DESIGN THINKING AND INNOVATION PERFORMANCE THROUGH THE MEDIATING EFFECTS OF DIGITAL TRANSFORMATION AMBIDEXTERITY: A CASE STUDY OF INNOVATIVE SMES IN GUANGXI, 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 Qin, hereby certify that the work embodied in this dissertation entitled "Design Thinking and Innovation Performance Through the Mediating Effects of Digital Transformation Ambidexterity: A Case Study of Innovative SMEs in Guangxi, 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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ABSTRACT

Title : Design Thinking and Innovation Performance Through the Mediating Effects of Digital Transformation Ambidexterity: A Case Study of Innovative SMEs in Guangxi, China

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Against the backdrop of global digitalization and intensified competition, Chinese small and medium-sized enterprises (SMEs) are now confronting the dual imperatives of accelerating digital transformation and enhancing innovation performance. This dissertation aimed to study: 1) the relationships between design thinking, digital transformation ambidexterity (exploitative and exploratory) and organizational innovation performance of Innovative SMEs in Guangxi, China; 2) the moderating roles of institutional environment (regulatory, normative, and cognitive) between design thinking and organizational innovation performance; and 3) developing a design thinking practice model for enhancing organizational innovation performance in innovative SMEs. A mixed-method approach was adopted. The research utilized quantitative analysis of 429 valid questionnaire responses and qualitative insights from interviews with 16 key informants.

The research results reveal that design thinking not only directly and positively affects innovation performance of SMEs but also exerts indirect positive effects through digital transformation ambidexterity, meanwhile indicate that normative and cognitive environment moderate the effect of design thinking on organizational innovation performance. This study emphasizes the importance of design thinking and digital transformation among SMEs. These findings provide

new perspectives for academic discussions on organizational innovation management and offer valuable practical insights for SMEs seeking to enhance organizational innovation performance and achieve competitive advantages via design thinking and digital transformation.

Keyword: design thinking, digital transformation, innovation performance, organizational ambidexterity, small and medium-sized enterprises

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CHAPTER 1
INTRODUCTION

1.1 Background of the problem

Currently, the world has entered a new period of turbulence and change, with insufficient economic growth momentum and an increase in unstable, uncertain, and unpredictable factors. In this context, the new round of technological revolution and industrial transformation provides important strategic opportunities for high-quality development of various countries.

Throughout human history, technological advancement has consistently served as a pivotal driver of social progress. Each of the four industrial revolutions has catalyzed transformative shifts in productivity, propelling society into successive eras of development, as shown in Figure 1.1.

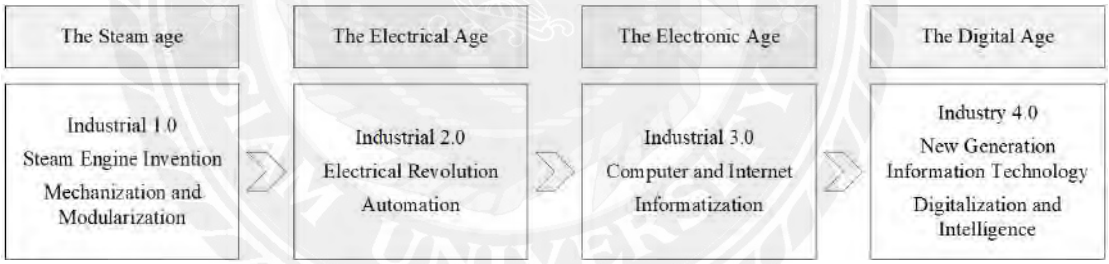

Figure 1.1 Evolution of the Four Industrial Revolutions
Source: Researcher (2025)

In the 21st century, the new generation of information technology represented by the Internet, cloud computing, big data, artificial intelligence, etc. has further deconstructed the traditional society based on industrial civilization, had a profound impact on the economic society, promoted industrial digital transformation, accelerated industrial structural adjustment and the development of the digital economy. At the end of November 2022, OpenAI Labs launched the generative artificial intelligence (AI) chatbot ChatGPT, sparking a storm of technological revolution. Its registered users reached 100 million in just two months, breaking previous records. It reshaped artificial intelligence, attracted widespread attention,

changed the technology ecosystem, and profoundly affected economic development trends and people's lifestyles. It can be believed that in the future, AI will deeply change many industries, and at the same time, it will add wings to the takeoff of the digital economy.

According to the "China Digital Economy Development Research Report" (2023) released by the China Academy of Information and Communications Technology, China's digital economy scale reached 50.2 trillion RMB in 2022, with a nominal year-on-year growth of 10.3%, notably higher than the nominal GDP growth rate for the same period over the past 11 years. The proportion of the digital economy to GDP is equivalent to that of the secondary industry to the national economy, reaching 41.5%, as shown in Figure 1.2.

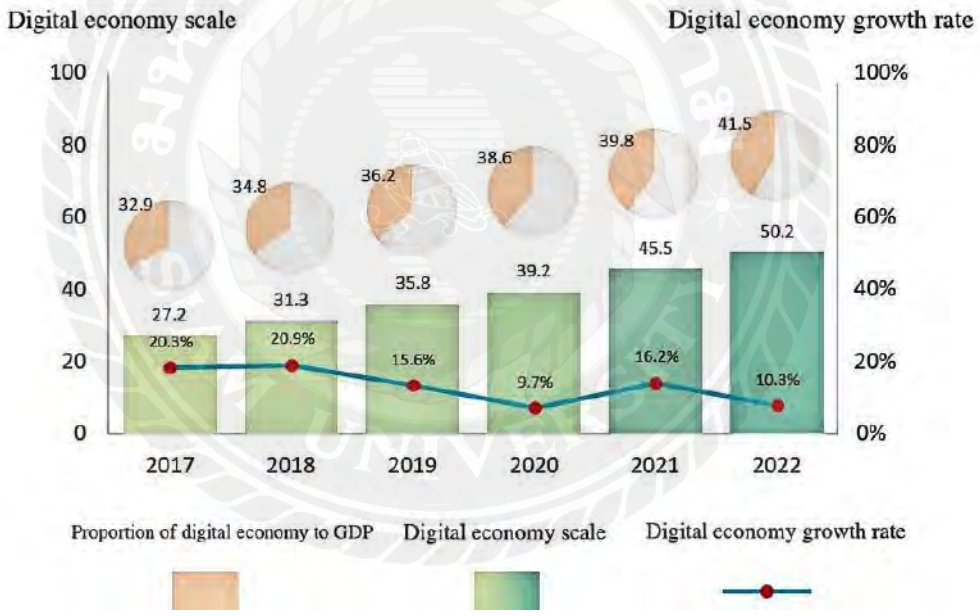

Figure 1.2 Development of Digital Economy in China from 2017 to 2022
Source: China Center for Information industry Development (2023)

In the digital era, digital transformation represents a strategic imperative for enterprises to drive business growth, serving as a critical initiative to enhance operational efficiency and quality. Existing literature on the link between digital transformation and innovation performance predominantly relies on the TOE (Technology-Organization-Environment) theory (Tornatzky & Fleischer, 1990). Specifically, enterprise innovation in the digital age is not driven by a single factor but

emerges from the synergy among technological capabilities, organizational structures, and environmental conditions.

In the process of innovation, design becomes an important driving force (Verganti, 2003). In General, what the public perceives as design is mostly the design of appearance, which focuses on beautifying the shape. Therefore, Brown (2008) mentioned that design was often seen as the final step in the product development process, which involved designing product packaging and beautifying decorations. Thus, it could be inferred that designers in the past rarely participated in the early stages of research and development, and did not play a central role in the company. In recent years, with the development of industrial technology, many enterprises had been constantly pursuing technological progress and constantly iterating and updating their products. As a result, products that place too much emphasis on technology and not on user experience are becoming increasingly unpopular in the market.

> *"Most people make the mistake of thinking design is what it looks like. People think it's this veneer – that the designers are handed this box and told, "Make it look good!" That's not what we think design is. It's not just what it looks like and feels like. Design is how it works" - Steve Jobs*

Therefore, excellent designers have become increasingly important in product development due to their keen observation ability, and some companies' designers have even reversed their own positions and begun to lead product research and development design. The most famous example of this is Apple Inc., where in the autobiography of Apple's Chief Design Officer, Jony Ive, it is described how Apple transformed from a technology oriented approach to a design oriented one, and made its design team the most authoritative class in the company. The revolutionary and successful innovations of iPod, iPhone, and iPad led Apple to unprecedentedly win the global consumer electronics market. In this era, designers began to reverse their industrial position with an innovative attitude.

Emphasizing the equal importance of design and thinking is the core of design thinking, which is essentially about solving specific problems in design contexts, such as specific products, services, processes, and business models. Therefore, managers do

not need to become professional designers, but rather need to equip them with professional skills akin to those of designers, including systematically and creatively identifying problems, visualizing situations and potential solutions, and actually solving problems. Traditionally, designers rely on design thinking to actively explore user needs and innovate within the constraints of the environment, using limited materials and technical resources, and designers possess both analytical and empathetic skills, adeptly leveraging rationality, sensibility, and emotion. He seamlessly integrates design methods with intuitive imagination to propose solutions (Cross, 2011; Liedtka, 2011).

Design thinking has caused a great sensation worldwide, not only being hailed as a remedy for innovation, but also becoming a new darling of business schools and innovation circles (Brown, 2008). In fact, from industry giants such as IBM, GE, and Samsung, to consulting firms such as Deloitte, McKinsey, and Accenture, all actively adopt design thinking. Design thinking continues to shine in the field of digital economy research.

Martin (2010) explored the role of design thinking in business innovation, arguing that design thinking helps businesses balance art and science, intuition and analysis, and exploration and exploitation in the innovation process. From this, it can be seen that there is a close relationship between design thinking and ambidexterity.

Organizational theorist James March (1991) proposed the concept of "ambidexterity", which mainly explores how organizations can explore new opportunities while maintaining existing business, that is, how to balance "exploration" and "exploitation". Exploitation refers to the in-depth cultivation and refinement of known fields, optimizing existing products, services, and processes to improve efficiency and effectiveness. This usually involves utilizing existing resources and knowledge to reinforce and replicate current successful models. On the contrary, exploration refers to finding new possibilities, including innovative products, expanding markets, and experimenting with new business models. This requires organizations to venture into unknown territories, which may mean taking on higher risks and uncertainties. March pointed out that most organizations tend to either focus on exploitation, maintaining stability and efficiency, or on exploration, pursuing

innovation and growth. However, the real challenge lies in how to achieve both simultaneously, without giving up on maintaining and optimizing existing core businesses, while continuously exploring future possibilities. Ambidexterity refers to the ability of an organization to effectively carry out these two seemingly contradictory activities simultaneously. To achieve ambidexterity, organizations may need to establish different structures, cultures, or management mechanisms to support exploration and exploitation activities separately, while ensuring coordination and complementarity among them.

Research shows that large companies actively promote design thinking internally, while the situation for small and medium-sized enterprises is not optimistic due to various difficulties such as financial constraints, a general lack of management experience, and unstable cooperation with external partners (Magistretti et al., 2020). Large enterprises are more likely to quickly adopt innovative business models and adjust their strategic layouts, while small and medium-sized enterprises face challenges in their market competitive advantages and sustainable development (Khurana et al., 2021). For government management agencies and university research teams, it is very important to help small and medium-sized enterprises build innovation-driven sustainable development capabilities. However, there is currently a lack of empirical research on how small and medium-sized enterprises can use design thinking to promote innovation.

According to the data from the Ministry of Industry and Information Technology (MIIT) and the State Administration for Market Regulation of China, by 2024, the number of small and medium-sized enterprises (SMEs) in China exceeded 52 million, accounting for more than 90% of the total number of Chinese enterprises. SMEs are the most active component of China's national economy, and in most regions, they even dominate the local economic sector. China aims to cultivate 1 million innovative SMEs by 2025, according to a government guideline on the development of SMEs during the 14th Five-Year Plan period (2021-25).

Innovative SMEs, characterized by their high capacity and potential for innovation, can introduce innovations in products, technology, management, or business models. These enterprises serve as a critical source of economic innovation,

driving industrial upgrading and enhancing economic competitiveness. At the same time, they make significant contributions to employment and social development. With the rapid advancement of technology and intensifying market competition, innovative SMEs are playing an increasingly important role in stimulating economic growth, promoting employment, and fostering innovation.

Due to the increased uncertainty in international trade, the process of cultivating innovative SMEs has not been smooth, but outstanding enterprises continue to emerge. According to data from the Ministry of Industry and Information Technology , as of the latest statistics, 215,000 innovative SMEs have been cultivated. These enterprises are primarily concentrated in high-tech industries, manufacturing, and information technology sectors. Additionally, there is a growing number of innovative SMEs in emerging fields such as artificial intelligence, big data, and biomedicine.

According to the report of the "2022 China Enterprise Digital Transformation Index" released by Accenture, part of the sampled Chinese enterprises have realized a notable increase in operating revenues and profits through digital transformation, with this ratio reaching 17%, an improvement from previous levels. Nevertheless, from an overall perspective, the performance of enterprises in digital transformation is still not up to par. This suggests that despite the current active promotion of digital transformation by many enterprises, Chinese firms tend to overemphasize significant growth in income and profits as the only standard for measuring a successful transition. Digital transformation is not easy to focus on economic results-driven, and innovation-driven digital transformation is more vital. With the intensification of Sino-US trade frictions and the disappearance of China's demographic dividend, the traditional competitive advantages of China's small and medium-sized enterprises no longer exist, and various unexpected events have occurred one after another, further promoting the in-depth application of digital technology in enterprises.

"Striving to Strengthen Through Ocean Development" is a development guideline proposed by China's top national leadership for Guangxi. As a frontier hub for China-ASEAN (Association of Southeast Asian Nations) opening-up and cooperation, the study of innovative SMEs in Guangxi carries unique strategic value and typical significance. In 2024, Guangxi had a GDP of 393 $ billion, with a population of 50.13

million and an urbanization rate of 57.39%. The economic scale and population structure of Guangxi provide a solid foundation for the development of innovative SMEs. As the only provincial-level region in China connected to ASEAN by both land and sea as shown in Figure 1.3. Guangxi has a coastline of 1,595 kilometers and a land border of 1,020 kilometers, with an area of 237,600 square kilometers.

Figure 1.3 The location of Guangxi facing ASEAN
Source: Researcher (2025)

Guangxi is endowed with unique natural resources. In the field of mineral resources, the reserves of resources such as aluminum, manganese, tin and tungsten rank among the top in China. In terms of agricultural resources, the sugarcane output of Guangxi accounts for more than 60% of the country's total. The forest coverage rate reaches 60.2%, and the recoverable volume of commercial timber forests ranks first in China. Moreover, Guangxi is rich in hydropower resources, and the proportion of clean energy continues to increase. The organic integration and efficient development of these natural resources have laid a solid foundation for the development of Guangxi's industry.

The China-ASEAN Expo, a core platform for deepening cooperation between China and ASEAN, is permanently located in Nanning, the capital of Guangxi. Since its launch in 2004, the expo has facilitated the signing of cross-border cooperation projects totaling over 68.6 $ billion. It has driven the import and export volume between Guangxi and ASEAN from 3.19 $ billion in 2003 to 54.6 $ billion in 2024, accounting for 52.6% of the region's total foreign trade value. ASEAN has remained Guangxi's largest trading partner for 25 consecutive years. SMEs in Guangxi feature a prominent "both ends outside" model: over 60% of raw materials are imported from ASEAN, and more than 50% of products are exported to the ASEAN market. Their innovative activities are naturally integrated into the regional industrial chain, making Guangxi a key hub for cross-border industrial chain integration under the Regional Comprehensive Economic Partnership (RCEP) framework.

Table 1.1 gives policy documents issued by Guangxi in recent years to encourage the development of SMEs.

Table 1.1 Policy documents issued by Guangxi for SMEs

Title of Policy Document	Issuance Date	Main Content
Several Policy Measures for Guangxi to Implement the Three-Year Action Plan for a New Round of Industrial Revitalization	2024	Provides support policies for SMEs from aspects such as industrial technological innovation, financing support for industrial projects, growth and efficiency improvement of industrial enterprises, and gradient development of manufacturing enterprises, establishing a general framework for SME support policies.
Three-Year Action Plan for a New Round of Industrial Revitalization in Guangxi	2024	Promotes the development of SMEs in the industrial sector, with specific content supporting the relevant industrial revitalization policies.
Guangxi's Three-Year Action Plan for Cultivating	2024	Sets out overall requirements and proposes eight actions, including high-quality enterprise gradient cultivation,

Title of Policy Document	Issuance Date	Main Content
Specialized, Refined, Characteristic, and Innovative Enterprises (2024–2026)		innovation capability enhancement, digital empowerment transformation, and quality brand creation, to accelerate the development of SMEs toward specialization, refinement, characteristic innovation, and novelty.
Administrative Measures for Service Vouchers for Cultivating and Strengthening Manufacturing Enterprises in Guangxi (Trial)	2024	Innovates fiscal support for manufacturing SMEs by introducing service vouchers to help enterprises access technical support or consulting services needed for cost reduction, efficiency improvement, transformation and upgrading, and financing for listing, supporting key enterprise projects.
Regulations of Guangxi Zhuang Autonomous Region on Promoting Small and Medium-sized Enterprises	2025	Covers multiple aspects such as optimizing the development environment and safeguarding legitimate rights and interests, including defining government responsibilities, establishing special development funds and funds, implementing tax incentives, improving financing docking mechanisms, and supporting entrepreneurship subjects.

Source: Researcher (2025)

In China, economic transformation represents the most critical and significant context that enterprises must confront. Amidst the profound changes in economic, political, and social spheres, the market economic system has been continuously established and improved. Although China's market economy has achieved rapid development, there is still much room for improvement in its institutional environment. On the one hand, the formal institutional structure based on rules is being continuously established and refined; on the other hand, the imperfections in the legal framework, political structure, and factor markets have made informal institutions still play a

significant role.

1.2 Significance of the problem

1.2.1 Current status and challenges of SMEs in Guangxi

Guangxi has established a gradient cultivation system of "innovative small and medium-sized enterprises → specialized, refined, distinctive, and innovative SMEs → national-level innovative Little Giant enterprises." By 2024, Guangxi had nurtured 1,490 innovative SMEs, 860 specialized, refined, distinctive, and innovative enterprises, and 91 national-level Little Giant enterprises. At the policy level, Guangxi has introduced several policies to provide institutional support for enterprise development. However, the effectiveness of these policies still requires further verification. SMEs in Guangxi have spontaneously established associations and built service platforms to achieve coordinated development of industrial chains. These platforms provide SMEs with services such as technical guidance, project collaboration, technological consulting, and free training. They also promote advanced management concepts and models to help enterprises enhance their quality and management capabilities. The pursuit of innovation has become a common internal goal for the majority of SMEs in Guangxi.

In conclusion, the innovation practices of SMEs in Guangxi have distinct regional characteristics, the value of policy experimentation, and international linkage effects. Selecting Guangxi as a research case can not only deeply analyze the innovation logic of SMEs in border areas within an open economy, but also provide theoretical support for the coordinated development of the regional economy, which has important academic innovation value and practical guiding significance. The rationale for selecting innovative SMEs over conventional SMEs in this study is to precisely investigate the factors influencing firm-level innovation performance. Innovative SMEs, as carefully selected high-quality enterprises, embody the direction of advanced productive forces and possess greater exemplariness, making them more suitable for demonstrating industry-leading practices.

Despite the remarkable advancements achieved of SMEs in Guangxi, a number of specific challenges persist (as shown in Table 1.2), which can be categorized into two dimensions: external environment and internal organizational factors.

Table 1.2 Specific Challenges of SMEs in Guangxi

Dimension	**Specific Challenges**
External Environment	
1.**Financing Environment**	- High loan thresholds due to lack of collateral/credit guarantees - High financing costs
2.**Policy Implementation**	- Fragmented supporting policies with poor local execution - Lengthy approval processes - Special funds "crowded out" by large corporations
3.**Market Environment**	- Declining export orders - Homogeneous competition - Weak industrial chain coordination
4.**Cost Pressures**	- Volatile raw material prices - Annual labor cost increases - Industrial electricity prices higher than neighboring provinces
Internal factors	
1.**Management Deficiencies**	- Family-owned operations with irregular finances - High compliance risks - Digital transformation lag
2.**Talent Shortages**	- Most SMEs lack R&D institutions - Extremely low R&D investment - Mid/high-level talent outflow to neighboring provinces
3.**Innovation Weaknesses**	- Few independent brands; reliance on traditional products - Most SMEs lack new product development - Weak industry-academia collaboration
4. **Operational Mindset**	- Mentality of small-scale complacency - Slow response to market changes - Lack of modern corporate systems

Source: Website of the Department of Industry and Information Technology of Guangxi (2025)

1.2.2 The impact of design thinking and digital transformation

Through searching CNKI and WOS, there are few academic papers on the relationship between design thinking and innovation in the field of small and medium-

sized enterprises. This study will enrich the academic achievements of using quantitative methods to study design thinking and deepen the theoretical research of design thinking in China. Facing the pitfalls of digital transformation, small and medium-sized enterprises can achieve good innovation performance by mastering the dual capabilities of exploitative and exploratory digital transformation through design thinking.

Design thinking redefines and solves problems through a people-oriented approach, making products, services, and experiences more meaningful and humanized, close to users, and creating new value. It is increasingly valued and favored by the public, and has become one of the key elements of competitiveness for enterprises and organizations. In academia, design thinking has long been a popular research topic, and more and more scholars are exploring the theoretical definition (Dorst, 2011; Plattner et al., 2012) and framework (Roberts et al., 2016) of design thinking from different perspectives and fields, thereby deepening their understanding and use of it.

Digital transformation is a key measure for SMEs to enhance their innovation capabilities and is the only way for SMEs to achieve high-quality development. In recent years, the trend of telecommuting and digital marketing has also significantly increased the demand for certainty among a large number of small and medium-sized enterprises. According to a report released by McKinsey & Company, the success rate of digital transformation for Chinese enterprises is only 19%. SMEs encounter more complex circumstances, a variety of demands, and significant challenges during their digital transformation. According to the report's data, currently, only 3% of Chinese SMEs are in the deep application stage of digital transformation, 8% are in the implementation stage, while the vast majority of other SMEs are in the initial stage of digital transformation. China Center for Information industry Development (CCID) had summarized three major pain points of digital transformation for SMEs: high cost, technical level, and talent reserve. These pain points make it easy for enterprises to fall into the wrong areas during the transformation process, including: lack of basic understanding of digitalization; treat digital transformation as a work project rather than a strategy; the organizational structure has not been adjusted; the effectiveness of driving business innovation is not obvious; blindly worshipping consulting firms, etc.

1.2.3 The necessity of the research

At the practical level, this study helps SMEs managers to value user-centered business philosophy, better understand the real needs and pain points of users, and develop innovative products or services that truly meet market demand. At the same time, it helps enterprise decision makers enhance their design leadership and avoid falling into the trap of digital transformation, which can lead to the loss of funds. The application of AI technology in the industry is becoming increasingly popular, and the innovation capabilities of SMEs are facing a comprehensive reshaping. This research can help SMEs effectively organize and manage innovation activities under limited resources, foster a cross-team innovation culture, and improve the efficiency and effectiveness of innovation.

In terms of policy guidance, the results of this study have led government agencies to develop more precise innovation support policies, especially to cultivate more sustainable SMEs, which can provide more jobs and better employment opportunities for college students, the elderly, and the disabled. At the same time, the further promotion of design thinking in China will help solve more complex social problems.

1.3 Research Question

1) What are the relationships between design thinking, digital transformation ambidexterity, and institutional environment, organizational innovation performance of innovative SMEs in Guangxi, China?

2) How can innovative SMEs improve their organizational innovation performance?

1.4 Research Objective

1) To analyze the direct effect of design thinking on organizational innovation performance of innovative SMEs in Guangxi, as well as its indirect effect mediated by digital transformation ambidexterity.

2) To explore how the institutional environment moderates the impact of design thinking on organizational innovation performance of innovative SMEs in Guangxi.

3) To develop a design thinking practice model for enhancing organizational innovation performance in innovative SMEs.

1.5 Scope of the study

This study focuses on analyzing the impact of design thinking on organizational innovation performance of innovative SMEs, and examines the mediating effects of digital transformation ambidexterity and the moderating effects of institutional environment.

1) Scope of area

The innovative small and medium-sized enterprises in Guangxi Province, China.

2) Scope of content

This research will be based on the following theories and concepts: TOE framework, institutional theory, design thinking, innovation theory, digital transformation, and ambidexterity theory.

3) Scope of method

This study adopts a mixed-methods research approach, combining quantitative and qualitative data collection and analysis.

4) Scope of population

For quantitative research, questionnaires will be distributed to middle and senior managers of innovative SMEs in Guangxi Province, China.

For qualitative research, the participants will be selected from the academic community, government departments and innovative SMEs in Guangxi Province.

5) Scope of time

This research will begin in September 2023 and finish in May 2025.

1.6 Theoretical and Practical Contributions

1) This study will provide a foundation for design thinking based on enterprise management and organizational behavior theories, which can become a starting point for more related theoretical and empirical research in the future. This study proposes

a new path for small and medium-sized enterprises to improve innovation performance in the context of the digital economy, enriching the theoretical system of design thinking research.

2) The expected practical benefits would include enhancing the business managers' cognition of the constitution and importance of design thinking, providing new directions for promoting modern business management education, and proposing possible directions for how to cultivate design thinking.

3) Design thinking's emphasis on user needs and experiences can help create more effective and responsive government services. Design thinking can optimize workflows, service delivery, and internal systems through human-centered design, and provide a proven framework for creative problem-solving and innovation in government.

1.7 Definitions

Design Thinking (DT): Design thinking is a human-centered, creative problem-solving process. Design thinking draws on methods from engineering, design, and social sciences to iteratively ideate, prototype, and refine solutions matched to user needs.

Digital Transformation Ambidexterity (DTA): Digital transformation is defined as the transformation and innovation of value generation, acquisition or delivery of enterprises via digital technology. This study divides digital transformation into exploitative and exploratory digital transformation. Exploitative digital transformation increases the efficiency of existing operational processes, such as using the internet to enable diverse communication with other partners to reduce R&D costs and using digital resources to reconfigure business models and value networks, or rather focuses on improving the existing products, processes, and capabilities using digital technology, while exploratory digital transformation explores future markets to gain a competitive advantage, such as forecasting future markets and creating new products and services with digital technologies such as AI.

Organizational Innovation performance (OIP): OIP has two dimensions. The first dimension is subjective, measuring innovation performance through the

application of innovative ideas and methods; the other dimension is objective, transforming actual standards into specific measurable things is a form of performance.

