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The Relationship between R&D Intensity, Network Relationships, and Innovation Performance - Taking High tech Enterprises in Zhejiang Province as an Example

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Abstract

This study aims to analyze the impact of government subsidies and intellectual property protection on corporate R&D investment from the perspective of the external innovation environment; second, based on the research paradigm of "structure-behavior-innovation performance" (SCP), from the perspective of organizational behavior, The research design is developed to study the relationship between certain network characteristics and innovation performance. However, these research paradigms may ignore the active role of innovation subjects in the construction of network relationships across organizational levels, network opportunities, and resource development and utilization. This thesis takes high-tech enterprises as the main body, opens the black box of the impact of R&D intensity on innovation performance, and emphasizes how R&D investment can improve the efficiency of R&D results transformation through the strengthening of network relationship (network centrality, network density). At the same time, it can attract more potential partners to actively seek cooperation, and continuously improve the core competitiveness and management capabilities of the enterprise. Firstly, the variables studied and related theories were sorted out through literature review, and the concept of consistency of innovation tendencies was initially defined. Afterwards, based on the analysis of typical cases, the theoretical model and research hypothesis of the influence of R&D intensity on innovation performance through network relationship under the regulation of consistency of innovation tendencies were proposed, and the mechanism of R&D intensity on innovation performance was deeply excavated.

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Introduction

In 2021, the high-tech industry will continue to lead the growth of designated industries. The added value of high-tech industries in Zhejiang Province will be 749.497 billion yuan, a year-on-year increase of 8.4%. The growth rate is 4.5 percentage points higher than that of designated industries, and the contribution rate to designated industrial growth will reach 112.1 %. It is reported that in 2021, there will be 6,619 newly recognized high-tech enterprises in the province, exceeding the annual target of 4,000. Zhejiang Province is a position where strategic emerging industries become top 100 business owners. Among them, the two major fields of advanced manufacturing and new materials have 32 and 28 top 100 companies respectively, and they are also the industries with the fastest progress compared with 2019. Second, the update rate of the top 100 list is the highest in history. Among the top 100 companies in 2021, 29 are newly listed companies, of which 12 are from the new material technology industry. Third, the innovation capabilities of the top 100 companies lead the pack, and the "February 8th effect" has obvious characteristics. The top 100 enterprises have invested a total of 50.07 billion yuan in research and development funds, and the proportion of research and development funds to their main operating income is 7.9%, which is 2.5 percentage points higher than the average level of high-tech enterprises and more than three times that of industrial enterprises above designated size.In the value chain of enterprise development, most enterprises in my country used to focus on manufacturing, sales, and service. For R&D and innovation, first, there was a problem of insufficient capacity; second, they did not attach great importance to strategy, resulting in my country's industrial upgrading is difficult. The key problem of the two is that there is no core technology with independent intellectual property rights, and finally there is a phenomenon that developed countries such as Europe and the United States are stuck in key core technology fields. Therefore, it is necessary and urgent for enterprises to strengthen investment in R&D and innovation. Practice has proved that those enterprises that attach great importance to R & D and innovation not only achieve short-term innovation performance, but also lay a solid foundation for the improvement of long-term innovation performance. A typical example is that in recent years, the FAW Group has increased its investment in research and development beyond historical levels in the development of its own brand Hongqi vehicles, which has driven its subordinate auto parts companies to also increase investment in their research and development links and has realized the development of automobiles. Against the trend of the industry's sluggish development. The practice of existing enterprises has proved that increasing investment in research and development is an inevitable choice to realize the transformation and upgrading of my country's enterprises and industries, and thus make my country a powerful country. However, there are still a series of problems in the innovation and development of Chinese enterprises. For example, the current innovation is still based on a single technology, without considering the full life cycle management of products for the consumer market; there is no guarantee for a sound technological innovation mechanism and system. Risks may exist in every link leading to innovation, which undermines the stability and sustainability of innovation; laws and regulations such as intellectual property protection need to be further improved; an innovation system centered on enterprises has not yet been established; information security and risk control need to be strengthened urgently. However, which specific factors have an important impact on the R&D effect of the enterprise, and through what mechanism will further affect the innovation performance is still a key issue in the field of enterprise management that needs to be resolved urgently. Based on this, this thesis conducts an in-depth analysis of the cooperative R&D process and mechanism of action among high-tech enterprises in the above problems. On the one hand, it can analyze the micro-restriction mechanism and what factors affect the innovation of enterprises, and it also can provide relevant theoretical support on how to promote high-tech enterprises to increase R&D

intensity policies. (Ariu, 2016; Booltink & Saka 2017; Chen & Dong 2016; De & Free 2010; Li 2023; Love et al. 2014; Lu et al. 2020; Dong 2013; Ma 2016 ; Wei 2015)

