Analysis or Exploratory Factor Analysis

The research hypothesis has been clarified in the study, and the appropriate factor analysis tools are selected according to the purpose of the study—principal component analysis, factor analysis, cluster analysis, etc. The relevant questions in the questionnaire are combined to construct several factors and standardize the data. The appropriate number of factors is determined by observing indicators such as factor contribution ratio and factor loading matrix. The meaning and impact of each factor are explained based on the factor loading matrix and the internal consistency analysis of the explanatory variables. Appropriate tools and methods are selected, reasonably interpreted, and analyzed according to the actual situation and the purpose of the study. The validity of the questionnaire is ensured through analytical studies.

(3) Structural Equation Model Analysis

Structural equation modeling requires data collection using questionnaires or other suitable means and data processing and analysis, such as data cleaning, missing value processing, and standardization. A measurement model is established, including measurement indicators for each variable and test indicators such as the model's internal consistency. Integrate the measurement and theoretical models to establish a structural model, including indicators such as the relationship between individual variables and the model's fitness. Fit tests are performed on the established structural model, such as RMSEA, CFI, GFI, AGFI, and other indicators. Estimate each parameter in the structural model and test the hypotheses to verify the reasonableness and stability of the model. The model results are interpreted and analyzed. The model is optimized and improved according to the actual situation and research objectives, and corresponding suggestions are made.

Structural equation modeling analysis requires a combination of statistical methods and techniques to establish a reasonable model and adequately process and analyze the data. At the same time, it is necessary to combine the actual situation and theoretical analysis, make reasonable interpretations and analyses, and put forward corresponding suggestions and improvement measures.

3.9 A Model of Board Capital for Innovation Performance of High-Tech Enterprises

Based on data analysis, the research constructs the model of Board capital's influence on the TIP of high-tech enterprises. The main influencing factors of the model include HCB, SCB, and ICB. The three dimensions of Board capital affect TIR and QTIS respectively to realize the final influence on TIP. After clarifying the relationship between the variables, the model of Board capital influence on the TIP of high-tech enterprises is constructed according to the relationship between the variables. The model provides the basis and measures to improve the TIP of high-tech enterprises.

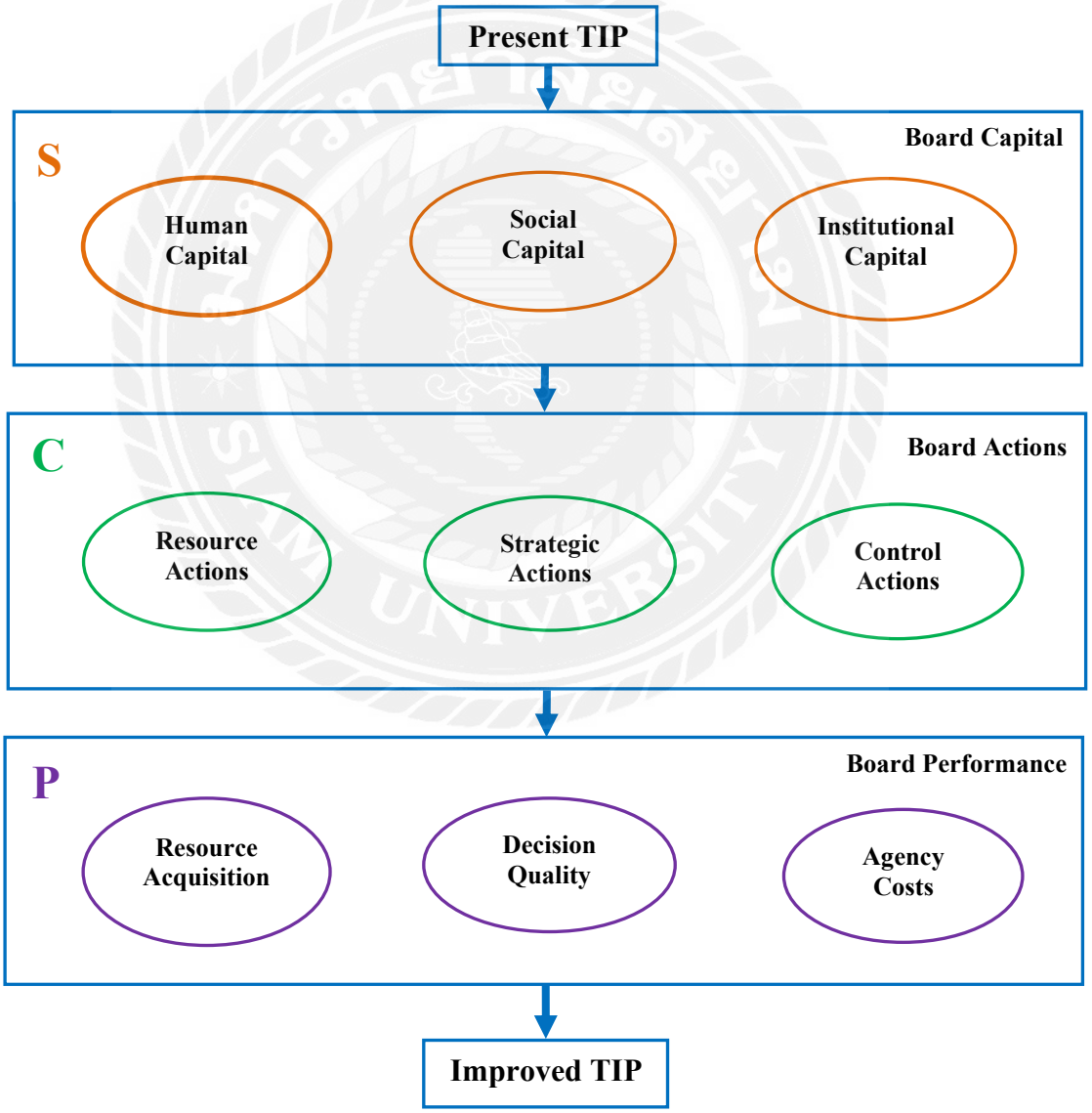

Figure 3.2 Model of Board Capital for Innovation Performance of High-Tech Enterprises

In this study, board capital is considered one of the important factors affecting the technological innovation performance of high-tech firms. According to the researchers' data analysis, they split board capital into three dimensions: human capital board, structural capital board, and intellectual capital board. these three dimensions represent the human capital, structural capital, and intellectual capital of the board members, respectively.

In the course of the study, the researcher identified a model of the impact of board capital on the TIP of high-tech firms, in which the main influencing factors include HCB, SCB, and ICB. These three dimensions of board capital are considered to influence the technological innovation resources (TIR) and the quality of technological innovation (QTIS), which ultimately affects the technological innovation performance (TIP).

After clarifying the relationship between the variables, the researcher constructed a model of the impact of board capital on TIP in high-tech firms. This model provides the basis and measures to improve the technological innovation performance of high-tech enterprises. By analyzing and optimizing the human capital, structural capital, and intellectual capital of board members, enterprises can better access technological innovation resources and improve the quality of technological innovation, thus enhancing technological innovation performance. The establishment of this model can help high-tech enterprises to better understand and manage board capital to achieve better technological innovation performance.

Continuing to explain the impact of board capital on high-tech firms' innovation, the SCP (Structure-Conduct-Performance) paradigm shown in Figure 3.2 can be utilized. In this paradigm, the different dimensions of board capital can be regarded as the industrial structure (Structure), the behavior of board members (including the management and utilization of human, structural, and intellectual capital) can be regarded as the conduct (Conduct), and the technological innovation performance is the firm's performance in the market (Performance). Therefore, by optimizing the structure and behavior of board capital, the technological innovation performance of high-tech firms can be enhanced to achieve better market performance.

CHAPTER 4

RESEARCH RESULT

This Chapter Focuses on the Analysis of the Collected Data and Contains Five Sections:

4.1 Sample Characterization

4.2 Percentage Distribution of Constructs

4.3 Discriminatory Power, Reliability and Confirmatory Factors Analysis

4.4 The Structural Equation Models and Hypothesis Testing

4.5 Conclusion

A framework model is constructed based on the analysis in the previous three chapters, and questionnaires are distributed and collected. The analysis is conducted for the collected data. Based on the principal-agent theory, resources dependence theory, and higher-order echelon theory, the study has explored the human capital and social capital and institutional capital of the Board, technological innovation resources, quality of technological innovation strategy, technological innovation performance, and performance variables. SPSS and AMOS software are used in the data analysis process.

The statistical analysis process in this chapter mainly includes the statistics and description of control variables and data average distribution analysis. Also, the survey data are analyzed for reliability and validity. Reliability analysis uses Cronbach's Alpha and Corrected Item-Total Correlation (CITC). The validity test is performed using Confirmatory Factors Analysis, including path coefficients, Combined Reliability (CR), and Average variance extracted (AVE) values. Based on the analysis results, it is ensured that the survey data are reliable and distinguishable. Correlation analysis and structural equation modeling are performed after the data pass the reliability and validity tests. Structural equation modeling needs to verify the model fit, and the model fit needs to refer to the GFI, CFI, AGFI, and RMSEA data analysis metrics. The model

fit (model fit) must meet the requirements through data analysis. Correct the model according to the indicators. Ensure that the model fit meets the criteria. Finally, path analysis is performed for each variable to test the hypotheses and draw conclusions.

In this study, 450 questionnaires are distributed, and 420 questionnaires are returned. Questionnaires with missing values are deleted in the process of questionnaire data organization. Finally, 401 valid questionnaires are recovered, and the validity rate of the questionnaire is 89.11%. The rationality of the data is ensured through the organization of the data.

4.1 Demographic Characterization

Demographic characterization refers to the detailed description and analysis of the demographic characteristics in the sample for better understanding of the data, selection of appropriate models, and prediction and analysis. In this study, the main factors in the sample characterization include the sample's gender, age, education level, job position, number of Board members, and the industry of the high-tech firms. A total of 401 valid questionnaires are collected in this study.

Statistical results show there are 213 males, accounting for 53.1%, and 188 females, accounting for 46.9%; male samples are slightly higher than females. In the age variable survey, there are 130 under the age of 30, accounting for 32.4%; there are 137 under the age of 30-50, accounting for 34.2%; there are 134 over the age of 50, accounting for 33.4%. The age distribution of the sample is relatively even. The education level of the sample is divided into three options, in which High school and below is 110 (27.4%), Master's degree is 100 (24.9%), Bachelor's degree is 86 (21.4%), and the rest is 105 (26.2%). For the survey of positions, the number of Chairmen of the Board is 128 (31.9%), Directors of the Board is 128 (31.9%), and the rest is 145 (36.2%). In the number of Board members survey, the number of 3-4 members is 141 (35.2%), the number of 5-6 members is 151 (37.7%), and the number of more than

seven members is 109 (27.2%). In the study of Terms of membership of the Board of Directors, less than one year is 93 (23.2%), 1-2 years is 60 (15.0%), 3-5 years is 92 (22.9%), 6-7 years is 79 (19.7%), and more than seven years for 77 people, accounting for 19.2%. In the survey, the high-tech enterprises are divided into four categories, including 97 information technology manufacturing of the new generation, accounting for 24.2%, and 113 new energy and new material technology, accounting for 28.2%. High-end equipment manufacturing is 96, 23.9%, and Artificial intelligence is 95, accounting for 23.7%. See Table 4.1.

Table 4.1 Sample Feature Description

Variable	Options	Frequency	Percent%
Gender	Male	213	53.1
	Female	188	46.9
Age	Under 30	130	32.4
	30-50	137	34.2
	Over50	134	33.4
Education	High School and Below	110	27.4
	Master Degree	100	24.9
	Bachelor Degree	86	21.4
	The Rest	105	26.2
Position	Chairman of the Board	128	31.9
	Director of the Board	128	31.9
	The Rest	145	36.2
The Number of Members of the Board of Directors	3-4 People	141	35.2
	5-6 People	151	37.7
	More than 7 People	109	27.2
Term of Membership of Board of Directors	Less than 1 year	93	23.2
	1-2 years	60	15.0
	3-5 years	92	22.9
	6-7 years	79	19.7
	More than 7 years	77	19.2
The Industrial Nature of Your Enterprise	Information Technology Manufacturing of the New Generation	97	24.2
	New Energy and New Material Technology	113	28.2
	High-End Equipment Manufacturing	96	23.9
	Artificial Intelligence	95	23.7
Total		**401**	**100.0**

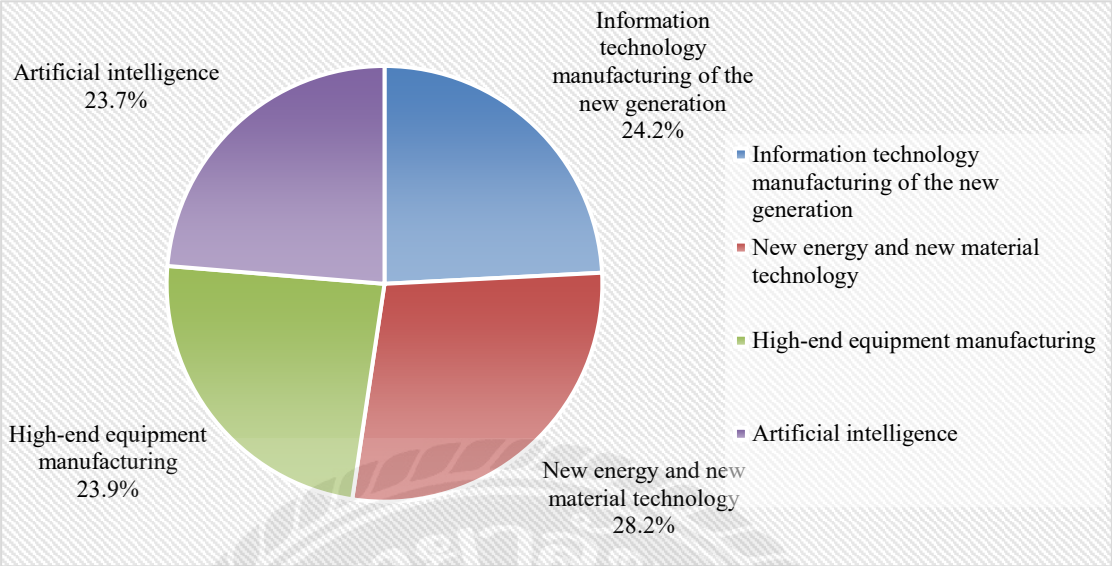

Figure 4.1 The Industrial Nature of High-Tech Enterprises

4.2 Percentage Distribution of Constructs

4.2.1 Human Capital of the Board

The human capital of the Board has a total of 5 items. According to Table 4.2, 45.4% of respondents agree that "Board members possess rich professional knowledge". "That Board members as a whole can use communication skills to reach consensus" is decided by 46.9% of the respondents. In the survey "Board members as a whole can quickly identify the causes of problems and the appropriate solutions", 47.4% of the respondents agree. In the study "Board members have strong attention, thinking, and memory abilities as a whole", 52.1% of the respondents agree. In the survey "Board members have a positive and optimistic attitude to solve problems", 56.6% of the respondents agree.