Institutional Environment (IE): IE refers to the overall structure of formal and informal rules, policies, laws, culture, and social norms that influence and constrain organizational behavior, which can be categorized into three dimensions with regulative, normative , and cognitive environment.

1.8 Structure of the Study

This section outlines the main chapters of this study, explains the content of all chapters, and provides a clear direction for this research.

Chapter 1: Introduction. This chapter presents the overview of the study, the problem statement, the purpose of the study, the brief contributions of the study, and thesis structure.

Chapter 2: Literature Review. In this chapter, the literature review is discussed. First of all, a concise presentation about design thinking will be discussed. Afterward, the definition of the description of Digital Transformation, organizational ambidexterity, and organizational innovation performance were described in detail. Then, the literature related to the study has been reviewed. The hypothesis of the research study has been suggested and a research model framework is developed.

Chapter 3: Research Methodology. This chapter describes the methodology and research design. The methodological and technical issues were discussed regarding the questionnaire design for the survey and also reliability is tested. The population, sampling, and statistical techniques and data analysis are employed in this section.

Chapter 4: Research Results. This chapter will present the data analysis as well as the findings from the descriptive statistics analysis, exploratory factor analysis, confirmatory factor analysis by structural equation modeling. Finally, the qualitative method part of the study includes in-depth interviews, synthesizing the opinions of relevant participants in Guangxi Province about the impact of implementing design thinking in SMEs, discussing the influence relationships between variables, and sorting out the key arguments of the research.

Chapter 5: Research Conclusions, Discussion and Recommendations. In this chapter, researcher will start with a summary. Furthermore, the conclusions of the study will be presented. Then in the next part, the discussion about the findings will be described in detail. Consequently, the recommendations to managers and the practical implications of the research will be analyzed in detail.

CHAPTER 2
LITERATURE REVIEW

The conceptual framework of this study is grounded primarily in two theoretical foundations: the Technology-Organization-Environment (TOE) framework and Institutional Theory. Together, these theories provide a robust lens for understanding how design thinking drives digital transformation ambidexterity and, in turn, influences organizational innovation performance within varying institutional contexts. To fulfill the intentions of this dissertation, the researcher accessed several research databases and platforms, including the Web of Science, Emerald Insight, EBSCOhost, CNKI, and Google Scholar. Journal articles, research studies, academic dissertations and books were reviewed. The details in this chapter will be separated into six parts as follows:

2.1 TOE framework
2.2 Institutional Theory
2.3 Relevant Concepts
2.4 Relevant Research
2.5 Gap Analysis from Existing Literature
2.6 Conceptual Framework, Hypothesis, and Operational Definition

2.1 TOE framework

Originally proposed by Tornatzky and Fleischer (1990), the TOE framework posits that an organization's decision to adopt and implement technological innovations is influenced by three key contextual factors: technological, organizational, and environmental contexts. This model has been widely adopted in studies of digital transformation and innovation, as it offers a comprehensive yet flexible structure for analyzing the drivers of technological change.

In the context of this study, the TOE framework serves as a foundational basis for understanding how design thinking—as an organizational capability—can influence both exploitative and exploratory digital transformation. Design thinking,

characterized by user-centeredness, iterative experimentation, and collaborative problem-solving, operates within the organizational context as a catalyst for transformation. By promoting creative ideation and empathy-driven innovation, design thinking equips firms to simultaneously pursue incremental (exploitative) and radical (exploratory) digital initiatives.

From the technological perspective, digital transformation itself represents a dynamic and rapidly evolving action. The ambidextrous approach—balancing exploitation and exploration—aligns with the TOE framework's emphasis on technology as both an enabler and outcome of innovation adoption. The framework helps explain why organizations that effectively leverage design thinking are better positioned to navigate complex technological landscapes.

The environmental context in the TOE framework—referring to external forces such as market competition, regulatory pressures, and cultural expectations—also overlaps with the components of Institutional Theory, creating an integrated platform for interpretation.

2.2 Institutional Theory

Institutional Theory, as proposed by DiMaggio and Powell (1983), explains how organizations are shaped by the institutional environments in which they operate. Researching institutional environments is crucial because institutions including both formal (laws, regulations) and informal (cultural norms, social values) directly influence economic performance, innovation, and entrepreneurial activity (North, 1990; Scott, 1995). As Baumol (1990) points out, the institutional framework defines whether entrepreneurial efforts contribute to productive, unproductive, or destructive activities. A well-functioning institutional environment fosters innovation, economic growth, and sustainability by providing clear regulations, property rights, and enforcement mechanisms, which are essential for reducing uncertainty and transaction costs (Peng, 1996; Busenitz et al., 2000). In dynamic and emerging markets, institutional frameworks also shape firm performance and resource allocation, showing the adaptability of businesses to evolving regulatory contexts (Xu et al., 2021).

North (1990) argues that institutions are the fundamental determinants of

economic performance. He posits that institutions—formal rules, informal constraints, and their enforcement—shape economic behavior by reducing uncertainty and transaction costs. His theory emphasizes how institutional changes drive economic growth or decline. Importantly, he explains that institutions evolve gradually and that their effectiveness depends on enforcement mechanisms, influencing long-term economic performance (North, 1990).

Scott (1995) presents a comprehensive framework for understanding institutions by categorizing them into three pillars: regulative, normative, and cognitive. He asserts that institutions not only constrain organizational behavior but also provide the social frameworks within which organizations operate. By highlighting the dynamic and multifaceted nature of institutions, Scott underscores how they are embedded in broader societal contexts and interact to influence organizational structures and practices.

Peng (1996) applies the resource-based view (RBV) to study firm behavior in two distinct institutional environments: the highly structured, regulatory Hollywood film industry of the mid-20th century and its less regulated contemporary counterpart. Peng demonstrates how different institutional contexts affect the ability of firms to leverage their resources for competitive advantage, showing that institutional environments shape strategic firm behavior and influence resource-based performance outcomes.

Busenitz, Gomez and Spencer (2000) introduced the concept of country institutional profiles, which describe the institutional conditions that influence entrepreneurial behavior across nations. The authors identified three dimensions with regulative, cognitive, and normative environment, which shape the entrepreneurial environment. Their findings suggest that institutional differences significantly affect entrepreneurial activity, with distinct institutional profiles promoting or hindering entrepreneurship in various countries.

Greenwood, Hinings,& Whetten (2014) discusses how organizations navigate institutional complexities in their fields, focusing on how conflicting demands from multiple institutional logics impact organizational structures and strategies. The authors propose that the complexity of institutional environments requires

organizations to balance pressures for legitimacy with demands for innovation, particularly when operating within multiple institutional contexts. They conclude that organizational success depends on the ability to manage and prioritize these competing demands.

Xu, Guan, Zhang and Jia (2021) explores the relationship between institutional environments, innovation capability, and firm performance, particularly in the context of emerging markets. The authors argue that favorable institutional environments, such as supportive regulations and government policies, enhance a firm's innovation capacity, leading to improved performance. However, they also caution that overly rigid institutional frameworks can stifle creativity and limit innovation, stressing the need for a balanced approach.

Swaminathan and Wade (2016) examines the effects of institutional environments on strategic alliances and firm performance, finding that institutional contexts significantly influence the formation and success of alliances. In more stable institutional environments, firms are more likely to engage in alliances that enhance performance, whereas in volatile or weakly regulated environments, alliances are often formed as a risk mitigation strategy. The authors emphasize that firms must adapt their alliance strategies to the specific institutional conditions they face.

Ahlstrom, Bruton, and Yeh (2020) reviewed highlights the role of institutions in shaping entrepreneurship, particularly in emerging markets. They argued that institutional environments, such as property rights and regulatory frameworks, create both opportunities and constraints for entrepreneurs. They discussed how institutional weaknesses can hinder entrepreneurial activity, while also noting that strong institutions can foster entrepreneurial innovation and growth by providing a stable environment for business operations.

According to the research question and content, this study focuses on the institutional environment for entrepreneurship and adopts the institutional framework of Busenitz et al. (2000). Measuring the institutional environment involves assessing both the formal and informal components that influence organizational and economic behavior. A common approach is to use country institutional profiles, as proposed by Busenitz et al.(2000), which evaluate three dimensions: regulative (e.g., laws,

regulations, enforcement), normative (e.g.,, societal values), and cognitive (e.g., cultural beliefs). This method allows researchers to compare institutional conditions across countries and examine their effects on entrepreneurship and firm strategy.

Another approach involves quantitative indices, such as the World Bank's Doing Business Index, which measures the ease of conducting business by evaluating regulatory frameworks, property rights, and contract enforcement. These indices provide a practical way to assess the effectiveness of institutions in promoting economic activity. Xu et al.(2021) also use empirical methods to measure the institutional support mechanisms for innovation, such as government policies, subsidies, and infrastructure investment, linking them to firm performance outcomes.

2.3 Relevant Concepts

2.3.1 Classification of SME

Small and medium-sized enterprises have become the backbone of promoting the development of social productive forces and have become the main creators of social wealth. However, while small and medium-sized enterprises spring up after a spring rain at the same time, many small and medium-sized enterprises are facing the development bottleneck that cannot be broken through. SMEs have made very important contributions to the economy in areas such as job creation, local resource utilization and output expansion. They also contribute to the transformation of traditional/local technologies, the production of intermediate products, the promotion of uniform development, income redistribution, and increasing the government's revenue base through taxation. In developing countries, SMEs contribute to economic growth and social promotion because they are usually owned and operated by locals and residents and use local resources and familiar technologies, unlike large companies that are often multinational companies using advanced technologies (Uchenwamgbe, 2013).

Despite the important role played by these business organizations, the literature claims that the development cycle for SMEs in China was typically around 3 years, with only one-third of these businesses continuing to operate normally after the 3-year

mark. (PBC, 2019). The high mortality rate of SMEs in China can be attributed to both environmental and internal factors. Environmental factors include financing difficulties, poor market credit environment, volatile market environment and insufficient government support. Internal factors are low management level, poor resource integration ability, insufficient innovation ability and strategic mistakes. This study focuses on the internal factors of innovation capacity, but first, it is important to understand SMEs.

There is no universally agreed definition of SMEs. The definition varies from country to country and even from sector to sector within the same country. The definition of SMEs is usually based on the number of employees, capital investment, balance sheet size, and sales turnover. Table 2.1 shows classifications of SMEs by Country/Multilateral Agency. Table 2.2 shows classifications of SMEs in China.

Table 2.1 Classification of SMEs by Country/Multilateral Agency

Body	Category	Value	Measure
World Bank	SME	≤ 300 Employees; ≤ $15 million turnover; ≤ $15 million assets	Employment, Turnover, and Assets
European Union	Micro	< 10 Employees; ≤ € 2 million Turnover or ≤ € 10 million Balance sheet totals.	Employment, Turnover, and Balance sheet total
	Small	< 50 Employees; ≤ € 10 million Turnover or ≤ € 10 million Balance sheet totals.	
	Medium	< 250 Employees; ≤ € 50 million Turnover or ≤ € 43 million Balance sheet total.	
USA	Micro	< 20 Employees	Employment
	Small	20-99 Employees	
	Medium	99-499 Employees	
Japan	Manufacturing	< 300 Employees or Assets <¥ 100 million	Employment or Assets

Body	Category	Value	Measure
	Wholesaling	< 50 Employees or Assets < ¥ 30 million	
	Retailing & Services	< 300 Employees or Assets < ¥ 10 million	

Source: Researcher (2024)

Table 2.2 Classification of SMEs by China

Field	Index	Unit	Medium	Small
Agriculture, forestry, animal husbandry, and fishery	Turnover (Y)	CNY 1M	5≤Y＜200	Y＜5
Manufacturing	Employees (X)	person	300≤X＜1000	X＜300
	Turnover (Y)	CNY 1M	20≤Y＜400	Y＜20
Information transmission services	Employees (X)	person	100≤X＜2000	X＜100
	Turnover (Y)	CNY 1M	10≤Y＜1000	Y＜10
Software and information technology services	Employees (X)	person	100≤X＜300	X＜100
	Turnover (Y)	CNY 1M	10≤Y＜100	Y＜10
Business services	Employees (X)	person	100≤X＜300	X＜100
	Assets (Z)	CNY 1M	80≤Z＜1200	Z＜80

Note: Medium and small enterprises must simultaneously meet the lower limit of the listed indicators.

Source: China National Bureau of Statistics (2025)

With the rise of a new round of scientific and technological revolution and industrial transformation, the rapid development of new technologies such as industrial Internet and artificial intelligence has helped China's manufacturing industry break the bottleneck of various businesses and technologies, and rapidly transformed from traditional processing mass production to small batch personalized production driven by user demand in the digital economy.

SMEs play an indispensable role in promoting regional economic development and employment. In recent years, the Chinese government has introduced a series of policy measures aimed at reducing operating costs, broadening financing channels, and supporting technological innovation for SMEs, creating more favorable conditions for their development. These policies have promoted the structural adjustment and technological upgrading of SMEs, enabling them to better meet the challenges of domestic and international markets. For example, by encouraging innovation and entrepreneurship, many SMEs have successfully transformed from traditional manufacturing to high-value-added services and high-tech industries, enhancing their market competitiveness.

Guangxi has established a three-dimensional standard framework for the evaluation of innovative SMEs. Firstly, in terms of eligibility access, enterprises are required to meet the national classification standards for SMEs. Secondly, the capability assessment adopts a "dual-track system". The direct recognition channel is conditional on landmark innovative qualifications such as science and technology awards at or above the provincial and ministerial levels, high-tech enterprise certifications, operation of provincial-level R&D institutions, or equity financing. The comprehensive evaluation system establishes a quantitative model from three aspects: innovative capability (intellectual property rights, R&D investment), specialization level (focus on the main business, product uniqueness), and growth potential (indicators such as revenue growth). Thirdly, the industrial orientation focuses on strategic emerging industries, high-tech manufacturing, and regional characteristic fields, with an emphasis on cultivating innovative entities in areas such as agricultural technology and biological breeding.

2.3.2 Design Thinking

This study searched the Web of Science with the topic "design thinking," restricting the field to Business, Management, Economics, and Art, and setting the time frame from 1985 to 2024, and got a total of 613 articles. The result of keyword analysis by VOSviewer 1.6.20. is shown in Figure 2.1

From the figure below, it can be observed that the application of design thinking is extremely broad. In recent years, it has intersected and integrated with various fields such as organizational performance, technological innovation, lean thinking, systems thinking, sustainable development, and other areas.

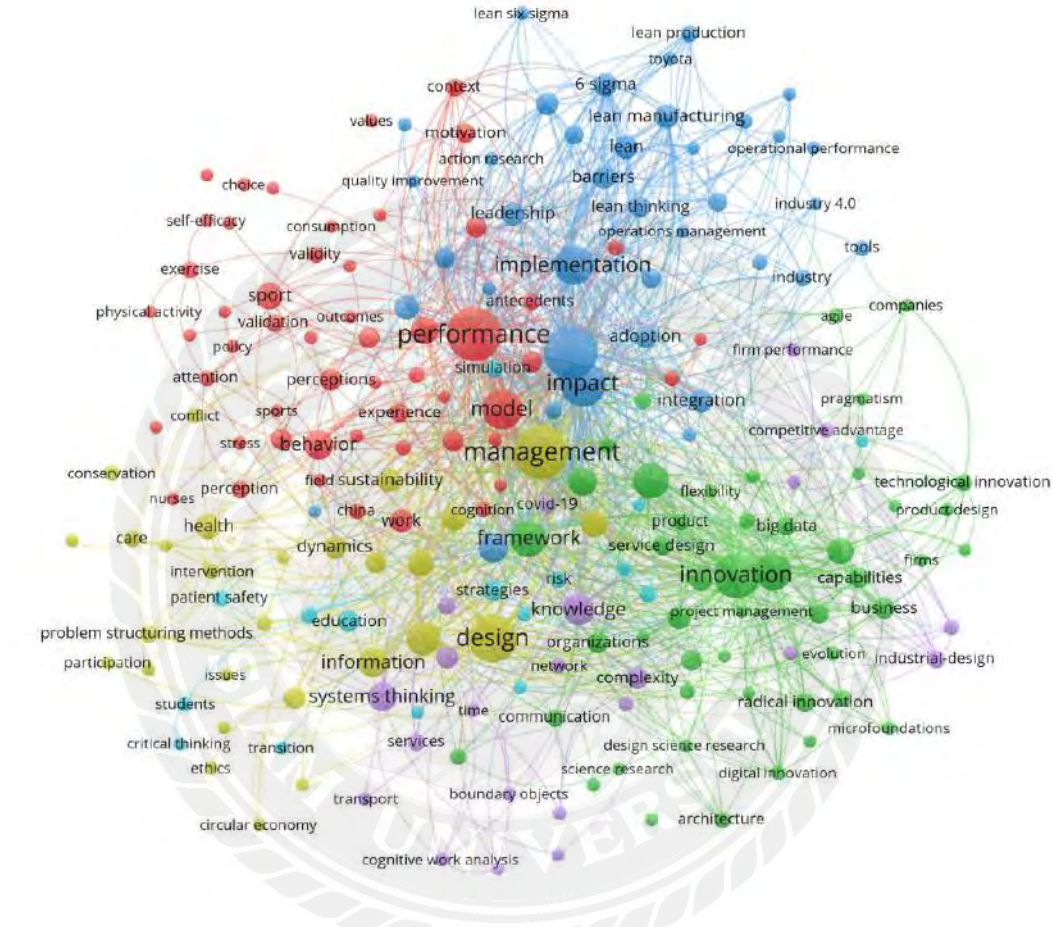

Figure 2.1 Keyword analysis map with the literatures about design thinking
Source: Researcher (2025)

2.3.2.1 History of design thinking

The early movement of design thinking, which can be located between the 1960s and 1970s, can be classified as scientific methods applied to the design of physical artefacts. At this point, design theories, methods and processes mainly contributed to industrial developments, for example being applied within the contexts of industrial design, engineering and architecture. The concept of design thinking has been gaining traction since the 1960s. Yet, in those early days, explanations of its application in design practice were rather sparse and tended to lack depth (Simon, 1969). Figure 2.2 shows the basic history of design thinking development.

The term “design thinking” was established some years later when Rowe used it to underline the multifaceted texture of making the decision in relation to problem solving (Rowe, 1987). Rowe identified the term with that part of the design process that is not controlled by an overemphasised step-by-step procedure, but instead opens out into an imaginative approach to problem solving.

Figure 2.2 Design thinking history
Source: Researcher (2025)

In the 1980s, there was a shift of attention to design thinking, in the sense of placing the emphasis on “designerly” ways of problem solving and investigating processes and approaches that might be seen as particular to designers. As a result, this kind of approach was considered in wider terms and organisational theory began to advocate its implementation in areas such as management strategy, which led to the improvement of manufacturing and knowledge transfer in organisations.

Richard Buchanan at Carnegie Mellon University, the dean of the School of Design, proposed the "evil problem" in design, which became the basic reference for design thinking (Buchanan, 1992), and even became the discussion reference of the whole design field. He describes the professional thinking mode of designers as a process of dealing with thorny problems, and can be said to be the first scholar to look at design thinking from the perspective of designers. Instead of following the previous step-by-step design process, he proposed a two-stage design process: an analytical problem definition step (Problem Definition), and a comprehensive problem solving sequence (Problem solution). He believes that using tools to identify the views and concerns of all participants, while generating assumptions that can be exploration and development, allows problem definitions and problem solving to proceed in parallel,

rather than advancing in sequence, integrating creative thinking with problem-solving methods.

Professor Krippendorff, a communication expert at the University of Pennsylvania, defined design as creating meaningful things (Krippendorff, 2005) rather than the Simon concept (artefact). Believe that the main purpose of design thinking is to innovate and solve problems. This means that designers need to combine innovation and problem solving, and constantly improve and improve the design through multiple cycles in the design process.

In 1991, David Kelley and Tom Kelley of Stanford University School of Business co-founded design consultant IDEO, and IDEO developed interactive-friendly terminology, steps, and toolkits that enable those without a design foundation to quickly and easily adapt to the design process. By the late 2000s, design thinking was perceived as an essential tool for businesses seeking to manage changes in organisational culture and improve customer experiences. Hence, it was applied in design-led organisations and service design consultancies through design toolkits such as human-centred design (HCD), customer journey mapping, and personas (Brown, 2008). In 2009, Martin, professor of the University of Toronto, Rotman, published the book The Design of Business: Why design thinking is the Next Competitive Advantage, which describes the concept of design thinking to business innovation (Martin, 2009).

With the success of IDEO, more and more management scholars begin to pay attention to the potential of design thinking in business innovation. In 2005, SAP founders Hasso Plattner and David Kelley founded Stanford d. School has become the base camp of design thinking, so design thinking has developed rapidly among world-renowned universities and large enterprises. In 2009, Stanford University School of Business opened a course called Design Thinking Bootcamp, which is designed to enable executives and managers in business institutions to understand design thinking and further enhance the influence of design thinking in the business field. IDEO also opened online courses in 2015, breaking through the limitations of space and industry to teach design thinking and further improve its influence.

Early research on design and innovation showed that professionally trained designers are able to play a key role in the innovation process, and that their expertise

and skills can help generate more innovative design solutions. In contrast, IDEO (Brown, 2009) and Rotman School of Management (Martin, 2009) emphasize that people from any academic background can learn from the thinking context and working style of designers and apply it to their business areas. This people-centered thinking method is widely applicable. User-centered design (User-Centered Design, UCD) (IDEO, 2015), put the user at the core of the design process, whether in business, technology, education, healthcare and other fields, all need to focus on the user experience, needs, expectations and pain points, to design solutions that can meet these needs. Therefore, design thinking is an interdisciplinary and multi-disciplinary methodology, with multi-disciplinary characteristics (Kimbell, 2011).

Since 2010, the research results of design thinking have been blossoming. Nowadays, design thinking has flourished in engineering, education, agriculture, medical care, psychology and other related fields, and achieved remarkable interdisciplinary research results. Especially in the field of management science, Design thinking and related topics, such as strategic management (Liedtka, 2000), innovation management (Verganti, 2006; Brown, 2009), and organizational management (Dunne & Martin, 2006; Brown, 2008; Michlewski, 2008), et al.

2.3.2.2 The concept of design thinking

Design thinking has been variously called a logic, principles, practices, tools, discourse, philosophy, and mental model (Gruber et al., 2015; Leavy, 2010).

IDEO, through its leading position in the design and innovation fields, has vigorously promoted design thinking, and successfully made the concept advocated by IDEO CEO Tim Brown become the mainstream of design thinking today. Tim Brown (2008) explained in Harvard Business Review: " Design thinking is a knowledge, using the perceptual thinking and methods of designers to find people's real needs, and at the same time considering the feasibility of technology and business, and transforming it into customer value and market opportunities." Brown (2008) also mentioned that the process of design thinking is a series of spaces to interact with each other, rather than a series of fixed order steps, including three spaces (Figure 2.3):

(1) Inspiration: for the circumstances (be they a problem, an opportunity, or both) that motivate the search for solutions;

(2) Ideation:for the process of generating, developing, and testing ideas that may lead to solutions;

(3) Implementation:for the charting of a path to market.

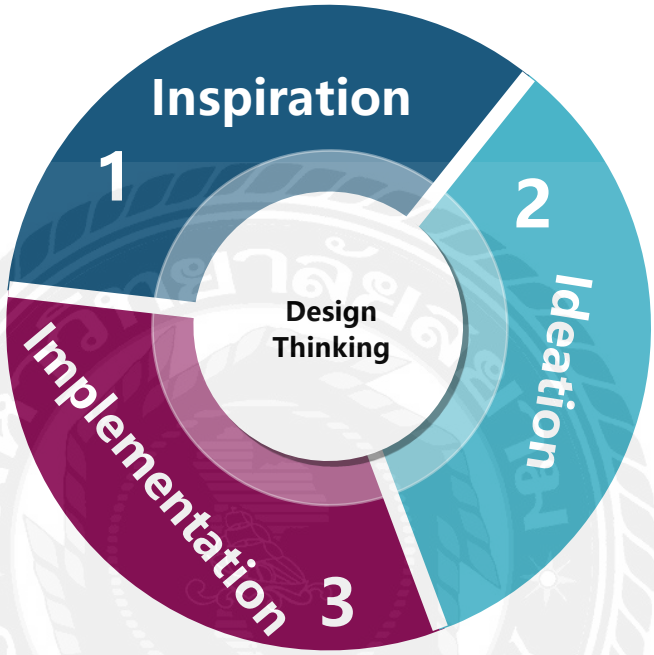

Figure 2.3 The 3I space of design thinking
Source: Brown (2008)

This process of exploration constantly interacts, especially in the first two stages, until the idea is corrected or the case takes a new direction (Brown, 2008). Tim Brown (2009) believes that people don't know what they want, but their "behavior" reflects their needs. A design thinker Work is to help people find hidden in the heart, even oneself didn't perceive the needs in the process of looking for demand, however, is very complex and long, process appear many options need to decide, convergence thinking (convergent thinking) is a practical and effective practice, but when you want to explore the possibility of innovation, divergent thinking (divergent thinking) can enrich our options. Design thinking is a knowledge that can both pursue innovation and is compatible with practice. Tim Brown (2009) believes that the process of design thinking includes convergent thinking and divergent thinking, and the two constantly

interact to find the best solution. In 2005, the British Design Institute also proposed a similar concept, forming the design process through divergence and convergence cycles, called double diamond diagram. They divided the design into four stages: discover, define, develop, deliver, the thinking patterns used by designers in different stages of design (British Design Council, 2005) in Figure 2.4.