Problem Statement

The country's emphasis on innovation and development and the increasingly fierce market competition situation have made enterprises turn their attention to R&D activities. The "2020 China's Top 500 Enterprises Development Report" pointed out that the R&D investment of the top 500 domestic enterprises continued to increase, breaking through trillions, and reaching the highest level in history, of which the average R&D investment of enterprises reached 2.495 billion yuan. At present, most studies have confirmed that R&D investment is positively correlated with innovation performance. The R&D behavior of enterprises can obtain monopoly income for a certain period, which makes enterprises stand out in the market and obtain high returns (Ariu, 2016; Booltink & Saka 2017; Chen & Dong 2016; De & Free 2010; Li 2023; Love et al. 2014; Lu et al. 2020; Dong 2013; Ma 2016; Wei 2015). R&D investment can help SMEs create new products, develop efficient production processes and stimulate strategic cooperation among firms (De & Free, 2010). R&D investment not only has a good role in promoting high-tech innovation performance, but even in non-high-tech enterprises, R&D investment can also drive the improvement of innovation performance (Booltink & Saka-Helmhout, 2017). Lu et al. (2020) conducted an empirical study on the R&D intensity of Chinese electronics companies and found that there is a positive correlation between R&D intensity and innovation performance. Further research shows that in companies with good innovation performance, R&D intensity has a more significant impact on innovation performance. A social network is a network formed by a collection of different types of social relations, such social relations may be transaction relations, cooperative relations, friendship, membership, etc. With the development of social network theory, it not only focuses on individual relationships, but also covers collective relationships, such as the relationship with economic organizations and social groups. The network relationship between enterprises is the concept of enterprise network relationship formed by replacing enterprise nodes with individual nodes. Corporate strategic decisions and pricing are no longer solely determined by the market but are determined jointly by social norms and the market, which also expands classical economics resources are the basis for enterprises to obtain competitive advantages. In the high-tech industry, products are becoming increasingly complex, technical division of labor is more precise, procurement tends to be globalized, and the innovation process is gradually evolving from core enterprise-led to network collaborative innovation. Enterprise service capabilities and product market competitiveness can be improved by relying on the knowledge co-creation of related enterprises, upstream suppliers and downstream customers in the network, and knowledge can be diffused through applied learning between network nodes (Lu et al. 2020). For enterprises, due to the short establishment time, the internal resources and capabilities obtained through network integration are relatively weak, while enterprises in the central position of the network will receive the trust and respect from other members (Lu et al. 2020), and can be Establish a good relationship, combine some resources of the company, strive for external financing, invest in attractive new products, and form a competitive advantage. At the same time, enterprises gradually enhance their network center status to gain the trust of external networks, build their unique advantage protection mechanism, and ensure the continuous advantages and virtuous circle of enterprise development. Therefore, using network relationships to improve innovation performance is an important choice for high-tech enterprises.

Research objectives

Based on the aims of the planned study, the following research objectives are developed: 1. To discuss the influence of R&D intensity of high-tech enterprises in Zhejiang Province on

innovation performance; (2) To discuss the impact of the network relationship of high-tech enterprises in Zhejiang Province on innovation performance ; (3) To discuss the influence of R&D intensity of high-tech enterprises in Zhejiang Province on network relationship ; (4) To explore the mediating role of network relationship between R&D intensity and innovation performance ;(5) To discuss the moderating effect of the consistency of innovation tendencies of high-tech enterprises in Zhejiang province .

Research questions

This thesis builds a relationship model based on R&D intensity and innovation performance under the background of technological innovation, integrates R&D intensity, innovation performance, network relationship, consistency of innovation tendencies and other theories, proposes network relationship as an intermediary variable, and consistency of innovation tendencies as an adjustment variable. The model of the relationship among them is studied by means of literature research, implementation of questionnaire survey, and data statistics. Based on this, this thesis proposes the following research questions. (1) What is the relationship between R&D intensity and innovation performance of high-tech enterprises in Zhejiang Province? (2) What is the relationship between network relationship and innovation performance of high-tech enterprises in Zhejiang Province? (3) What is the relationship between the R&D intensity of high-tech enterprises in Zhejiang Province and the network relationship? (4) Does network relationship play a mediating role between R&D intensity and innovation performance? (5) Does the consistency of innovation tendencies regulate and mediate the relationship between R&D intensity and innovation performance through network relationship ?

Scope of study

This study takes the R&D intensity and network relationship of high-tech enterprises as the starting point and conducts an in-depth analysis of the intermediary role of consistency of innovation tendencies. By reading the literature, investigate and understand the research status of domestic high-tech enterprises' R&D intensity and network relationship's influence on innovation performance. After analyzing the status quo and characteristics of R&D intensity in high-tech enterprises, the network relationship is analyzed from different structures and levels, laying the foundation for subsequent research. Secondly, through the analysis of the current situation of the case study, combined with relevant theories, the moderating variables of R&D intensity and network relationship on innovation performance of high-tech enterprises are found out, and a theoretical model reflecting the relationship between each variable is constructed. Finally, it gives the empirical research results of R&D intensity and network relationship of high-tech enterprises on innovation performance.

Literature review

R&D Intensity

R&D intensity comes from the field of economics. The "innovation theory" was first put forward in Schumpeter's "Economic Development Theory". According to Schumpeter, the essence of R&D is the process of building a new production function. Economic growth has a promoting effect, and at the micro level, R&D investment helps to improve the innovation performance of enterprises. The stage of classical economic growth theory believes that the main reasons for economic growth are capital accumulation, technological innovation and savings, and the growth of national wealth can be obtained through the improvement of production efficiency and the use of more income for productive labor. The scale and intensity of R&D investment is an important indicator for evaluating the innovation performance of an enterprise, and it is also an important guarantee for its own technological innovation. R&D intensity is not only a part of the company's current technological performance, but also a part of the company's

generation of new ideas and new models, which will eventually serve the birth of new products and patented technologies. Lu et al. (2020) research found that services are more flexible than products, knowledge-intensive companies may be more strategically flexible than product companies, and can provide better services, which is conducive to the transfer of knowledge through long-term partnerships. Coupled with the strategic role of KIBS (Knowledge Intensive) in the economic development of enterprises, regions and countries, it plays an important role in the creation of knowledge, transfer and dissemination of knowledge and high value-added services for partner organizations, and promotes the learning of innovative results and improved (Love et al., 2014).As major technological disruptions may change the way firms compete in the market and re-establish power relations between policy makers and new entrants. The innovative dynamism of industries with high R&D investment promotes a constant competition for technological superiority between new entrants and incumbent organizational structures, and periodically rekindles competition.