4.2.2 Social Capital of the Board of Directors

The social capital of the Board has six items in the survey. According to Table 4.2, 63.3% of respondents agree that the "Board of Directors is in contact with many customers, suppliers, enterprises, scientific research institutes, universities, technical

intermediary organizations, governments, and financial institutions". The survey "Board of Directors is in frequent contact with customers, suppliers, enterprises, scientific research institutes, universities, technical intermediary organizations, governments, and financial institutions" is agreed upon by 58.6% of the respondents. In the study, 60.6% of the respondents agree that "there exists mutually beneficial cooperation between Board of Directors and customers, suppliers, enterprises, scientific research institutes, universities, technical intermediary organizations, governments, and financial institutions. In the survey "Research institutes, universities, technical intermediary organizations, governments, and financial institutions", 63.8% of the respondents agree. The survey "Board of Directors can communicate effectively with customers, suppliers, enterprises, scientific research institutes, universities, technical intermediary organizations, governments, and financial institutions due to the shared benefits", 46.1% of the respondents agree. Similar value orientation exists between the Board of Directors and customers, suppliers, enterprises, scientific research institutes, universities, technical intermediary organizations, governments, and financial institutions due to the shared benefits", 52.4% of the respondents agree.

4.2.3 Institutional Capital of the Board

The total items in the acquirement of technological innovation resources are 6. According to Table 4.2, 56.1% of the respondents agree that "enterprises can timely acquire information for technological innovation". About 50.6% of the respondents agree with the statement "Enterprises can acquire sufficient information for technological innovation". In the survey "Enterprises can timely acquire knowledge for technological innovation", 59.4% of the respondents agree. A survey "Enterprises can acquire a large amount of knowledge for technological innovation" shows that 57.9% of the respondents agree. In the survey "Enterprises can timely acquire the fund for technological innovation", 53.4% of the respondents agree. In the survey "Enterprises

can acquire sufficient funds for technological innovation", 58.9% of the respondents agree.

4.2.4 Acquirement of Technological Innovation Resources

The total number of questions in the acquirement of technological innovation resources is 6. According to Table 4.2, 56.1% of the respondents agree that "enterprises can timely acquire information for technological innovation". 50.6% of the respondents agree that "enterprises can acquire sufficient information for technological innovation". In the survey "Enterprises can timely acquire knowledge for technological innovation", 59.4% of the respondents agree. In the survey "Enterprises can acquire a large amount of knowledge for technological innovation", 57.9% of the respondents agree. In the survey "Enterprises can timely acquire the fund for technological innovation", 53.4% of the respondents agree. In the survey "Enterprises can acquire sufficient funds for technological innovation", 58.9% of the respondents agree.

4.2.5 Quality of Technological Innovation Strategy

There are six items in the quality of technological innovation strategy. According to Table 4.2, 69.6% of the respondents agree that "the technological innovation path of enterprises is consistent with internal conditions such as knowledge system structure, innovation personnel capability, and organizational learning ability". 63.6% of respondents agree with the statement "The technological innovation path of enterprises is consistent with the external market environment and policy environment". In the survey "the technological innovation mode of enterprises is consistent with their technological capability, network capability, and innovation protection mechanism", 67.6% of the respondents agree. The survey "The technological innovation mode of enterprises is consistent with the external market and policy environments" shows that 66.8% of the respondents agree. In the survey of "the technological innovation investment mode of enterprises is consistent with the cash capacity and risk bearing

capacity", 62.8% of the respondents agree. In the survey "the technological innovation investment mode of enterprises is consistent with the external policy environment and market environment", 53.1% of the respondents agree.

4.2.6 Technological Innovation Performance

The total items in technological innovation performance are 4. According to Table 4.2, 56.6% of the respondents agree that "compared with similar enterprises, the number of patents granted to enterprises is higher". 59.6% of respondents agree that "compared with similar enterprises, the number of new product projects developed by enterprises is higher". The survey "compared with similar enterprises, the profit margin of total assets of enterprises is higher" is agreed upon by 55.6% of the respondents. The survey "compared with similar enterprises, the cash assets of operating activities of enterprises are higher" shows that 67.8% of the respondents agree.

Table 4.2 Percentage Distribution

Statement		Strongly Disagree	Disagree	Neutrality	Agree	Strongly Agree
Human Capital of the Board of Directors	Q1	10.0%	7.2%	37.4%	30.4%	15.0%
	Q2	7.2%	9.2%	36.7%	31.7%	15.2%
	Q3	6.5%	7.5%	38.7%	25.4%	21.9%
	Q4	4.0%	5.5%	38.4%	33.2%	19.0%
	Q5	9.2%	5.5%	28.7%	32.4%	24.2%
Social Capital of the Board of Directors	Q6	7.0%	3.7%	25.9%	37.7%	25.7%
	Q7	8.2%	7.0%	26.2%	40.1%	18.5%
	Q8	8.0%	9.5%	21.9%	25.2%	35.4%
	Q9	11.2%	4.7%	20.2%	45.1%	18.7%
	Q10	8.0%	10.5%	35.4%	33.2%	13.0%
	Q11	8.2%	4.2%	35.2%	37.9%	14.5%
Institutional Capital of the Board	Q12	4.2%	13.0%	23.7%	36.9%	22.2%
	Q13	7.0%	10.2%	27.2%	27.7%	27.9%
	Q14	5.2%	14.2%	25.7%	37.7%	17.2%
	Q15	6.2%	14.2%	21.7%	21.9%	35.9%
	Q16	8.7%	10.5%	30.7%	32.2%	18.0%
	Q17	9.2%	9.7%	25.9%	35.4%	19.7%
Acquirement of Technological Innovation Resources	Q18	4.0%	17.5%	22.4%	35.7%	20.4%
	Q19	3.0%	7.5%	38.9%	30.2%	20.4%
	Q20	0.2%	18.7%	21.7%	33.7%	25.7%
	Q21	8.0%	8.7%	25.4%	11.5%	46.4%
	Q22	0.5%	8.5%	37.7%	33.4%	20.0%
	Q23	3.2%	11.5%	26.4%	13.7%	45.1%

Statement		Strongly Disagree	Disagree	Neutrality	Agree	Strongly Agree
Quality of Technological Innovation Strategy	Q24	0.5%	7.5%	22.4%	42.6%	26.9%
	Q25	6.2%	7.5%	22.7%	44.6%	19.0%
	Q26	3.5%	3.2%	25.7%	36.4%	31.2%
	Q27	1.2%	9.0%	22.9%	31.2%	35.7%
	Q28	2.5%	8.0%	26.7%	35.7%	27.2%
	Q29	8.5%	12.2%	26.2%	27.4%	25.7%
Technological Innovation Performance	Q30	3.2%	12.7%	27.4%	30.4%	26.2%
	Q31	8.2%	10.7%	21.4%	32.2%	27.4%
	Q32	3.5%	10.5%	30.4%	28.4%	27.2%
	Q33	2.0%	12.7%	17.5%	37.4%	30.4%

4.3 Discriminatory Power, Reliability, and Confirmatory Factors Analysis

The research questionnaire has collected 401 valid questionnaires. The questionnaire data are subject to a reliability test and validity test. Structural equation modeling is performed when the reliability and validity tests pass the requirements.

4.3.1 Reliability

1. Human Capital of the Board

In the study, Cronbach's Alpha and Corrected Item-Total Correlation (CITC) tests are performed on the obtained data, as well as Cronbach's Alpha if Item Deleted tests for each question item. The Cronbach's Alpha is above 0.7, and the Corrected Item-Total Correlation (CITC) needs to be above 0.5 to meet the requirements of internal consistency and reliability. According to the analysis results, Table 4.6 shows that the Corrected Item-Total Correlation (CITC) value for each item in the Human capital of the Board is above 0.5. The Cronbach's Alpha is 0.877, which is greater than 0.7. By analyzing the results, each item Cronbach's Alpha if Item Deleted is less than Cronbach's Alpha, which indicates that each question item meets the requirements and can improve the scale's reliability. Therefore, the reliability of the human capital of the Board scale is better.

Table 4.3 Human Capital of Board Scale Reliability Analysis

Dimension	Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
Human Capital of the Board	Q1	0.752	0.840	0.877
	Q2	0.677	0.858	
	Q3	0.687	0.856	
	Q4	0.727	0.848	
	Q5	0.705	0.852	

2. Social Capital of the Board

Data analysis of Social capital is conducted. According to the analysis results in Table 4.7, the Corrected Item-Total Correlation (CITC) value for each question item in the social capital of the Board is higher than 0.5. Meanwhile, the Cronbach's Alpha for each question item if Item Deleted is 0.880, 0.868, 0.874, 0.874, 0.867, and 0.875, which are all less than Cronbach's Alpha 0.892. Cronbach's Alpha value is more than 0.7. This indicates that each question item meets the requirements and can improve the scale's reliability.

Table 4.4 Social Capital of Board Scale Reliability Analysis

Dimension	Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
Social Capital of the Board	Q6	0.664	0.880	0.892
	Q7	0.743	0.868	
	Q8	0.711	0.874	
	Q9	0.705	0.874	
	Q10	0.756	0.867	
	Q11	0.702	0.875	

3. Institutional Capital of the Board

The data on the institutional capital of the Board is analyzed. According to the analysis results, as shown in Table 4.8, the Corrected Item-Total Correlation (CITC) value of each question item in the institutional capital of the Board is higher than 0.5. Meanwhile, Cronbach's Alpha if Item Deleted for each question item is 0.879, 0.884, 0.887, 0.885, 0.887, and 0.889, which are all less than Cronbach's Alpha 0.902. The Cronbach's Alpha values are all greater than 0.7. This indicates that each question item

meets the requirements and can improve the scale's reliability. This indicates that the reliability of the data is good.

Table 4.5 Institutional Capital of Board Scale Reliability Analysis

Dimension	Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
Institutional Capital of the Board	Q12	0.779	0.879	0.902
	Q13	0.740	0.884	
	Q14	0.724	0.887	
	Q15	0.740	0.885	
	Q16	0.717	0.887	
	Q17	0.707	0.889	

4. Technological Innovation Resources

Data analysis is conducted on Technological Innovation Resources. According to the analysis results in Table 4.9, the Corrected Item-Total Correlation (CITC) for each question item in the Technological Innovation Resources value is higher than 0.5. Meanwhile, the Cronbach's Alpha if Item Deleted for each question item is 0.870, 0.886, 0.887, 0.887, 0.888, and 0.885, which are less than the Cronbach's Alpha 0.892. The Cronbach's Alpha value is more significant than 0.7. This indicates that each question item meets the requirements and can improve the scale's reliability. It indicates that the data reliability is good.

Table 4.6 Technological Innovation Resources Scale Reliability Analysis

Dimension	Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
Technological Innovation Resources	Q18	0.822	0.870	0.892
	Q19	0.723	0.886	
	Q20	0.710	0.887	
	Q21	0.730	0.887	
	Q22	0.715	0.888	
	Q23	0.728	0.885	

5. Quality of Technological Innovation Strategy

The data analysis of the Quality of technological innovation strategy is conducted. According to the analysis results, as shown in Table 4.10, the Corrected Item-Total for each question item in the Quality of Technological Innovation Strategy Correlation (CITC) value is higher than 0.5. Meanwhile, Cronbach's Alpha if Item Deleted for each question item is 0.869, 0.867, 0.867, 0.870, 0.866, and 0.869, which are less than Cronbach's Alpha 0.888. The Cronbach's Alpha values are all greater than 0.7. This indicates that each question item meets the requirements and can improve the scale's reliability. It indicates that the data reliability is good.