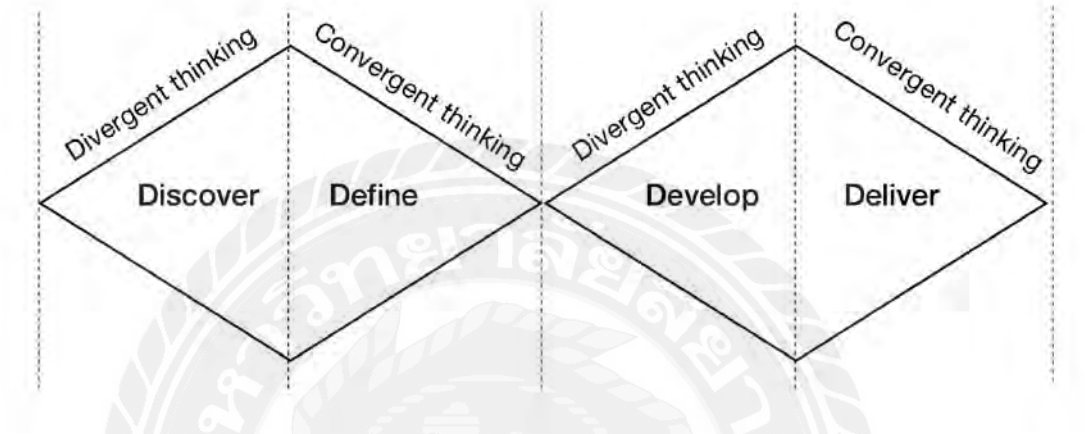

Figure 2.4 The double diamond diagram
Source: British Design Council (2005)

Tim Brown (2009) also mentioned that in divergent thinking and convergence thinking, analysis and synthesis are important thinking skills. Analysis refers to analyzing and observing complex problems one by one; synthesis refers to extracting meaningful patterns from a large number of original data (Brown, 2009). Design thinking is the comprehensive use of these two skills to make decisions. In 2009, Roger Martin, a professor at the Rotman School of Management at the University of Toronto, Canada, published "Design Thinking Is This Way" (The Design of Business), which mentions a similar concept: design thinking is the best balance between analytical and intuitive thinking, while considering the reliability of analysis and the validity of intuition. Roger Martin (2009) believes that organizations and individuals with the principles of design thinking will continue to pursue a balance between reliability and effectiveness, art and science, intuition and analysis, exploration and development.

The three-stage process of design thinking mentioned above is actually the ancestor of many design methodologies. The following are IDEO Company and Stanford School of Design d.school, IBM Company, Darden Business School, Daylight Design Company, these five well-known design thinking methodology

processes. As can be seen in the figure below, the core ideas of these five methodologies are all based on the three stages of conception, thinking and implementation. Each step puts the users' needs in the middle. Although different approaches describe design thinking with different steps, the overall process remains similar, as shown in Figure 2.5.

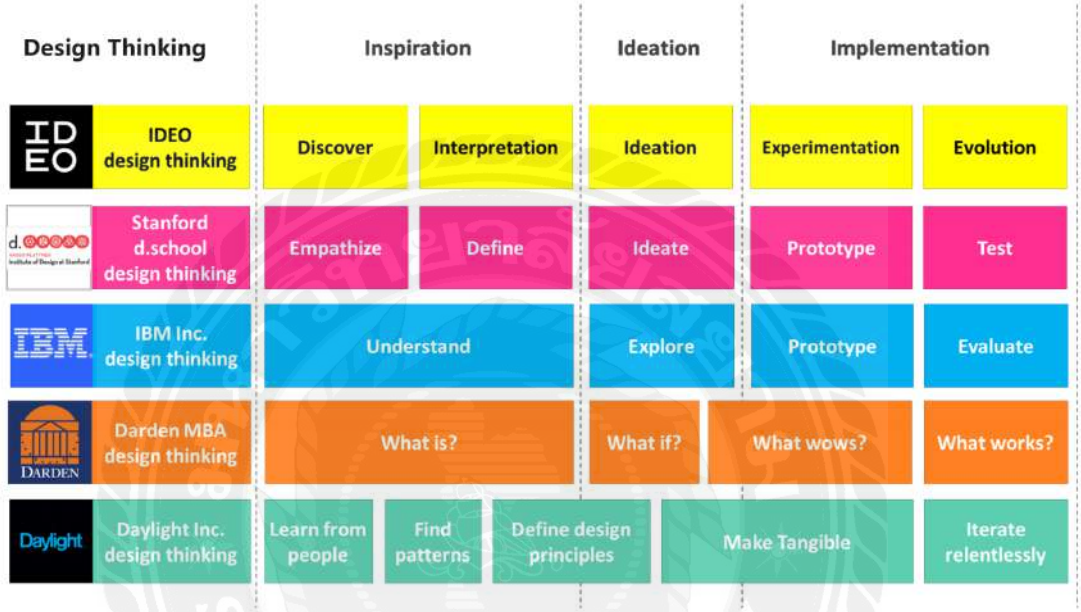

Figure 2.5 Design Thinking themes from practice
Source: Chen, Li-Tong (2017)

One of the most popular is the Stanford School of Design d.school The methodology, they divided the process of design thinking into five steps (d.school bootcamp bootleg, 2011):

(1) Empathy: To exert empathy, it is necessary to observe users' life behavior with them; interact with users and pause appropriately; and experience themselves as a user.

(2) Define: Integrate the discoveries of the previous steps, and turn them into insights and requirements.

(3) Ideate: Come up with a large number of creative ideas, and then screen.

(4) Prototype: Develop the prototype of ideas, which can be an object, interface, space, role-playing activities, etc. In order to let others quickly understand what the idea is really looking like.

(5) Test: Constantly test and correct the prototype to quickly verify the right and wrong of ideas, which is conducive to the iteration and recycling process.

In the field of management, scholars have proposed different definitions of design thinking. The next segment will introduce these contents.

2.3.2.3 The attributes and Characteristics of design thinking

In addition to the methodology of design thinking, the mindsets and Characteristics of design thinking are also an important part. Through the analysis of the existing literature, the connotation of the two words attributes and characteristics is basically similar in the study of design thinking, Table 2.3 describes Design thinking Characteristics from relevant literature.

Table 2.3 Design thinking Characteristics from literature

Source	Alternative Ways of Defining the Essence of Design Thinking
Micheli et al. (2018)	Ten "attributes" associated with the concept of design thinking derived from 104 articles (1985-2017), nine influential books, and three applied models: (1) Creativity and innovation, (2) User-centeredness and involvement, (3) Problem solving, (4) Iteration and experimentation, (5) Inter-disciplinary collaboration, (6) Ability to visualize, (7) Gestalt view, (8) Abductive synthesis, (9) Tolerance of ambiguity and failure, and (10) Blending analysis with intuition. (1) and (3) describe the goals of design thinking. The other 8 attributes can be viewed as guiding "principles" that can shape practice.
Luchs (2016)	Six "principles" (mindsets or philosophy that guide practice) synthesized from 24 contributed articles: (1) People-centric, (2)Cross-disciplinary and collaborative, (3)Holistic and integrative, (4) Flexibility and comfort with ambiguity, (5) Multimodal representational skills, and (6) Growth mindset

Source	Alternative Ways of Defining the Essence of Design Thinking
Liedtka (2017)	Five "observed practices of design thinking" at 22 organizations: (1) Deep understanding of user needs, (2) Heterogeneity of teams, (3) Dialog-based conversations, (4) Multiple solutions that are winnowed, and (5) Creation of structured and facilitated processes
Carlgren et al. (2016)	Five "themes" (groups of practices) derived from 6 organizations: (1) User-focus, (2) Problem reframing, (3) Visualization, (4) Experimentation, (5) Diversity
Seidel & Fixson (2013)	Four "methods" assessed in 14 novice innovation teams (1) Need finding, (2) Brainstorming,(3) Prototyping, and (4) Team reflexivity
Beverland (2015)	Four "hallmarks": abductive reasoning, iterative thinking and experimentation, holistic perspective, and human-centeredness.
Zheng (2018)	Six core "traits" of DT, including problem-driven, stakeholders focused, diversity-pursuit, experimentation, visualization and abductive reasoning.
Nakata and Hwang (2020)	Three "mindsets" constituted by human-centeredness, abductive reasoning, and learning by failing.

Source: Researcher (2024)

Based on the summary of Micheli (2018), the following Table 2.4 lists the 10 characteristics of design thinking.

Table 2.4 The Attribute s of Design Thinking

Attribute	Comprehensive Description
Creativity and Innovation	The capacity to produce unique and valuable ideas, and the process of translating these ideas into innovative solutions and products that are brought to market, reflect an essential outcome and process within design thinking.

Attribute	Comprehensive Description
User-centered and Involvement	An approach that prioritizes understanding and meeting the needs of the end-user throughout the design process, emphasizing empathy and active engagement with users to ensure relevance and desirability of the outcomes.
Problem Solving	The application of design thinking to address complex and multifaceted challenges, especially those that are not easily defined or solved through traditional, linear methods, often termed "wicked problems".
Iteration and Experimentation	A core design thinking process involving repeated cycles of prototyping, testing, and refining ideas, which allows for continuous improvement and adaptation based on feedback and learning.
Interdisciplinary Collaboration	The integration of diverse expertise from different fields and disciplines to foster a comprehensive approach to problem-solving, leveraging varied perspectives to generate more innovative solutions.
Ability to Visualize	The skill to convert abstract concepts and ideas into visual formats, such as sketches, models, or diagrams, which helps in better understanding, exploring, and communicating the potential solutions.
Gestalt View	The holistic consideration of a problem within its broader context, recognizing the interrelatedness of its parts and the system as a whole, which facilitates a more integrated and comprehensive understanding.
Abductive Reasoning	A non-linear form of reasoning that involves generating plausible hypotheses or explanations to explore unknowns or uncertainties, often starting from an incomplete understanding of a situation.
Tolerance of Ambiguity and Failure	An openness to accept and work within conditions of uncertainty, and the willingness to learn from failures as valuable experiences that contribute to the evolution of ideas and solutions.

Attribute	Comprehensive Description
Blending Rationality and Intuition	The harmonious combination of logical, analytical thinking with intuitive insights, allowing for a balanced approach to problem-solving that leverages both the head and the heart in decision-making processes.

Source: Researcher (2025)

All the above literature mentioned abductive reasoning. abductive reasoning has important differences from deductive reasoning and inductive reasoning, which are analyzed in the following Table 2.5.

Table 2.5 Difference of reasoning interpretation

	Deductive reasoning	**Induction reasoning**	**Abductive reasoning**
description	Introduce the necessary conclusion of specific facts from the general principle; the correct conclusion must be correct	Extract general rules from specific examples; the conclusion may be large, but not necessarily	Look for the best explanation to match observed phenomena; do not provide inevitability but provide reasonable speculation
instance	All people will die (general principle) Socrates is a man (specific facts) Therefore, Socrates will die (conclusion)	All the swans seen are white (specific examples) Therefore, all swans are white (general rule)	Lamights on (observation) Therefore, someone may turn on the switch (best explanation)
Reasoning direction	From general to specific	From specific to general	From observation to speculation
Conclusion deterministic	Necessary (if correct)	Likelihood, but not necessarily	Providing reasonable speculation is not necessarily necessary
Application domain examples	Mathematical proof, logical analysis	Theoretical formation of scientific experiments, pattern recognition	Creative problem solving, diagnostics, criminal investigation
information requirements	Complete and accurate prior knowledge	A large number of concrete examples	Related observation data, open thinking

	Deductive reasoning	Induction reasoning	Abductive reasoning
decision support	certainty decision	Trend-based predictions	Exploratory decision-making

Source: Researcher (2025)

Retroactive reasoning is used in design thinking because it allows people to make innovative assumptions and decisions despite uncertainty and lack of complete information, which is particularly useful in exploring new areas and solving problems.

At present, scholars have put forward different opinions on the composition and characteristics of design thinking based on their own research field, and the characteristics of design thinking are the basis of quantitative research.

2.3.3 Innovation Performance

2.3.3.1 Definition of innovation

Innovation plays an extremely important role in today's highly competitive business environment. Innovation is the cornerstone of the sustainable development of an enterprise. It can not only help to enhance the core competitiveness of enterprises, but also help enterprises adapt to the changing market environment, drive economic growth, improve organizational capacity, and build a positive corporate image.

American economist Joseph Schumpeter first proposed technological innovation in the Theory of Economic Development in 1912. He defined technological innovation as "recombination of factors of production," in the form of introduction of a new product, introducing a new production method, opening up a new market, obtaining new sources of supply of raw materials or semi-finished products, realizing a new form of industrial organization and so on.

Drucker (1985) claimed that innovation is a special tool for entrepreneurs to use change as an opportunity to provide different businesses or services. This definition assumes that innovation means change, while treating innovation as a tool for entrepreneurs to produce new goods or new services in the hands of entrepreneurs, which is very consistent with Schumpeter's theory of innovation and economic

development. Drucker further noted that innovation can be presented as a subject, and that it can be learned and practiced. Different scholars define innovation in different ways (as shown in Tabel 2.6).

Table 2.6 Definition of Innovation

Authors	Definition
Acs and Audretsch,1988	A process that begins with an invention, proceeds with the development of the invention, and results in the introduction of a new product, process, or service to the market place.
Damanpour, 1992	The adoption of an idea or behaviour, whether a system, policy program, device, process, product, or service, that is new to the adopting organization.
Amabile, 1996	The successful implementation of creative ideas within an organization
Lumpkin and Dess, 1996	Innovativeness reflects a firm's tendency to engage in and support new ideas, novelty, experimentation, and creative processes that may result in new products, services, or technological processes.
Brouwer and Kleinknecht,1996	R&D intensity, sales growth, SME presence, employees, R&D function, dependence on mother company, R&D focus consultation of innovation centre, sector, location, external knowledge, collaboration.
Hoffman et al.1998	Qualified scientists & engineers, owner-manager leadership (and education), nature of commercialisation and marketing efforts degree of marketing involvement, macroeconomic conditions finance, external linkages.
Luecke and Katz,2003	Innovation is generally understood as the introduction of a new thing or method ...Innovation is the embodiment, combination, or synthesis of knowledge in original, relevant, valued new products, processes and services.
Shane and Ulrich, 2004	Innovation includes the creation of products, the commercialisation of new technologies, and the birth of new companies.

Authors	Definition
De Jong and Marsili, 2006	Innovation can either be “entrepreneurial”, generated by entrepreneurial activity and creativity of small and new firms, or “routinised”, when innovation comes from formal R&D expenditures by large and established firms.
Avlonitis and Salavou,2007	Innovation is a company's ability to introduce new products which are also successful.

Source: Researcher (2025)

Innovation is the process by which new ideas are generated, developed, and implemented to create new products, services, or processes that are then introduced to the market or society for the first time. Innovation is driven by a combination of factors, including curiosity, creativity, and the desire for improvement. It requires a mindset that embraces change, advocates ideation, and encourages experimentation. Innovation can occur in various contexts, such as business, science, technology, social sectors, or public services. It can lead to economic growth, social progress, improved quality of life, and sustainable development.

2.3.3.2 Types of innovation

1) Product innovation

Product innovation refers to the process of creating a new product or redesigning the function of a new or old product, including the process of brand new product innovation and improving product innovation. The research of product innovation began in the early 20th century, and Joseph Schumpeter proposed the concept of innovation, including new products, new production methods, new markets, new raw materials and new forms of organization. Products have traditionally been defined as tangible, physical items or raw materials, from toothpaste to steel tubes, from computers to industrial adhesives, from jets to cars, all of which can be products.

product innovation is the form of innovation that is most often identified in SMEs. Thus far, many authors have investigated product innovation and factors that determine product innovation. Acs and Audretsch (1988) investigated 240 manufacturing firms in order to compare innovation in small and large firms. They investigated several factors (as shown in table 2.6) and used a log relationship to identify a relationship

between the variables and innovation. They found that the total number of innovations is closely related to R&D expenditures and patented inventions. It is found that domain specific innovativeness (the willingness of the founder to innovate) and supplier interaction were the main factors to determine product innovativeness (Verhees & Meulenberg, 2004). Also, R&D for products was seen as an important factor for small firms to innovate. Rao (2004) researched a number of variables that might be related to incremental product innovation and found that technology planning, support for experimentation, and R&D intensity are the main drivers of incremental product innovations. Several other authors did also have interesting findings concerning product innovation. It is found that entrepreneurial orientation promotes radical innovations. Also, commercialization is very important for product innovations in order to be successful (Salavou & Lioukas, 2003; Unger & Zagler, 2003). Abratt and Lombard (1993) found ten determinants of product innovation, among which are product launches, type of product innovation, and new product. Product innovation in a SME in the developing countries is largely an adoption of product or method that have already been developed elsewhere (Van Dijk, 2001)

In the early stage of the product life cycle of the enterprise products, the market has not formed the leading design of products, and the changes of the enterprise products change greatly. Successful product innovation must be constantly improved in function, appearance, quality, safety and other aspects to meet the needs of customers, so as to win more customer base and realize the market competitive advantage of the enterprise.

2) Service innovation

Services are fast overtaking manufacturing to form a dominant proportion of the world economy. Service innovation is increasingly seen as a vector of sustainable growth and competitive advantage at the firm, industry and economy level (Randhawa & Scerri, 2015).

Service innovation is a dynamic process in which enterprises change service elements systematically and organized in order to improve service quality and create new market value. Service innovation is not only about technological advancement; it

also involves changes in society and organizations. For example, adjustments may be needed in employee training, workflows, corporate culture, and other aspects to support new service models. Moreover, with the development of digital technologies such as big data analytics, artificial intelligence, and the Internet of Things, service innovation increasingly relies on these emerging technologies to achieve personalization, customization, and real-time responsiveness to customer needs.

With the continuous development of technological innovation and the transformation of economic structure, developed countries represented by the United States, the service industry GDP proportion has exceeded the second industry, the traditional manufacturing giant companies began to pay attention to customer service, such as, International Business Machines (IBM) company gradually by computer manufacturing enterprises to software solutions provider, its software services business has become the main channel of revenue (Mills & Snyder 2010).

The service sector encompasses a wide variety of activities and markets ranging from consumer services such as hotels and banks to business services such as IT and legal, and large-scale public sector services such as health and education. The usage of technology is equally diverse; personal services like hairdressing involve basic technologies, while financial services are more knowledge-intensive and use advanced information technologies. As a result of this diversity, innovation in services involves transformation in a variety of aspects ranging from how the service is designed and developed to how it is delivered and managed (Miles 2005, 2010; Trott 2012). Service innovation can be said to be an amalgamation of product innovation, that is, the introduction of a new product, or a significant qualitative change in an existing product, and process innovation, that is, the introduction of a new process for making or delivering goods and services (Greenhalgh & Rogers 2007). Service Innovation refers to the introduction of new ideas, methods, and technologies in service design, delivery, and service experience to create more efficient, effective, or attractive services. (den Hertog, 2000), and often entails new ways in which customers view and use the service. Agarwal and Selen (2011) conceptualize service innovation as an “elevated service offering” that is made up of “new client interface/customer encounter; new service delivery system; new organizational architecture or marketing proposition; and/or

improvements in productivity and performance through human resource management", further highlighting its multidimensional aspects (Randhawa & Scerri, 2015).

3) Product-service innovation

A solution-based business model considering digital servitization (Brekke et al.2023; Kohtamäki et al.2019) allows manufacturers to gain a competitive advantage by using product-service innovation (PSI), providing the opportunity for data sharing knowledge and externalizing risks (Bustinza et al. 2019). According to Bustinza et al. (2019), PSI is "an integrated product and service offering that delivers value in use". There is a need to generate customized service-based augmented innovation through such digitalization based on a solution-based servitization model (Queiroz et al. 2020). This will lead manufacturers to pursue more advanced solutions based on deep learning and AI-based capabilities (Kohtamäki et al. 2022). The application of AI is accelerating the transformation of the industry and subverting the traditional innovation path. Mariani et al. (2023) stated the adoption of AI combined with other digital technologies, supports businesses to adapt or to replace products/services, change the way they create, contribute and share value, improve their technological capabilities. The market is very popular and optimistic about AI, and all famous business consulting giants believe that the market volume of AI will explode in the next few years. (Precedence 2023; Naeem et al. 2024).

2.3.3.3 Organizational innovation performance

The dependent variable in this study is innovation performance, defined as the contribution of product and process innovations to a firm's economic performance (Meeus & Oerlemans, 2000; Tajasom et al., 2015). Based on this definition, innovation performance can be measured by a firm's innovative activities such as research and development (R&D) spending, patenting and patents, and new products (Löfsten, 2014). Innovation performance refers to the extent to which firms introduce inventions to the market, for example, the rate at which they introduce new products, process systems, or devices (Tajasom et al., 2015). Previous studies have measured innovation performance using R&D investment and patents, and new products as indicators of innovation activities in firms. Still, these measures are more relevant for big firms and may not be suitable for SMEs, which formed the focus of the present study.

Most SMEs do not have R&D departments but engage in innovative activities by modifying their products to meet customers' needs, and such products are difficult to patent (Tajasom et al., 2015). For this reason, Beneito (2006) suggested that the choice of indicators of innovation performance should be determined both by the objectives of the analysis to be performed and by the available data. In this study, the objective was to ascertain the relationship, if any, between design thinking and innovation performance of SMEs in China.

There are many dimensions to measure the innovation performance. If we want to truly and credibly obtain the innovation performance of an enterprise, we should not blindly apply the indicators. We need to choose the indicators that best reflect its sustainable development ability according to the type and scale of the enterprise. In particular, the index system of mature large enterprises cannot be used for small and medium-sized enterprises. There are many invisible champions or giants in the industry among small and medium-sized enterprises, so we should be cautious and objective in measuring the innovation performance of small and medium-sized enterprises.

2.3.4 Digital Transformation

This study has searched the Web of Science with the topic "Digital Transformation" restricting the field to Business, Management and Economics from 2000 to 2024. and get a total of 702 publications. Figure 2.6 has shown the Keyword analysis using the VOSviewer 1.6.20.

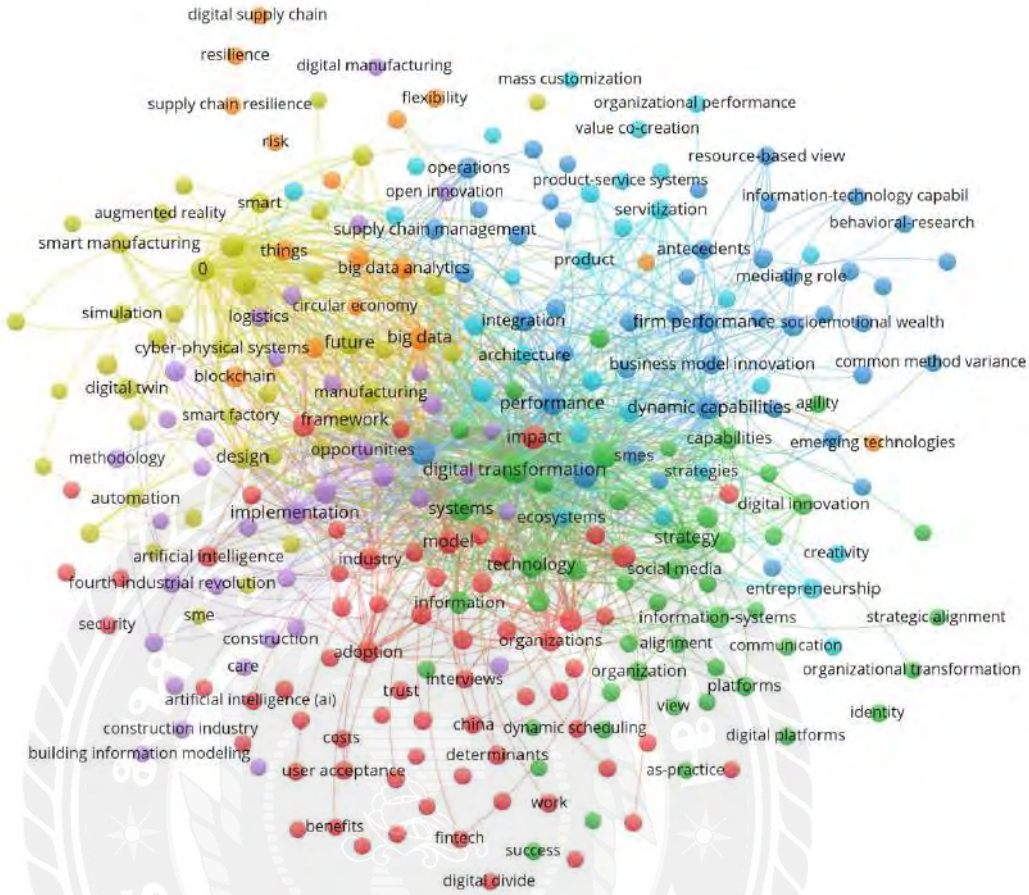

Figure 2.6 Keyword analysis map with the literature about digital transformation
Source: Researcher (2025)

2.3.4.1 The concept of digital transformation

Globalization in recent decades has placed increasing pressure on businesses to change. This requires businesses to efficiently integrate to not only stay alive, but thrive in competitive environments. Efficient integration can only be achieved through digital processes and collaborative tools (White, 2012). With this being the case, the importance of digital transformation has increased. Given the multidisciplinary nature and broad coverage of digital transformation research, this study reviews the multidisciplinary literature to understand the knowledge about the digital transformation of enterprises. To better understand the existing knowledge, the intersection of different domains must be studied, rather than relying on a single domain (Tarafdar & Davison, 2018). Despite the global focus on research and

understanding of digital transformation, and the authors' efforts to accurately define the topic, digital transformation has not yet been defined, and any boundaries that can help define it remain unclear. Existing explanations describe a wide range of business environments and digital technologies, etc. Table 2.7 summarizes the common definitions of digital transformation:

Table 2.7 Digital Transformation Definitions

Author (s)	Definition
Westerman et al. (2011)	Using technology to radically improve the performance or reach of enterprises.
Stolterman et al. (2004)	Comprising the changes associated with the application of digital technology in all aspects of human society.
Martin (2008)	Using information and communication technology, not when trivial automation is performed, but in the case where fundamentally new capabilities are created in business, public government, and in the lives of people and society.
Clohessy et al.(2017)	Digital technology brings changes to the company's business model, resulting in changes in the product or organizational structure or process automation.
Liere-Neheler et al. (2017)	Use new digital technologies (social media, or embedded, style devices) to achieve major business improvements (such as enhancing the customer experience or creating new business models).
Hanelt et.al (2021)	Organisational change triggered and shaped by the wide spread of digital technology.

Source: Researcher (2025)

The digital transformation concept needs to be differentiated from digitization and digitalization. Verhoef et al.(2021) identify three phases of digital transformation: digitization, digitalization, and digital transformation, as shown in Figure 2.7.

Figure 2.7 Three phases of digital transformation
Source: Grsso. Anotonio (2025, https://deltalogix.blog/)

Digital transformation is a company-wide phenomenon with broad organizational implications in which, most notably, the core business model of the firm is subject to change through the use of digital technology. In pursuit of digital transformation, firms thus search for and implement business model innovation (Verhoef et al., 2021).