Innovation Performance

Innovation performance refers to the operating efficiency and performance of operators during a certain period of operation. The level of enterprise operating efficiency is mainly manifested in profitability, asset operation level, debt repayment ability and follow-up development ability. The performance of the operator is mainly reflected by the achievements and contributions made by the operator to the operation, growth and development of the enterprise in the process of operating and managing the enterprise. The origin, development, and impact of innovation-driven innovation on the regional economy based on knowledge spillover theory. Findings: The applicability of innovation drive in advanced economies is relatively large, although empirical evidence suggests that the main premises of knowledge spillover theory are prevalent in most advanced economies. However, it is not certain that innovation-driven ideas based on knowledge spillover theory can be generalized in different contexts in different developing countries. After conducting a multilevel logistic analysis of nearly 250,000 people, the authors found that these people from 45 developing countries, compared with what has been studied in the knowledge spillover theory literature, the different backgrounds in developing economies exist in A limited link has emerged between knowledge spillovers and innovation. That is, the logic of generating knowledge spillover through R&D investment (innovation-driven) and promoting regional economic growth is not suitable for developing economies or backward regions. This reminds us that the R&D investment of new enterprises does not always bring the desired results. New enterprises need to examine the feasibility, economy, strategy and management mode of their innovation activities from a broader perspective when conducting research and development activities.

Network Relationship

This research involves the role of network relationships in the path process of the impact of R&D intensity on innovation performance. It studies if the change of R&D intensity stimulates the change of network relationship and even the structure of the network through the accumulation of knowledge and resources and the change of dynamic capabilities, so that affects the rapid and accurate identification of new opportunities, the efficiency of acquiring new knowledge, and the commercialization of R&D results. The ability of enterprises to acquire knowledge and resources is closely related to the network level and network characteristics of the enterprise level. Simultaneous research on the variables at these two levels (network level and firm level) will help us understand the transfer process of knowledge, experience, and resources in the network, and have an important impact on the research on the innovation behavior process of firms. Network centrality is one of the indicators to measure the structural position of an enterprise in the network. By studying how the enterprise reflects its position in

the network through the network position and the role it plays. Network centrality and network density are two important concepts in network structure theory. Among them, network centrality refers to the degree to which an enterprise is close to the center in the entire network environment. Generally, the higher the network centrality an enterprise has the more resources it obtains through the network environment, and the richer the information it masters, which is beneficial for the enterprise to obtain a better competitive advantage. At the same time, a high network centrality will also indirectly affect the enterprise's learning ability and absorptive capacity, thereby affecting enterprise performance. Network density is an important parameter of fierce network competition. Generally, the higher the network density of an enterprise, the closer the connection between the enterprise and the cooperative enterprise, and the stronger the ability of the enterprise to obtain resources, which will help the enterprise to exert its competitive advantage and obtain more good profit. There is a positive correlation between network density and the technological innovation capability of enterprises, so improving the network density of enterprises is conducive to promoting the competitiveness of enterprises within the network, and further realizing the overall technological innovation through competition, which will help improve the operating efficiency of enterprises , optimize resource allocation and utilization, and ultimately improve corporate performance .Wei (2015) focused on the analysis of the relationship between the dual network embedding of cluster enterprises and the transition of innovation capabilities through the introduction and introduction of the concept of dual network embedding of cluster enterprises. The concept of innovative network embedding into the field of internationalization of enterprises. Lu et al. (2020) refers to the "structure-behavior- innovation performance " paradigm of traditional industrial economics, and combine social network theory, high-level team theory, and enterprise internationalization theory to construct a "mechanism-effect" embedded in an enterprise innovation network. The theoretical framework interprets the driving mechanism of enterprise innovation network embedding through different levels of theory and conducts research on listed companies in China's high-tech industry. Lu et al. (2020) systematically and comprehensively sorted out and presented the sources of corporate competitive advantage based on the capability view and network view.

Consistency Of Innovation Tendencies

The degree to which the innovation partners in the innovation network can reach a consensus on the understanding and thinking tendency of the focus enterprise's innovation strategic goals, as well as the means and methods adopted in the process of realizing the strategic goals. A high consistency of innovation tendencies shows that the innovation subjects can reach an agreement on the understanding of the innovation strategic goals and conceptual thinking and form a synergy among the innovation subjects through consistent innovation strategic actions, improve innovation efficiency, and avoid problems caused by goals. Understand the waste of innovation resources and inefficient resource allocation caused by deviations and action differences, give full play to the overall advantages of cooperative innovation, and improve the innovation performance of core enterprises and innovation partners. This thesis mainly divides the types of R&D partners (competitors, suppliers, customers, universities and research institutes) by (Ariu, 2016; Booltink & Saka 2017; Chen & Dong 2016; De & Free 2010; Li 2023; Love et al. 2014). The researched on the consistency of innovation tendencies in open innovation and collaborative innovation, and You et al. (2014), Li et al. (2018) on the evaluation system for selection of innovation partners, on the selection of innovation alliance partners, combined with Venkatraman et al. (1984) on the application of adaptation theory in the classification of strategic management, and the conducted a meta-analysis test on all empirical studies on strategic consistency, and defined " consistency of innovation tendencies " as: Consistency of innovation tendencies refers to the goals, ideas and culture of innovation

partners in innovation networks for cooperative innovation. Consensus, as well as the adaptability in terms of R&D capabilities, R&D emphasis, and resource investment in the process of achieving strategic goals. Mainly through the selection of partners, the consistency of professional technology, the consistency of strategic direction, and the consistency of cultural values, etc., the moderating role of consistency of innovation tendencies in the process of R&D intensity affecting innovation performance through network relationship is carried out. And a conceptual measurement scale for innovation tendency consistency was preliminarily designed.