Table 4.7 Quality of Technological Innovation Strategy Scale Reliability Analysis

Dimension	Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
Quality of Technological Innovation Strategy	Q24	0.708	0.869	0.888
	Q25	0.709	0.867	
	Q26	0.707	0.867	
	Q27	0.690	0.870	
	Q28	0.716	0.866	
	Q29	0.710	0.869	

6. Technological Innovation Performance

Data analysis is conducted on Technological Innovation Performance. According to the analysis results in Table 4.11, the Corrected Item-Total Correlation (CITC) for each question item in the Technological Innovation Performance value is higher than 0.5. Meanwhile, Cronbach's Alpha if the Item Deleted for each Item is 0.797, 0.790, 0.784, and 0.803, respectively, which is less than Cronbach's Alpha of 0.837. The Cronbach's Alpha value is more significant than 0.7. This indicates that each Item meets the requirements and can improve the scale's reliability. This indicates that the reliability of the data is good.

Table 4.8 Technological Innovation Performance Scale Reliability Analysis

Dimension	Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
Technological Innovation Performance	Q30	0.660	0.797	0.837
	Q31	0.680	0.790	
	Q32	0.690	0.784	
	Q33	0.647	0.803	

Through the above data analysis, it can be found that the Corrected Item-Total Correlation (CITC) of the survey data is higher than 0.5. Cronbach's Alpha is more significant than 0.7. Cronbach's Alpha if Item Deleted for each topic is less than Cronbach's Alpha. The reliability of the data is good and meets the requirements.

4.3.2 Confirmatory Factor Analysis

Confirmatory Factor Analysis (CFA) is used to validate whether the constructed measurement model fits the data well. It ensures that the measurement tools accurately reflect the concepts or variables involved in the study. Confirmatory Factor Analysis has the following main measures in the validation process: average variance extracted (AVE), composite reliability (CR), and path coefficients as a test of convergent validity and aggregation. At the same time, each question item needs to be differentiated; therefore, a differential validity test is required. The role of differential validity is based on the relationship between the square root of the AVE value and the standardized coefficient. According to relevant studies and standards, a minimum AVE value of 0.5 (Hair, Black, Babin, &Anderson, 2010) and a minimum CR requirement of 0.7 (Furnell & Larcker, 1981) are required to indicate good convergent validity and composite reliability. The study is conducted using the SEM method, which is used to conduct the study and construct the structural equation modeling. AMOS software and SPSS software are utilized for the overall study. Firstly, the model fitness test is carried out, and the relevant indexes meet the requirements. Secondly, parameter estimation is carried out to obtain the relevant research results.

Based on the results of the analysis in Table 4.12 and Figure 4.1, it can be seen that Human capital of board, Board social capital, Board institutional capital, Technological Innovation Resources, Quality of technological innovation strategy, Technological Innovation Performance variables for the CFA test, and the path coefficients estimate for each question item are all between 0.7 and 0.875. The path coefficients are all greater than 0.5, which meets the requirement.

The path coefficients for the five topics of the human capital of the Board are 0.827, 0.726, 0.734, 0.795, and 0.759. AVE is 0.592. CR is 0.878. All are in line with the CFA's requirements. The path coefficients for the six topics of social capital of the Board are 0.747, 0.809, 0.756, 0.762, 0.795, and 0.711. AVE is 0.584. CR is 0.584. The path coefficients for the six questions on the social capital of the Board are 0.747, 0.809, 0.756, 0.762, 0.795, and 0.711. AVE is 0.584. CR is 0.894. All align with CFA requirements. Board institutional capital path coefficients are 0.765, 0.79, 0.765, 0.788, 0.824, the AVE value is 0.610, and the CR value is 0.904, which aligns with the CFA's requirement standards. The path coefficients of the six questions of Technological Innovation Resources are 0.773, 0.764, 0.769, 0.769, 0.754, and 0.755. AVE value is 0.574. CR value is 0.890. All meet CFA's requirement standards. Four topics of Technological Innovation Performance have path coefficients of 0.716, 0.78, 0.766, and 0.739; the AVE value is 0.574, and the CR value is 0.890, which meets the CFA's requirement standards. AVE value is 0.564, and the CR value is 0.838, which meets the CFA requirement standard.

Table 4.9 AVE and CR of Variables

Path Relationship			Estimate	AVE	CR
Q1	<---	HCB	0.827	0.592	0.878
Q2	<---	HCB	0.726		
Q3	<---	HCB	0.734		
Q4	<---	HCB	0.795		
Q5	<---	HCB	0.759		
Q6	<---	SCB	0.747	0.584	0.894
Q7	<---	SCB	0.809		
Q8	<---	SCB	0.756		
Q9	<---	SCB	0.762		
Q10	<---	SCB	0.795		
Q11	<---	SCB	0.711		
Q12	<---	ICB	0.751	0.610	0.904
Q13	<---	ICB	0.765		
Q14	<---	ICB	0.790		
Q15	<---	ICB	0.765		
Q16	<---	ICB	0.788		
Q17	<---	ICB	0.824		
Q18	<---	TIR	0.773	0.617	0.906
Q19	<---	TIR	0.764		
Q20	<---	TIR	0.769		
Q21	<---	TIR	0.755		
Q22	<---	TIR	0.771		
Q23	<---	TIR	0.874		
Q24	<---	QTIS	0.757	0.574	0.89
Q25	<---	QTIS	0.774		
Q26	<---	QTIS	0.737		
Q27	<---	QTIS	0.769		
Q28	<---	QTIS	0.754		
Q29	<---	QTIS	0.755		
Q30	<---	TIP	0.716	0.564	0.838
Q31	<---	TIP	0.780		
Q32	<---	TIP	0.766		
Q33	<---	TIP	0.739		

It can be learned from the analysis that the human capital of the Board, social capital of the Board, institutional capital of the Board, Technological Innovation Resources, quality of technological innovation strategy, Technological Innovation Performance, and other variables of the study of the indicators meet the requirements. The survey data can be applied to the structural equation study.

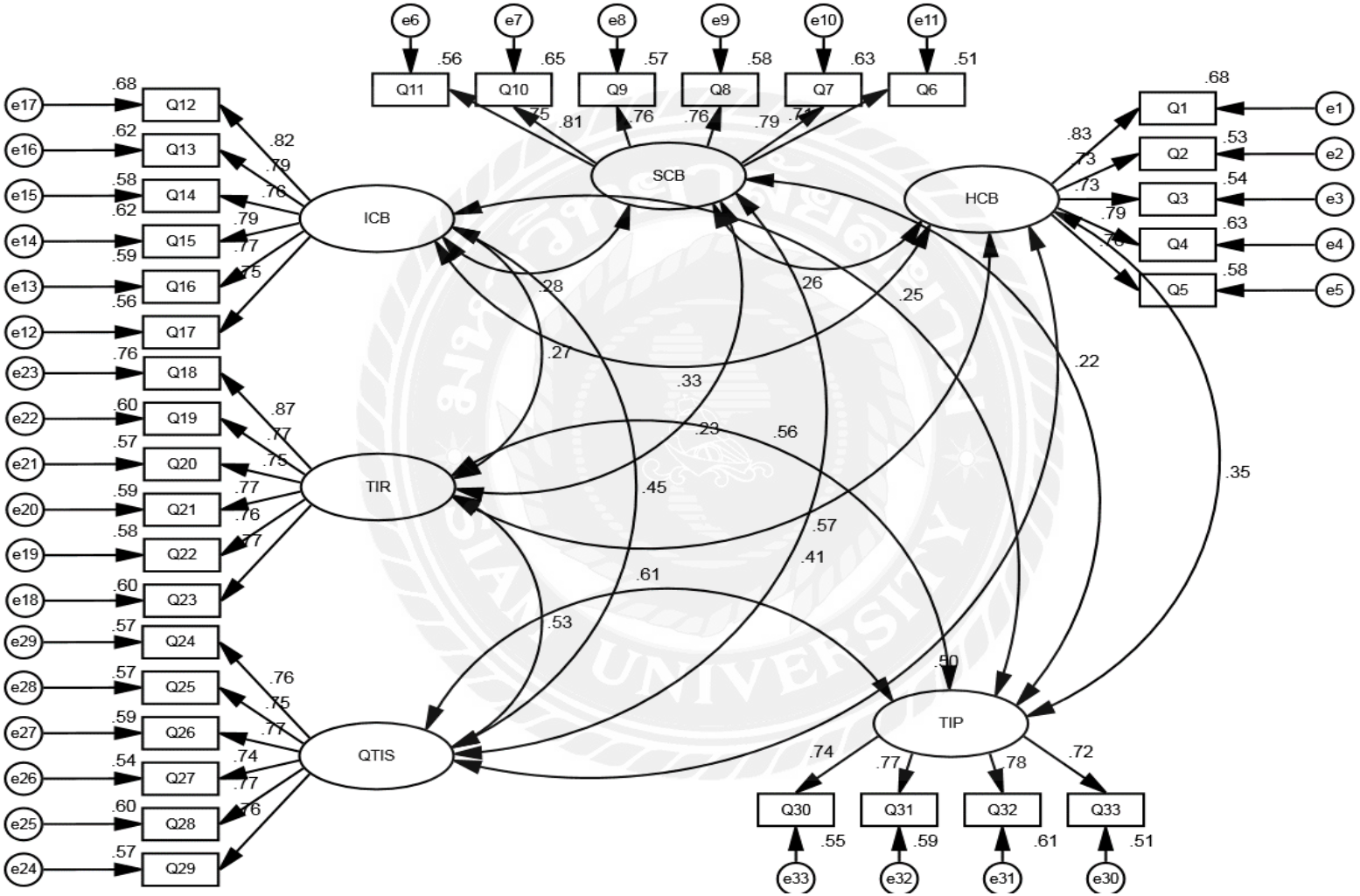

Figure 4.2 Confirmatory Factor Analysis of Variables

4.3.3 Discriminant Validity

The dimensions of each variable are analyzed for correlation in this study using Pearson's correlation analysis. The discriminant validity of the survey data is determined by comparing the Pearson correlation coefficient with the square root of the AVE. When the absolute value of the square root of AVE is always more significant than the Pearson correlation coefficient, it indicates good discriminant validity of the question items. By analyzing the data, it is clear that the correlation coefficients for each variable are less than the absolute value of the square root of the AVE. The absolute value of the square root of the human capital of Board AVE is 0.769, the absolute value of the square root of the social capital of Board AVE is 0.764, and the absolute value of the square root of the institutional capital of Board AVE has an absolute value of square root of 0.781. Technological Innovation Resources AVE has an absolute value of square root of 0.785. Quality of technological innovation strategy AVE has an absolute value of square root of 0.758. The absolute value of the square root of Technological Innovation Performance AVE is 0.751. Meanwhile, according to Table 4.10, the Pearson correlation coefficient is at most 0.9, and there is no problem with covariance, which meets the requirements. The analytical study of structural equation modeling can be carried out.

Table 4.10 Results of Discriminant Validity

Variables	√AVE	HCB	SCB	ICB	TIR	QTIS	TIP
HCB	0.769	0.769					
SCB	0.764	0.239**	0.764				
ICB	0.781	0.296**	0.254**	0.781			
TIR	0.785	0.500**	0.218**	0.244**	0.785		
QTIS	0.758	0.436**	0.365**	0.409**	0.482**	0.758	
TIP	0.751	0.298**	0.191**	0.221**	0.496**	0.524**	0.751

NOTE: * p<0.05 ** p<0.01 *** p<0.001

4.4 The Structural Equation Models and Hypothesis Testing

Based on the above data analysis and indicators, the research data meets the requirements for structural equation modeling. Structural equation modeling is performed on the data through AMOS software and explains the relationship between the variables to verify whether the hypotheses are valid. Structural equation modeling needs to test the model's fitness. Chi-square/df needs to be less than 3, which meets the research criteria. Meanwhile, GFI, AGIF and CFI need to be greater than 0.9 for excellent, more significant than 0.8, less than or equal to 0.9 for acceptable, and RMSEA needs to be less than 0.08 to meet the requirements of the model fit indexes (see Table 4.11). According to the results, the Chi-square in the study is 600.522; df is 483; Chi-square/df is 1.243, is less than 3, which meets the GFI, IFI, and CFI are all greater than 0.9, and RMSEA is 0.026 less than 0.08. Therefore, the model fitting indexes meet the requirements. The model is well-adapted and does not need to be processed or corrected for structural equation modeling and analysis.

Table 4.11 Model Fit Intercept (N=401)

Model Fit Indicators	Threshold Range	Observed Values
Chi-square	-	600.522
df	-	483
Chi-square/df	Below 5, best below 3	1.243
GFI	Above 0.9，0.8-0.9Acceptable	0.919
AGFI	Above 0.9，0.8-0.9Acceptable	0.905
CFI	Above 0.9，0.8-0.9Acceptable	0.984
RMSEA	Below 0.08	0.025

4.4.1 Direct Effect Validation

Based on the AMOS output (see Table 4.12, Figure 4.3), it can be concluded that the path coefficient of the impact of the human capital of the Board on Technological Innovation Resources is 0.551. The regression weight estimate has a standard error (S.E.) of about 0.059. The regression weight estimate is 9.283 (C.R.)

standard errors above zero, p<0.001. Estimates of standardized Estimates of standardized regression weights are 0.525.