2.3.4.2 The elements of digital transformation

In the viewpoint of a comprehensive digital transformation, A nine-element framework (as shown in Figure 2.8) initially developed in the MIT salon review, which features research-based articles on strategic leadership, digital innovation, and sustainable business (Westerman, Bonnet,& McAfee, 2014). These 9 elements are firmly established on the most fundamental characteristics of digital transformation (Bonnet&Westerman, 2020). They cover various dimensions required for digital transformation, including customer understanding, revenue growth, customer touchpoints, process digitization, employee support, performance management, digital modification business, new digital business, and digital globalization. These elements are divided into three axes: customer experience, operational processes, and business models. This is crucial as it enables enterprises to systematically improve customer satisfaction, optimize internal efficiency, and innovate in value creation, thereby ensuring comprehensive growth and competitive advantage. By focusing on these axes,

companies can effectively respond to market dynamics and drive sustainable success. By delving into these dimensions and exploring their interrelationships, it could be gained a deeper understanding of the multifaceted nature of digital transformation plans.

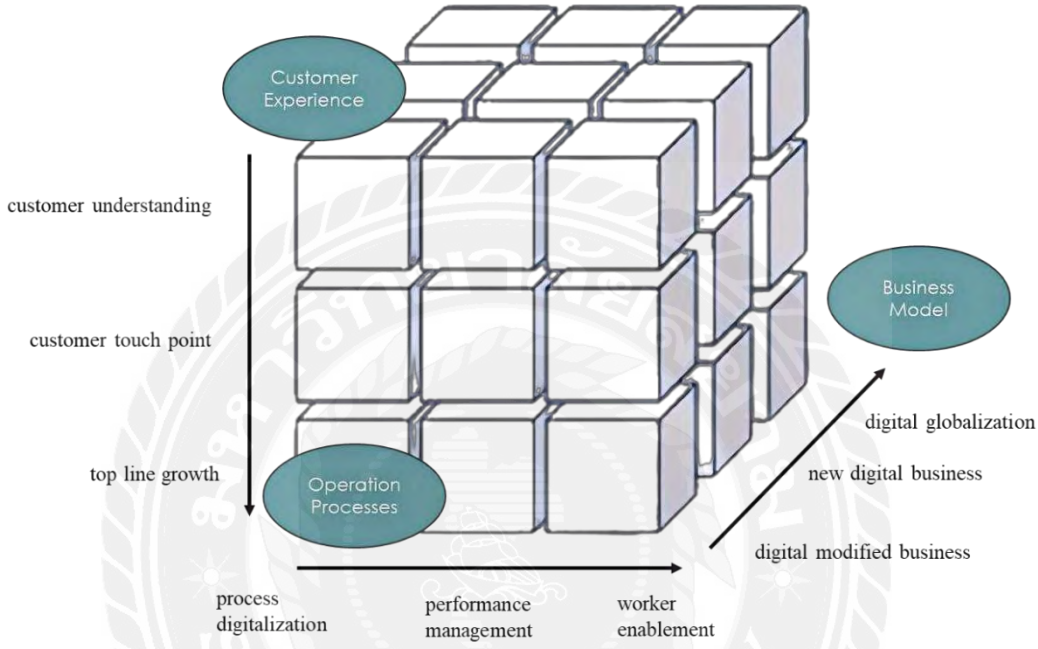

Figure 2.8 The 3-Axis-9 Elements of Digital Transformation in MIT Salon
Source: Westerman et al., (2014)

Kane et al. (2015) believe that it is not enough to use digital technology only to promote the digital transformation process, but also requires the use of digital ability, strategy, culture and talent development. Immature digital enterprises focus on using single digital technologies to solve specific business problems, but mature digital enterprises focus on integrating digital technologies such as social, action, analytics and cloud to transform their business models, operational processes and customer experience.

Ibarra et al. (2018), referencing the concept of Industry 4.0, identified four ways of digital transformation in the manufacturing industry: "Internal and external process optimization", "Improvement of customer interface", "New Ecosystem and Value Network" and "New Business Model: Smart Products and Services". As shown in Figure 2.9, the four methods of digital transformation of the manufacturing industry

(Ibarra, et al., 2018), the process of transformation from left to right represents the intensity of transformation, and the bottom up is the degree of business model change. Therefore, the higher the demand for business model innovation, the greater the transformation they need to undergo. The business model of innovation through digital transformation is the ultimate goal of digital transformation.

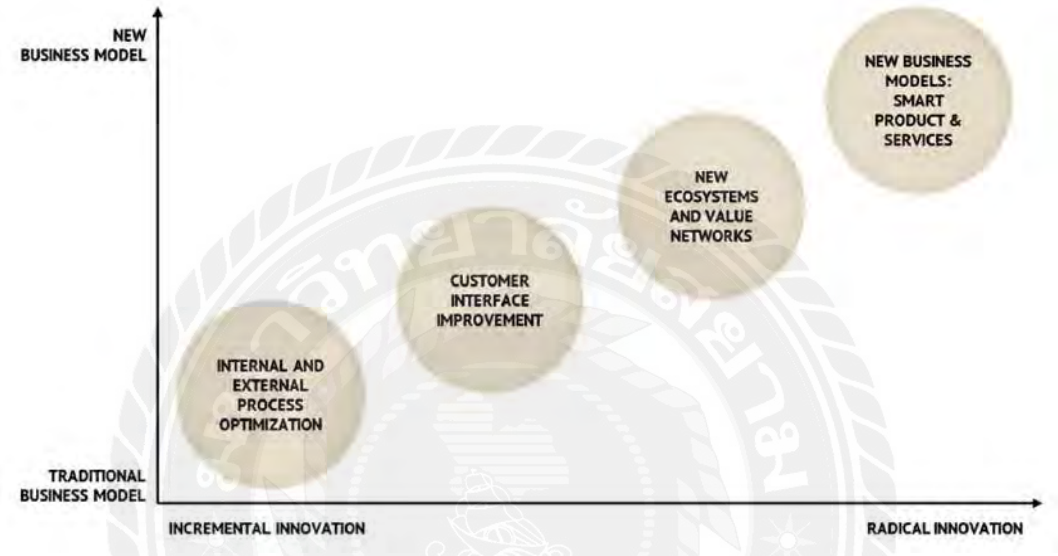

Figure 2.9 Four ways of digital transformation in manufacturing companies
Source: Ibarra, et al. (2018)

2.3.4.3 Digital Transformation in SMEs

Digital transformation has become the focus of global research in the field of SMEs. Many experts believe that small and medium-sized enterprises face great challenges in terms of capital and technical resources, especially compared with large enterprises. Therefore, the current research focus is mostly on how to reduce the economic burden of transformation and provide the necessary support and guidance for SMEs. The view of this study is that the digital transformation of SMEs requires not only the acquisition of resources and technologies, but also how to adopt and integrate digital technologies efficiently. Because SMEs often lack the comprehensive digital transformation capabilities of large enterprises, and there are significant differences between them, it is difficult to directly apply standardized technology and

software solutions. Therefore, when discussing the digital transformation of SMEs, we must give special consideration to how to meet the personalized needs of these enterprises. To address these challenges, Li and Lv (2021) believes that SMEs can access customized services by building close partnerships with technology companies. Although this type of cooperation may face problems such as unclear knowledge transfer, inefficient cooperation and high costs. At the same time, building a comprehensive policy system to support the digital transformation of SMEs and clarifying the role of the government in promoting this transformation process are also an important direction of future research.

Feher and Varga (2017) suggest that companies should conduct small-scale pilot experiments before fully implementing the digital transformation strategy. This helps to cultivate the internal acceptance of the transformation and risk-taking willingness of the enterprise, and lay the foundation for the subsequent promotion in other departments. In this way, companies can gradually learn and adjust their strategies based on experimental feedback to achieve the long-term goal of digital transformation.

Digital transformation is a comprehensive change, which is not only related to the application of technology, but also related to the reshaping of corporate culture, organizational structure and business model. Understanding the multi-level nature of this concept will help to dig deeper into the key challenges and opportunities faced by SMEs in the process of digital transformation. With the continuous development of science and technology, digital transformation has become an indispensable link for enterprises to maintain competitive advantages and adapt to rapid changes (Bharadwaj et al., 2013). SMEs play an important role in this wave of transformation, because their successful transformation has a stable and sustainable impact on the entire economic system. Before exploring the interaction between different success factors, it is necessary to understand the main variables that drive the successful digital transformation of SMEs. These include strategic consistency, leadership commitment, IT infrastructure, employee skills and engagement, cross-functional collaboration, customer-centric, agile methodology, change management, data analysis capabilities, and network security.

2.3.5 Organizational Ambidexterity

This study has searched the Web of Science with the topic "Organizational ambidexterity" restricting the field to Business, Management and Economics from 2000 to 2024, and got a total of 702 publications. Figure 2.10 shows the Keyword analysis using the Vosviewer 1.6.20.

As illustrated in the below diagram, the theory of organizational ambidexterity has converged with fields including dynamic capabilities, ambidextrous innovation, ambidextrous leadership, business model innovation, human resources, and psychology, resulting in a substantial and diverse corpus of scholarly work.

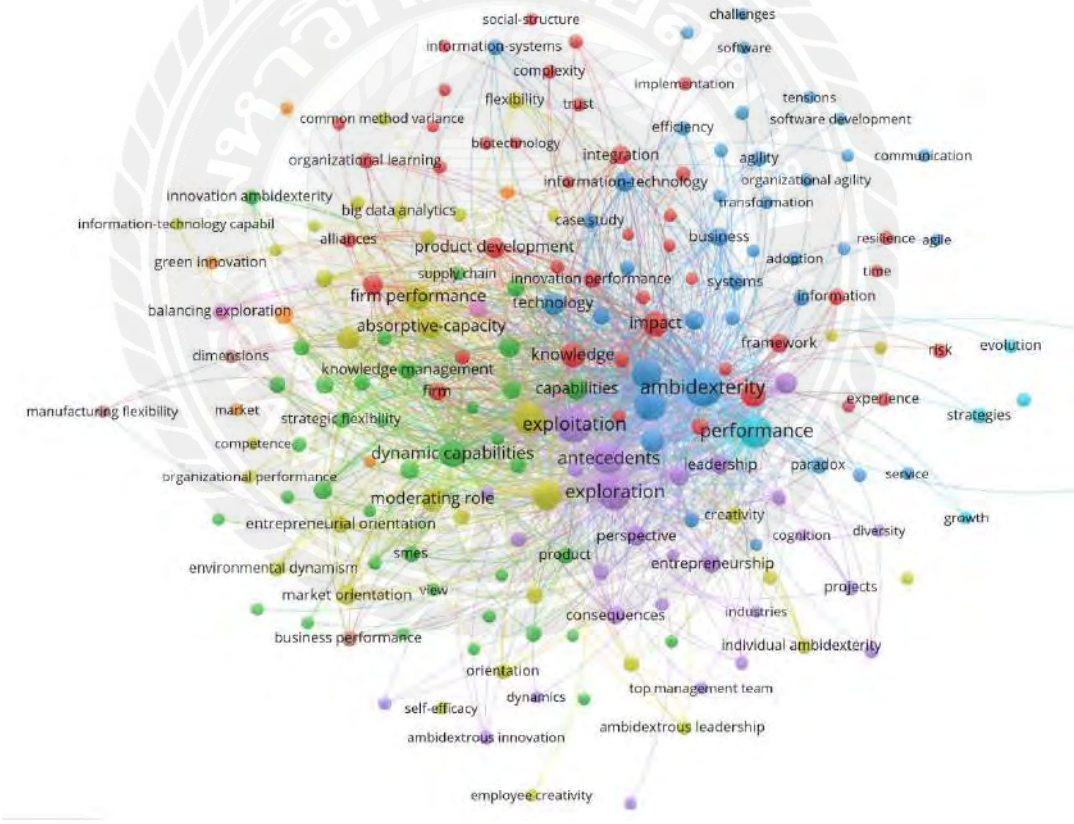

Figure 2.10 Keyword analysis map with the literature about organizational ambidexterity

Source: Researcher (2025)

2.3.5.1 The concept of Organizational Ambidexterity

Ambidexterity is recognized by numerous scholars as essential for organizational sustainability (O'Reilly & Tushman, 2013). Duncan (1976), in his seminal work, proposed that to balance the competing demands of innovation and efficiency, organizations needed to adapt their structures over time, aligning them with the firm's strategy. This approach, termed sequential ambidexterity, involved shifting organizational structures over time. March (1991) later conceptualized ambidexterity as the balance between exploration and exploitation. Tushman and O'Reilly (1996) argued that in rapidly changing environments, sequential ambidexterity might not suffice, and organizations must engage in exploration and exploitation simultaneously. They suggested this could be achieved by creating autonomous subunits focused on either exploration or exploitation, each with its distinct alignment of people, structures, processes, and cultures, yet with targeted integration to optimize the use of resources and capabilities. Gibson and Birkinshaw (2004) expanded on this by suggesting that organizations could foster ambidexterity by designing features that empower individuals to determine how to allocate their time between exploratory and exploitative activities. This approach, known as contextual ambidexterity, is achieved by developing processes or systems that enable individuals to balance the demands for alignment and adaptability.

The evolution of ambidexterity research can be categorized into three main types: sequential, structural, and contextual ambidexterity (O'Reilly & Tushman, 2013). Despite the development of these concepts over time, the literature consistently defines ambidexterity as an organization's ability to both explore new opportunities and exploit existing capabilities—to thrive in established markets and technologies that value efficiency, control, and incremental improvement, while also competing in new markets and technologies that require flexibility, autonomy, and innovation. Alghamdi (2018) further defined ambidexterity as an organization's capacity to simultaneously exploit existing knowledge and explore new information.

2.3.5.2 Types of organizational ambidexterity

Organizational ambidexterity has evolved into three distinct types over time (Tushman & O'Reilly, 2013), each offering solutions to the challenge of balancing

exploration and exploitation at the organizational level: structural ambidexterity introduced by Duncan (1976), sequential ambidexterity conceptualized by Tushman and O'Reilly (1996), and contextual ambidexterity developed by Gibson and Birkinshaw (2004).

1) Structural Ambidexterity

Scholars have argued that exploration and exploitation are best performed by separate divisions within a company to achieve what is known as structural or simultaneous ambidexterity (Tushman & Euchner, 2015) or architectural ambidexterity. Additionally, researchers have noted that structurally ambidextrous organizations should delineate two distinct areas within which each ambidextrous activity can occur (Bonesso et al., 2013). This approach can also be applied at the individual employees level, where work functions are separated within an organizational department (Good & Michel, 2013). According to O'Reilly and Tushman (2008), structural ambidexterity requires not only separate structural units for exploration and exploitation but also distinct competencies, systems, incentives, processes, and cultures—each internally aligned.

2) Sequential Ambidexterity

Tushman and Romanelli (1985) proposed that organizations evolve through periods of significant change, adapting to environmental shifts by sequentially realigning their structures and processes. More recently, the concept of temporal shifting has been introduced as a means for organizations to achieve ambidexterity. For example, Brown and Eisenhardt (1997), in their study of small electronics firms adapting to technological changes, suggested that firms use "semi-structures" and "rhythmic switching" to alternate between periods of exploitation and exploration. Nickerson and Zenger (2002) referred to this process as "vacillation," arguing that firms find it easier to switch between formal structures than to change culture and informal organization. Ford and Hewlett-Packard were cited as examples of companies employing this approach. A simulation study by Siggelkow and Levinthal (2003) also indicated that sequencing organizational structure changes to promote temporary decentralization can effectively facilitate exploration and exploitation.

3) Contextual Ambidexterity

Khazanchi, Lewis, and Boyer (2007) proposed that alignment and adaptability are influenced by a culture that supports both flexibility and control within an organization. In their study of 271 manufacturing businesses, they discovered that a culture of flexibility fosters creativity, while control norms enhance execution. Hargadon and Sutton (1997) illustrated a similar dynamic in their study of IDEO, a well-known product design firm with a culture emphasizing both creativity and implementation. More recently, Chatman et al.(2013) demonstrated that norms for adaptability, such as risk-taking, quick responses to opportunities, and innovation , are linked to firm performance in dynamic environments. Thus, the alignment and adaptability attributed to contextual ambidexterity may stem from a culture that balances flexibility and control (Bueschgens, Bausch,& Balkin, 2010).

Although it is conceptually straightforward to envision how contextual ambidexterity might function within a specific setting or technological context, it is more challenging to understand how it would enable a company to respond to disruptive or discontinuous changes in technologies and markets. For instance, when print newspapers decided to compete in the digital space, it required significant restructuring and resource reallocation (Gilbert, 2005). Such decisions cannot be left entirely to lower-level employees; at some point, senior management must provide the necessary resources and legitimacy for the new technology or business model. Similarly, given the new skill sets required, it is improbable that individual employees would possess the technical capabilities needed for online news without the approval and investment of senior management.

2.3.6 Digital Transformation Ambidexterity

Early researchers used the term "IT ambidexterity" has increasingly become a critical capability for modern firms (Benitez et al., 2018). To effectively respond to environmental changes, organizations must simultaneously exploit existing IT resources and explore potential IT resources (Nwankpa and Datta, 2017). This dual approach enhances firms' IT strategies and practices (Benitez et al., 2018).

Specifically, IT exploration refers to a firm's ability to adopt and integrate emerging technologies and resources to develop new IT capabilities and seize market opportunities. In contrast, IT exploitation involves leveraging and refining current technologies and resources to maximize their efficiency (March, 1991; Lee et al., 2015). Both practices have been found to positively impact organizational performance (Nazir and Pinsonneault, 2012). Therefore, firms should pursue IT exploration and exploitation in a manner where they complement each other rather than conflict (Nwankpa and Datta, 2017). By balancing these two objectives, a firm can more effectively respond to both current and emerging business needs, thus enhancing its agility. In this study, IT exploration and exploitation are treated as independent variables to assess their respective impacts on organizational agility.

Jing et al.(2023) investigated how digital ambidextrous capabilities influence SMEs' transformation performance through business model innovation. They found that digital exploitation capabilities are positively linked to market-driven business model innovation, while digital exploration capabilities are positively associated with driving-market business model innovation. Similarly, Zhang et al. (2023) categorized digital transformation into exploitative and exploratory transformations using ambidexterity theory. Their findings indicated that both exploitative and exploratory digital transformations significantly and positively affect corporate performance, with business model innovation playing a significant mediating role.

2.4 Relevant Research

2.4.1 Relevant research on design thinking and organizational innovation performance

This study has searched the Web of Science with the topic "Design Thinking" and "innovation performance" restricting the field to Business, Management and Economics from 2000 to 2024, and got a total of 233 publications. Figure 2.11 has shown the Keyword analysis using the VOSviewer 1.6.20.

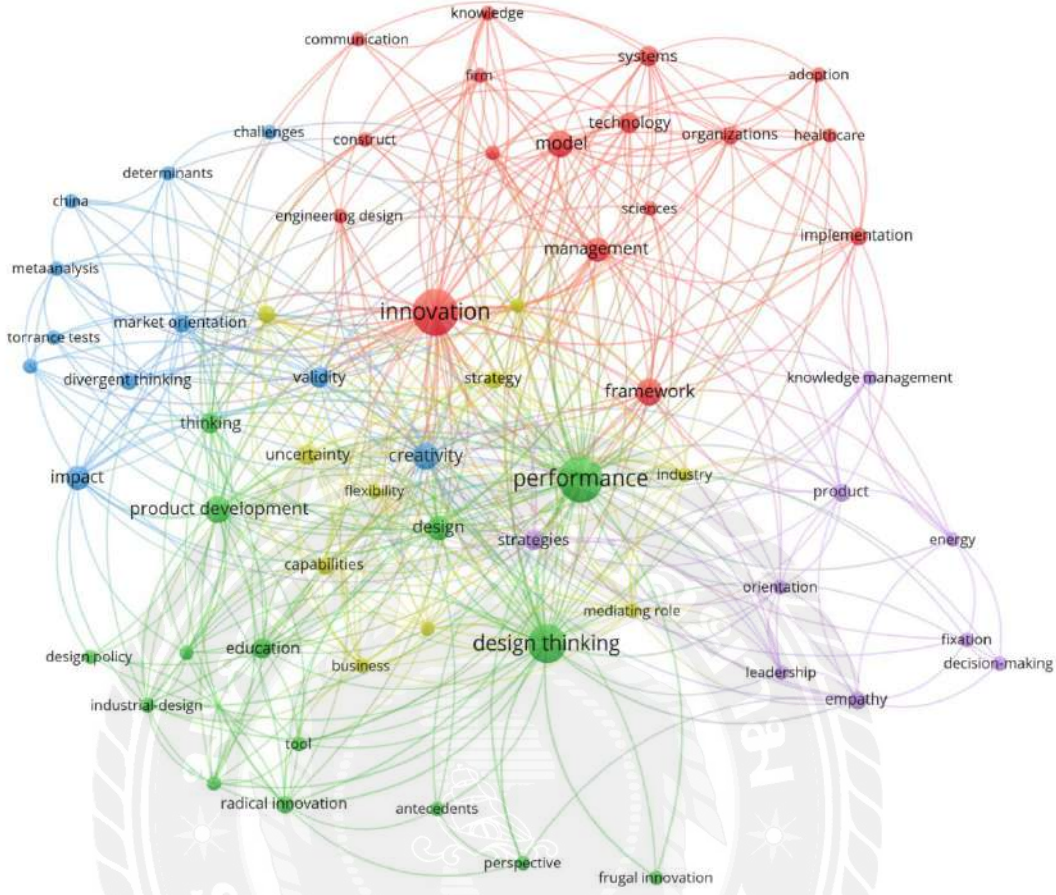

Figure 2.11 Keyword analysis map with the literature about design thinking and organizational innovation performance
Source: Researcher (2025)

Recent studies highlight the significant connection between design thinking and innovation performance. Design thinking is an iterative process that emphasizes user-centered problem solving, multidisciplinary collaboration, creativity, and rapid prototyping. It involves stages such as needfinding, brainstorming, and prototyping, aimed at understanding user needs and creating innovative solutions that enhance organizational performance.

Research suggests that design thinking improves innovation performance by fostering creativity and team collaboration. For instance, the divergent thinking encouraged by design thinking processes allows teams to generate multiple ideas before converging on the most viable solutions. This structured approach helps reduce

insecurity in teams, enhances problem-solving, and boosts team performance, particularly in innovation-driven environments (Zhang et al.2024; Heldal 2023).

Another key aspect is that design thinking promotes empathy and user-centered design, leading to a deeper understanding of customer needs, which is crucial for developing innovative products and services. By integrating ethnographic techniques and co-creation with users, design thinking not only facilitates creativity but also ensures the solutions are highly relevant to user needs (Rösch et al. 2023).

For businesses, applying design thinking principles, such as prototyping and testing enables organizations to experiment, fail fast, and learn, ultimately increasing their capacity for sustainable innovation (Zhang et al. 2024; Rösch et al. 2023).

Teerayout Wattanasupachoke (2012) explored the impact of design thinking on a firm's innovation and performance. His research indicated that design thinking, through fostering a deep understanding of customer needs and combining this knowledge with the creative ideas of employees, significantly enhances a firm's ability to innovate. The application of design thinking in business operations not only stimulates out-of-the-box thinking but also contributes to developing innovative products and services. However, despite the positive influence on innovation, the study found that design thinking does not have a direct relationship with performance. This is attributed to the fact that design thinking primarily focuses on operational process improvements and the development of creative product/service concepts, which do not directly translate into higher performance metrics. Nonetheless, the creativity generated through design thinking can be nurtured into innovations that eventually lead to better financial performance over time.

Varun Nagaraj and colleagues (2020) delved into the impact of team design thinking on new product development (NPD) projects. Their study demonstrated that team design thinking empowers NPD teams to develop more innovative products by breaking down the cognitive and routine-based inertia that often hinders a team's capacity to innovate. Through an analysis of 247 NPD projects, they uncovered that team design thinking is positively linked to the creation of useful products even in

familiar contexts. Additionally, the study examined how a team's unfamiliarity with the product context affects these relationships, finding that the team's unfamiliarity can influence the effectiveness of design thinking practices in fostering product innovation.

Jennifer Hehn and her co-authors (2018) focused on the application of design thinking methods in service innovation. They conducted a Delphi study to gather the insights of design thinking experts, resulting in the identification of 59 design thinking methods considered particularly relevant for service innovation out of a pool of 172 methods. These findings extend the theoretical foundation of design thinking and provide practitioners with valuable insights into which design thinking methods, if appropriately applied, can enhance user-centered problem-solving, thereby facilitating the creation of services.

Elsbach and Stigliani (2018) investigated the interplay between design thinking tools and organizational culture. Their research highlighted that specific design thinking tools support the development of certain organizational cultures, and conversely, certain cultures facilitate the use of design thinking tools. For instance, cultures that value collaboration and experimentation are conducive to the use of design thinking tools, whereas cultures emphasizing productivity, performance, and specialized silos can hinder their adoption. Moreover, the use of design thinking tools generates emotional experiences and tangible artifacts that help users understand why and how certain cultures support the effective use of these tools.

Design thinking is a human-centered problem-solving methodology that encourages understanding user needs through empathy and promotes innovation via iterative processes of defining problems, ideating solutions, prototyping, and testing. At the organizational level, design thinking can stimulate interfunctional collaboration among team members and foster a culture of openness and inclusivity, where employees are encouraged to propose new ideas and learn from failures. When an organization integrates design thinking into its strategic planning and daily operations, it can accelerate the pace of innovation in products and services, enhance customer satisfaction, and ultimately strengthen its market competitiveness. The application of design thinking also helps build more agile and responsive organizational structures, enabling businesses to better adapt to changing market demands and technological

advancements. Thus, design thinking serves not only as a catalyst for innovation but also as a vital tool for organizational transformation and continuous improvement.

2.4.2 Relevant research on design thinking and digital transformation

This study has searched the Web of Science for the topic "digital transformation" and "design thinking" restricting the field to Business, Management and Economics from 2014 to 2024, and got a total of 954 publications. Figure 2.12 has shown the Keyword analysis using the VOSviewer 1.6.20.