Methodology

Research Design

According to the research idea of " proposing a problem - analyzing a problem - solving a problem", this thesis expounds the theoretical basis of the research and establishes a research model. First, design the research process and survey questionnaire for empirical analysis, select high-tech companies that meet the research theme as samples, and select appropriate measurement scales to form the survey questionnaire according to the core concepts involved in the hypothesis. The content of the questionnaire mainly includes R&D intensity, network relationship, innovation performance, consistency of innovation tendencies scales; use SPSS, AMOS and other software to test the reliability and validity of the theoretical research model. Secondly, the empirical analysis and hypothesis testing of the theoretical research model are carried out by using the multiple linear regression analysis method, and the test results are discussed.

Data collection

The research object of this thesis is the high-tech enterprises in Zhejiang Province. In this thesis, 50 high-tech enterprises in Zhejiang Province were selected, and 12 questionnaires were distributed to each investigated enterprise, and a total of 600 questionnaires were distributed. The questionnaire was filled in on-site and collected by mail. 600 questionnaires were distributed, and 580 were recovered. Eliminating invalid answers and blank questionnaires, the remaining valid questionnaires were 518, and the effective recovery rate was 86.33 %.

Target population

The term "target population" refers to a certain group of people that the researchers would like to focus their attention on while carrying out the study (Sekaran & Bougie, 2016). There are many distinct target groups that may be found in various types of research; therefore, we need to choose which target population will provide us with the best opportunities to collect data and information for our study. The high-tech enterprises employees in Zhejiang Province of China are the population that will serve as the focal point of this investigation. This study collected 518 questionnaires.

Sampling frame and sampling location

The high-tech enterprises employees in Zhejiang Province of China were the focus of this research. The sampling frame consisted of all high-tech enterprises' employees in Zhejiang Province of China that participated in this study. The Zhejiang Province of China were chosen as the locations for the sample collection for this study.

Sampling size

The size of the sample that is collected from the whole population is known as the sampling size. The size of the sample should be large enough to eliminate the possibility of sampling errors and biases. Full population research will be impractical and prohibitively expensive to

carry out; instead, establishing a sampling size will be the most effective way to cut down on the time and money required to carry out a study. To our study, the population that we focused on 50 high-tech enterprises employees in Zhejiang Province of China. This study collected 518 samples.

Questionnaire design and instrumentation

Measurement Dimensions and Methods of R&D Intensity

(1) Absolute indicators of R&D investment

The choice of absolute indicators is mainly to measure the scale of enterprise R&D, and the calculation formula is as follows:

R&D funding investment = R&D investment in the current period

R&D personnel investment = total number of technical personnel

(2) Relative indicators of R&D investment

The choice of this indicator can directly reflect the degree of importance that enterprises attach to R&D innovation. In terms of the inspection of the impact of R&D investment on enterprises, the advantage of R&D investment relative to the indicator is more significant. The calculation formula is as follows:

R&D investment intensity = current R&D investment / current operating income

Proportion of technical personnel = technical personnel in the current period / active employees in the current period

Taking reference from the methods widely used in the current research literature on the micro level related to this, and because the relative indicators are more comparable and more pertinent, the relative indicators are selected in the measurement of the company's R & D investment. In this thesis, we choose the proportion of R&D investment in the total operating income of the enterprise as the measure of R&D funding investment and analyze the R&D indicators of the enterprise based on the proportion of researchers in all personnel. Because different companies have large absolute gaps in R&D investment, there is no comparability among different companies. However, the relative number index can avoid the influence of the differences between different individuals, and the comparability is strong. Therefore, the measurement index selected in this thesis is the relative index of R&D investment, and the specific items are as follows:

Table 3-1 Measurement scale of R&D intensity

measurement dimension	item	describe
R&D funding investment RDM	RDM 1	R&D funding investment: The ratio of R&D investment to main business income. (R&D expenses include: direct investment in R&D (purchase of materials, equipment, patents and related usage and maintenance costs);. Expenses arising from entrusting external development or cooperation (expenses arising from cooperation with relevant colleges, research institutes, etc.); other expenses (water, electricity, gas, communication, office, etc.).
R&D personnel investment RDP	R D P 1	Proportion of R&D personnel: number of R&D personnel/total number of employees

Measurement Dimensions and Methods Of Network Relationship

1. Network Centrality

The location of the central network is closely related to the innovation results formed by an individual unit in the organization. Consistent with the views of some scholars, one of the main aspects of "social structure" includes the network status of individual units, which has the effect of enhancing the new value generated by the unit and the ability to achieve economic goals. As the position of the enterprise in the network is closer to the center, the channels for the

enterprise to obtain knowledge will be more abundant, and thus the absorption capacity for knowledge transfer needs will be stronger. For reference, it is divided into 4 items: most of the different types of business contacts in the cooperation network will occur through this enterprise; and this enterprise will often use new knowledge in the cooperation network Solve the problems that arise; the knowledge and information flowing in the cooperation network of this enterprise are relatively rich; compared with the cooperation network connections of competitors, the stability of this enterprise is higher.