The path coefficient of the effect of the social capital of the Board on Technological Innovation Resources is 0.094. The regression weight estimate has a standard error (S.E.) of about 0.064. The regression weight estimate is 1.488 (C.R.), which is less than 1.96 with significance p=0.137 and hence not significant. Estimates of standardized regression weights are 0.076.

The path coefficient of the institutional capital of the Board on Technological Innovation Resources is 0.075. The regression weight estimate has a standard error (S.E.) of 1.331 (C.R.), which is less than 1.96 with significance p=0.183 and hence not significant. Estimates of standardized regression weights are 0.069.

The path coefficient of the effect of the human capital of the Board on the quality of the technological innovation strategy is 0.131. The regression weight estimate has a standard error (S.E.) of about 0.044. The regression weight estimate is 3.012 (C.R.) standard errors above zero, p<0.01. Estimates of standardized regression weights are 0.178.

The path coefficient of the effect of the social capital of the Board on the quality of the technological innovation strategy is 0.197. The regression weight estimate has a standard error (S.E.) of about 0.043. The regression weight estimate is 4.545 (C.R.) standard errors above zero, p<0.01. Estimates of standardized regression weights are 0.225.

The path coefficient of the effect of the institutional capital of the Board on the quality of the technological innovation strategy is 0.186. The regression weight estimate has a standard error (S.E.) of about 0.038. The regression weight estimate is 4.837 (C.R.) standard errors above zero, p<0.01. Estimates of standardized regression weights are 0.245.

The path coefficient of influence of Technological Innovation Resources on the quality of technological innovation strategy is 0.220. The regression weight estimate has a standard error (S.E.) of about 0.041. The regression weight estimate is 5.347 (C.R.) standard errors above zero, p<0.001. Estimates of standardized regression weights are 0.313.

The path coefficient of the impact of Technological Innovation Resources on Technological Innovation Performance is 0.269. The regression weight estimate has a standard error (S.E.) of about 0.050. The regression weight estimate is 5.423 (C.R.) standard errors above zero, p<0.001. Estimates of standardized regression weights are 0.324.

The path coefficient of influence of the quality of technological innovation strategy on Technological Innovation Performance is 0.513. The regression weight estimate has a standard error (S.E.) of about 0.075. The regression weight estimate is 6.831 (C.R.) standard errors above zero, p<0.001. Estimates of standardized regression weights are 0.434.

Table 4.12 Results of Structural Equation Modeling

Path Relationship			**Estimate**	**S.E.**	**C.R.**	**P**	**Estimates of Standardized Regression Weights**
TIR	<---	HCB	0.551	0.059	9.283	***	0.525
TIR	<---	SCB	0.094	0.064	1.488	0.137	0.076
TIR	<---	ICB	0.075	0.056	1.331	0.183	0.069
QTIS	<---	HCB	0.131	0.044	3.012	**	0.178
QTIS	<---	SCB	0.197	0.043	4.545	***	0.225
QTIS	<---	ICB	0.186	0.038	4.837	***	0.245
QTIS	<---	TIR	0.220	0.041	5.347	***	0.313
TIP	<---	TIR	0.269	0.05	5.423	***	0.324
TIP	<---	QTIS	0.513	0.075	6.831	***	0.434

NOTE: * p<0.05 ** p<0.01 *** p<0.001

The study results show the relationship between the human capital of the Board, social capital of the Board, institutional capital of the Board, Technological Innovation Resources, quality of technological innovation strategy, and Technological Innovation Performance. The causal relationship between each variable is clear. According to Figure 4.5, the coefficient path directly responds to the relationship between the variables. The study results show that The HCB of high-technology companies has positively affected TIR (H1). The HCB of high-technology companies positively affects QTIS (H2). The SCB of high technology companies does not affect TIR (H3). The SCB of high-technology companies positively affects QTIS (H4). The ICB of high-technology companies does not affect TIR (H5). The ICB of high-technology companies positively affects QTIS (H6). The TIR of high technology companies positively affects QTIS (H7). The TIR of high-technology companies positively affects TIP (H8). The QTIS positively affects TIP in high-technology companies (H9).

Table 4.13 Hypotheses Testing

NO.	Hypothesis	Result
H1	The HCB of high-technology companies has a positive effect on TIR.	Supported
H2	The HCB of high-technology companies has a positive effect on QTIS.	Supported
H3	The SCB of high technology companies has a positive effect on TIR.	Unsupported
H4	The SCB of high-technology companies has a positive effect on QTIS.	Supported
H5	The ICB of high-technology companies has a positive effect on TIR.	Unsupported
H6	The ICB of high-technology companies has a positive effect on QTIS.	Supported
H7	The TIR of high technology companies has a positive effect on QTIS.	Supported
H8	The TIR of high-technology companies has a positive effect on TIP.	Supported
H9	The QTIS has a positive effect on TIP in high-technology companies.	Supported

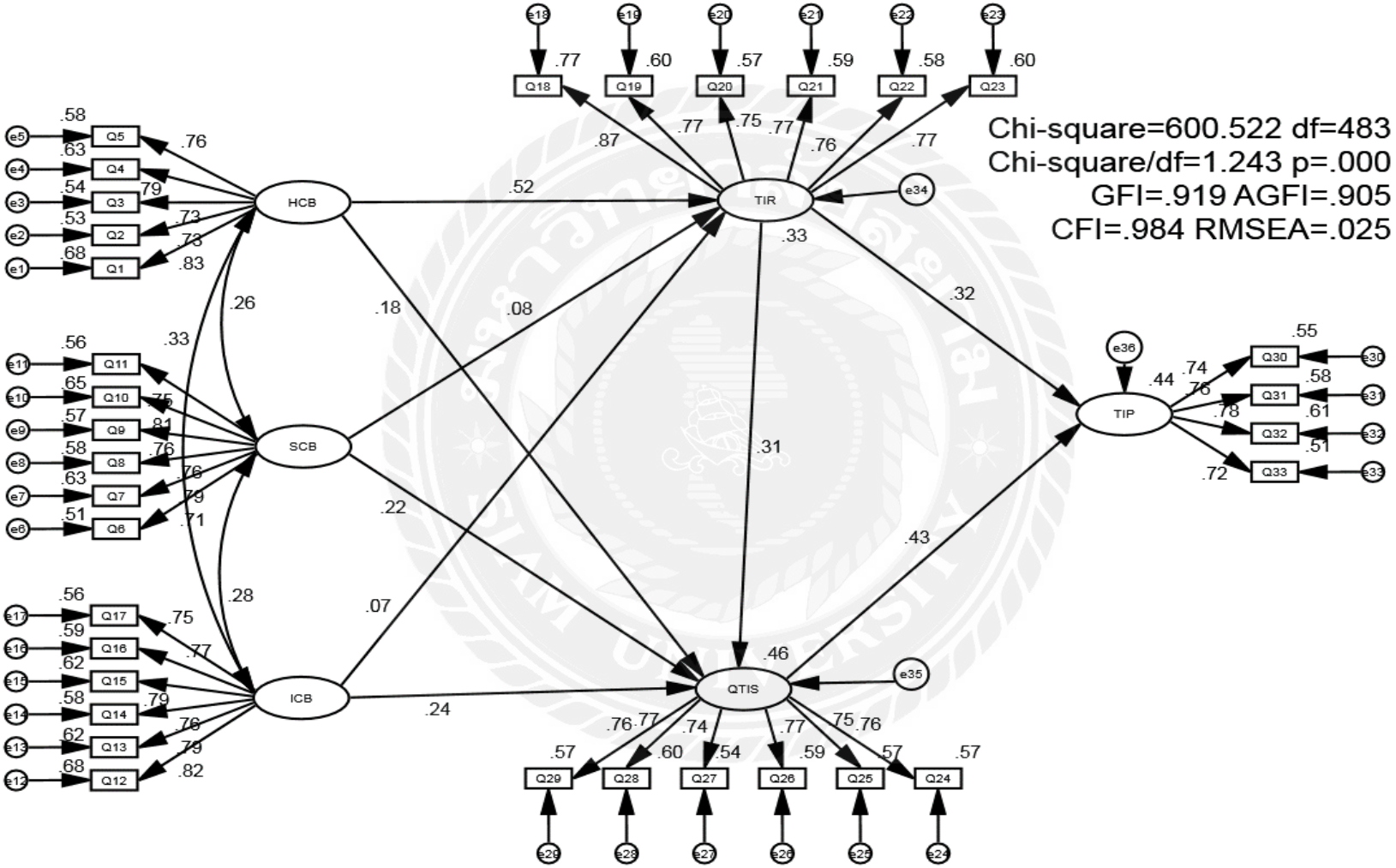

Figure 4.3 The Modified Structural Equation Model

H1: The HCB of high-technology companies has a positive effect on TIR. **(Accepted Hypothesis)**.

This hypothesis suggests a positive relationship exists between the level of human capital and technological innovation resources on the Boards of Directors of high-tech firms. As the level of Board members' human capital increases, technological innovation resources increase accordingly. This implies that the firm's top management's knowledge, skills, and experience are essential in driving technological innovation. High-tech firms usually rely on advanced technology and innovation, so the human capital of Board members may play a vital role. Technological Innovation Resources include R&D teams, patents, technological equipment, and innovation culture, which are crucial for the competitiveness and growth of a firm in the field of science and technology. Hi-tech firms are likely to invest more in enhancing the human capital of Board members as a critical factor contributing to the increase in Technological Innovation Resources. This may also mean that firms will emphasize candidates' technological expertise and innovation capabilities in Board composition and selection.

H2: The HCB of high-technology companies has a positive effect on QTIS. **(Accepted Hypothesis)**.

This hypothesis suggests a positive relationship exists between the level of human capital and the quality of technological innovation strategies on the Board of high-tech firms. As the level of human capital of Board members increases, the quality of technological innovation strategies increases accordingly. In the high-tech sector, developing technology innovation strategies requires deep technical understanding and industry insight. A high-quality technology innovation strategy should be able to effectively guide the company to succeed in technology development and marketing, improve competitiveness, and realize long-term sustainable development.

H3: The SCB of high technology companies has a positive effect on TIR. **(Unaccepted Hypothesis).**

If this hypothesis does not hold, it may indicate that the relationship between the level of social capital and technological innovation resources does not show a positive trend in the Boards of directors of high-tech companies. This may mean that social relationships, collaboration, and networks among Board members do not directly

contribute to the firm's accumulation of technological innovation resources. The company's investment in socialization and the network of relationships among Board members may not be the main determinants of the level of technological innovation resources. It may also suggest that companies should focus more on other factors in Board composition and management, such as individual expertise and experience, rather than relying too much on social capital among Board members.

H4: The SCB of high-technology companies has a positive effect on QTIS. **(Accepted Hypothesis)**.

The validity of this hypothesis may indicate that social capital is positively related to the quality of technological innovation strategies on the Boards of directors of high-tech firms. This implies that social relationships, cooperation, and networks among Board members may positively affect the development of high-quality technological innovation strategies in the firm. Good social capital among Board members contributes to information sharing, increased cooperation, and shared understanding, which may play a vital role in developing technological innovation strategies. The positive effects of social capital may manifest in better teamwork and more efficient exchanges of ideas, thus providing a more holistic and multidimensional viewpoint for developing technological innovation strategies.

H5: The ICB of high-technology companies has a positive effect on TIR. **(Unaccepted Hypothesis)**.

Failure of the hypothesis indicates that the relationship between the level of institutional capital and technological innovation resources in the Board of Directors of high-tech companies does not show a positive trend. The institutional capital of the Board of Directors, such as the company's internal system, rules and regulations, governance structure, and other factors, does not directly contribute to the accumulation of technological innovation resources in the company. The institutional capital has a relatively small impact on technological innovation resources. In contrast, other factors, such as the company's R&D investment, innovation culture, and market orientation, maybe more critical. A firm's investment in regulations and governance structure may not significantly contribute to developing technological innovation resources.

H6: The ICB of high-technology companies has a positive effect on QTIS. **(Accepted Hypothesis)**.

This hypothesis indicates a positive relationship between the level of institutional capital and the quality of technological innovation strategies on the Board of high-tech firms. The institutional capital of the Board of Directors, such as the company's internal systems, regulations, governance structure, and other factors, contributes positively to developing a high-quality technological innovation strategy. The better they establish a sound institutional framework and governance structure, the more likely their technological innovation strategy development will be systematic and organized. Institutional capital's positive effects may manifest in more robust decision support, more efficient implementation mechanisms, and better risk management, all of which contribute to the quality of technology innovation strategies.

H7: The TIR of high technology companies has a positive effect on QTIS. **(Accepted Hypothesis).**

This hypothesis's validity indicates a positive relationship between the level of technological innovation resources and the quality of technological innovation strategies in high-tech firms. This means that high-tech firms have richer technological innovation resources that contribute to the quality of their technological innovation strategies. The firm's strength in technology, investment in R&D, and the competence of its innovation team are critical to a high-quality technological innovation strategy. The positive effects of technological innovation resources include a more advanced technological base, more patents, and a stronger R&D team, which help the firm develop a technological innovation strategy with a competitive advantage.