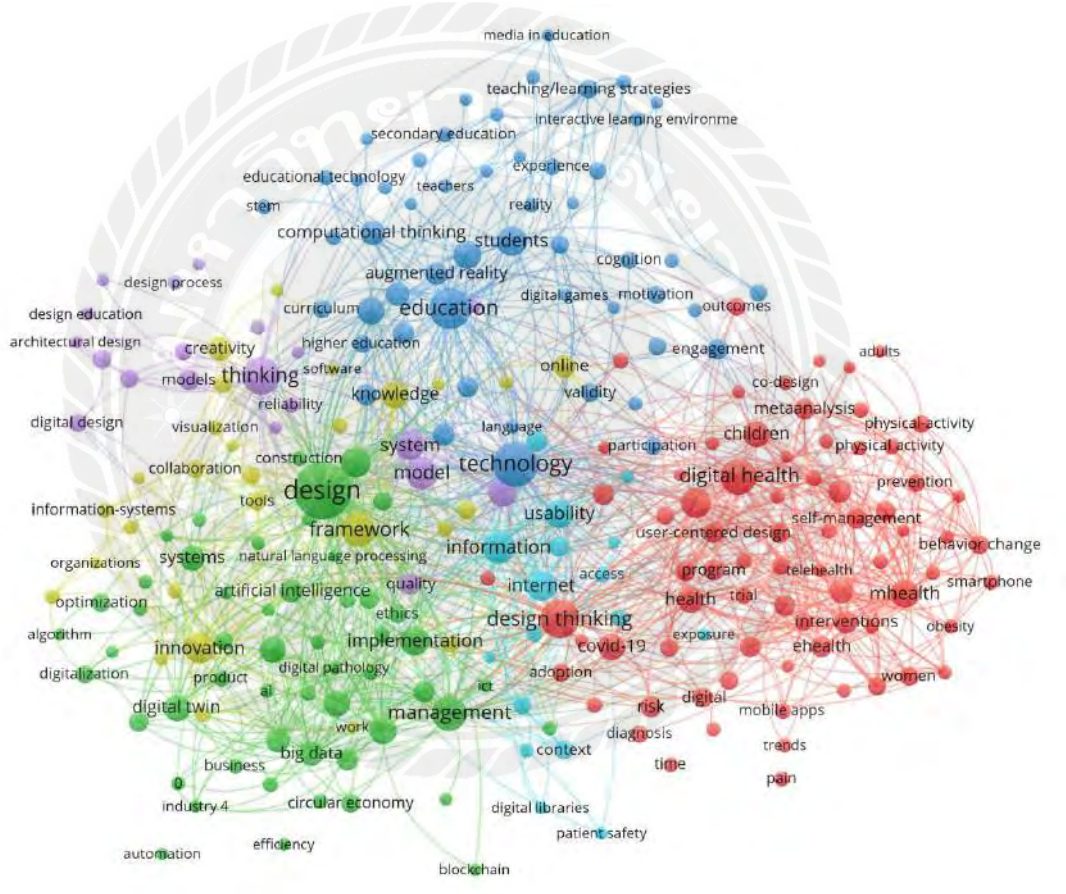

Figure 2.12 Keyword analysis map with the literature about design thinking and digital transformation

Source: Researcher (2025)

In recent years, the integration of design thinking with digital transformation has gained increasing attention in academic research. Gurusamy et al. (2016) propose an integrated framework that combines design thinking and agile methodologies to

facilitate faster, more innovative project delivery in the context of digital transformation. They highlight that the increasing reliance on mobile and internet applications has compelled businesses to reassess their customer needs and undergo digital transformation to remain competitive. The authors argue that while Agile methods are popular for developing innovative solutions, design thinking is instrumental in driving transformation, evolution, and innovation, enabling organizations to manage both current and future business opportunities more effectively. By merging the core processes of these two approaches, the proposed framework aims to support ongoing digital transformation efforts, providing a structured yet flexible approach that can be adapted to various organizational contexts. This integration is designed to address the limitations of traditional approaches, offering a new perspective on how to tackle the challenges of digital transformation.

Fehér and Varga (2019) explore the potential for digital transformation within the Hungarian banking industry, employing a "One Week Sprint" method inspired by design thinking principles. In collaboration with two local banks, their research concentrates on real estate opportunities and small to medium-sized enterprise (SME) offerings, with a particular emphasis on the utilization of customer journeys and personas as critical elements in supporting digital innovation. The authors highlight that when developing consumer-oriented products or solutions, the application of customer journeys and personas is more straightforward and effective, fostering a deeper sense of empathy. Conversely, in the context of corporate solutions, they observe that the value of personas diminishes due to a lack of human connection, and the construction of customer journeys necessitates a higher level of expertise from consultants. This study not only presents the outcomes of an innovative project but also provides insights into the practical challenges and benefits associated with these tools, contributing to the understanding of how design thinking can be effectively applied in the financial sector.

Gusakov (2020) highlights the critical role of design thinking in enabling businesses to achieve leadership during their digital transformation. The author argues that while the adoption of new digital technologies is essential, it is not sufficient on its own for companies to succeed; instead, a fundamental shift in organizational culture

and business processes is required. This includes fostering an environment where creativity is valued, employees are actively involved in change, and there's a readiness to embrace iterative development and learning from mistakes. Design thinking, with its emphasis on user-centric innovation, multidisciplinary collaboration, and the continuous iteration of ideas, plays a key part in this process. It aids in developing new digital business models, enhancing customer experiences, and transforming organizational cultures to be more agile and responsive. By integrating design thinking, companies can better navigate the complexities of digital transformation, leading to more innovative products, services, and ultimately, a sustainable competitive advantage.

Magistretti et al. (2021) elucidate the critical role of design thinking as a set of dynamic capabilities in driving digital transformation. They argue that digital transformation, characterized by deep-seated changes in organizational activities, processes, and capabilities due to digital technologies, requires organizations to sense, seize, and reconfigure opportunities. By examining four consulting projects across different industries, they identify five design thinking dynamic capabilities—extending, debating, cropping, interpreting, and recombining—that are essential for managers to cultivate. These capabilities enable firms to transform technological challenges into opportunities, fostering a more human-centric approach to digital transformation. The study highlights how design thinking, with its focus on user needs and creative problem-solving, can lead to the development of innovative and valuable digital solutions, thus facilitating a successful transition to the digital era.

Govers and van Amelsvoort (2023) present a theoretical essay that integrates socio-technical systems (STS) design thinking with the era of digital transformation. They argue that as digital technologies reshape economic systems, organizations, and work, there is a need to reconsider how these elements are designed. The authors emphasize that digital transformation is not just about technology but also involves cultural change, requiring organizations to continuously challenge the status quo, experiment, and become comfortable with failure. By incorporating digital thinking into the STS-D (Socio-Technical Systems Design) approach, they propose a method for aligning technical possibilities with social needs, thereby creating sustainable

organizational solutions. To overcome common challenges in digital transformation, such as unfamiliarity with digital possibilities or lack of vision, the essay introduces "absurd reverse thinking" as a strategy to inspire new business models. This approach encourages organizations to question and reverse their current business principles, leading to the emergence of innovative and potentially disruptive business models. The integration of digital affordances and constraints into the organizational design from the outset, alongside the proposed design routines, aims to facilitate effective digital and organizational transformation.

Oliveira, Zancul, and Salerno (2024) explore the adoption of design thinking as a structured approach for innovation and digital transformation within an incumbent healthcare organization. Their longitudinal analysis, conducted over six years in a hospital's innovation department, examines how design thinking supports the development of capabilities essential for digital transformation. The study highlights that design thinking, through its user-centered, empathetic, and collaborative nature, not only aids in tackling complex challenges but also contributes to the continuous learning and capability building necessary for organizations to thrive in a rapidly changing digital landscape. By employing a mixed-methods approach, including interviews, document analysis, and participant observations, the authors demonstrate the positive impact of design thinking on fostering dynamic capabilities. This research contributes to the literature by illustrating the process through which design thinking can be effectively implemented at the organizational level, offering valuable insights for practitioners aiming to lead their organizations towards successful digital transformation.

Habicher et al. (2022) explore the role of design thinking as a catalyst for transformation processes within small and medium-sized enterprises (SMEs), focusing on enhancing company resilience, embracing digitalization, and fostering democratic leadership, while also considering socio-ecological sustainability. The study reveals that design thinking is an effective method for promoting business and leadership transformation, particularly in response to contemporary trends such as digitalization. However, it appears less operationalized for deeper socio-ecological transformations. The research underscores the importance of SMEs as key drivers for sustainable

change, suggesting that these companies need to develop a socio-ecological consciousness, long-term thinking, and creative approaches to contribute to collective well-being. The authors advocate for the use of design thinking to support more holistic and sustainable business models, although they note that this approach is currently underutilized for comprehensive sustainability efforts. Through a qualitative, explorative methodology, the paper provides insights into how design thinking can facilitate innovation, digitalization, and participatory leadership, which are essential for SMEs to adapt and thrive in a rapidly changing environment.

These relevant research collectively indicate that design thinking plays a significant role in promoting digital transformation, enhancing organizational adaptability and competitiveness, and fostering more democratic and sustainable organizational structures.

2.4.3 Relevant research on digital transformation and innovation performance

This study has searched the Web of Science for the topic "digital transformation ambidexterity" and "innovation performance" restricting the field to Business, Management and Economics from 2014 to 2024, and got a total of 50 publications. Figure 2.13 shows the keyword analysis using the VOSviewer 1.6.20.

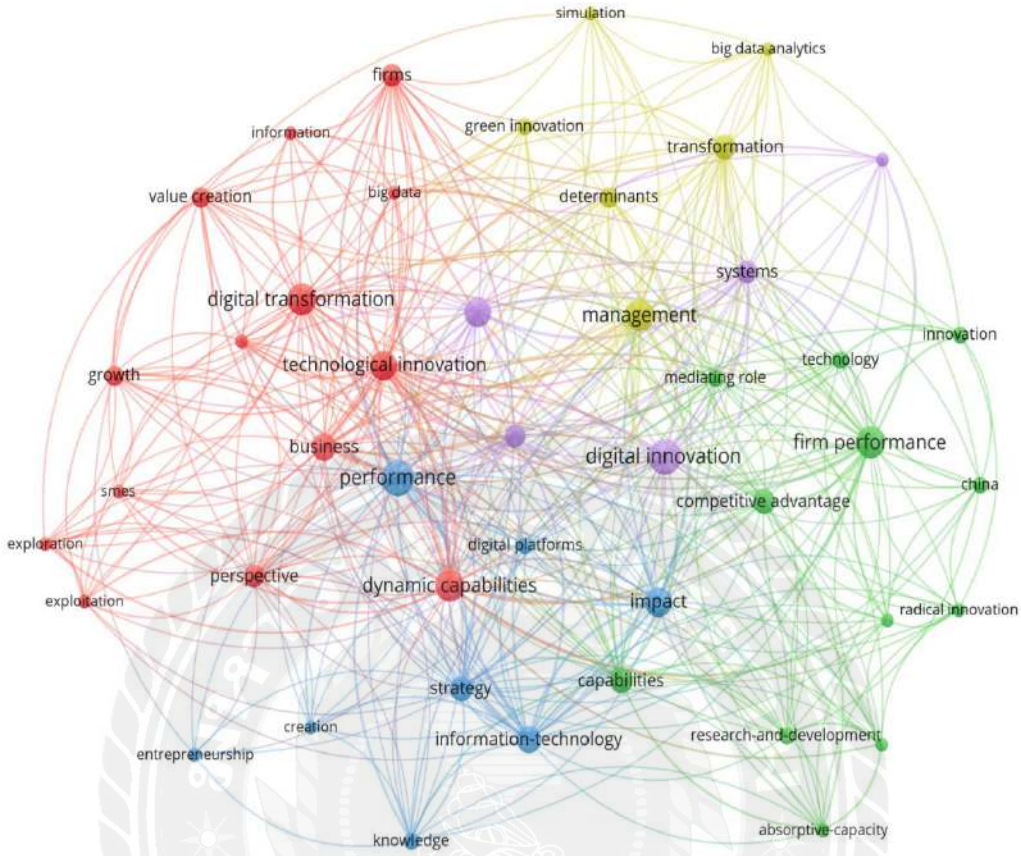

Figure 2.13 Keyword analysis map with the literature about Digital Transformation ambidexterity on Innovation Performance
Source: Researcher (2025)

In recent years, international journals have produced a wealth of research on the impact of digital transformation on innovation performance. Digital transformation drives the improvement of corporate innovation performance through various channels, with its effects not only reflected in the introduction of technological tools but also involving profound changes at the organizational structure and strategic levels. First, the widespread application of digital technologies has significantly accelerated the innovation process of enterprises. During product development, companies can use big data analytics, artificial intelligence, and other technologies to more quickly and accurately identify market needs and predict consumer behavior, thereby shortening the product development cycle and increasing the success rate of innovations (Nambisan et al., 2020; Vial, 2021). Particularly in a dynamic competitive environment,

real-time feedback driven by data allows companies to continuously iterate on innovations, enhancing the market fit of products and services.

Moreover, digital technologies have not only changed the way companies innovate internally but have also promoted the implementation of open innovation. Through technology platforms such as cloud computing and Blockchain, companies can more easily integrate innovative resources from external partners, suppliers, and customers, forming a more open and interconnected innovation ecosystem (Verhoef et al., 2021). This enhanced cross-organizational collaboration is especially crucial for resource sharing and knowledge transfer in highly complex and globalized markets, which can improve overall innovation efficiency and the quality of outcomes.

At the same time, digital transformation has had a profound impact on the organizational structure and decision-making models of enterprises. In a digital environment, flatter management structures and data-driven decision-making processes accelerate information flow and decision speed, allowing companies to more flexibly adjust strategies and resource allocation, and respond swiftly to market changes and innovation demands (Hanelt et al., 2021). This not only enhances the company's adaptability but also improves internal coordination and execution efficiency, ensuring that innovation strategies can be smoothly advanced. Furthermore, digital technologies have facilitated a cultural shift within organizations, promoting a transition from traditional hierarchical management towards a more collaborative and innovation-driven culture, further strengthening the company's innovation potential (Kraus et al., 2022).

The impact of digital transformation on corporate innovation performance exhibits significant heterogeneity, with the industry background, digital maturity, and level of resource investment of different enterprises substantially affecting their transformation outcomes. In high-tech-intensive industries, such as information technology and pharmaceuticals, companies are typically better positioned to benefit from digital transformation because these sectors inherently rely on data-driven innovation processes and technological applications (Zaoui & Souissi, 2020). However, in traditional manufacturing or low-tech-intensive industries, the impact of digital

transformation is relatively weaker. These companies may face challenges such as weak technological foundations, difficulty in cultural transformation, and lower acceptance of new technologies, leading to less pronounced effects of digital transformation on their innovation performance compared to technology-oriented enterprises (Weking et al., 2020).

The digital maturity of an enterprise is also a decisive factor. Companies that already possess a high level of digitalization are typically able to integrate new technologies with existing business processes more rapidly, thereby promoting the enhancement of innovation performance. For example, cutting-edge technologies such as big data and artificial intelligence can help these companies manage innovation processes more effectively, improve decision-making efficiency, and thus accelerate the innovation cycle of products and services (Nambisan et al., 2020). In contrast, enterprises at the early stages of digitalization often face issues of inadequate technological adaptation and management capabilities, making it difficult for them to fully leverage the innovative opportunities brought about by digital technologies.

Furthermore, leadership within the organization, cultural transformation, and the enhancement of employee skills are also seen as critical factors affecting the success of digital transformation. Research indicates that digital leadership plays a vital role in driving technology adoption and innovation strategy. Enterprises with strong digital leadership are better positioned to integrate innovation objectives into the overall organizational strategy, thereby stimulating the innovative potential of employees (Weking et al., 2020). At the same time, during the process of digital transformation, companies must focus on providing digital skills training and fostering cultural change among their staff to ensure that the entire organization can adapt to the introduction and application of new technologies. Without this ongoing investment and transformation, businesses may encounter resistance during the transition, limiting the effectiveness of their innovation performance improvement (Bouwman et al., 2018).

In general, digital transformation offers numerous opportunities for innovation, but its effects are not uniformly realized. The successful enhancement of innovation performance depends on the company's ability to effectively integrate technology,

strategy, and organizational resources, as well as to foster a culture that supports innovation. These factors collectively determine the extent and sustainability of the impact of digital transformation on the innovation performance of different enterprises (Zaoui & Souissi, 2020; Nambisan et al., 2020).

In small and medium-sized enterprises (SMEs), the impact of digital transformation on innovation performance exhibits a series of unique characteristics and challenges. Due to their limited resources and weaker technological foundations, SMEs often face shortages in funding, talent, and technical capabilities, which restrict the application of traditional innovation methods. However, digital transformation provides these businesses with a breakthrough pathway. The application of digital technologies, such as cloud computing, the Internet of Things (IoT), and big data analytics, enables SMEs to access a large amount of market information and technical support at relatively low costs. These tools can help them optimize production processes, enhance operational efficiency, and ultimately boost innovation capabilities (Clohessy et al., 2020).

The introduction of digital technology in SMEs also allows for more flexible responses to market changes. For instance, IoT technology enables real-time monitoring of supply chains and production, significantly improving the speed of response to market fluctuations. This capability is particularly important, as SMEs are typically more sensitive to market changes than larger companies, and a quick reaction can notably strengthen their competitive advantage (Li et al., 2022). Additionally, cloud computing provides cloud-based resources and services, allowing SMEs to acquire computing power and storage resources on demand without incurring high hardware costs. This flexibility offers SMEs greater space for innovation, enabling faster product design, testing, and iteration, thus accelerating the innovation process (Kane et al., 2021).

However, despite the new innovative pathways provided by digital transformation, its implementation still faces various challenges. Firstly, the initial cost of technology adoption and transformation may exceed what many SMEs can afford, especially in the absence of government or other external financial support. Secondly, SMEs often

lack highly skilled digital talent, making it difficult to effectively utilize new technologies and carry out the necessary organizational changes. This requires continuous training and skill development, which adds complexity and uncertainty to the transformation process (Khin & Ho, 2019). Moreover, while the management structure of SMEs is usually more flexible, this can sometimes lead to a lack of strategic planning, hindering the smooth progress of digital transformation (Garg & Garg, 2021).

The implementation of digital transformation in SMEs faces a series of unique and complex challenges. These challenges largely stem from the deficiencies of SMEs compared to large enterprises in terms of technology investment, digital skills development, and organizational change. Given their limited resources, SMEs may not be able to bear the high costs of technology investments, and they often lack specialized teams for developing digital skills. Furthermore, the implementation of organizational changes might also be constrained by financial and human resource limitations, thereby restricting their potential during the digital transformation process (Zahra et al., 2021).

Additionally, the flat management structure typical of SMEs can accelerate decision-making and increase flexibility in responding to market changes. However, this flat structure can also result in inadequate strategic planning. Without systematic strategic planning and a well-defined management hierarchy, these businesses may face higher levels of uncertainty during digital transformation. The acceleration of the decision-making process does not necessarily compensate for the lack of a comprehensive digital transformation strategy, and it might even exacerbate the challenges and risks involved (Garg & Garg, 2021).

Research indicates that the success of SMEs in digital transformation often relies on external support. This support includes policy incentives, assistance from technology partners, and dedicated digital training. Policy incentives can alleviate the financial pressures faced by SMEs during the transformation, technology partners can provide the necessary technical support and consultancy, and digital training can help employees enhance relevant skills and knowledge (Hsieh & Wu, 2023). Such external support is crucial for SMEs, as it can significantly improve the success rate of their digital transformation.

Despite these challenges, digital transformation still presents a wide range of innovation opportunities for SMEs. If they can fully integrate new technologies and address the challenges related to resources and management, SMEs will be able to greatly enhance their innovation performance. Studies show that SMEs that successfully implement digital transformation have seen a significant improvement in their market competitiveness, with strengthened innovation and market responsiveness, leading to sustainable development (Li et al., 2022; Kane et al., 2021). Therefore, although digital transformation poses challenges for SMEs, its potential is enormous and can serve as a vital driver for innovation and growth.

Overall, digital transformation brings unprecedented momentum and opportunities for the innovation performance of SMEs. This transformation not only helps businesses improve efficiency and explore new markets but also drives innovation. However, the effectiveness of digital transformation largely depends on the company's ability to absorb digital technology, the extent of internal management reform, and the level of external resource support. While SMEs have certain advantages in flexibility and market adaptability, the limitations in resources and capabilities mean that they may face significant uncertainties when implementing digital transformation. This uncertainty and diversity make the impact of digital transformation on innovation performance complex and varied.

2.5 Gap Analysis from Existing Literature

The existing literature on design thinking, digital transformation, and innovation performance in small and medium-sized enterprises (SMEs) identifies critical research gaps that this study addresses by focusing on context-specific mechanisms and mixed-method insights. Although prior research has established that design thinking positively influences innovation performance (Liedtka, 2015; Magistretti et al., 2022), it often overlooks how unique SME characteristics shape this relationship. These characteristics include resource constraints and flat hierarchical structures. For instance, while studies on large firms emphasize the general problem-solving benefits of design thinking, fewer investigations explore how SMEs adapt iterative, user-centric methodologies to achieve incremental innovations with limited R&D budgets (Magistretti et al., 2023). The mediating role of digital transformation ambidexterity—

how design thinking drives exploitative initiatives and exploratory initiatives in resource-constrained settings—remains under-theorized. This gap is significant because it could explain why SMEs struggle to balance short-term efficiency and long-term experimentation (Jing et al., 2023; Zhang et al., 2023).

In the intersection of design thinking and digital transformation, research gaps persist in understanding the unique challenges faced by SMEs. Most studies rely on frameworks developed for large enterprises, neglecting how SMEs use design thinking tools to address skill shortages or align stakeholders during digital pivots (Carlgren et al., 2016). Normative and cognitive institutional environments, which influence SMEs' willingness to adopt design thinking, including industry norms for customer-centricity or shared beliefs in digital competence, are also under-researched. This is despite evidence that regulatory environments may impose disproportionate compliance costs on small firms (Busenitz et al., 2000; Xu et al., 2021).

Regarding the related research on digital transformation and innovation performance, the literature often treats transformation as a unified construct, ignoring the divergent effects of its exploitative and exploratory dimensions in SMEs. For instance, exploitative efforts may enhance process efficiency, while exploratory initiatives drive radical product innovations. However, few studies examine how SMEs balance these two modes under institutional pressures (Nambisan et al., 2019).

This study bridges these gaps by using mixed methods to explore micro-level mechanisms through qualitative interviews and validate macro-level trends through structural equation modeling. It specifically investigates how design thinking influences innovation performance via the mediating role of digital transformation ambidexterity and the moderating role of institutional environments. By grounding its findings in the unique realities of SMEs, the research enhances theoretical understanding of how resource-constrained firms leverage design thinking and institutional resources. It also offers actionable insights for practitioners and policymakers aiming to foster sustainable innovation in SMEs.

2.6 Conceptual Framework, Hypothesis, and Operational Definition

2.6.1 Conceptual Framework and Hypothesis

Building on the theoretical background literature discussed above, the conceptual framework of the research model has been proposed, as shown in Figure 2.14. Firstly, the research model depicts that the impact of design thinking on digital transformation ambidexterity appears rather significant. Design thinking has a considerable positive impact on exploitative and exploratory digital transformation. Secondly, exploitative and exploratory digital transformation are posited to impact innovation performance positively. Third, the institutional environment moderates the effect of design thinking on innovation performance.

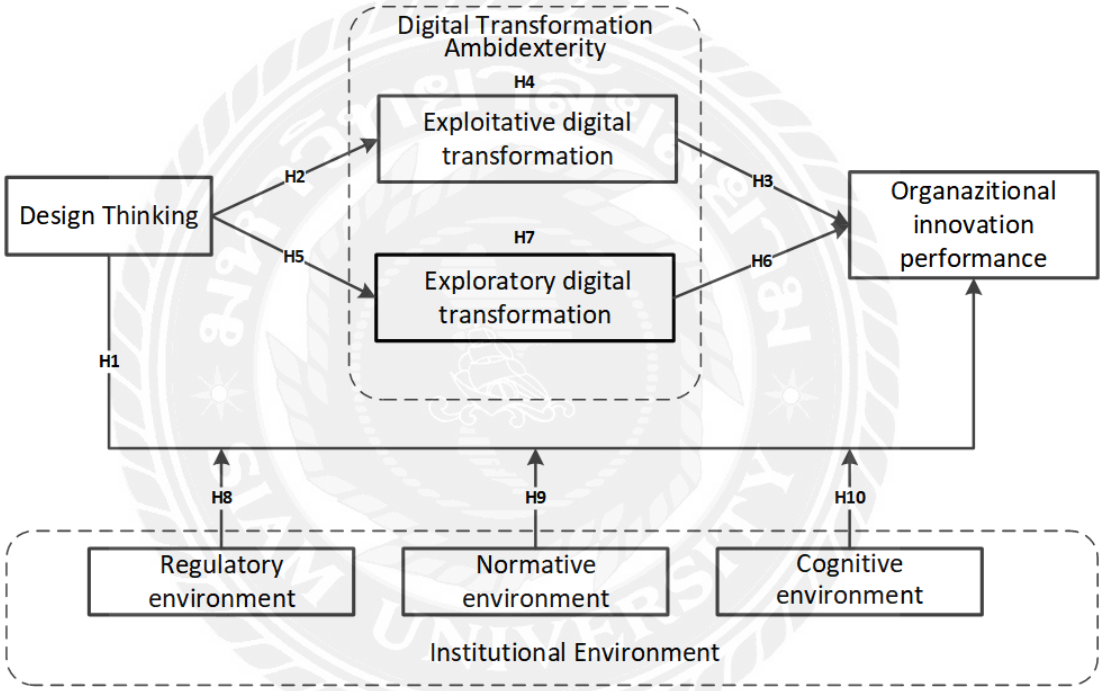

Figure 2.14 Conceptual Framework of the Research Model
Source: Researcher (2025)

In this research, the institutional environment is explicitly modeled to include regulatory, normative, and cognitive contexts. These institutional dimensions are posited to influence both the adoption of design thinking and the effectiveness of digital transformation strategies. For instance, regulatory environments may directly or indirectly encourage organizations to engage in digital transformation. Meanwhile, normative environments, shaped by professional standards and industry best practices, promote the diffusion of design thinking as a legitimate innovation methodology. The cognitive environment, encompassing shared beliefs, mental models, and cultural

frames, may enhance or constrain an organization's capacity to embrace new approaches such as exploratory transformation.

By integrating Institutional Theory into the model, this study acknowledges that digital transformation is not only a technological or strategic endeavor, but also a socially and culturally embedded process. The mediating role of digital transformation ambidexterity between design thinking and innovation performance is thus understood through both an organizational capabilities viewpoints (TOE) and a sociological viewpoints (Institutional Theory).

From the above framework, several hypotheses can be listed as follows:

H1: Design thinking positively affects organizational innovative performance.

H2: Design thinking positively affects exploitative digital transformation.

H3: Exploitative digital transformation positively affects innovation performance.

H4: Design thinking positively affects organizational innovative performance through the mediating effect of exploitative digital transformation.

H5: Design thinking positively affects exploratory digital transformation.

H6: Exploratory digital transformation positively affects innovative performance.

H7: Design thinking positively affects organizational innovative performance through the mediating effect of exploratory digital transformation.

H8: Design thinking positively affects organizational innovative performance through the moderating effect of regulatory environment.