2. Network Density

In the literature on social networks and building teams, the result of the relationship between the number of connections in the cooperative network and the maximum possible number of connections is the network density. As the number of people participating in the cooperative network increases, the network density is more likely to be reduced. (Ariu, 2016; Booltink & Saka 2017; Chen & Dong 2016; De & Free 2010; Li 2023; Love et al. 2014) defined network density in the structural characteristics of social networks. This thesis mainly uses this as a reference and believes that the degree of interaction and interrelationship between different individuals in the network is network density, that is, different individuals in the network. The average of the degree to which individuals interact with each other.

Table 3-2 Measurement scale of network relationship

measurement	item	describe
network centrality (NC)	NC1	Most of the various business contacts in the cooperation network will pass
	NC2	The company often uses new knowledge from the collaborative network to
	NC3	The knowledge and information flowing in the cooperation network of this
	NC4	The company has a more stable cooperative network than competitors
network density (ND)	ND1	Both the cooperative enterprise and the enterprise can keep their promises
	ND2	The cooperative enterprise will not take advantage of the weakness of the
	ND3	Frequent information exchange between the cooperative enterprise and
	ND4	The partner company and the company can provide each other with the
	ND5	Partners and the company help each other solve each other's problems
	ND6	Partners and the company work together to overcome difficulties

Measurement Of Consistency of Innovation Tendencies

(Ariu, 2016; Booltink & Saka 2017; Chen & Dong 2016; De & Free 2010; Li 2023; Love et al. 2014) developed a scale of partner consistency of innovation tendencies suitable for the research background of this thesis based on the research of partners on the selection of evaluation systems , there are five items in the scale. And from a comprehensive point of view, evaluate whether there is unity among partners in terms of innovation awareness, ability, and willingness to cooperate with each other. Based on the resource-based view and social network theory, this thesis discusses the consensus of the concept of innovation partners in the innovation network on the concept of innovation, goals and culture among innovation partners, and the investment in the process of realizing the strategic goals. The concept of consistency of innovation tendencies is defined from the perspective of capability adaptability in terms of resources, emphasis, and technical research and development strength. Based on this definition, this thesis designs the consistency of innovation tendencies measurement table.

Table 3-3 Measurement scale of consistency of innovation tendencies

measurement dimension	item	describe
consistency of innovation tendencies (IC)	IC1	We align with our partners' technological innovation goals
	IC2	Our technical research and development capabilities are comparable to those of our partners

	IC3	We and our partners attach equal importance to research and development
	IC4	We align with the corporate culture of our partners
	IC5	The management concepts of our partners agree with each other

Measurement of Innovation Performance

Measures the innovation performance of enterprises through 5 measurement items. 5 items include: Our products contain first-class advanced technology and craftsmanship, our new product development success rate is relatively high, the number of our patent applications is increasing, our innovative products have a good response in the market, and our ability to compete with industry competitors Launch new products faster. The innovation performance measurement scale is shown in Table 3-4.

Table3- 1Innovation performance measurement scale

measurement dimension	item	describe
innovation performance (NVP)	NVP 1	Our products contain first-class advanced technology and craftsmanship
	NVP 2	Our new product development success rate is relatively high
	NVP 3	Our number of patent applications is constantly increasing
	NVP 4	Our innovative products are well received in the market
	NVP 5	We can launch new products faster than industry competitors

Findings

Demographic Profile

Descriptive statistics refers to the activities of describing characteristics of data using tabulation and classification, graphics and calculation of summary data. Descriptive statistical analysis is to statistically describe the relevant data of all variables in the survey population. The specific features are shown in Table 4.1.

Table 4-1 Survey Sample Characteristics (N = 518)

Basic Features	Number of samples	Percentage (%)	Basic Features	Number of samples	Percentage (%)
D ratio of the previous year (R&D/TI)			High-tech industry (INDustry)		
3%-8%	29	5.60	Electronic and	85	16. 41
8%-13%	126	24. 32	Biological	39	7. 53
13%-18%	145	27.99 _	Aerospace	36	6.95
18%-23%	100	19. 31	Advanced	81	15.64
23%-28%	118	22. 78	marine technology	21	4. 05
Enterprise size (size)			Medicine	93	17.95
1-50A	76	14. 67	IT	133	25.68
51-75 people	75	14. 48	check	30	5. 79
75-100 people	199	38. 42	Enterprise age (age)		
100-200	134	25. 87	under 3 years	48	9.27
200-300	34	6. 56	3 - 6 years	33	6. 37
age			6 - 10 years	112	71.62
20-30 years	47	9.07	over 10 years	325	12. 74
30-40 years	390	75. 29	gender		
40-50 years	52	10. 04	female	88	16.99 _
over 50 years	29	5.60	male	430	83.01

Data source: Statistical results based on the sample characteristics of this study.