H8: The TIR of high-technology companies has a positive effect on TIP. **(Accepted Hypothesis).**

This hypothesis indicates a positive relationship between the level of technological innovation resources and technological innovation performance in high-tech firms. This means that high-tech firms have richer technological innovation resources that help to enhance their technological innovation performance. The firm's technological innovation resources, including its advanced technology base, unique patents, and an efficient R&D team, positively affect the firm's performance in technological innovation. This may lead to more innovative products, higher market

shares, and a better competitive position.

H9: The QTIS has a positive effect on TIP in high-technology companies. **(Accepted Hypothesis)**.

This hypothesis indicates a positive relationship between the quality of technological innovation strategy and technological innovation performance in high-tech firms. This implies that developing high-quality technological innovation strategies helps drive the firm's performance in technological innovation. By developing more effective and forward-looking technological innovation strategies, high-tech firms can better direct their R&D and innovation activities to achieve more significant performance. A high-quality technology innovation strategy may include clear objectives, effective resource allocation, sound risk management, and a good match with market demand and the competitive environment.

4.5 Conclusion

This chapter analyzes the collected data. Descriptive statistical analysis, reliability and validity analysis, validation factor analysis, correlation analysis, and construction of structural equations are performed on the relevant data, mainly using SPSS and AMOS. The hypotheses are verified based on the analyzed indicators of the relevant data. The validation results show that there is no significant effect of Board social capital on Technological Innovation Resources and no significant effect of Board institutional capital on Technological Innovation Resources. The human capital of the board, Board social capital, Board institutional capital, Technological Innovation Resources, quality of technological innovation strategy, and Technological Innovation Performance have no significant effect on Technological Innovation Resources, Innovation Strategy, and Technological Innovation Performance.

CHAPTER 5
RESEARCH CONCLUSION, DISCUSSION AND RECOMMENDATION

According to the structural equation calculation, it is learned that Board capital affects the acquisition of technological innovation resources and the quality of technological innovation strategic decision-making. Technological innovation performance is also affected by the three variables. Based on the results of the previous research, this chapter is as follows.:

5.1 Research Conclusion

5.2 Discussion

5.3 Recommendation

5.4 Future Research

5.1 Research Conclusion

Questionnaires of this study are designed on relevant research. Each questionnaire has 33 research questions. The sample size is calculated. According to government statistics, in 2021, there were 23,345 high-tech enterprises (http://tjj.shandong.gov.cn/) in Shandong Province. The sample size is calculated to be at least 399. A questionnaire on the Board of Directors of private high-tech enterprises in Shandong Province is collected in the study. Calculations and analyses are carried out based on structural equation modeling.

The objectives of this study are threefold and are as follows: (1) To determine the factors of Board capital investment on the technological innovation performance of High-Tech Enterprises. (2) To explore the effect between Board capital and Technological Innovation Resources and the quality of technological innovation strategy of High-Tech Enterprises. (3) To explore how Technological Innovation Resources and the quality of technological innovation strategy affect technological

innovation performance. The study has constructed a structural equation model with nine hypotheses and set up an independent variable (Board capital) to test the dependent variables (innovation performance, technological innovation resources, and quality of technological innovation strategy) to validate the analyses. The interrelationships between the variables are investigated.

Knowledge of statistical measurement is used in the study, using descriptive statistics and structural equation modeling to analyze the collected data. The conclusions of the essential statistical characteristics of the samples in the study are mainly as follows:

1) Demographic information shows that 53.1% of the survey samples are male (213) and 46.9% are female (188), with the male samples being slightly higher than the female ones; the distribution of the age variables in the survey of each age stage is relatively even; and in the survey of the education level, the distribution is relatively even.

2) In the study of each variable, Board capital, innovation performance, technological innovation resources, and quality of technological innovation strategy are correlated. According to the results of structural equation modeling, each variable has a relationship. However, the Human capital of the board (HCB), Board Social Capital (SCB), and Board Institutional Capital (ICB) are not related to Technological Innovation Resources. There is a low correlation with Technological Innovation Resources (correlation coefficients of 0.298,0.191 and 0.221, respectively, see Table 4.13).

3）The structural equation model is constructed based on the literature review; for the structural equation model, the model fit test must be performed by calculating the results of the model indexes, which show that GFI, AGIF, and CFI all exceed 0.9, more significant than 0.8, less than or equal to 0.9 as acceptable. RMSEA needs to be less than 0.08 to meet the requirements of the model fit indexes. SPSS and AMOS software are used in the data analysis process. The statistical analysis process mainly includes the statistics and description of control variables and data average distribution analysis. At the same time, the survey data are analyzed for reliability and validity. Cronbach's Alpha and Corrected Item-Total Correlation (CICT) are used for the

reliability analysis. The validity test uses Confirmatory Factor Analysis, including path coefficients, Combined Reliability (CR), and Average variance extracted (AVE) values. Based on the analysis results, it is ensured that the survey data are reliable and distinguishable. Correlation analysis and structural equation modeling are carried out after the data pass the reliability and validity tests. The hypotheses of structural equation modeling are verified. The positive correlation between Board Social Capital (SCB) and Board Institutional Capital (ICB) on Technological Innovation Resources is insignificant, and the hypothesis is not established. All other hypotheses are valid.

This study has collected a total of 401 valid questionnaires, and a structural Board capital, innovation performance, technological innovation resources, and quality of technological innovation strategy are constructed using structure equation modeling. The hypothesized relationships between the variables are verified through calculations. This study answers the three questions respectively:

(1) What Factors of Board Capital Affect the Innovation Performance of High-Tech Enterprises?

The results of the structural equation test show that Human capital of board (HCB), Board social capital (SCB), and Board institutional capital (ICB) are the main components of Board capital. The three dimensions of Board capital are an organic whole, and they are interdependent and interact with each other to have synergistic functions and effectiveness. (Nutt, 2008; Sauerwald et al., 2014). The three-dimensional synergistic process of Board capital is the process of three-dimensional synergistic formation of synergistic Board capital; the Human capital of the board is the primary production factor and the core of the Board to achieve the performance of capital. Board social capital is the primary mode of operation. It is the environmental condition for the realization of the capital performance of the Board of Directors. Board institutional capital is the "infrastructure" or "knowledge platform" supporting the operation of the Board, which is the key to realizing Board capital performance. The human capital of the board (HCB), Board Social Capital (SCB) and Board Institutional Capital (ICB) affect the innovation performance of High-Tech Enterprises.

(2) Does Board Capital Affect the Technological Innovation Resources and Quality of the Technological Innovation Strategy of High-Tech Enterprises?

From the relationship between the Human capital of the board and the acquisition of technological innovation resources (Grant, 2020), the structural equation modeling test confirms that the level of Human capital of the board has a significant positive impact on the acquisition of resources, indicating that the Board capital is an important facilitator that affects the acquisition of resources (Makaryanawati, 2018). That is to say, in a Board with a higher human capital level, the overall cognitive level and cognitive state are higher, and the accuracy of the identification of the resources required for enterprise technological innovation, the selection of channels for obtaining technological innovation resources and the interaction with the main body of technological innovation resources provision are better, which is conducive to the acquisition of technological innovation resources. In terms of the relationship between Human capital of board and the quality of technological innovation strategic decision-making, the results of structural equation modeling tests all confirm that the level of Human capital of board has a significant positive effect on the quality of technological innovation strategic decision-making, indicating that the level of Human capital of board is an essential factor affecting the acquisition of resources. This result verifies the correctness of the view of Makaryanawat (2018) et al. Boards with higher levels of human capital can comprehensively analyze the complex environment faced by technological innovation strategic decisions and can make correct technological innovation strategic decisions in the face of uncertainty in the external environment.

Looking at the relationship between Board social capital and access to resources for technological innovation, the structural equation modeling test confirms that the level of Board social capital cannot significantly affect access to resources. This is inconsistent with the hypothesis of this study. The possible reason is that Board members come from different departments of the firm, and there are barriers to communication and effective resource sharing between them. Looking at the relationship between Board social capital and the quality of technological innovation strategic decisions, the results of the structural equation modeling tests all confirm that there is a significant positive effect of Board social capital on the quality of technological innovation strategic decisions. The quality of technological innovation and strategic decision-making relies on information. Social connections help the Board of Directors obtain more information for strategic decision-making. The larger the size

of the Board's social network, the more help it receives from social network members. More social network members from different industries can provide entrepreneurs with new and heterogeneous information. The more adequately it scans the environment, and the better it can make high-quality strategic decisions on technological innovation.

Regarding the relationship between Board institutional capital and resources acquisition for technological innovation, the structural equation modeling test confirms that there can be no significant effect of Board institutional capital on resources acquisition. This is not in line with the hypothesis of this paper. The Board of Directors comes from various departments and only gathers together when the Board meets to make decisions. They seldom communicate and discuss the company's daily affairs regularly (Xie, 2003). In the process of corporate technology resources acquisition, the Board of Directors seldom communicates and discusses the issue of resources acquisition, and the role of the Board institutional capital needs to be effectively played. In terms of the relationship between Board institutional capital and decision-making quality, the results of structural equation modeling show that the level of Board institutional capital has a significant positive effect on the quality of technological innovation strategy decision-making, indicating that the level of Board institutional capital is an essential factor affecting the quality of technological innovation strategy decision-making. This result verifies the correctness of the viewpoints of Xie Yongzhen (2003) and others.

(3) Does Technological Innovation Resources and Quality of Technological Innovation Strategy Affect Technological Innovation Performance in High-Tech Enterprises?

From the relationship between resources acquisition and innovation performance, the results of the structural equation model test and neural network model test show that technological innovation resources acquisition has a significant positive impact on technological innovation performance. It indicates the critical role of resource acquisition on innovation performance enhancement, which is consistent with Boge et al.'s (2001) point of view, that is, the accessibility of the resources, to a certain extent, determines the ability and level of innovation in the enterprises, and is an essential factor affecting technological innovation in firms (Pan & Fan, 2021).

From the relationship between the quality of technological innovation strategic decision-making and technological innovation performance, the quality of technological innovation strategic decision-making has a significant positive impact on technological innovation performance. It indicates the critical role of the quality of technological innovation strategic decision-making in the improvement of technological innovation performance, which is consistent with the viewpoint of Billand et al. (2019), that is, the degree of adaptation of technological innovation strategy with the internal and external environments of the enterprise is an essential factor affecting the technological innovation performance, which can point out the direction of technological innovation and guide the technological innovation activities.

From the relationship between the acquisition of technological innovation resources and the quality of technological innovation strategic decision-making, the quality of technological innovation strategic decision-making has a significant positive impact on technological innovation performance, indicating the critical role of the quality of technological innovation strategic decision-making in the improvement of technological innovation performance (Nutt, 2008). It is assumed that in the process of innovation strategy decision-making, the more enterprise resources are acquired, the fewer resource constraints are imposed on innovation strategy decision-making, and the more innovation strategy decision-making options are formed, which can improve the freedom of innovation strategy selection and the quality of innovation strategy decision-making. Consistent with Nutt's (2008) empirical analyses, firms with a stable supply of core resources have a higher quality of technological innovation strategic decisions than firms with a scarcity of core resources.

5.2 Discussion

Variables are Discussed one by one Based on the Study's Results while Explai ning the Interrelationships Between the Variables.

5.2.1 Discussion on Variable: Board Capital

The key to the synergistic development of human capital, social capital, and institutional capital of the Board of Directors is establishing the communication and

learning mechanisms of the Board. The communication mechanism of the Board is interdependent in the communication process of Board members, and the subject of communication, the content of communication, the channels of communication, the rules of communication, and the power of communication are unified. To establish a good and stable relationship network, Board members must maintain close contact. Their relationship quality depends mainly on the Board communication mechanism. Board members use communication mechanisms to exchange knowledge, skills, and experiences (Davidsson & Honig, 2003). This not only enhances the level of Human capital of the board, but more importantly, it enhances the trust and willingness to cooperate among the members, which leads to a more robust relationship network and, ultimately, to an increase in the level of Board institutional capital. In addition, Board internal members can make use of the communication mechanism to establish new contacts with Board external members and form a new social relationship network with the help of their human capital, that is to say, to generate new social capital.

The human capital of the board positively promotes the acquisition of technological innovation resources and the quality of technological innovation strategic decision-making in high-tech enterprises (assumption H1, H2 is valid). The acquisition of technological innovation resources and the quality of technological innovation strategic decision-making are the key promotional factors of technological innovation performance, and at the same time, the acquisition of technological innovation resources positively affects the quality of technological innovation strategic decision-making (Fama & Jensen, 2021). Therefore, the Human capital of the board has an impact on technological innovation performance through the following three paths: First, the Human capital of the board can effectively obtain the resources needed for technological innovation from the outside, thus improving technological innovation performance; second, the Human capital of the board can improve the quality of the enterprise's technological innovation strategy decision-making and thus improve technological innovation performance. Third, the Human capital of the board improves the enterprise's access to resources, which improves the quality of the enterprise's innovation strategy decision-making and technological innovation performance.

When the Board's social capital level is low, its effect on the acquisition of technological innovation resources is not significant. When Board social capital accumulates to a certain level, it will positively promote the acquisition of technological innovation resources (Hypothesis H3 does not hold, and Hypothesis H4 holds). At the same time, acquiring technological innovation resources will positively affect the quality of technological innovation strategic decision-making (Goh, 2009). In contrast, the acquisition of technological innovation resources and the quality of technological innovation strategic decision-making are critical factors for improving technological innovation performance. Therefore, when the level of Board social capital accumulates to a certain degree, there are two paths to its effect on the acquisition of technological innovation resources; one is that Board social capital can improve the acquisition of technological innovation resources and performance; the other is that Board social capital can improve the acquisition of technological innovation resources. The acquisition of resources can improve the quality of technological innovation strategic decisions and performance. Among these two paths, the influence path through resources acquisition is larger, indicating that Board social capital mainly influences innovation performance through influencing resources acquisition.