H9: Design thinking positively affects organizational innovative performance through the moderating effect of normative environment

H10: Design thinking positively affects organizational innovative performance through the moderating effect of cognitive environment

2.6.2 Operational Definition

1) Independent Variable

Design Thinking: DT is a user -centered, creative problem-solving process. It involves understanding needs and problems, insight formation, rapid learning, creating, testing, and feedback. Design thinking draws on methods from engineering, design, and social sciences to iteratively ideate, prototype, and refine solutions matched to user needs. In this study, Design thinking had five factors including user-centered, abductive reasoning, team diversification, iteration & experimentation, and visualization & representation.

User-centered: Lockwood (2010) takes the experience of users as the core of design thinking to solve problems and conducts in-depth exploration and research on the daily life, challenges, and ideas of target customers through interaction with them. Fraser (2007) describes it as a deep understanding of the user. This requires understanding who is affected by the problem, how they are concerned, where they live, their experience of the problem, their needs, and how they can be improved. Design thinking practitioners focus on how the potential solutions will meet the needs of the end users, thus creating empathy for the users. Design thinking can effectively analyze, refine, and redefine users' needs. As enterprises pay more attention to users' needs, the importance and frequency of use of design thinking in the team gradually increase.

Abductive reasoning: Abductive reasoning differs from individual to general or general to particular rationale. It is an imagination of what is possible (rather than an analysis of what is actually). Abductive reasoning promotes an "attitude towards viable solutions based on claims rather than evidence," where team members can rely on existing frameworks or solve problems by refactoring and challenging existing practices and assumptions.

Team diversification: In the design thinking process, team members need to interact with users to understand what needs to be designed, interact with other stakeholders to determine whether there are any constraints, and team members also need to discuss ideas together and reach a consensus on issues and potential solutions. In this process, if team members have different backgrounds and ways of thinking, the whole team's creativity will be improved.

Iteration and Experimentation: This is a dynamic process that supports innovators in exploring different possibilities through a series of rapid and low-cost experiments, while maintaining a strong focus on user needs. Each iteration is a step toward a better solution.

Visualization and Representation: Boni (2009) believes that moving from abstract thinking to visual thinking and thinking over those visualizations is at the heart of innovative design. Deserti and Rizzo (2014) propose that designers' visual ability defines their practices and problem-solving methods. Therefore, visualization has become an essential part of design thinking. Team members can show their ideas and plans through charts, cartoons, videos, prototypes, etc.

2) Dependent Variable

Organizational Innovation Performance: Have two dimensions. The first dimension is subjective, measuring innovation performance through the application of innovative ideas and methods; the other dimension is objective, transforming actual standards into specific, measurable things is a form of performance.

3) Mediating Variable

Digital Transformation Ambidexterity: Digital transformation is the transformation and innovation of value generation, acquisition, or delivery of enterprises via digital technology. This study divides digital transformation into exploitative and exploratory digital transformation. Exploitative digital transformation increases the efficiency of existing operational processes, such as using the internet to enable diverse communication with other partners to reduce R& D costs and using digital resources to reconfigure business models and value networks or instead focusing on improving the existing products, processes, and capabilities using digital technology.In contrast, exploratory digital transformation explores future markets to gain a competitive advantage, such as forecasting future markets and creating new products and services with digital technologies such as AI.

4) Moderating Variable

Institutional Environment: refer to the overall structure of formal and informal rules, policies, laws, cultures, and social norms that affect and constrain an organization's behavior. Institutional environment has three dimensions including regulatory, normative, and cognitive environment.

Regulatory environment refers to the officially enacted laws and policies by governmental authorities, typically characterized by clear constraints and requirements.

Normative environment refers to the widely recognized responsibilities and ethics within an industry, as well as the established moral expectations.

Cognitive environment refers to the shared values, beliefs, and collective vision that are commonly recognized and accepted by members of a group or organization.

CHAPTER 3
RESEARCH METHODOLOGY

This chapter elaborates on the methodology of the research with a mixed-methods approach. This chapter provides a detailed introduction to quantitative and qualitative research methods, such as population and sampling, data collection methods, variable analysis, questionnaire design, and data analysis methods. The details in this chapter are divided into six sections as follows:

3.1 Research Design

3.2 Population and Sample

3.3 Research Tools

3.4 Data Collection Strategy and Procedure

3.5 Data Analysis

3.6 Research Ethics

3.1 **Research Design**

This study aims to explore how design thinking influences organizational innovation performance of innovative SMEs in Guangxi and examines the mediating effects of digital transformation ambidexterity and the moderating effects of institutional environment. This study used mixed-methods research approach as shown in Figure 3.1.

Mixed-methods research refers to the use of qualitative and quantitative methods in a study at the same time or sequentially to form a study. Creswell and Clark (2017) proposed that mixed-methods research had advantages over quantitative or qualitative research, and neither method can obtain complete knowledge from it.

In the specific research process, quantitative research was the main focus, supplemented by qualitative research, jointly exploring the the relationship between design thinking, organizational innovation performance, exploitative digital transformation, and exploratory digital transformation in order to form a deeper understanding and research perspective, promote the application of design thinking to enhance innovation performance in SMEs.

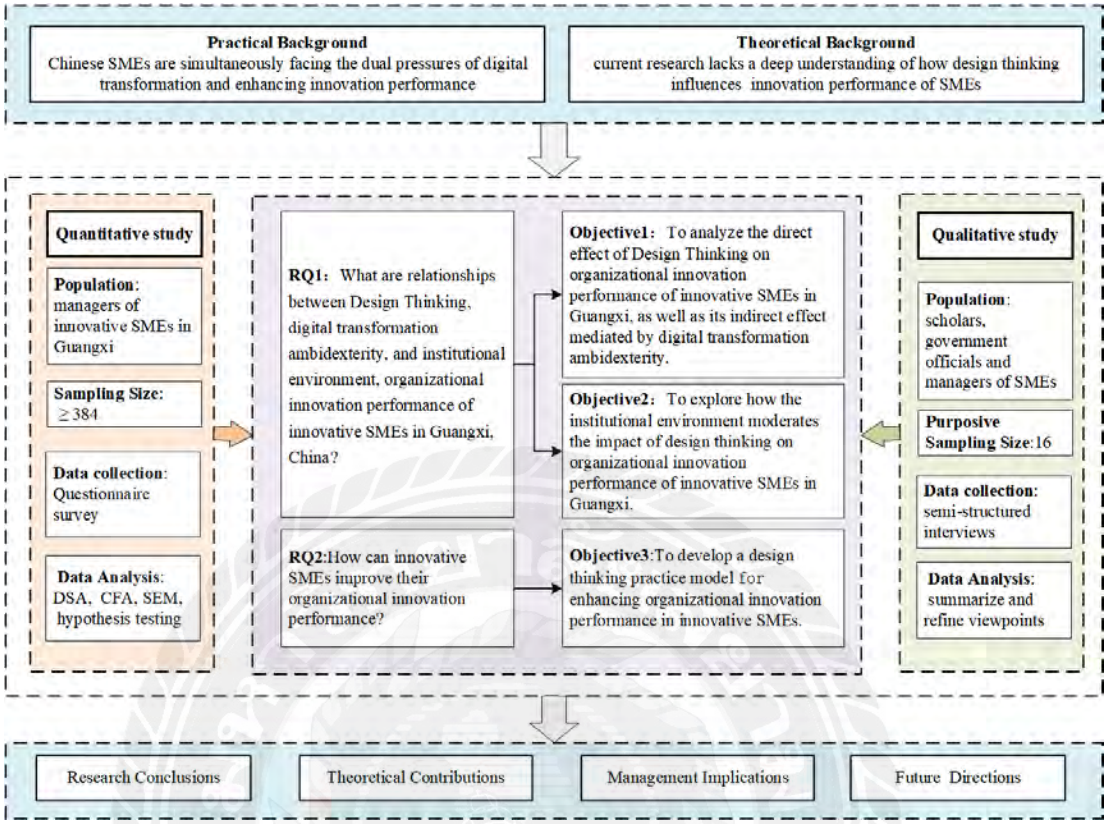

Figure 3.1 Research framework
Source: Researcher (2025)

3.2 Population and Sample

3.2.1 Quantitative research part

3.2.1.1 Population

This study selected the middle and senior managers in innovative SMEs in Guangxi as the population. The list of these 1,490 innovative SMEs was sourced from the official website of the Department of Industry and Information Technology of the Guangxi Province. Each enterprise on the list had undergone a rigorous and standardized certification process to ensure fairness. According to China's National Standard GB/T 4754-2017 *Industrial Classification of the National Economy*, the industry distribution of innovative SMEs in Guangxi was shown in table 3.1 below.

Table 3.1 Industry Distribution of Innovative SMEs in Guangxi

Category	Subclass	Counts	Percents
Agriculture, Forestry, Animal Husbandry, and Fishery	-	21	1.41%
Manufacturing	Subtotal	**1074**	**72.08%**
	Processing of Agricultural and Sideline Products	95	6.38%
	Food Manufacturing	73	4.90%
	Manufacture of Chemical Raw Materials and Products	141	9.46%
	Pharmaceutical Manufacturing	98	6.58%
	Non-metallic Mineral Products Manufacturing	76	5.10%
	General Equipment Manufacturing	114	7.65%
	Specialized Equipment Manufacturing	104	6.98%
	Automobile Manufacturing	87	5.84%
	Computer, Communication, and Electronic Equipment Manufacturing	107	7.18%
	Wood Processing & Furniture Manufacturing	71	4.77%
	Others	108	7.25%
Electricity, Heat, Gas, and Water Supply	-	27	1.81%

Category	Subclass	Counts	Percents
Construction	-	30	2.01%
Information Transmission, Software, and IT Services	Software and IT Services	126	8.46%
Scientific Research and Technical Services	Professional Technical Services	73	4.90%
	Research and Experimental Development	68	4.56%
Water Conservancy, Environment, and Public Facilities Management	-	36	2.42%
Other Categories	-	35	2.35%
Total		1,490	

Source: Department of Industry and Information Technology of Guangxi Province (2025)

The questionnaire would be distributed to middle and senior managers in innovative SMEs in Guangxi.

3.2.1.2 Sample

In this study, through the method of stratified sampling, and based on the Industrial classification, sampling was mainly carried out in the Manufacturing, IT Services and other industries. The research selected 20 enterprises as the initial samples from above industries, and a questionnaire survey protocol was sent to the human resources department of each enterprise. When an enterprise agreed to receive the survey, the human resources department would assist in collecting questionnaires from 8 middle and senior executives. At the same time, in order to reduce the refusal rate of survey, snowball sampling was carried out simultaneously within each industry.

Starting from the initial enterprises in each industry, more cooperative enterprises were obtained through their recommendations.

The minimum sample size for a questionnaire survey can be calculated using the formula. In this formula:

n represents the sample size;

Z is the statistic associated with the confidence level, which is typically set at 95% in statistical tests, corresponding to a statistic of 1.96; the higher the confidence level, the more reliable the conclusions.

p stands for the probability of the option, and in surveys, it is often taken as 0.5;

e represents the sampling error, which is generally set at 5%; the smaller the sampling error, the more reliable the conclusions.

$$n = \frac{Z^2 p(1-p)}{e^2} = \frac{1.96^2 \times 0.5 \times (1-0.5)}{0.05^2} \approx 384$$

Therefore, it can be known that the sample size of quantitative research should not be less than 384.

3.2.2 Qualitative research part

To ensure the quality of the research and to complement the limitations of quantitative research, this study also employs qualitative data collection and analysis methods, such as in-depth interviews. In terms of sample selection, the study adopts a purposive sampling approach, choosing and confirming research subjects based on the research objectives and themes. Following the principle of rich case information, the study selected 16 representative participants from different fields including enterprises, the government, and the academic community, with the aim of obtaining multifaceted analysis data and insights.

When selecting research participants from the enterprises, government, and academic community, it was typically necessary to consider certain eligibility criteria to ensure they possess sufficient expertise and experience related to the research topic.

Participants from enterprises should have more than 10 years of working experience in SMEs of Guangxi, and have more than 5 years of management experience.

Participants from government should be involved in formulating SMEs developing policies and regulations and have been working in the government for more than 5 years.

Participants from the academic community should be well-known experts or scholars. They should possess exceptional expertise and rich experience in SMEs, and have established a strong and respected reputation within the relevant field.

As shown in Table 3.2, in-depth interviews were conducted with 16 key informants including 3 government officials, 3 scholars, and 10 senior executives.

Table 3.2 The basic information of Participants with in-depth interviews

ID	Participant	Position	Service Years	Field
1	A	Official of the Industry and Information Technology Bureau in X city	14	Government
2	B	Official of the Science and Technology Bureau in X city	25	Government
3	C	Official of the Science and Technology Bureau in Y city	18	Government
4	E	Scholar focusing on business management	24	Research Institution
5	F	Scholar focusing on business management	17	University
6	G	Scholar focusing on SMEs	19	University
7	H	CEO	16	IT services
8	I	Senior Management	13	Manufacturing
9	J	CIO	12	Manufacturing
10	K	Senior Management	15	Manufacturing
11	L	CTO	18	Manufacturing
12	M	CEO	15	Manufacturing
13	N	CMO	17	Manufacturing
14	O	COO	10	Manufacturing

ID	Participant	Position	Service Years	Field
15	P	Human Resources Director	21	Manufacturing
16	Q	Senior Management	14	IT services

Source: Researcher (2025)

3.3 Research Tools

3.3.1 Questionnaire survey

To address the complexities inherent in the research problem and derive robust answers to the formulated research questions, this study relies on primary data as the foundation for analysis. Primary data were systematically collected through a structured questionnaire survey, designed to elicit detailed responses from the target sample and ensure the empirical rigor necessary for addressing the research objectives. Ebert et al. (2018) explained that the questionnaire is the preliminary data in quantitative data collection, which defines the questionnaire as a measuring tool that asks individuals to answer a series of questions or respond to a series of statements according to their opinion. Moreover, the main purpose of the questionnaire is to translate the researcher's information needs into a specific set of reports that the respondent is willing and able to answer (Rathi & Ronald, 2022). Thus, to address the research problem and derive the findings from hypothesis testing, this study designed a questionnaire grounded in the developed theoretical model. The instrument was systematically administered to middle and senior executives of innovative SMEs in Guangxi, aligning data collection with the research conceptual framework and empirical objectives.

1) Create a questionnaire following the research objectives

The questionnaire is based on the research objectives that form the parts of the questionnaire. The details are as follows: Demographic characteristics of the respondents to ensure the relationship between the background of the respondents and the construction of the research variables developed. Meanwhile, the other part is a form of the statement that the respondent will fill in, which consists of each variable: design thinking, exploitative digital transformation, exploratory digital transformation,

organizational innovation performance and Institutional Environment. The questionnaire for this study has a closed structure, with respondents checking boxes to indicate their level of agreement or disagreement with the research statement. The questions are designed in clear and simple language to provide accurate, unbiased, and complete information.

For measuring innovation performance, this study draws on the research of Lovelace et al. (2001) and uses a 4-item scale. The measurement of institutional environment is based on the theories of Scott (1995) and Busenitz et al. (2000), developing a scale from three dimensions: regulatory, normative, and cognitive with a total of 12 items.

The questionnaire prepared by the researcher uses a measurement scale that belongs to the ordinal principle, namely the Likert Scale. Kothari (2004) stated that The Likert scale is a tool used to measure attitudes, opinions, and perceptions of individuals or groups regarding social phenomena. It translates variables into variable indicators. The type of Likert scale that was used in this study is the point Likert scale as shown in Table 3.3.

Table 3.3 Five levels of Likert Scale

Level	Score
Strongly Agree	5
Agree	4
Undecided	3
Disagree	2
Strongly Disagree	1

Source: Researcher (2025)

According to relevant studies, the basic characteristics of enterprises may directly interfere with research results. Therefore, this study adopts enterprise size, enterprise nature, enterprise age and industry as control variables to ensure the reliability and stability of the research results. Multiple options are designed for each control variable and assigned values, as shown in Table 3.4.

Table 3.4 Control variables

Characteristics	Items	code
Enterprise size	Under 20 employees	1
	20-299 employees	2
	300 employees or more	3
Enterprise nature	State-owned	1
	Private	2
	Foreign invested	3
	Other	4
Enterprise age	Under 5 years	1
	5– 10 years	2
	10– 15 years	3
	More than 15 years	4
Industry	Traditional Manufacturing	1
	Services	2
	High-tech Industries	3
	Other	4

2) Content Validity

Using IOC (Item Objective Congruence Index) to check Content Validity and seek comments from the following 5 specialists

(1) Dr Liu Li (2) Dr Guan Yongjun

(3) Dr Liao Xiaomei (4) Dr Zhou Zhaoxing

(5) Dr Huang Yaoxuan

The formula for IOC calculation is

$$IOC = \frac{\Sigma R}{n}$$

where IOC = Index of item-objective congruence value

R = Score from experts

ΣR = Total score from all experts

n = number of experts

Criteria to verify score is

+1 means "the measurement item is congruence with objective of study"

0 means "the measurement item is undecide with objective of study"

-1 means "the measurement item is inconsistent with the objective of the study"

IOC needs to be between 0.5-1.00 for every question.

Subsequently, finding mean of the IOC and using the following judgment:

Means between 0.5-1.00 means "the measurement is passing the criteria of experts"

Means below 0.5 means "the measurement needs to make change or correction"

Less than 0 means "the measurement is failing to meet the qualification by experts"

Each item of the questionnaire was passed the criteria from experts, the results were shown in Appendix C.

3) Pre-testing of the questionnaire

In this study, the questionnaire was sent to some SMEs in Guangxi, then a total of 77 questionnaires were collected. The questionnaire items were refined based on the pre-test to ensure the validity and reliability of the formal survey. The formula of Cronbach's α coefficient is

$$\alpha = \left[\frac{n}{(n-1)}\right]\left[1 - \frac{\Sigma_{i=0}^{n}/S_i^2}{S_t^2}\right]$$

where α = a coefficient of reliability

n = the number of informants

$\sum_{i=0}^{n}$ = the variance of the sum of informants

S_i^2 = the ratio of the variance of each informant

S_t^2 = the ratio of inter-informants' variance

4) Reliability analysis of initial questionnaire

Reliability analysis of initial questionnaire can be performed by SPSS software. Cronbach's α coefficient for each variable is shown in Table 3.5. The reliability for the total Cronbach's α value of each variable is high with the total Cronbach's α value of each variable reaching 0.800, while the reliability values of each dimension of the Design Thinking and Institutional Environment are high greater than 0.700. The reliability values for all variables in this questionnaire were regular. The qualified items could be formed into a formal questionnaire for follow-up investigation. The formal questionnaire was shown in Appendix A.

Table 3.5 Cronbach's α coefficient of variables and dimensions

Variables and dimensions	**literature reference**	**ITEMS**	**Cronbach's α**
Design Thinking		20	0.942
User-centered	Brown, 2008	4	0.731
Abductive Reasoning	Liedtka, 2014	4	0.826
Team diversification	Blizzard et al., 2015	4	0.868
Iteration and Experimentation	Carlgren, 2013	4	0.785
Visualization and Representation	Fraser, 2007	4	0.909
Exploitative digital transformation	Zhang et al., 2023	4	0.906
Exploratory digital transformation	Zhang et al., 2023	4	0.920
Innovation performance	Lovelace et al., 2000	4	0.884
Institutional Environment		12	0.927

Variables and dimensions	literature reference	ITEMS	Cronbach's α
Regulatory environment	Busenitz et al., 2000	4	0.909
Normative environment	Busenitz et al., 2000	4	0.866
Cognitive environment	Busenitz et al., 2000	4	0.930

Source: Researcher (2025)

3.3.2 Semi-structured Interview

To gather comprehensive and multi-angle insights, this study used semi-structured interviews with 16 participants. These participants were purposefully chosen from different backgrounds relevant to SMEs, ensuring a wide range of viewpoints for rich and detailed data collection.

A set of interview questions with open-ended formats would be created, focusing on the key themes outlined in the conceptual framework. Interviews would be arranged based on participants' availability and preferred methods, conducted via face-to-face meetings, phone calls, or video calls. Before each interview, participants would sign a consent form to confirm their voluntary participation. All interviews will be audio-recorded and later transcribed into text, allowing for thorough analysis and accurate citation of quotes in the study. When the interview was over, the researcher summarized participants' descriptions in a Word document file, then consulted the participants to confirm if there were any misunderstandings.

The semi-structured interview mainly revolved around several questions as shown in Table 3.6 below:

Table 3.6 Questions for the semi-structured interview

ID	Questions
Q1	Do you agree that design thinking has five factors including user-centered, abductive reasoning, team diversification, iteration & experimentation, and visualization & representation? Why?
Q2	Do you agree that digital transformation ambidexterity, which divides into exploitative and exploratory digital transformation? Why?
Q3	Do you agree that design thinking is positively associated with the innovation performance of innovative SMEs? Why?
Q4	Do you agree that design thinking is positively associated with digital transformation ambidexterity of innovative SMEs? Why?
Q5	Do you agree that digital transformation ambidexterity is positively associated with innovation performance of innovative SMEs? Why?
Q6	Do you agree that digital transformation ambidexterity plays a mediating role in the influence of design thinking on the innovation performance of innovative SMEs? Why?
Q7	Do you agree that institutional environment plays a moderating effect on the influence of design thinking on innovation performance of innovative SMEs? Why?
Q8	How can implementing design thinking enhance the innovation performance of an innovative SME?

3.3.3 Research design in the mixed-methods

Combining both quantitative and qualitative research methods, the research objectives, hypotheses, and interview questions of this study are mapped in the following Table 3.7.

Table 3.7 Research design in the mixed-methods

Research Questions	Research Objectives	Quantitative Research				Qualitative Research			
		Measurement	**Data**	**Method**	**Analysis tool**	**Interview Questions**	**Data**	**Method**	**Analysis tool**
RQ1: What are the relationships between the variables in this study?	Obj1: To validate the main effects and mediating effects	H1, H2, H3, H4, H5, H6, H7	Survey data	Path analysis, SEM	SPSS, AMOS	Q1,Q2,Q3 ,Q4, Q5, Q6	Interview transcripts	Content Analysis & Triangulation	Word, Excel
	Obj2: To analyze moderating effects	H8, H9,H10	Survey data	Hierarchical regression	SPSS	Q7	Interview transcripts	Content Analysis & Triangulation	Word, Excel
RQ2: How can innovative SMEs improve their organizational innovation performance?	Obj3: To develop a design thinking practice model	Conceptual framework model	Survey data	SEM	AMOS	Q8	Insights from participants	In-depth Interview & Inductive analysis	Word, Visio

Source: Researcher (2025)

3.4 Data Collection Strategy and Procedure

3.4.1 Quantitative research part

The data collection procedure of formal questionnaire would be exercised in the below steps:

1) The professional survey website "Questionnaire Star" was used to collect the questionnaire online.

2) From the official website of the Industry and Information Technology Department of Guangxi Province, download the list of SMEs that have been officially designated as innovative in recent years. Use this list to delineate the scope for this sample selection.

3) Based on the professional network of the researcher, 60 enterprises were initially selected from the manufacturing sector, IT services sector, and other industries. Questionnaire protocols were sent to each enterprise's HR department. If the enterprise agreed, the HR department was requested to assist in collecting eight completed questionnaires from mid-to-senior level managers.

4) Participating enterprises were also asked to recommend this survey to their partner enterprises, thus expanding the sample size through snowball sampling.

5) Researcher should log in to the website of "Questionnaire Star" at any time to keep track of the collection status of the questionnaires and download the questionnaire data in a timely manner for statistical analysis.

3.4.2 Qualitative research part

First, it is necessary to select candidates for the interview participants. This study contacts entrepreneurs and government officials through officially published information. After obtaining the preliminary consent of the candidates, an interview agreement is sent to them. The candidates will finally confirm whether to participate in the interview after reviewing the interview questions. The formal interview time is agreed upon by both parties and is mainly conducted through real-time connections via the WeChat APP.

Interviews were utilized to gather information from the study participants. According to Fusch and Ness (2015), interviews can be employed to achieve data saturation. Austin and Sutton (2014) noted that interviews should continue until no new information is obtained. For this purpose, this study developed 7 interview questions related to the research question to ask each participant.

Interview notes were recorded on a personal computer using Microsoft Word to enhance reliability, validity, and reduce bias. After each interview, the notes were reviewed and compared with the interview transcription. The use of a recording device, in this case, a mobile phone, helped to accurately capture the interviews (Austin & Sutton, 2014). The interviews were recorded, and detailed notes of the participants' responses were compiled on a personal computer using Microsoft Word, providing a secondary source of the collected information. The interview transcriptions were then compared with the notes to minimize errors and ensure that there were no significant misrepresentations of the information.

3.5 Data Analysis

3.5.1 Quantitative Data Analysis

1) Descriptive Statistics

Descriptive statistics will detail the features basic of the data in this study. Providing the summaries of simple about the measure and the sample. In this study, the statistics descriptive were employed to summarize the characteristics of data and highlight the respondent profiles.

2) Reliability Test and Exploratory Factor Analysis

Performing an exploratory factor analysis (EFA), it requires a test for all of the items and factors' reliability, conducting Bartlett's test, as well as checking the value of Kaiser-Mayer-Olkin (KMO). Normally, Cronbach's α of 0.6 is the rule of thumb of minimum criterion as suggested by Bagozzi & Yi (1988). Bartlett's Test of Sphericity and KMO were used to determine the factorability of the data (Pallant, 2020). The KMO Test is to measure how the data is suited for factor analysis. It tests the sufficiency of sampling for each element in the sample as well as the whole

experiment. The statistic is a calculation of the proportion of variables between variables that may be a typical variance. The value of KMO was suggested to be higher than the minimum criteria of 0.6 (Bagozzi & Yi 1988). Meanwhile, the value of KMO less than 0.6 indicates the sampling is not adequate and that remedial actions should be taken. EFA is a statistical method used to uncover the underlying structure of a relatively large set of variables to make them more meaningful. EFA is a technique within factor analysis, and its goal is to identify the underlying relationships between measured variables (Norris & Lecavalier, 2009). It is important to note that EFA procedures are more accurate when each factor is represented by multiple measured variables in the analysis. It is commonly used by researchers when developing a questionnaire which is a collection of questions used to measure a research topic, and serves to identify a set of latent constructs underlying a battery of measured variables. There are two sets of exploratory factor analysis employed, including a principal component analysis (PCA) and varimax rotation, to test the convergent validity and factor loading of items. The loading of each item must exceed the minimum criterion of 0.4 (Hair et al.,2006).