Through the frequency analysis of the R&D ratio in the previous year, it can be seen that the R&D ratio of 3%-8% of the enterprises is only 5.6%, which is the lowest in the total ratio; while the R&D ratio of 8%-13% of the enterprises has total enterprises 24.32% of the total number

of companies; while companies with a research and development ratio of 13%-18% accounted for 27.99% of the total number of companies, the highest proportion among all types; companies with a research and development ratio of 18%-23% accounted for 19.31% of the total number of companies %; companies with R&D ratios of 23%-28% accounted for 22.78% of the total number of companies; overall, the distribution of samples in terms of R&D ratios in the previous year was dominated by "13%-18%", accounting for 27.99% %. From the statistical analysis data frequency analysis of the high-tech industry, this thesis selects 8 representative industries, namely electronics and communication information, bioengineering, aerospace, advanced manufacturing technology, marine technology, medicine and medical treatment, IT , testing and inspection, among which, electronics and communication information enterprises accounted for 16.41%, bioengineering enterprises accounted for 7.53%, aerospace enterprises accounted for 6.95%, advanced manufacturing technology enterprises accounted for 15.64%, marine technology enterprises Accounting for 4.05%, pharmaceutical and medical enterprises accounted for 17.95%, IT enterprises accounted for 25.63%, testing and inspection enterprises accounted for 5.79%. On the whole, IT enterprises accounted for the highest proportion, followed by pharmaceutical and medical enterprises, followed by electronics and communication information companies and advanced manufacturing technology companies, the rest of bioengineering, aerospace, testing and inspection are relatively low, and marine technology has the lowest proportion. From the perspective of the age of the surveyed enterprises, the proportion of enterprises with an age of less than 3 years in the sample is only 9.27%; the proportion of enterprises with an age of 3-6 years is 6.37%, which is the lowest proportion among all types; The proportion of 6-10 years is 71.62%, which is the highest proportion among all types ; the proportion of enterprises over 10 years old is 12.74 % , which is a medium proportion among all types . In this thesis, the size of an enterprise is defined by the number of employees. The larger the number of employees, the larger the scale. According to the distribution of the survey samples, 14.67% of enterprises have fewer than 50 employees; 14.48%; enterprises with 75-100 employees accounted for 38.42%, which is the highest proportion; while enterprises with 100-200 employees accounted for 25.87%; enterprises with 200-300 employees The proportion is 6.56%, the lowest proportion. The distribution of samples in terms of enterprise size is mainly "75-200 people". The gender distribution of the surveyed samples is dominated by "men" , accounting for 83.01%; women accounted for 16.99%. Judging from the distribution of samples in terms of the age of the respondents, the samples are mainly "30-40 years old", accounting for 75.29%; among them, the number of people aged 20-30 accounted for 9.07%, and the number of people aged 40-50 accounted for 9.07%. 10.04%, and the number of people over 50 years old accounted for 5.6%. This meets the sample requirements for this article.

Reliability and Validity

Reliability

Reliability test of formal questionnaire

Reliability is reliability, which refers to the degree of consistency of the results obtained when the same method is used to repeatedly measure the same object. Reliability indicators are mostly represented by correlation coefficients, which can be roughly divided into three categories: stability coefficients (consistency across time), equivalence coefficients (consistency across forms) and internal consistency coefficients (consistency across items). Reliability indicators generally greater than 0.7 can be considered credible.

Table 3-8 Reliability Analysis of Formal Questionnaire

research variable	evaluation	Cronbach's alpha value	Cronbach's a l pha	Total Cronbach's alpha
network centrality (NC)	NC1	0.904	0.925 ＞ 0.9 Reliability is very good	
	NC2	0.904		
	NC3	0.904		
	NC4	0.904		
Consistency of innovation tendencies (IC)	IC1	0.913	0.885 ＞ 0.8, the reliability is better	
	IC2	0.913		
	IC3	0.915		
	IC4	0.914		
	IC5	0.912		
network density (ND)	ND1	0.905	0.911 ＞ 0.9 Reliability is very good	0.91 ＞ 0.9 , the reliability is very good
	ND2	0.904		
	ND3	0.903		
	ND4	0.903		
	ND5	0.904		
	ND6	0.905		
innovation performance (NVP)	NVP1	0.903	0.944 ＞ 0.9 the reliability is very good	
	NVP2	0.903		
	NVP3	0.903		
	NVP4	0.902		
	NVP5	0.902		
R&D intensity	RDM	0.906	one	
	RDP	0.906	one	

According to the Cronbach's alpha results of each dimension in the above table, we can find that the CITC value of each item in the questionnaire is greater than 0.5, indicating that most of the items in the questionnaire have a strong correlation with the total question, and the variables designed in the questionnaire The Cronbach's alpha values corresponding to the four dimensions of the scale are between 0.885 and 0.944, all greater than 0.8, indicating that the internal consistency of the questionnaire is good, so the reliability of the results of this survey is excellent. And the overall Cronbach's alpha is also greater than 0.9. Based on this result, we can think that all the questions are the measurement of the same concept, and there is no need to delete the items. In summary, the data results of this thesis have passed the reliability test.

Validity test

Exploratory Factor Analysis

Table 3-9 Measurement indicators and factor analysis of variables in the formal questionnaire

research variable	evaluation variable	Rotate Component Matrix (Factor Loadings)			
		Factor 1	Factor 2	Factor 3	Factor 4
network centrality NC	NC1		0.757		
	NC2		0.785		
	NC3		0.890		
	NC4		0.815		
consistency of innovation tendencies IC	IC1			0.812	
	IC2			0.802	
	IC3			0.916	
	IC4			0.819	

	IC5		0.782	
network density ND	ND1			0.900
	ND2			0.786
	ND3			0.763
	ND4			0.799
	ND5			0.778
	ND6			0.768
innovation performance NVP	NVP1	0.807		
	NVP2	0.813		
	NVP3	0.799		
	NVP4	0.754		
	NVP5	0.907		