When the level of Board institutional capital is in a particular range, it positively contributes to the quality of strategic decisions on technological innovation (Hypothesis H6 is valid); however, when Board institutional capital does not have a significant effect on the acquisition of technological innovation resources (Hypothesis H5 is not valid). Therefore, when the level of Board institutional capital is in a particular range, there is a path of its effect on technological innovation performance, and Board institutional capital can improve the quality of strategic decision-making in technological innovation, which in turn enhances technological innovation performance.

5.2.2 Discussion on Variable: Technological Innovation Resources

Board capital influences the innovation performance of high-tech firms through technological innovation resources—the critical role of resource acquisition on innovation performance improvement. The findings of the study are consistent with those of scholars. The identification, acquisition, and diversification of resources are associated with the enterprise's innovation capability and innovation level (Hillman &

Keim, 2001). The role of social capital and institutional capital of Board capital on resource acquisition is not significant. The reason may be that the transfer of resources needed for technological innovation, especially knowledge and information resources, is hidden and "sticky" in nature and in an environment where high-tech firms regard them as the key to competitive advantage and attach great importance to the relationship with universities and research institutes, intermediary organizations and industry associations. The subject of providing resources for technological innovation may be more concerned about its relationship with the subject of resource demand. We may judge the quality of its relationship with the resources demand subject to determine the object of resources transfer, resulting in a single threshold effect in the relationship between Board social capital and the acquisition of technological innovation resources.

More is needed for Boards to focus on increasing their capital because access to technological innovation resources has a more direct and practical influence on technological innovation performance (Hillman et al., 2019). Suppose firms need to acquire the resources needed for technological innovation promptly and accurately. In that case, the effect of a high level of Board capital on technological innovation performance may be significantly diminished, and it will not be easy to translate into higher technological innovation output effectively. Therefore, while focusing on improving the level of Board capital, the Board should also pay attention to the role of the bridge to the acquisition of technological innovation resources and improve the ability to acquire technological innovation resources.

5.2.3 Discussion on Variable: Quality of Technological Innovation Strategy

Technological innovation decision quality has a significant effect on firms' innovation performance. Board capital has an impact on the quality of technological innovation decisions. More is needed for the Board to focus on improving their human, institutional, and social capital because the quality of strategic decisions on technological innovation is a more direct and practical influence on technological innovation performance. Suppose the Board fails to make high-quality strategic decisions on technological innovation (Lai et al., 2012). In that case, even if it has a high level of human and institutional capital, it will not be easy to consistently and steadily transform it into a higher technological innovation output. Improving the

quality of strategic decisions is a crucial way to enhance technological innovation performance. Therefore, the Board should pay attention to the level of Board capital and the role of the bridge of the quality of strategic decision-making in technological innovation and endeavor to improve the quality of strategic decision-making in technological innovation.

A Board of Directors with a higher level of Board capital is conducive to stimulating the cognitive diversity and creativity of the Board, prompting Board members to make use of each other's wisdom to conduct extensive discussions during the strategic decision-making process, and thus is conducive to promoting the improvement of the quality of strategic decision-making. The higher the level of Board capital, the stronger the decision-making consensus ability, the more conducive to the emergence of group thinking that is prone to the perception of group members that the entire group is infallible, and group members do not express their doubts or different opinions. In the observation of high-tech enterprises in recent years, innovation strategy decision-making announcements can be difficult to find; most of the company's Boards (Kim & Cannella, 2008) resolve for a unanimous vote but rarely a negative vote. This overly "harmonious" voting result indicates that there may be group thinking in directors' decision-making process. Group thinking in the Board may lead to the final decision not based on the results of their intuitive decision-making, resulting in group decision-making bias and lowering the quality of innovation strategy decision-making.

5.2.4 Discussion on Variable: Innovation Performance

There are more factors influencing the innovation performance of high-tech enterprises. This study proposes the influence of three factors, namely, Board capital, access to technological innovation resources, and quality of technological innovation decisions, on the innovation performance of high-tech enterprises. The human capital of Board capital affects the innovation performance of enterprises through the access to technological innovation resources and the quality of technological innovation decisions; Board institutional capital and social capital affect the innovation performance of enterprises more through the quality of technological innovation decisions. This is the same as some scholars' research (Leitch et al., 2012). The improvement of innovation performance of high-tech enterprises needs to play the role

of Board capital further, from its ability to identify resources to its quality and sound Board environment. The resources acquisition channels and resources acquisition methods of innovative technologies of high-tech enterprises are further expanded and improved. The quality of technological decision-making of enterprises needs to be further expanded by combining Board capital and technological resources. The way to improve the innovation performance of high-tech enterprises includes obtaining more resources and making high-quality innovation decisions; that is to say, by acquiring technological innovation resources to achieve innovation performance improvement, Board of Directors can make efficient innovation decisions.

5.2.5 Discussion on all Variables

Based on previous studies, the three-dimensional structure of Board capital is proposed, and Board capital scale and measurement models are developed. Based on theoretical analysis and logical reasoning, the research hypotheses are put forward, and the theoretical model of the mechanism of Board capital affecting technological innovation performance is constructed (Lockett & Wright, 2005). The data are obtained through a questionnaire survey, and structural equation modeling and neural network modeling are used for empirical testing. The three-dimensional structural framework of Board capital is constructed. In the composition of Board capital, in addition to human and social capital in the traditional sense, institutional capital is also an essential dimension. The three-dimensional components and relationships are analyzed, and the three-dimensional structural framework of Board capital is proposed. That is, Board capital comprises three dimensions: Human capital of the board, Board social capital, and Board institutional capital. The mechanism by which Board capital affects the technological innovation performance of high-tech enterprises is found. Through theoretical analyses and empirical tests on the mechanism of Board capital influencing the technological innovation performance of high-tech enterprises, it is found that Board capital influences the technological innovation performance through the following three paths:

- Influencing the Technological Innovation Performance of High-Tech Enterprises Through Influencing the Acquisition of Technological Innovation Resources;

● Influencing the Technological Innovation Performance of High-Tech Enterprises Through Influencing the Quality of Technological Innovation Strategic Decisions;

● Influencing the Technological Innovation Performance of High-Tech Enterprises Through Influencing the Quality of Technological Innovation Resources Acquisition and Technological Innovation Strategic Decisions.

The study finds that Board capital influences the technological innovation performance of high-tech enterprises through the following three paths: influencing the acquisition of technological innovation resources, influencing the quality of technological innovation strategic decisions, and influencing the technological innovation resources and the quality of technological innovation strategic decisions.

5.3 Recommendations

5.3.1 Recommendations for Board Capital Findings

1. Findings:

(1) A High Level of Human Capital on Board Helps to Improve Technological Innovation Performance.

(2) A High Level of Human Capital on Board Helps to Improve the Quality of Strategic Decision-Making in Technological Innovation.

(3) A High Level of Board Social Capital Helps to Improve Technological Innovation and Strategic Decision-Making.

(4) A High Level of Board Institutional Capital Helps to Improve the Quality of Strategic Decision-Making in Technological Innovation.

2. Recommendations:

(1) Boards should focus on Human capital of board accumulation. Boards should focus on how human capital contributes to the innovation process and actively improve the level of human capital. Knowledge, skills, and competencies among the elements of human capital can be improved through systematic theoretical learning

paths. Improving Board members' knowledge, skills and abilities lies most notably in the self-practice, self-cultivation, and self-improvement of Board members (Merton, 2017). Theoretical knowledge and practical activities are closely linked. Multi-channel and all-round training and learning are to improve the level of Human capital of the board and inner quality. Board members should be full of energy and motivation, be active and innovative, and take the initiative to participate in various learning and social activities.

(2) The board should comprehensively improve the intrinsic quality of Board members. The knowledge, experience, ability, and intrinsic quality of Board members are the basis of cognition and emotion, which are the key factors affecting the quality of strategic decision-making. Changes in emotional processing caused by the intrinsic quality of Board members profoundly affect various high-level cognitive processes of the Board, including memory, judgment, and decision-making, which in turn affects the quality of strategic decision-making. Cultivate Board members with comprehensive and solid abilities. Create a perfect Board member system.

(3) The board should improve its social network structure, relationship, and cognition, and actively cultivate and develop social capital. The board should continuously improve its network relationship and expand its social network structure and its scale. Through the gradual expansion of the connection of relevant network lines, the source of resources can be enriched. So is the richness and diversity of resources and the diversity of choices. The board is the core body of an enterprise at the governance level; it should not take the pursuit of short-term economic benefits as the way to build the value of the social network; it should pursue long-term development, actively obtain the trust and long-term cooperation of external network members, and build a high-quality relationship network (Nahapiet & Ghoshal, 1998). The board needs to exchange knowledge with the network members so that the knowledge spreads from the Board's experience to the level of social network organization and to establish a comprehensive and adequate knowledge-sharing environment of information exchange, knowledge integration, knowledge transfer, knowledge storage and knowledge retrieval of technical, cultural and institutional management.

(4) The board should optimize the institutional capital system. Enterprises should establish a fair and reasonable Board remuneration system by their development situation, based on the fairness and reasonableness of the distribution system and the distribution process, which in turn makes the results of the distribution of relevant benefits fair and reasonable to improve the sense of trust of Board members' organizations. The board may establish a system of filing summaries of Board work so that it may record the notes (Ooi et al., 2017), problems, and solutions encountered in its work in a targeted manner and provide a reference for other similar tasks to be carried out in the future. To enhance the culture of trust in the Board, the Board should create a favorable environment to promote social interaction among its members, and it can also take measures to maintain trust among its members to achieve excellent psychological contact.

5.3.2 Recommendations for Technological Innovation Resources Findings

1. Findings:

(1) The Human Capital of the Board Positively Affects Technological Innovation Resources Acquisition.

(2) Board Social Capital has no Significant Effect on the Acquisition of Technological Innovation Resources.

(3) Board Institutional Capital has no Significant Effect on Acquiring Technological Innovation Resources.

2. Recommendations:

(1) Strengthen the ability of Board capital to identify the need for technological innovation resources. Technological innovation resources acquisition should be identified first. The human capital of the board has a positive effect on the acquisition of technological innovation resources, indicating that human capital is adequate in resource identification in high-tech enterprises. Identifying resource demand will directly affect the quantity and quality of resource acquisition. For the Board to improve its ability to acquire resources, resource awareness must run through the whole resource acquisition process. Resource acquisition, as a social demand of individuals, needs to

be transformed from "implicit" to "explicit" resource needs. Strengthening the Board's capital ability to identify resources will effectively enhance the enterprise's resource acquisition ability.

(2) Expand the channels for acquiring technological innovation resources. It is found that only the Human capital of the board has a positive effect on the acquisition of technological innovation resources. Board social capital and institutional capital do not significantly affect the acquisition of technological innovation resources. Therefore, high-tech enterprises technology should expand access to technological innovation resources (Tasavori et al., 2018). The board is not passively reacting to its external network. However, it should actively use the network relationship to expand access to technological innovation resources to obtain all the resources needed for technological innovation. The board should actively participate in constructing innovation resources acquisition channels and networks and continuously acquire and use new resources. The board can use government departments, research institutions, suppliers, financial institutions, and other social network channels to obtain more diversified resources.

(3) Strengthen cooperation and improve the binding mechanism. Due to the multiplicity of technological innovation resources acquisition goals, the uncertainty of the internal and external environments, the dynamics of time, and the acquisition of technological innovation resources often exceed the scope of individual capabilities, which requires cooperation among Board members (Yli-Renko et al., 2002). A sound Board constraint mechanism helps Board members to transform their particular self-interests and private interests into ultra-utilitarian, collective, public, and legitimate interests, increases the sense of organizational identity and cohesion, weakens conflicts caused by divergent interests, and improves the level of collaboration in the acquisition of technological innovation resources.

5.3.3 Recommendations for Quality of Technological Innovation Strategy Findings

1. Findings:

(1) The Human Capital of the Board Positively Affects the Quality of the Technological Innovation Strategy.

(2) Board Social Capital has a Positive Effect on the Quality of Technological Innovation Strategy.

(3) Board Institutional Capital Positively Affects the Quality of Technological Innovation Strategy.

(4) Technological Innovation Resources Positively Affect the Quality of Technological Innovation Strategy.

2. Recommendations:

(1) Enhancing the Cognitive Level of Human Capital on the Board

The cognitive characteristics of Board members affect the strategic decision-making process and its effectiveness. Board members should fully understand their characteristics and the impact of those characteristics on the cognitive process, improve their cognitive schema, enhance the level of cognitive needs through training, build their strengths, and avoid their weaknesses to enhance the quality of the cognitive process, and ultimately enhance the quality of strategic decision-making. The board should consciously allocate its attention to the information related to strategic decision-making, such as innovation policies, macro-controls, etc., which can help high-tech enterprises perceive the market changes, adjust the internal resources structure, and match the social environment. When facing uncertainties, Board members can consider multiple ways with a broad perspective through a high-intensity activity base and make decisions by evaluating criteria (Zhao et al., 2015).