3) Confirmatory Factor Analysis

A measurement model is a confirmatory factor analysis (CFA) model in which there is unmeasured covariance between each possible pair of latent variables. There are straight arrows from the latent variables to their respective indicators. Also, there are straight arrows from the error and disturbance terms to their respective variables. However, no direct effects or straight arrows are connecting the latent variables. It is noteworthy that "unmeasured covariance" means one almost always draws two-headed covariance arrows connecting all pairs of an exogenous variable (both latent and simple, if any) unless there is a strong theoretical reason not to do so.

This study employed the first and second-order CFA. The first-order CFA was used to test the extent to which the measured variable represents the dimensions explored in the EFA step. The second-order CFA is a mathematical tool used to prove the theorized build loads on a certain number of underlying -constructs or components in the sample. By using the confirmatory factor analysis, the convergent validity and the discriminant validity will be tested to assess the correct construct in the conceptual

model. Convergent validity is related to the degree to which the two measurements of the constructions, which logically would be related to each other, objectively correspond. Convergence validity was tested using the value of the average extracted variances (AVE) and considering the loading of items. To determine the degree to which the tests of various definitions are distinct, discriminant validity testing is used. The AVE method is used to check the discriminant validity. According to Fornell and Larcker (1981), if the correlated latent variable's AVE is greater than the square of the latent variables' association, then discriminating significance is reached instead.

4) Structure Equation Model Analysis

Structural equation modeling (SEM) has similar purposes to multiple regression. However, it is more powerful in the way that it takes into account the modeling of interactions, correlated independents, measurement error, correlated error terms, multiple latent independents each measured by multiple indicators, and one or more latent dependents. SEM can be used as a more powerful alternative to multiple regression, path analysis, factor analysis, time series analysis, and analysis of covariance. It can also be said that SEM is an extension of the general linear model (GLM) of which multiple regression is a part.

SEM is multiple statistical methods that are used to analyze structural relationships. SEM includes a diverse set of mathematical models, computer algorithms, and statistical methods that fit networks of constructs to data. This technique is the combination of factor, and multiple regression analysis and is used to analyze the structural relationship between measured variables and latent constructs. In this analysis, SEM is employed to test the relationship (proposed hypotheses) between constructs (endogenous variables and exogenous variables).

3.5.2 Qualitative Data Analysis

1) Thematic Examination of Interview Data

Interview responses underwent systematic thematic examination to identify recurring ideas and relationships. This process involved organizing textual data into meaningful groups while tracking common subjects, recurring trends, and distinct classifications. Through careful evaluation, critical elements emerged including

innovation influencers, leadership obstacles, and sector developments. These findings formed the foundation for exploring design thinking applications to enhance innovation outcomes of SMEs in Guangxi.

2) Triangulation and Detailed Assessment

Triangulation in qualitative analysis involved cross-verifying findings through multiple researchers to ensure reliability. The process includes: collecting data via diverse interviews, analyzing patterns across these sources, and comparing interpretations among researchers. This method identified consistencies, contradictions, or gaps in data. This method could reduce researcher bias, enhancing credibility, and deepening contextual understanding. By combining perspectives, it reveals hidden dynamics and validates conclusions beyond single source limitations. Triangulation also fosters richer insights by connecting subjective experiences with objective evidence, ensuring findings are both rigorous and holistically grounded in real-world complexity.

3) Combined Findings and Practical Implementation

Qualitative findings were merged with quantitative research results to create complete understanding. Qualitative findings helped explain the deeper meaning behind quantitative results, enabling development of concrete strategies tailored to boost innovative capabilities SMEs in Guangxi sector. The mixed-method research approach yielded actionable guidance while maintaining academic rigor.

3.6 Research Ethics

This study strictly followed ethical standards throughout the investigation. Participants were clearly informed they could discontinue involvement at any stage without penalties. All personal data remained protected through privacy measures that prevented identification of contributors. Collected information was used solely for the declared study objectives under established guidelines. The researcher received official ethical validation (Certification ID: 2991170) from Protecting Human Research Participants Online Training Inc., with additional approval (Reference code: PIM-REC 008/2568) granted for all survey materials and discussion protocols by the ethics review board prior to data collection. The researcher obtained prior clearance from the

institutional ethics committee to ensure compliance with responsible investigation practices.

CHAPTER 4
RESEARCH RESULT

This chapter examines data analysis. The data has been analyzed using descriptive statistics, reliability analysis, exploratory factor analysis, confirmatory factor analysis (CFA), structural equation modeling (SEM), and hypothesis testing. Subsequently, a qualitative analysis of the interview data was conducted.

4.1 Descriptive Statistics from The Survey Questions

This study conducted a questionnaire survey through an online link distributed to middle and senior managers of innovative SMEs in Guangxi. Finally, a total of 467 samples were collected. After screening, 429 samples were valid, which were used for subsequent analysis.

4.1.1 Descriptive Statistics of Demographic Information

Table 4.1 provides descriptive statistics of demographic information for 390 respondents. It shows that 70.63% of the respondents are male and 19.37% are female. In terms of roles, 67.13% are middle managers, and 32.87% are senior managers. For the size of the enterprises, 14.92% have under 20 employees, 42.66% have 20-299 employees, and 42.42% have 300 or more employees. The ownership structure indicates that 16.32% of the enterprises are State-owned, 72.26% are private, 4.9% are foreign-invested, and 6.53% fall into other categories. In terms of industry type, 41.03% are in traditional manufacturing, 14.69% in services, 30.77% in high-tech industries, and 13.52% in other industries. Lastly, the years of the enterprises show that 16.08% are under 5 years old, 23.08% are 5-10 years old, 27.51% are 10-15 years old, and 33.33% are more than 15 years old.

Table 4.1 Descriptive Statistics of Demographic Information

Items	Categories	N	Percent (%)
Gender	Male	303	70.63
	Female	126	29.37
Role	Middle Manager	288	67.13

Items	Categories	N	Percent (%)
	Senior Manager	141	32.87
Enterprise size	Under 20 employees	64	14.92
	20-299 employees	183	42.66
	300 employees or more	182	42.42
Enterprise nature	State-owned	70	16.32
	Private	310	72.26
	Foreign invested	21	4.90
	Other	28	6.53
Industry	Traditional Manufacturing	176	41.03
	Services	63	14.69
	High-tech Industries	132	30.77
	Other	58	13.52
Enterprise age	Under 5 years	69	16.08
	5– 10 years	99	23.08
	10– 15 years	118	27.51
	More than 15 years	143	33.33
Total		429	100.0

Source: Researcher (2025)

4.1.2 Descriptive Statistics of Relational Factors

The survey comprises a series of statements, designed to Participants' opinions on various aspects. For each statement, the responses are categorized into Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree, along with the corresponding mean values, standard deviations, skewness and kurtosis.

According to Best (1981), the interpretation of the score would be Mean Significance Level.

1.00-1.80	Strong Disagree
1.81-2.60	Disagree

2.61-3.40	Neutral
3.41-4.20	Agree
4.21-5.00	Strong Agree

The descriptive statistics data was measured for the 44 items of the questionnaire using SPSS. As shown in Table 4.2, it can be observed that the Skewness for each item is less than 0, indicating an asymmetry in the data distribution with a higher concentration of larger values and the presence of extreme small values. A Kurtosis greater than 0 signifies that the distribution is more peaked than the normal distribution, with thicker tails, implying a greater number of outliers. Conversely, a Kurtosis value less than 0 indicates a flatter distribution compared to the normal distribution, with thinner tails, suggesting fewer outliers.

Table 4.2 Descriptive Statistics of the items

Variable/ Items	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
Design Thinking						
UC1	2	5	4.212	0.723	0.149	-0.643
UC2	1	5	3.988	0.747	0.764	-0.589
UC3	2	5	4.135	0.736	-0.150	-0.501
UC4	2	5	4.163	0.718	-0.327	-0.443
AR1	2	5	3.960	0.734	-0.231	-0.295
AR2	1	5	3.907	0.724	0.137	-0.303
AR3	2	5	3.869	0.725	-0.239	-0.204
AR4	2	5	3.874	0.732	-0.446	-0.123
TD1	2	5	3.995	0.752	0.006	-0.456
TD2	1	5	3.979	0.772	0.227	-0.516
TD3	2	5	3.958	0.766	-0.157	-0.398
TD4	2	5	3.951	0.723	0.229	-0.447
IE1	1	5	3.876	0.753	0.502	-0.552
IE2	2	5	3.825	0.776	-0.158	-0.349
IE3	2	5	3.886	0.796	-0.194	-0.406
IE4	1	5	3.865	0.792	0.260	-0.550
VR1	2	5	4.002	0.731	0.171	-0.471
VR2	2	5	3.942	0.764	-0.094	-0.408
Exploitative digital transformation						
EID1	2	5	3.995	0.710	-0.348	-0.229
EID2	2	5	3.995	0.717	-0.515	-0.184

Variable/ Items	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
EID3	2	5	3.995	0.752	-0.523	-0.257
EID4	1	5	3.963	0.742	-0.205	-0.251
Exploratory digital transformation						
ERD1	2	5	3.897	0.742	-0.345	-0.213
ERD2	2	5	3.858	0.743	-0.426	-0.143
ERD3	2	5	3.848	0.748	-0.223	-0.252
ERD4	2	5	3.874	0.741	-0.171	-0.278
Organizational Innovation performance						
OIP1	2	5	4.049	0.707	-0.243	-0.309
OIP2	2	5	4.054	0.687	-0.306	-0.243
OIP3	1	5	4.117	0.701	0.442	-0.492
OIP4	2	5	4.068	0.719	-0.451	-0.291
Institutional Environment						
RE1	1	5	3.734	0.767	0.060	-0.350
RE2	1	5	3.716	0.738	0.161	-0.333
RE3	2	5	3.706	0.738	-0.174	-0.209
RE4	1	5	3.664	0.782	0.023	-0.247
NE1	2	5	3.988	0.668	-0.051	-0.223
NE2	1	5	3.984	0.692	0.186	-0.276
NE3	2	5	3.923	0.721	-0.444	-0.147
NE4	2	5	4.026	0.646	0.091	-0.233
CE1	2	5	4.047	0.672	0.293	-0.380
CE2	2	5	4.119	0.650	-0.066	-0.275
CE3	2	5	4.133	0.669	0.122	-0.395
CE4	2	5	4.107	0.675	0.354	-0.452

Source: Researcher (2025)

According to Table 4.2, the mean values of all items were greater than 3.40. Therefore, it can be concluded that all measurement items in this questionnaire survey are rated at or above the 'Agree' level.

4.2 Reliability and Validity

4.2.1 Reliability

The Cronbach's α coefficient was measured for the 44 items of the questionnaire using SPSS. As shown in table 4.3, the α values for all factors are greater than 0.7, indicating that the reliability meets the standards of this study, and the data are reliable.

Table 4.3 Cronbach Reliability Analysis

Variable	Factors	Items	Corrected Item-Total Correlation (CITC)	Cronbach α if Item Deleted	Cronbach's α
Design Thinking	User-centered	UC1	0.744	0.874	0.895
		UC2	0.720	0.883	
		UC3	0.814	0.848	
		UC4	0.797	0.855	
	Abductive Reasoning	AR1	0.782	0.893	0.912
		AR2	0.815	0.882	
		AR3	0.802	0.886	
		AR4	0.802	0.886	
	Team diversification	TD1	0.835	0.888	0.920
		TD2	0.853	0.882	
		TD3	0.818	0.895	
		TD4	0.754	0.915	
	Iteration and Experimentation	IE1	0.761	0.870	0.897
		IE2	0.768	0.867	
		IE3	0.782	0.862	
		IE4	0.770	0.867	
	Visualization and Representation	VR1	0.779	0.893	0.912
		VR2	0.778	0.894	
		VR3	0.836	0.873	
		VR4	0.806	0.884	
Digital transformation Ambidexterity	Exploitative digital transformation	EID1	0.774	0.899	0.914
		EID2	0.821	0.884	
		EID3	0.838	0.877	
		EID4	0.786	0.895	
	Exploratory digital transformation	ERD1	0.817	0.911	0.928
		ERD2	0.830	0.907	
		ERD3	0.836	0.905	
		ERD4	0.844	0.902	
Organizational Innovation performance	Organizational Innovation performance	OIP1	0.813	0.868	0.905
		OIP2	0.821	0.865	
		OIP3	0.770	0.883	
		OIP4	0.743	0.893	
Institutional Environment	Regulatory environment	RE1	0.790	0.891	0.913
		RE2	0.844	0.873	
		RE3	0.814	0.883	
		RE4	0.761	0.902	
	Normative environment	NE1	0.768	0.863	0.894
		NE2	0.783	0.857	
		NE3	0.803	0.850	
		NE4	0.712	0.883	
	Cognitive environment	CE1	0.737	0.884	0.900
		CE2	0.782	0.868	
		CE3	0.789	0.865	
		CE4	0.795	0.863	

Source: Researcher (2025)

4.2.2 Validity

Although this study drew on established scales from previous scholars, some measurement items had been customized to meet the needs of this research. Therefore, it could be considered that there was good content validity. Regarding the Validity Testing Section, this study firstly used SPSS to conduct the KMO and Bartlett's test to measure whether the scale is suitable for factor analysis.

Secondly, Exploratory Factor Analysis (EFA) was performed using principal component analysis and varimax rotation to analyze the variables.

Finally, Confirmatory Factor Analysis (CFA) was conducted using the AMOS model and the online SPSSAU software. Firstly, if the standardized factor loading values of the items for each latent variable are greater than 0.5, and the CR (Composite Reliability) value is greater than 0.7, it indicates that the scale has good convergent validity. Additionally, in this study, the criteria for assessing the fit between the data and the model include: $X2/df$ less than 3, RMSEA (Root Mean Square Error of Approximation) less than 0.08, GFI (Goodness-of-Fit Index) greater than 0.9, IFI (Incremental Fit Index) greater than 0.9, TLI (Tucker-Lewis Index) greater than 0.9, and CFI (Comparative Fit Index) greater than 0.9. This process was applied separately to measure four variables: design thinking, ambidextrous digital transformation, organizational innovation performance, and institutional environment.

4.2.2.1 Design Thinking

(1) KMO and Bartlett's Test

Firstly, this study analyzed whether the data was suitable for factor analysis. As seen from Table 4.4, the KMO value is 0.936, which is greater than 0.6, meeting the prerequisite requirements for factor analysis, indicating that the data can be used for factor analysis research. Additionally, the data passed the Bartlett's test of sphericity ($p < 0.05$), suggesting that the data is suitable for factor analysis.

Table 4.4 KMO and Bartlett's Test of 20 items about Design Thinking

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.936

Bartlett's Test of Sphericity	Approx. Chi-Square	6754.893
	df	190
	Sig.	.000

Source: Researcher (2025)

(2) Exploratory Factor Analysis

As shown in Table 4.5, factor analysis extracted a total of 5 factors, with eigenvalues all greater than 1. The variance explained by these 5 factors after rotation is 16.241%, 16.002%, 15.898%, 15.761%, and 14.758%, respectively. The cumulative variance explained after rotation is 78.659% which is greater than 50%.

Table 4.5 Total Variance Explained of Design Thinking

ID	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.080	50.399	50.399	10.080	50.399	50.399	3.248	16.241	16.241
2	1.798	8.991	59.390	1.798	8.991	59.390	3.200	16.002	32.243
3	1.628	8.142	67.532	1.628	8.142	67.532	3.180	15.898	48.141
4	1.190	5.949	73.481	1.190	5.949	73.481	3.152	15.761	63.902
5	1.036	5.179	78.659	1.036	5.179	78.659	2.952	14.758	78.659
6	0.449	2.244	80.904	-	-	-	-	-	-
7	0.438	2.189	83.093	-	-	-	-	-	-
8	0.385	1.926	85.019	-	-	-	-	-	-
9	0.370	1.850	86.869	-	-	-	-	-	-
10	0.339	1.696	88.565	-	-	-	-	-	-
11	0.307	1.535	90.100	-	-	-	-	-	-
12	0.296	1.482	91.582	-	-	-	-	-	-
13	0.273	1.363	92.945	-	-	-	-	-	-
14	0.251	1.256	94.201	-	-	-	-	-	-
15	0.236	1.182	95.383	-	-	-	-	-	-
16	0.223	1.113	96.496	-	-	-	-	-	-
17	0.196	0.980	97.476	-	-	-	-	-	-
18	0.178	0.889	98.365	-	-	-	-	-	-
19	0.165	0.826	99.191	-	-	-	-	-	-
20	0.162	0.809	100.000	-	-	-	-	-	-

Source: Researcher (2025)

The data in this study were rotated using the varimax method to identify the relationships between factors and research items. Table 4.6 shows the principal

component analysis of the factors and their corresponding research items, as well as the relationships between factors and research items.

Table 4.6 Rotated Component Matrix

	Component				
	1	**2**	**3**	**4**	**5**
UC1	0.174	**0.773**	0.122	0.254	0.177
UC2	0.090	**0.780**	0.214	0.128	0.200
UC3	0.146	**0.806**	0.176	0.231	0.234
UC4	0.210	**0.805**	0.153	0.195	0.209
AR1	0.165	0.315	0.352	0.185	**0.695**
AR2	0.168	0.296	0.287	0.206	**0.747**
AR3	0.207	0.253	0.217	0.204	**0.783**
AR4	0.178	0.155	0.221	0.253	**0.812**
TD1	0.230	0.220	0.163	**0.817**	0.201
TD2	0.213	0.243	0.181	**0.819**	0.214
TD3	0.268	0.211	0.191	**0.791**	0.188
TD4	0.295	0.206	0.198	**0.716**	0.210
IE1	0.184	0.129	**0.795**	0.185	0.212
IE2	0.187	0.169	**0.808**	0.149	0.183
IE3	0.198	0.209	**0.767**	0.198	0.239
IE4	0.217	0.175	**0.773**	0.139	0.251
VR1	**0.794**	0.171	0.186	0.253	0.109
VR2	**0.826**	0.094	0.165	0.196	0.156
VR3	**0.816**	0.161	0.221	0.235	0.179
VR4	**0.789**	0.206	0.216	0.222	0.193

Source: Researcher (2025)

When conducting validity analysis using exploratory factor analysis, the results show that the 5 dimensions correspond to 20 items in Table 4.6, which aligns well with professional expectations. This indicates that the logical internal structure identified by the research method is consistent with the internal logical structure in a professional sense, thus confirming the validity of the data. The measurement that divides design

thinking into the dimensions of user-centered, abductive reasoning, team diversity, iteration & experimentation, and visualization & representation is reasonable.

(3) Confirmatory Factor Analysis

The questionnaire data for design thinking were tested using AMOS. As shown in Table 4.7, the model fit indices of the 5-factor model of design thinking meet the statistical standards. Additionally, as shown in Figure 4.1, the model fit is satisfactory, indicating that the division and measurement of the 5 factors of design thinking in this study are valid.

Table 4.7 The model fit indices of the 5-factor model of design thinking

Indicators	χ^2	*df*	χ^2/df	GFI	RMSEA	CFI	NFI	TLI	IFI
Criteria	-	-	<3	>0.9	<0.10	>0.9	>0.9	>0.9	>0.9
Value	326.1	160	2.038	0.931	0.049	0.975	0.953	0.971	0.975

Source: Researcher (2025)

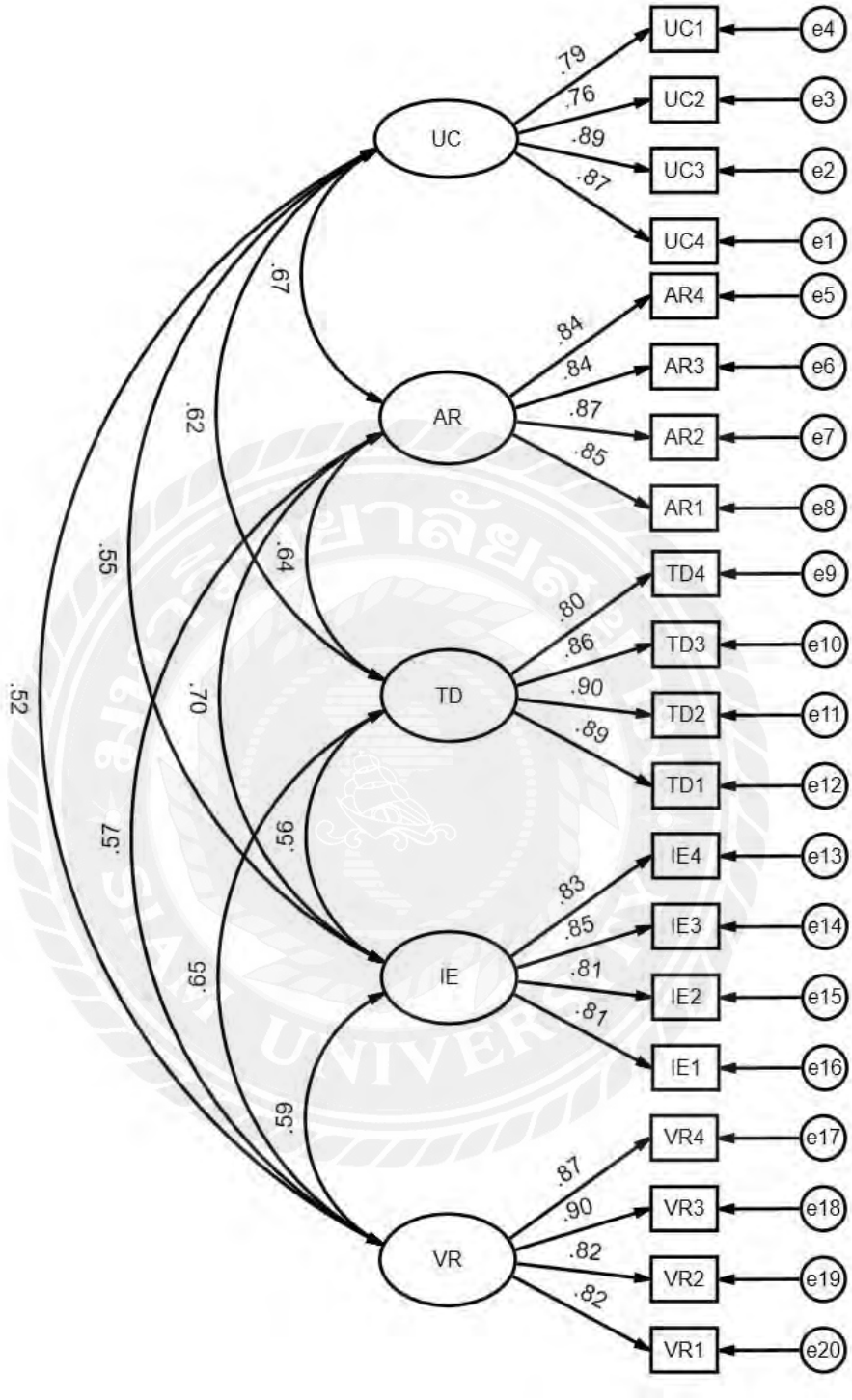

Figure 4.1 Measurement model of CFA for Design Thinking
Source: Researcher (2025)

This confirmatory factor analysis (CFA) examined the 20 measurement items of the 5 factors related to design thinking. The effective sample size for this analysis was 390, which exceeded ten times the number of measurement items, making the sample size appropriate. The factor loading values show the correlation between the factors (latent variables) and the measurement items (observed variables). As shown in Table 4.8, in the measurement relationships of the design thinking factors, the standardized factor loadings have absolute values greater than 0.7 and are statistically significant at the $p<0.001$ level, indicating good measurement relationships. Additionally, each AVE for all 5 factors is greater than 0.5, and the CR is all above 0.7, indicating that the data have good convergent validity.

Table 4.8 Convergent validity testing of design thinking

Factors (latent variable)	Items (observable variable)	Std. Estimate	AVE	CR	*P*
User-centered	UC1	0.791	0.686	0.897	***
	UC2	0.761			
	UC3	0.887			
	UC4	0.867			
Abductive Reasoning	AR1	0.847	0.723	0.912	***
	AR2	0.869			
	AR3	0.845			
	AR4	0.839			
Team diversification	TD1	0.886	0.744	0.921	***
	TD2	0.902			
	TD3	0.862			
	TD4	0.798			
Iteration & Experimentation	IE1	0.811	0.684	0.896	***
	IE2	0.814			
	IE3	0.849			
	IE4	0.833			
Visualization &	VR1	0.821	0.722	0.912	***

Factors (latent variable)	Items (observable variable)	Std. Estimate	AVE	CR	*P*
Representation	VR2	0.815			
	VR3	0.895			
	VR4	0.866			

Source: Researcher (2025)

To analyze discriminant validity, the square root of AVE can indicate the 'convergence' of a factor, while the correlation coefficients indicate the relationships between factors. If the 'convergence' of a factor is strong (significantly stronger than the absolute values of the correlation coefficients with other factors), it indicates that the factor has discriminant validity. As shown in Table 4.9, for UC, the square root of AVE is 0.839, which is greater than the maximum absolute value of the correlation coefficients with other factors (0.661). For AR, the square root of AVE is 0.865, which is greater than the maximum absolute value of the correlation coefficients with other factors (0.661). For TD, the square root of AVE is 0.876, which is greater than the maximum absolute value of the correlation coefficients with other factors (0.641). For IE, the square root of AVE is 0.839, which is greater than the maximum absolute value of the correlation coefficients with other factors (0.654). For VR, the square root of AVE is 0.868, which is greater than the maximum absolute value of the correlation coefficients with other factors (0.632).

Table 4.9 Discriminant Validity of Design Thinking

	UC	AR	TD	IE	VR
UC	**0.828**				
AR	0.607	**0.850**			
TD	0.566	0.590	**0.863**		
IE	0.494	0.634	0.519	**0.827**	
VR	0.464	0.514	0.605	0.531	**0.850**

Note: The bold numbers on the diagonal are the square roots of AVE.

Source: Researcher (2025)

4.2.2.2 Digital Transformation Ambidexterity

Digital transformation Ambidexterity included Exploitative digital transformation and Exploratory digital transformation.

(1) KMO and Bartlett's Test

As shown in Table 4.10, the KMO value is 0.930, which is greater than 0.6, meeting the prerequisite for factor analysis, indicating that the data is suitable for factor analysis research. Additionally, the data passes the Bartlett's test of sphericity ($p<0.001$), suggesting that the research data is appropriate for conducting factor analysis.