Note : KMO= 0.935 ;
Bartlett 's test for sphericity (approximate chi-square = 8533.927, df = 210 , Sig = 0.000) ;
Cumulatively explained total variance: 75.132%. After the data of the formal questionnaire scale meets the reliability requirements of the scale, the validity of the scale needs to be tested to determine whether it has a sufficient level of validity. Validity means effectiveness. It refers to the measurement tools or the degree to which a means can accurately measure what it is intended to measure. Validity refers to the extent to which the measured results reflect the content to be investigated. The more consistent the measurement results are with the content to be investigated, the higher the validity; otherwise, the lower the validity. Similarly, factor analysis is also required for formal questionnaires to reduce the dimensionality of all data. The factor analysis method can find hidden representative factors among many variables to reduce the dimensionality of the data and classify variables of the same nature into one Factors can reduce the number of variables to facilitate data comparison and analysis, and can also test the hypothesis of the relationship between variables. Through the validity analysis of the formal questionnaire, the results show that the KMO value of the formal questionnaire is 0.935, which is greater than 0.8. In the bartlett sphericity test, the approximate chi-square value is 8533.927, and the significance probability is 0.000, which is less than 0.01. Therefore, the null hypothesis of Bartlett's sphericity test is rejected. Based on this, the questionnaire data in this thesis meet the conditions for factor analysis. And the results of the total variance explained by each dimension of the questionnaire, it can be seen that there are 4 factors with a characteristic root greater than 1, and the total variance explanation rate of the 4 factors is 68.628%, which is greater than 60%, indicating that these 4 factors represent 68.628 in the scale. % of the main information, it can be considered that the degree of interpretation of the scale designed in this thesis is relatively good.

Confirmatory Factor Analysis

The execution result diagram of the structural equation model obtained through the operation of the structural equation modeling software Amos23.0 intuitively shows the path coefficients among the various research variables. All path coefficients can be divided into two types: load coefficient and path coefficient. Among them, the loading coefficient reflects the relationship and influence degree between the observed variable and the latent variable, and the path coefficient reflects the correlation relationship and influence degree between the latent variables. When estimating the parameters of the model, the significance test of the load coefficient and path coefficient can be carried out to examine whether each research variable has statistical significance. When estimating the parameters of each research variable, you can observe the CR value in the Z statistic, and the CR value represents the ratio of the estimated value of each research variable parameter to its standard deviation. In addition, the probability value P value corresponding to the CR value can also be observed. If P<0.01, it indicates that

there is a significant difference in the path coefficient value at the 0.01 level. Through the software operation of the structural equation model, the loading coefficient value between each observed variable and latent variable is obtained, as shown in the convergent validity analysis of the table.

Table 3-10 Convergent Validity Analysis

	variable relationship		coefficient	standard	critical	P	Standardized	AVE	CR
NC1	< ——	NC	1.000				0.789		
NC2	< ——	NC	1.062	0.050	21.296	***	0.833		
NC3	< ——	NC	1.365	0.056	24.275	***	0.919	0.717	0.927
NC4	< ——	NC	1.092	0.050	21.687	***	0.844		
IC1	< ——	IC	1.000				0.762		
IC2	< ——	IC	0.957	0.055	17.348	***	0.741		
IC3	< ——	IC	1.483	0.068	21.902	***	0.933	0.612	0.887
IC4	< ——	IC	0.975	0.056	17.451	***	0.745		
IC5	< ——	IC	0.907	0.055	16.593	***	0.712		
ND1	< ——	ND	1.000				0.895		
ND2	< ——	ND	0.821	0.033	25.052	***	0.831	0.724	0.913
ND3	< ——	ND	0.856	0.033	25.808	***	0.844		
ND4	< ——	ND	0.815	0.032	25.163	***	0.833		
ND5	< ——	ND	0.822	0.031	25.022	***	0.832		
ND6	< ——	ND	0.835	0.033	25.123	***	0.835		
NVP1	< ——	NVP	1.000				0.835		
NVP2	< ——	NVP	0.966	0.041	23.545	***	0.833		
NVP3	< ——	NVP	0.991	0.042	23.466	***	0.832		
NVP4	< ——	NVP	1.042	0.044	23.732	***	0.838	0.710	0.945
NVP5	< ——	NVP	1.243	0.045	27.771	***	0.918		

Convergent validity can use the factor loading and average variance of the observed variables to extract values (Average Variance Extracted , AVE) two indicators to judge, it is generally considered that the factor loading of the observed variable is greater than 0.5 and reaches the significance level of 0.05 , and the AVE value of the observed variable is greater than 0.5 , which means that the measurement model has High convergent validity.

Through the analysis of the above table, it can be found that:

(1) network centrality validity test

NC network centrality is 0.789 to 0.919, the combined reliability is 0.927, and the AVE value of the observed variable is 0.717, all exceeding the corresponding limit value, indicating that the measurement of network centrality has good reliability and validity.

(2) Consistency of innovation tendencies validity test

IC consistency of innovation tendencies is 0.712 to 0.933, the combination reliability is 0.612, and the AVE value of the observed variable is 0.887, all exceeding the corresponding limit value. It shows that the measurement of network centrality has good convergent validity.

(3) network density validity test

The factor loading value range of each item of ND network density is 0.831 to 0.895, the combined reliability is 0.913, and the AVE value of the observed variable is 0.724, all exceeding the corresponding limit value. It shows that the measurement of network centrality has good convergent validity.