(2) Enhancing the Strategic Awareness of the Board

The board should strengthen the connection with social networks instead of unquestioningly expanding the size of social networks. The board should establish strategic awareness and improve the quality of Board decision-making. Uncertainties in the external environment are of great significance to the decision-making of the Board. In high-tech enterprises, the rapid flow of information and resources will prompt decision-makers to form a comprehensive decision-making cognition quickly, and decision-makers possess the information processing skills required for decision-making, which will help enterprises make decisions quickly. Firms establish strategic alliances to cope with external shocks and threats. Such strategic alliances can facilitate

the flow of resources and information, increase information transparency within the industry, make it easier for decision-makers to focus on the most helpful information, and avoid inefficiencies due to information asymmetry. In this way, Boards can strengthen their links with other organizations and improve the speed and comprehensiveness of decision-making.

(3) Improving Board Behavioral Integration

Behavioral integration among Board members consists of three main components: teamwork, communication, and participation in decision-making. The board should hold regular meetings, encourage Board members to actively participate in the meetings, and make more rationalized suggestions, which will ultimately lead to high-quality decision-making. The board should also formulate regular and non-regular communication plans, form inherent rules and regulations, establish a multi-channel information exchange platform, and use information technology to improve information sharing. By participating in decision-making and discussing controversial opinions, Board members can enhance mutual trust among members, thus improving decision-making effectiveness (Fama, 2021).

(4) Improving Technological Innovation Resources

Enterprises with a stable supply of core resources make higher-quality technology innovation strategy decisions than those with a scarcity of core resources—the promotion effect of technological innovation resources acquisition on the quality of technological innovation strategic decision-making. The quantity and quality of information on technological innovation strategy affect the decision makers' forecast of external market demand and judgment of the market environment. The board's ability to acquire technological innovation resources can improve the evaluation ability of technological innovation strategic decision-making. The board can think about strategies from diverse perspectives, conduct more discussions, achieve an all-round objective evaluation of the quality of strategic decisions on technological innovation, and ensure that high-quality strategic proposals are selected from a large number of strategic decision-making proposals on innovation (Sauerwald et al., 2014).

5.3.4 Recommendations for Innovation Performance Findings

1. Findings:

(1) Technological Innovation Resources have a Positive Impact on Innovation Performance.

(2) Quality of Technological Innovation Strategy Positively Affects Innovation Performance.

2. Recommendations:

(1) Improving the Acquisition of Technological Innovation Resources to Achieve Innovation Performance Improvement

The study finds that Board capital can improve an enterprise's innovation performance by acquiring technological innovation resources. Technological innovation is not only a process of creating new knowledge within the enterprise but also a process of absorbing new knowledge from outside. To further improve the technological innovation performance of the enterprise, the Board should acquire new knowledge from the outside, especially the interaction with universities and other scientific research institutions to obtain the knowledge needed for technical innovation (Zhou et al., 2019). Moreover, unlike acquiring information, acquiring knowledge depends more on the trust relationship established through long-term interaction between the Board universities, and other research institutes. The board should strive to establish a long-term network of mutual trust with universities and other research institutes instead of a short-term connection.

(2) Enhancing the Quality of Board Technological Innovation Decision-Making to Realize Improved Innovation Performance

If the Board fails to make high-quality strategic decisions on technological innovation, it will not be easy to consistently and steadily transform human capital and institutional capital into higher technological innovation outputs, even if they have a high level of human and institutional capital. Improving the quality of strategic decisions on technological innovation is crucial to enhancing technological innovation performance. The board should make full use of the interrelationship between human

capital, social capital, and institutional capital to improve the quality of the Board's technological innovation decision-making in the decision-making process and realize the improvement of the innovation performance of high-tech enterprises (Makaryanawati, 2018).

5.3.5 Recommendations for High-Tech Enterprises

1. Findings:

(1) Part of the Positive Impact of Board Capital on Technological Innovation Performance is Realized Through Access to Technological Innovation Resources.

(2) Part of the Positive Impact of Board Capital on Technological Innovation Performance is Realized Through the Quality of Strategic Decisions on Technological Innovation.

2. Recommendations:

(1) Strengthening the Ability of the Board to Acquire Technological Innovation Resources

Technological innovation resources acquisition is one of the main behaviors of the Board in the process of technological innovation, and the result of the Board capital value realization based on the resources acquisition behavior is that the high-tech enterprise can acquire sufficient technological innovation resources. Acquisition of technological innovation resources is a crucial factor influencing technological innovation performance. Board capital is a key facilitator of technological innovation resources acquisition. Regarding the interrelationship between Board capital, access to technological innovation resources, and technological innovation performance of high-tech enterprises, a high level of Board capital tends to obtain high-quality and timely technological innovation resources, which is conducive to improving technological innovation performance (Pan & Fan, 2021).

(2) Enhancing the Quality of Board Strategic Decisions on Technological Innovation

Board capital is a crucial contributor to the quality of strategic decision-making in technological innovation. Board capital is the basis of strategic decision-making

behavior (Nutt, 2008). It plays a vital role in the identification, selection, and processing of information resources and decision-making at all stages of the technological innovation strategic decision-making process. Strengthening the information communication and transfer in the whole process of resources acquisition, improving the willingness of Board members to transfer information, and encouraging Board members to carry out work exchanges in the resources acquisition process can improve the quality of the Board's technological innovation and strategic decision-making (Billand et al., 2019).

5.4 Research Contribution

Based on the analysis and discussion of the research results, the model of Board capital impact on technological innovation performance is constructed based on the SCP (Structure- Conduct- Performance) paradigm. In the model for Board capital, there are three main dimensions, which are the Human capital of the Board (HCB), Social capital of the Board (SCB), and Institutional capital of the Board (ICB).

- Human Capital of Board (HCB)
  - ✓ Rich professional knowledge: Board members need to have a wide range of specialized knowledge to provide expert advice and recommendations in the decision-making process.
  - ✓ Communication skills: Board members need to have good communication skills to be able to express themselves clearly and to communicate and collaborate effectively with other members.
  - ✓ Abilities to identify the causes of problems: Board members need to have the ability to analyze problems and dig deep into the root causes of problems to support the development of solutions.
  - ✓ Strong attention, thinking, and memory abilities: Board members need to have a strong attention span and be able to focus on analyzing complex information and situations to make quick decisions. At the same time, good thinking and memory skills help them to deal effectively with large amounts of information and data.

- ✓ Optimistic attitudes: Board members should maintain an optimistic attitude towards challenges and opportunities, and be able to remain calm under pressure to inject positive energy into the organization's development.

- Social capital of Board (SCB)
  - ✓ Frequent contact: Maintaining regular contact between members is key to building trust and cooperation. Regular meetings, discussions, and communication help to enhance teamwork and collaboration.
  - ✓ Mutual trust: It is important to build mutual trust among members. This trust is based on personal integrity, professional competence, and commitment to the common goals of the organization.
  - ✓ Contact with a large number of Directors: Board members should network with people from a variety of backgrounds, experiences, and areas of expertise. Such diversity facilitates access to different perspectives and advice, promoting innovation and holistic decision-making.
  - ✓ Beneficial cooperation: Collaboration among members should be beneficial and promote the achievement of business goals. By working together, the board is better able to solve problems, develop strategies, and achieve long-term organizational growth.
  - ✓ Effective communication: Effective communication is key to ensuring that board members understand each other's perspectives, participate in decision-making, and work together to achieve goals. This includes listening, expressing clear ideas and opinions, and sharing important information promptly.
  - ✓ Similar value orientation: Members should be similar in their value orientation to ensure that they are aligned in major decisions and actions. Shared values help build a common vision and promote team cohesion and stability.

- Institutional capital of Board (ICB)
  - ✓ Incentive mechanisms: Incentives are created to motivate board members

to better perform their duties and align their interests with those of the company. These incentives may include compensation structures, stock options, incentive programs, etc. to motivate members to contribute to the long-term success of the company.

- ✓ Complete audit committee: A well-established audit committee is responsible for overseeing the company's financial reporting and internal control systems to ensure compliance with relevant regulations and accounting standards. This helps to increase investor confidence in the company's financial reporting and enhances the company's transparency and reliability.
- ✓ Procedures following specific tasks: Upon completion of a particular assignment, clear procedures are in place to ensure transparency and compliance in the execution of the assignment. These procedures may include steps such as evaluation of the results of mandate implementation, preparation of reports, and tracking of implementation.
- ✓ Good rapport: Building good relationships among board members is essential to help promote cooperation, communication, and effective decision-making. Strong relationships can be achieved through regular meetings, mutual support, and respect.
- ✓ Trust each other: It is important to build mutual trust among board members. This trust is based on personal integrity, professional competence, and commitment to the long-term interests of the company.
- ✓ Encourage full expression: To promote good decision-making and innovation, the board should encourage members to fully express their ideas, opinions, and concerns. This open environment helps stimulate creative thinking and avoids the silencer effect or disagreements in the team.

Board capital has an impact on the acquisition of innovative technology resources and the quality of technological decisions, corresponding to the behavior of the Board, which has an impact on the resource acquisition behavior and decision-

making behavior of high-tech firms along with the control behavior.

- Resources Actions
  - ✓ Strengthen the ability to identify innovation resources: Board members with rich social and intellectual capital are more likely to identify and recognize new sources of innovation. They may have extensive networks of contacts and access to information on the latest technologies and industry trends. In addition, their specialized knowledge and experience make them better able to understand emerging trends and opportunities in the technology sector.
  - ✓ Expand the channels for acquiring technological innovation resources: Board-capital-rich firms may be able to access technology innovation resources through diverse channels. This includes establishing partnerships with other firms, academia, industry organizations, and government agencies, among others, to share knowledge and resources to accelerate the process of technological innovation.
  - ✓ Strengthen cooperation and improve the binding mechanism: Board members with good relationships and mutual trust are more likely to enter into cooperative agreements and develop effective constraints in their cooperation. Such cooperation may include technology development, sharing of R&D results, and co-investment in innovation projects. By enhancing cooperation, firms can reduce wasted resources and increase innovation efficiency.
- Strategic Actions
  - ✓ Enhance the cognitive level: Firms with capital-rich boards typically have a higher level of cognition, including a deeper understanding of technology trends, market dynamics, and the competitive environment. This elevated level of cognition helps boards better assess and identify innovative technology resources, understand the potential impact of technological innovation, and provide a more comprehensive information base for decision-making.
  - ✓ Enhance strategic awareness: Companies with capital-rich boards of

directors usually focus more on long-term development and strategic planning rather than just short-term gains. They have a clearer understanding of the company's strategic direction and goals and are better able to guide the acquisition of resources for technological innovation and the decision-making process to ensure the consistency of technological innovation with the company's overall strategy.

- ✓ Improve Board behavioral integration: Companies with capital-rich boards tend to have more complete and efficient board operation mechanisms. They can make better use of the diverse expertise and experience of their board members to promote integration and coordination of board behavior. This integrative behavior helps to improve the efficiency and quality of board synergy in acquiring and making decisions about technology innovation resources.
- ✓ Optimize technological innovation strategic decisions: Firms with rich board capital are better able to optimize strategic decisions on technology innovation, including determining the direction of technology investment, developing new products or services, and seeking technology partners. They can consider the risks and benefits of technological innovation more comprehensively and formulate strategic plans that are more in line with the company's long-term interests.

➢ Control Actions

- ✓ Focus on Human capital of board accumulation: Board human capital refers to the knowledge, skills, experience, and competencies of board members. By focusing on board human capital accumulation, companies can ensure that board members have sufficient expertise and experience to better understand and respond to complex business environments and challenges. This includes ongoing training, education, and attracting new members with extensive experience and industry knowledge to the board.
- ✓ Improve the intrinsic quality of Board members: The intrinsic qualities of a board member include aspects such as integrity, accountability, decision-

making ability, and leadership. Improving the intrinsic qualities of board members means ensuring that they have good moral character, decision-making ability, and leadership skills to make the right decisions in the face of challenges and to lead and manage the business in the right way.

- ✓ Improve the social network structure: The social network structure of board members is critical to the growth and success of the enterprise. By building and refining the social networks of board members, an enterprise can better access resources, obtain information, build collaborative relationships, and better respond to changes and challenges in the external environment. This includes active participation in industry associations, building partnerships with other businesses and organizations, and expanding investor and government relationships.
- ✓ Optimize the institutional capital system: Institutional capital refers to systems, regulations, and processes within the organization, as well as contracts and agreements with external partners. Optimizing the institutional capital system means ensuring that the enterprise has a good organizational structure, a clear division of responsibilities, and an efficient communication and decision-making mechanism, as well as a framework and rules for cooperation with external partners. This helps to improve operational efficiency, reduce risk, and build a good business reputation.

Board capital affects Board behavior, and Board behavior affects Board performance concerning corporate governance, and therefore has an impact on Board innovative behavior, as shown in Figure 5.1.

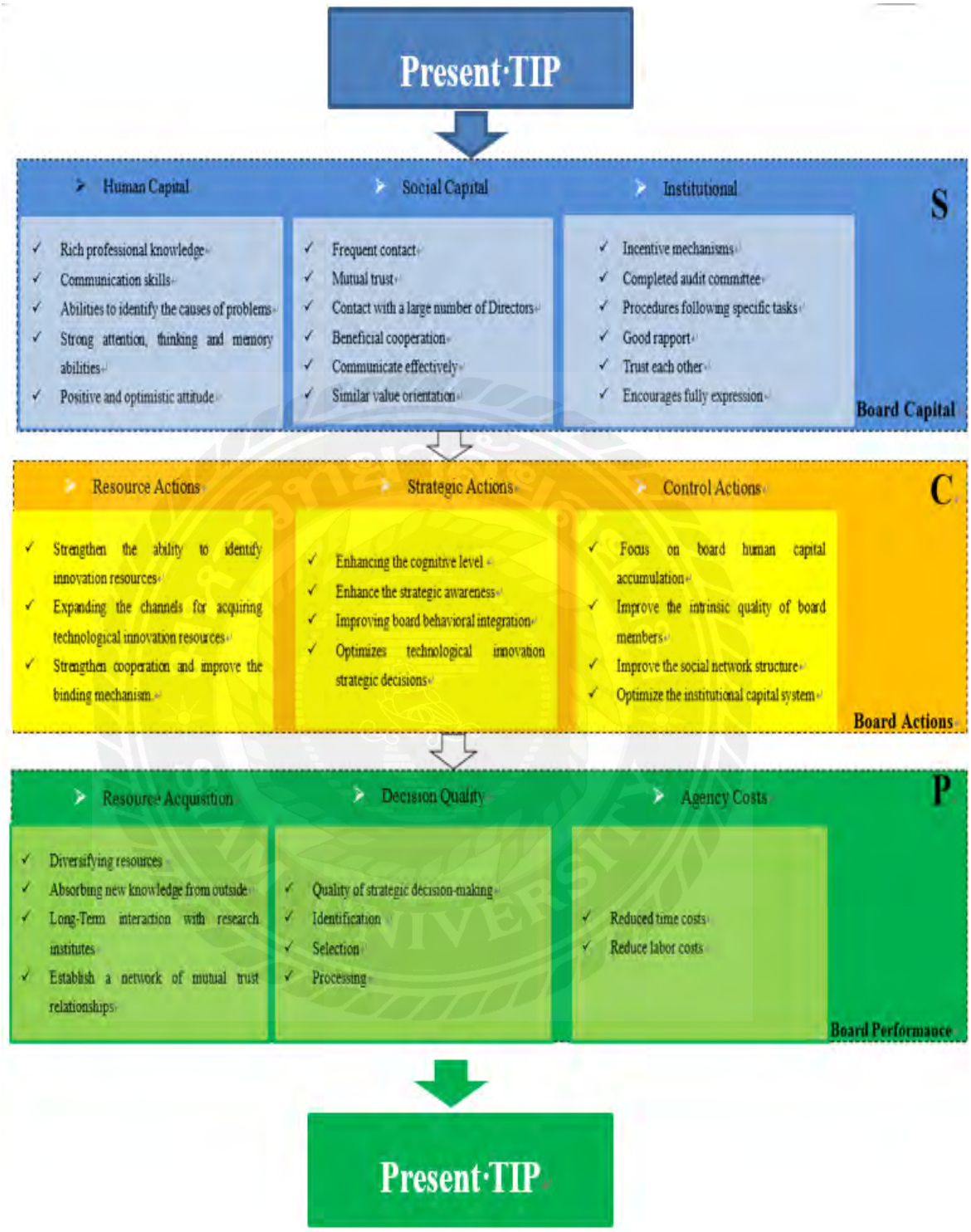

Figure 5.1 The Model of Board Capital Impact on Technological Innovation Performance

5.5 Research Limitations

The limitations of this study are mainly in the following areas:

(1) As to the study of Board capital, only the effects of social capital, human capital, and institutional capital on the innovation performance of high-tech enterprises are investigated. The correlation and coordination among the three are not explored.

(2) The factors affecting the innovation performance of high-tech enterprises in the study are limited to the two factors of technological innovation resources and the quality of technological innovation decisions. However, the factors affecting the innovation performance of enterprises are not limited to these factors.

5.6 Future Research

This paper focuses on the impact of Board capital on technological innovation performance in terms of critical technological innovation factors. Data on access to technological innovation resources and the quality of strategic decision-making in technological innovation are obtained using a questionnaire survey. Future research directions include adopting appropriate methods to address the issue that the three-dimensional synergy of Board capital may be a moderating variable of the three-dimensional Board capital affecting the technological innovation performance of high-tech enterprises. The objectivity of the questionnaire for data collection needs to be further improved, as well as the diversified validation of critical factors of technological innovation performance. It is to explore the direct impact of Board capital on technological innovation performance as well as other influencing factors of the relationship between Board capital and technological innovation performance, such as the enterprise's innovation ability, technology transformation ability, etc., and continue to explore other possible relationship mechanisms of Board capital affecting technological innovation performance.

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Appendix

Questionnaire

THE EFFECT OF BOARD CAPITAL DEVELOPMENT ON INNOVATION PERFORMANCE OF HIGH-TECH ENTERPRISES IN SHANDONG PROVINCE, CHINA

To Questionnaire Respondent

Thank you for your participation. This questionnaire is divided into two parts. The first part is demographic information. The second part is about the influence factors of the effect of Board Capital on Innovation Performance of High-tech Enterprises in Shandong Province. The information obtained from this research is for academic purposes only. All your personal information will be kept confidential. Thank you again for your participation. If you need further information or need our help, please contact us.

In order to ensure the objectivity and accuracy of the research results, please give objective answers.

Mr. Wangfei, Ph.D. Student
Siam University

<u>Part 1</u> Demographic information

Remark: The first part of the questionnaire is about yourself and the Board of Directors. Please check "√" before the options that match.

1. Gender ☐ Male ☐ Female

2. Age ☐ under 30 ☐ 30-50 ☐ over50

3. Education ☐ High school and below ☐ Master degree
☐ Bachelor degree ☐ Others

4. Position ☐ Chairman of the Board
☐ Director of the Board
☐ Others

5. The number of members of Board of Directors

☐ 3-4 people ☐ 5-6 people

☐ more than 7 people ☐ Others

6. Term of membership of Board of Directors

☐ less than 1 year ☐ 1-2 years

☐ 3-5 years ☐ 6-7 years

☐ more than 7 years

7. The industrial nature of your enterprise

☐ Information technology manufacturing of the new generation

☐ New energy and new material technology

☐ High-end equipment manufacturing

☐ Artificial intelligence

<u>Part 2</u> Relational factors

Please rate your agreement level. Tick "√" in the appropriate box. There are five levels: "1. Totally disagree; 2. Disagree; 3. Not sure; 4. Agree; 5. Strongly agree".

Item	Your Manager/Executive….....	Alternative Answer				
		1	2	3	4	5
Capital of Board						
1.1	**Human capital of Board of Directors**					
1	Board members as a whole possess rich professional knowledge.					
2	Board members as a whole can use communication skills to reach consensus.					
3	Board members as a whole are able to quickly identify the causes of problems and the appropriate solutions.					
4	Board members as a whole have strong attention, thinking and memory abilities .					
5	Board members have positive and optimistic attitude to solve problems.					
1.2	**Social capital of Board of Directors**					
6	Board of Directors is in contact with a large number of customers, suppliers, enterprises, scientific research institutes, universities, technical intermediary organizations, governments and financial institutions.					
7	Board of Directors is in frequent contact with customers, suppliers, enterprises, scientific research institutes, universities, technical intermediary organizations, governments and financial institutions.					
8	There exists mutual trust between Board of Directors and customers, suppliers, enterprises, scientific research institutes, universities, technical intermediary organizations, governments and financial institutions.					
9	There exists mutually beneficial cooperation between Board of Directors and customers, suppliers, enterprises, scientific research institutes, universities, technical intermediary organizations, governments and financial institutions.					

Item	Your Manager/Executive….....	Alternative Answer				
		1	2	3	4	5
10	Board of Directors can communicate effectively with customers, suppliers, enterprises, scientific research institutes, universities, technical intermediary organizations, governments and financial institutions due to the shared benefits.					
11	There exists similar value orientation between Board of Directors and customers, suppliers, enterprises, scientific research institutes, universities, technical intermediary organizations, governments and financial institutions due to the shared benefits.					
1.3	**System capital of Board of Directors**					
12	The material and spiritual incentive mechanisms of Board of Directors are relatively complete and independent.					
13	The systems of Board of Directors and the audit committee are complete.					
14	There is a clear procedure to follow in a specific task undertaken by Board of Directors.					
15	Board members have a good rapport with each other and understand each other's intentions quickly.					
16	Board members trust each other.					
17	Board of Directors encourages its members to fully express their views in collective decision-making.					
Acquirement of technological innovation resources						
18	Enterprises can timely acquire information for technological innovation.					
19	Enterprises can acquire sufficient information for technological innovation.					
20	Enterprises can timely acquire knowledge for technological innovation.					
21	Enterprises can acquire a large amount of knowledge for technological innovation.					
22	Enterprises can timely acquire the fund for technological innovation.					

Item	Your Manager/Executive….....	Alternative Answer				
		1	2	3	4	5
23	Enterprises can acquire sufficient fund for technological innovation.					
Quality of technological innovation strategy						
24	The technological innovation path of enterprises is consistent with internal conditions such as knowledge system structure, innovation personnel capability and organizational learning ability.					
25	The technological innovation path of enterprises is consistent with the external market environment and policy environment.					
26	The technological innovation mode of enterprises is consistent with their technological capability, network capability and innovation protection mechanism.					
27	The technological innovation mode of enterprises is consistent with the external market environment and policy environment.					
28	The technological innovation investment mode of enterprises is consistent with the cash capacity and risk bearing capacity.					
29	The technological innovation investment mode of enterprises is consistent with the external policy environment and market environment.					
Technological innovation performance						
5.1	**Task performance**					
30	Compared with similar enterprises, the number of patents granted to enterprises is higher.					
31	Compared with similar enterprises, the number of new product projects developed by enterprises is higher.					
32	Compared with similar enterprises, the profit margin of total assets of enterprises is higher.					
33	Compared with similar enterprises, the cash assets of operating activities of enterprises are higher.					

You have completed this questionnaire.

Thank you for your support.

ใบรับรองจริยธรรมการวิจัยในมนุษย์
สถาบันการจัดการปัญญาภิวัฒน์

หมายเลขใบรับรอง: PIM-REC 028/2566

ข้อเสนอการวิจัยนี้ และเอกสารประกอบของข้อเสนอการวิจัยตามรายการแสดงด้านล่าง ได้รับการพิจารณาจากคณะกรรมการจริยธรรมการวิจัยในมนุษย์ สถาบันการจัดการปัญญาภิวัฒน์แล้ว คณะกรรมการฯ มีความเห็นว่าข้อเสนอการวิจัยที่จะดำเนินการมีความสอดคล้องกับหลักจริยธรรมสากล ตลอดจนกฎหมายข้อบังคับและข้อกำหนดภายในประเทศ จึงเห็นสมควรให้ดำเนินการตามข้อเสนอการวิจัยนี้ได้

ชื่อข้อเสนอโครงการ: The Effect of Board Capital Development on Innovation Performance of High-Tech Enterprises in Shandong

รหัสข้อเสนอการวิจัย (ถ้ามี): (ไม่มี)

หน่วยงาน: มหาวิทยาลัยสยาม

ผู้วิจัยหลัก: Mr. Wang Fei

ลงนาม.....

(อาจารย์ ดร.พิเชษฐ์ มุสิกะโปดก)
ประธานคณะกรรมการจริยธรรมการวิจัยในมนุษย์
สถาบันการจัดการปัญญาภิวัฒน์

วันที่รับรอง: 17 สิงหาคม 2566 **วันหมดอายุ:** 17 สิงหาคม 2567

เอกสารที่คณะกรรมการรับรอง

1. โครงร่างการวิจัย
2. ข้อมูลสำหรับชี้แจงกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย และ ใบแสดงความยินยอมจากกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย
3. เครื่องมือที่ใช้ในการวิจัย/เก็บรวบรวมข้อมูล เช่น แบบสอบถาม แบบสัมภาษณ์ ประเด็นในการสนทนากลุ่ม เป็นต้น

เงื่อนไขการรับรอง

1. นักวิจัยดำเนินการวิจัยตามที่ระบุไว้ในโครงร่างการวิจัยอย่างเคร่งครัด
2. นักวิจัยรายงานเหตุการณ์ไม่พึงประสงค์ร้ายแรงที่เกิดขึ้นหรือเปลี่ยนแปลงกิจกรรมวิจัยใดๆ ต่อคณะกรรมการพิจารณาจริยธรรมการวิจัยในมนุษย์ภายในกำหนด
3. นักวิจัยส่งรายงานความก้าวหน้าต่อคณะกรรมการพิจารณาจริยธรรมการวิจัยในมนุษย์ตามเวลาที่กำหนดหรือเมื่อได้รับการร้องขอจากคณะกรรมการฯ
4. หากการวิจัยไม่สามารถดำเนินการเสร็จสิ้นภายในกำหนด ผู้วิจัยต้องยื่นขออนุมัติใหม่ก่อนอย่างน้อย 1 เดือน
5. หากการวิจัยเสร็จสมบูรณ์ ผู้วิจัยต้องแจ้งปิดโครงการตามแบบฟอร์มที่กำหนด

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Publishing Research

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