(4) innovation performance validity test

The factor loading value range of each item of NVP innovation performance is 0.789 to 0.918, the combined reliability is 0.945, and the AVE value of the observed variable is 0.710, all

exceeding the corresponding limit value. It shows that the measurement of network centrality has good convergent validity.

When the CR value of each factor is greater than 0.7 and the AVE value is greater than 0.50, it is generally considered that the convergent validity is good. In addition, when the square root value of each factor AVE is higher than the correlation coefficient between this factor and other factors, it indicates that the discriminant validity is high. The test results of the relevant indicators of convergent validity and discriminant validity are listed in the table. It can be seen from the table that the basic AVE values of each dimension are greater than 0.5, and the CR values are greater than 0.7, indicating that the convergent validity of this dimension is high.

Table 3-11 Discriminant validity analysis

	network centrality (NC)	consistency of innovation tendencies (IC)	network density (ND)	innovation performance (NVP)
network centrality (NC)	0.847			
consistency of innovation tendencies (IC)	-0.003	0.783		
network density (ND)	0.566 **	-0.019	0.851	
innovation performance (NVP)	0.608 **	0.030	0.557 **	0.842

Note: The bold diagonal items are the square roots of AVE.
Significant standard: *p<0.10; **p<0.05; ***p<0.001

In order to judge the discriminant validity of the scale, if the square root of AVE is greater than the corresponding correlation coefficient, it means that each variable has good discriminant validity. As shown in the discriminant validity analysis of the table, the correlation coefficients of all key variables are lower than the corresponding According to the discriminant validity table, the square root of each AVE in this table is greater than the correlation coefficient value with other factors, so the discriminant validity among the internal factors of each variable is very good.

Table 3-12 Model fitness index

CMIN	df	CMIN/DF	NFI	IFI	TLI	CFI	GFI	RMSEA
417. 382	183.000 _	2.281	0.952	0.972	0.968	0.972	0.935	0.050
Suggested value		< 3	> 0.9	> 0.9	> 0.9	> 0.9	> 0.9	< 0.08

By comparing the covariance matrix of the sample with the regenerated covariance matrix, the difference between the two is obtained, and the difference between them is shown by the fitting index, which can be used to test the original theoretical hypothesis model How well it fits the sample data. The fit index is generally divided into three types: absolute fit index, relative fit index, and information index. There are different types of fitting indices, and their measurement of the degree of model fitting can reflect the differences in the sample size, determinism, relativity, and complexity of the model. Absolute fit index and relative fit index are the two types that are mostly used in research. Commonly used absolute fit indices include: CMIN/DF (ratio of chi-square degrees of freedom), GFI (goodness of fit index, RMSEA (Root of Excellence of Approximate Error); Commonly used relative fitting indices include NFI (Normative Fitting Index), CFI (Comparative Fitting Index), etc. As shown in the above table, the criteria for judging each fitting index are given. It can be seen from the table that the CMIN/DF value of the confirmatory factor analysis model of the independent variable in this thesis is 2.281, which is less than the standard maximum value of 3, and the index test is passed; while the RMSEA is 0.05, which is less than the standard maximum value of 0.080, and the index test is passed; GFI's If the value is 0.935, which is greater than the standard minimum value of 0.9, the index inspection is passed; if the CFI is 0.972, which is greater than the standard requirement of 0.9, the index inspection is passed; if the IFI is 0.972, which is greater than the standard requirement of 0.9, the index inspection is passed; NFI is 0.952, which is greater than the standard requirement 0.9, the index test is passed; TLI values are greater than 0.968,

greater than the standard requirement of 0.9, the index test is passed. This shows that all adaptation indicators meet the requirements, that the model matches the scale better, and the model fit is higher, and the model is established.

Conclusion

(1) R&D intensity has a positive impact on innovation performance. Through in-depth research, the mechanism and impact path of R&D intensity of high-tech enterprises on innovation performance are confirmed. Empirical analysis finds that R&D funds and R&D personnel investment of high-tech enterprises have a positive impact on innovation performance.

(2) R&D intensity has a positive impact on network relationship . Through in-depth research, the mechanism and influence path of R&D intensity of high-tech enterprises on network relationship are confirmed. Empirical analysis finds that R&D funding investment and R&D personnel investment of high-tech enterprises have a positive effect on network centrality and network density in network relationship. To influence.

(3) Network relationship has a positive impact on innovation performance. Through in-depth research, the mechanism and influence path of the high-tech enterprise network relationship on innovation performance are confirmed. The empirical analysis finds that the network centrality and network density in the high-tech enterprise network relationship have a positive impact on innovation performance.

(4) Network relationship has an intermediary role. This thesis explores the relationship among R&D intensity, network relationship and innovation performance, which shows that in high-tech new enterprises, R&D intensity has a positive impact on network centrality and network density, network centrality and network density have a positive impact on innovation performance , network centrality and network density have a mediating effect in the relationship between R &D intensity and innovation performance .

(5) The consistency of innovation tendencies has a regulating effect. Empirical studies have found that the regulatory role of consistency of innovation tendencies in the process of network centrality and innovation performance is established. The moderating effect of consistency of innovation tendencies between network density and innovation performance was tested. Consistency of innovation tendencies plays a regulating role in the process of R &D funding investment affecting innovation performance through network centrality. Consistency of innovation tendencies plays a regulating role in the process of R &D personnel investment affecting innovation performance through network centrality. Consistency of innovation tendencies plays a regulating role in the process of R &D funding investment affecting innovation performance through network density. Consistency of innovation tendencies plays a regulating role in the process of R &D personnel investment affecting innovation performance through network density.

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