Table 4.10 KMO and Bartlett's Test of Digital transformation Ambidexterity

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.927
Bartlett's Test of Sphericity	Approx. Chi-Square	2845.798
	df	28
	Sig.	.000

Source: Researcher (2025)

(2) Exploratory Factor Analysis

Regarding the factor extraction situation and the amount of information explained by the factors, it can be seen from Table 4.11 that the factor analysis extracted a total of 2 factors. The variance explained by these 2 factors after rotation is 34.348% and 35.080%, respectively. The cumulative variance explained after rotation is 69.428%.

Table 4.11 Total Variance Explained

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.554	69.428	69.428	3.762	34.348	34.348
2	0.930	11.626	81.054	5.554	35.080	69.428

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
3	0.326	4.080	85.134	-	-	-
4	0.282	3.524	88.658	-	-	-
5	0.268	3.350	92.008	-	-	-
6	0.225	2.809	94.816	-	-	-
7	0.220	2.747	97.563	-	-	-
8	0.195	2.437	100.000	-	-	-

Source: Researcher (2025)

Table 4.12 demonstrates the information extraction of factors for the research items and the correspondence between factors and research items. By analyzing the factor loading values, the relationship between each factor and the items can be determined. Exploitative digital transformation (EID) and Exploratory digital transformation (ERD) can be clearly distinguished from Table 4.12.

Table 4.12 Rotated Component Matrix

	Component	
	1	2
EID1	.332	**.813**
EID2	.343	**.843**
EID3	.354	**.867**
EID4	.347	**.823**
ERD1	**.872**	.379
ERD2	**.854**	.326
ERD3	**.812**	.328
ERD4	**.852**	.364

Note: Rotation Method: Varimax with Kaiser Normalization.
Source: Researcher (2025)

(3) Confirmatory Factor Analysis

The fit results of the 2-factor model for digital transformation ambidexterity with the data are shown in Table 4.13. It can be seen that all fit indicators of the 2-factor model for digital transformation ambidexterity have reached a good level.

Table 4.13 The model fit indices of Digital transformation Ambidexterity

Indicators	χ^2	*df*	χ^2/df	GFI	RMSEA	CFI	NFI	TLI	IFI
Criteria	-	-	<3	>0.9	<0.10	>0.9	>0.9	>0.9	>0.9
Value	30	19	1.561	0.983	0.036	0.996	0.990	0.994	0.968

The measurement model for the Digital transformation Ambidexterity is illustrated in Figure 4.2. The confirmatory factor analysis results are presented in Table 4.14. It can be seen that the standardized factor loading values for each item are greater than 0.5, the CR (Composite Reliability) values are greater than 0.7, and they are significant at the $p < 0.001$ level, indicating that the model has good convergent validity.

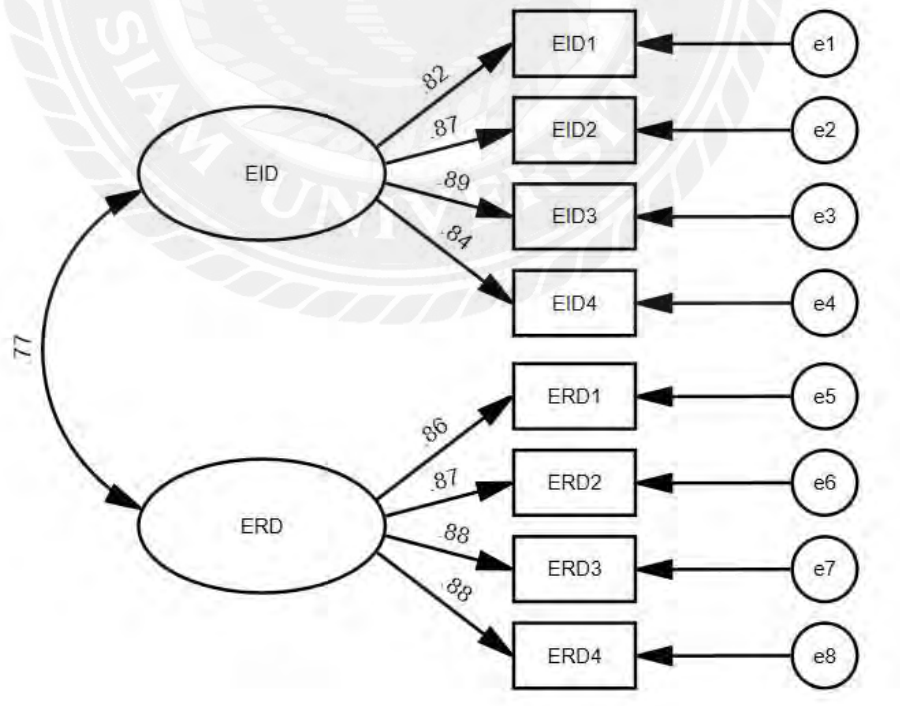

Figure 4.2 Measurement model of CFA for Digital transformation Ambidexterity
Source: Researcher (2025)

Table 4.14 Convergent validity testing of Digital transformation Ambidexterity

Factors (latent variable)	Items (observable variable)	Std. Estimate	AVE	CR	*P*
Exploitative digital transformation (EID)	EID1	0.817	0.729	0.915	***
	EID2	0.868			
	EID3	0.889			
	EID4	0.840			
Exploratory digital transformation (ERD)	ERD1	0.864	0.764	0.928	***
	ERD2	0.869			
	ERD3	0.880			
	ERD4	0.883			

Source: Researcher (2025)

Table 4.15 shows the results of the discriminant validity analysis. For EID, the square root of the AVE (Average Variance Extracted) is 0.874, which is greater than the maximum absolute value of the inter-factor correlation coefficients (0.757), indicating that it has good discriminant validity. For ERD, the square root of the AVE is 0.894, which is also greater than the maximum absolute value of the inter-factor correlation coefficients (0.757), indicating that it also has good discriminant validity.

Table 4.15 Discriminant Validity of Digital transformation Ambidexterity

	EID	ERD
EID	0.854	
ERD	0.716	0.874

Source: Researcher (2025)

4.2.2.3 Organizational Innovation performance

(1) KMO and Bartlett's Test

As shown in Table 4.16 below, the KMO (Kaiser-Meyer-Olkin) measure of sampling adequacy is 0.827, which is greater than 0.8, fulfilling the prerequisite for factor analysis and indicating that the data is very suitable for factor analysis.

Additionally, the data passes the Bartlett's Test of Sphericity ($p<0.001$), suggesting that the research data is appropriate for conducting factor analysis.

Table 4.16 KMO and Bartlett's Test of Organizational Innovation performance

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.844
Bartlett's Test of Sphericity	Approx. Chi-Square	1107.607
	df	6
	Sig.	.000

Source: Researcher (2025)

(2) Exploratory Factor Analysis

Table 4.17 presents an analysis of the factor extraction situation and the information volume of the extracted factors. From the table, it can be seen that the factor analysis has extracted a total of 1 factor, with an eigenvalue greater than 1. The variance explained by this 1 factor after rotation is 77.960%, and the cumulative variance explained after rotation is also 77.960%.

Table 4.17 Total Variance Explained of Organizational Innovation performance

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.118	77.960	77.960	3.118	77.960	77.960
2	0.359	8.975	86.935	-	-	-
3	0.306	7.651	94.586	-	-	-
4	0.217	5.414	100.000	-	-	-

Source: Researcher (2025)

Table 4.18 shows the information extraction situation of the factors regarding the measurement items, as well as the correspondence between factors and measurement items. From the table, it can be seen that the communality values for all measurement items are above 0.4, indicating a strong association between the measurement items and the factor. This suggests that the factor can effectively extract information. After ensuring that the factor can extract most of the information from the measurement

items, the next step is to analyze the correspondence between the factors and the measurement items.

Table 4.18 Rotated Component Matrix of Organizational Innovation performance

	Component
	1
OIP1	0.900
OIP2	0.905
OIP3	0.872
OIP4	0.853

Source: Researcher (2025)

(3) Confirmatory Factor Analysis

The fitting results of the organizational innovation performance measurement model and data are shown in Table 4.19. It can be seen that each fitting index of the single factor model of organizational innovation performance has reached a good level.

Table 4.19 The model fit indices of Organizational Innovation performance

Indicators	χ^2	*df*	χ^2/df	GFI	RMSEA	CFI	NFI	TLI	IFI
Criteria	-	-	<3	>0.9	<0.10	>0.9	>0.9	>0.9	>0.9
Value	3.47	2	1.734	0.996	0.041	0.999	0.997	0.996	0.999

Source: Researcher (2025)

The measurement model of organizational innovation performance is shown in Figure 4.3 below, and the results of confirmatory factor analysis are shown in Table 4.20. It can be seen that the standardized factor load value of each item is greater than 0.5, the CR value is greater than 0.7, and it is significant at the level of P less than 0.001, indicating that the model has good convergence and validity.

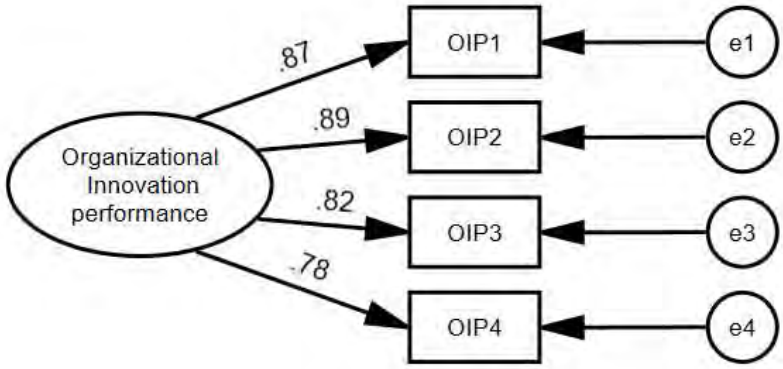

Figure 4.3 Measurement model of CFA for Organizational Innovation performance
Source: Researcher (2025)

Table 4.20 Convergent validity testing of Organizational Innovation performance

Factors (latent variable)	Items (observable variable)	Std. Estimate	AVE	CR	*P*
Organizational Innovation performance (OIP)	OIP1	0.874	0.708	0.906	***
	OIP2	0.886			
	OIP3	0.817			
	OIP4	0.783			

Source: Researcher (2025)

4.2.2.4 Institutional Environment

Institutional Environment includes Regulatory environment (RE), Normative environment (NE), and Cognitive environment (CE).

(1) KMO and Bartlett's Test

Firstly, it is analyzed whether the research data is suitable for factor analysis. As can be seen from the table 4.21 below, KMO is 0.910, which is greater than 0.8, which meets the prerequisite requirements of factor analysis, which means that the data can be used for factor analysis research. And the data passed the Bartlett sphericity test ($p<0.05$), indicating that the research data is suitable for factor analysis.

Table 4.21 KMO and Bartlett's Test of Institutional Environment

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.910
Bartlett's Test of Sphericity	Approx. Chi-Square	3742.779
	df	66
	Sig.	.000

Source: Researcher (2025)

(2) Exploratory Factor Analysis

Table 4.22 shows the factor extraction and the information content of factor extraction. It can be seen that three factors are extracted by factor analysis, and the variance interpretation rate of these three factors after rotation is 27.746%, 27.126% and 24.550% respectively, and the cumulative variance interpretation rate after rotation is 79.421%.

Table 4.22 Total Variance Explained of Institutional Environment

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.762	56.348	56.348	6.762	56.348	56.348
2	1.815	15.126	71.474	1.815	15.126	71.474
3	.954	7.947	79.421	.954	7.947	79.421
4	.412	3.431	82.853			
5	.379	3.155	86.007			
6	.327	2.729	88.736			
7	.292	2.430	91.166			
8	.263	2.192	93.358			
9	.252	2.097	95.455			
10	.212	1.770	97.225			
11	.176	1.463	98.688			
12	.157	1.312	100.000			

Source: Researcher (2025)

Table 4.23 shows the information extraction of factors from items and the correspondence between factors and items. By analyzing the factor loading values, the relationship between each factor and item can be determined. According to Table 4.23, all items have factor loadings greater than 0.4, constituting 3 factors.

Table 4.23 Rotated Component Matrix of Institutional Environment

ITEMS	Component		
	1	2	3
RE1	**0.856**	0.254	0.223
RE2	**0.851**	0.214	0.245
RE3	**0.829**	0.221	0.243
RE4	**0.837**	0.262	0.226
NE1	0.351	0.194	**0.847**
NE2	0.242	0.186	**0.726**
NE3	0.267	0.292	**0.861**
NE4	0.261	0.207	**0.813**
CE1	0.229	**0.845**	0.208
CE2	0.206	**0.831**	0.193
CE3	0.236	**0.871**	0.332
CE4	0.235	**0.843**	0.326

Source: Researcher (2025)

(3) Confirmatory Factor Analysis

The fitting results of the Institutional Environment measurement model and data are shown in Table 4.24. It can be seen that each fitting index of the 3-factor model of Institutional Environment has reached a good level.

Table 4.24 The model fit indices of Institutional Environment

Indicators	χ^2	*df*	χ^2/df	GFI	RMSEA	CFI	NFI	TLI	IFI
Criteria	-	-	<3	>0.9	<0.10	>0.9	>0.9	>0.9	>0.9
Value	149	51	2.922	0.948	0.067	0.974	0.961	0.966	0.920

Source: Researcher (2025)

The measurement model of organizational innovation performance is shown in Figure 4.4 below, and the results of confirmatory factor analysis are shown in Table 4.25. It can be seen that the standardized factor load value of each item is greater than 0.5, the CR value is greater than 0.7, and it is significant at the level of P less than 0.001, indicating that the model has good convergence and validity.

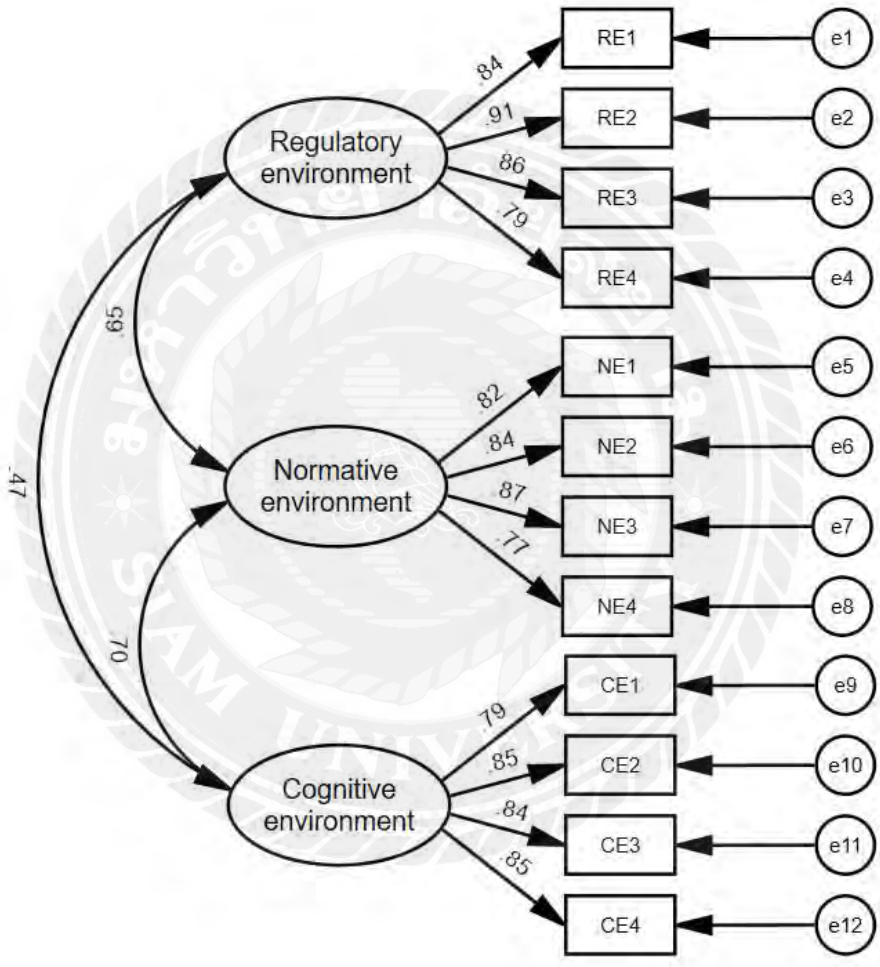

Figure 4.4 Measurement model of CFA for Institutional Environment
Source: Researcher (2025)

Table 4.25 Convergent validity testing of Institutional Environment

Factors (latent variable)	Items (observable variable)	Std. Estimate	AVE	CR	*P*
Regulatory environment	RE1	0.843	0.727	0.914	***
	RE2	0.912			

Factors (latent variable)	Items (observable variable)	Std. Estimate	AVE	CR	*P*
(RE)	RE3	0.856			
	RE4	0.794			
Normative environment (NE)	NE1	0.825	0.681	0.895	***
	NE2	0.838			
	NE3	0.866			
	NE4	0.771			
Cognitive environment (CE)	CE1	0.788	0.693	0.900	***
	CE2	0.847			
	CE3	0.840			
	CE4	0.852			

Source: Researcher (2025)

Table 4.26 shows the discrimination validity. For RE, the square root value of AVE is 0.859, which is greater than the maximum value of the absolute value of correlation coefficient between factors of 0.619, which means that it has good discrimination validity. For NE, the square root value of AVE is 0.840, which is greater than the maximum absolute value of correlation coefficient between factors of 0.642, which means that it has good discrimination validity. For CE, the square root value of AVE is 0.851, which is greater than the maximum absolute value of correlation coefficient between factors of 0.642, which means that it has good discrimination validity.

Table 4.26 Discriminant Validity of Institutional Environment

	RE	NE	CE
RE	**0.852**		
NE	0.589	**0.825**	
CE	0.427	0.632	**0.832**

Source: Researcher (2025)

4.3 Correlation Analysis

The correlation analysis of the seven key variables: Design thinking (DT), Exploitative digital transformation (EID), Exploratory digital transformation (ERD), Organizational Innovation performance (OIP), Regulatory environment (RE), Normative environment (NE), and Cognitive environment (CE). Correlation analysis is used to study the relationship between quantitative data, including whether there is a relationship and the degree of closeness of that relationship. Generally speaking, if the correlation coefficient *r* is less than 0.4, it indicates a low correlation; if *r* is greater than or equal to 0.4 and less than 0.7, it indicates a moderate correlation; if *r* is greater than or equal to 0.7, it indicates a high correlation.

Table 4.27 Results of Pearson's Correlation Analysis for Each Dimension
Note: * $p<0.05$ ** $p<0.01$ *** $p<0.001$

	Mean	**S.D.**	**DT**	**EID**	**ERD**	**OIP**	**RE**	**NE**	**CE**
DT	3.975	0.529	1						
EID	3.987	0.652	0.696***	1					
ERD	3.869	0.674	0.680***	0.716***	1				
OIP	4.058	0.656	0.573***	0.554***	0.579***	1			
RE	3.699	0.707	0.509***	0.508***	0.544***	0.558***	1		
NE	4.007	0.598	0.516***	0.554***	0.510***	0.452***	0.545***	1	
CE	4.077	0.613	0.369***	0.435***	0.373***	0.356***	0.389***	0.578***	1

Source: Researcher (2025)

As shown in Table 4.27, Design thinking (DT) has a significant relationship with EID, ERD, OIP, RE, NE, and CE at the significance level of $p < 0.001$. The correlation coefficients are 0.675, 0.653, 0.573, 0.509, 0.516, 0.369, respectively, and all values are greater than 0, indicating a positive correlation between Design Thinking and these six variables. Additionally, other variables also show a positive correlation with each other.

4.4 Structural Equation Model

In the actual testing process, some variables do not conform to a normal distribution; therefore, if correlation analysis is used, the causal relationships between variables are not adequately established. Hence, this study employs structural equation modeling (SEM) to test the hypotheses. In fact, the sample size, variable relationships, and characteristics of the variables in this study also meet the conditions for using SEM: First, structural equation modeling requires a sample size of at least 200; Second, After testing, it has been confirmed that there is a linear relationship between variables. Third, after testing, it has been confirmed that some of the variables in this study do not satisfy a normal distribution. Based on the above reasons, this study adopts the generalized least squares method to construct the structural equation model, utilizing SEM to investigate the relationships among variables.

The framework model proposed in this study was constructed using AMOS as shown in Figure 4.5. The main index of the model fit meets the requirements with χ^2=202, *df*=113, χ^2/df=1.79, GFI=0.9435, CFI=0.983, NFI=0.963, TLI=0.980, IFI=0.984, RMSEA=0.045, as shown in Table 4.28, so the model is reasonable.

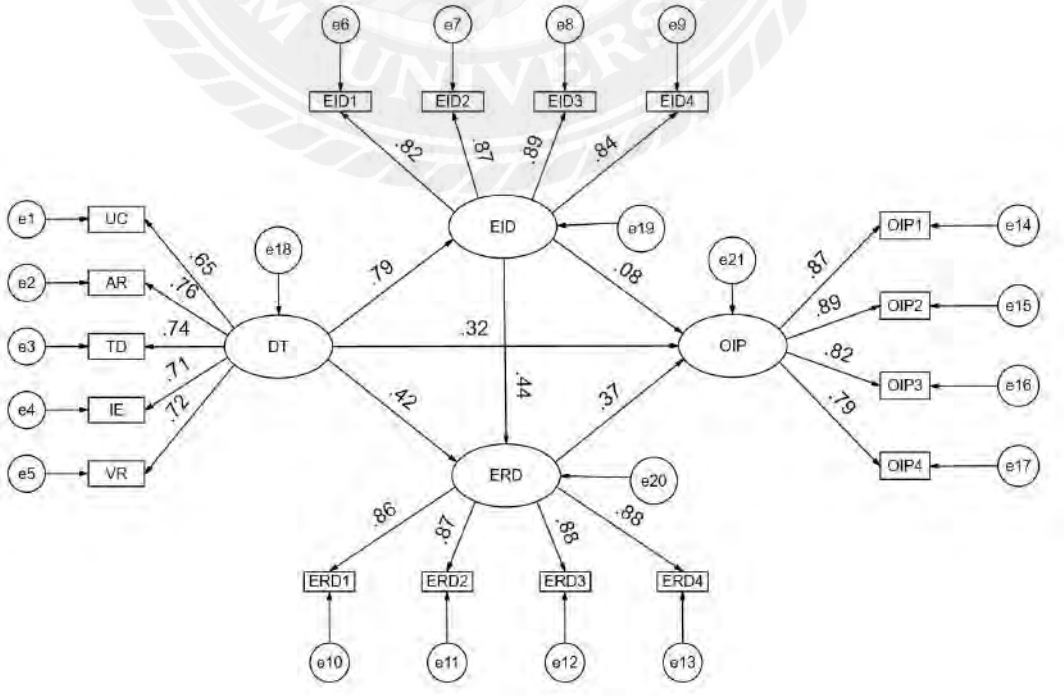

Figure 4.5 The Structural Equation Model
Source: Researcher (2025)

Table 4.28 The model fit indicators of framework

Indicators	χ^2	*df*	χ^2/df	GFI	RMSEA	CFI	NFI	TLI	IFI
Criteria	-	-	<3	>0.9	<0.10	>0.9	>0.9	>0.9	>0.9
Value	202	113	1.79	0.943	0.045	0.983	0.963	0.980	0.984

Source: Researcher (2025)

4.5 Hypotheses Test

This study takes innovative SMEs in Guangxi as the research object, uses Enterprise Size, Nature, Age, and Industry as control variables, and employs tools such as SPSS and PROCESS to test 10 hypothesized relationships among Design Thinking (DT), Exploitative Digital Transformation (EID), Exploratory Digital Transformation (ERD), and Organizational Innovation Performance (OIP) through hierarchical regression analysis. Based on the regression results, this study also draws a moderating effect diagram of the institutional environment.

4.5.1 Hypotheses Test of Main Effect

To test the direct impact of Design thinking on Organizational innovation performance (H1), this study constructs the hierarchical regression models using SPSS software for verification. From the Table 4.29, it can be seen that this hierarchical regression analysis involves two models. The independent variables in Model 1 are Enterprise Size, Nature, Age, and Industry. Model 2 adds DT on the basis of Model 1, and the dependent variable of both models is OIP.

As shown in the Table 4.29, when Enterprise Size, Nature, Age, and Industry are used as independent variables and OIP is used as the dependent variable for linear regression analysis, the R-squared value of Model 1 is 0.034. The regression coefficient of Size is 0.092, but it is not significant (t=1.933, p=0.054>0.05), meaning that Size does not have an impact on OIP. The regression coefficient of Nature is -

0.084, which is also not significant (t=-1.826, p=0.069>0.05), indicating that Nature does not affect OIP. The regression coefficient of Age is 0.056, with no significance (t=1.796, p=0.073>0.05), suggesting that Age has no influence on OIP. The regression coefficient of Industry is 0.013, showing no significance (t=0.452, p=0.651>0.05), meaning that Industry does not impact OIP. Therefore, it can be concluded that none of Enterprise Size, Nature, Age, and Industry have an effect on OIP.

For Model 2, after adding DT on the basis of Model 1, the change in the F is significant (p<0.05), indicating that the inclusion of DT has explanatory significance for the model. Additionally, the R-squared increases from 0.034 to 0.350, meaning that DT can explain 31.6% of the variation in OIP. Specifically, the regression coefficient of DT is 0.566 and is significant (β=0.566, p=0.000<0.01), indicating that DT has a significant positive impact on OIP.

Table 4.29 Results of hierarchical regression analysis for DT->OIP

	Organizational Innovation Performance (OIP)					
	Model 1			Model 2		
	t	*p*	***β***	*t*	*p*	***β***
Control variables						
Size	1.933	0.054	**0.100**	2.258	0.024	**0.096**
Nature	-1.826	0.069	**-0.088**	-1.382	0.168	**-0.055**
Age	1.796	0.073	**0.092**	1.394	0.164	**0.059**
Industry	0.452	0.651	**0.022**	-0.752	0.452	**-0.030**
Independent variable						
DT				14.334	0.000	**0.566*****
R^2	0.034			0.350		
Adjust R^2	0.025			0.342		
F	*F* (4,424)=3.780,*p*=0.005			*F* (5,423)=45.572,*p*=0.000		

* p<0.05 ** p<0.01 *** p<0.001
Source: Researcher (2025)

4.5.2 Hypotheses Test of Mediating Effect

The hierarchical regression method proposed by Baron and Kenny (1986) judges the mediating effect by comparing changes in different regression coefficients. Despite some controversies, it remains an effective testing tool as the most commonly used method for testing mediating effects in management research. To obtain more accurate test results, the Bootstrap method is considered more effective than the stepwise regression method and the Sobel test in testing mediating effects (Preacher & Hayes, 2004). Using the PROCESS program developed by Hayes (2022), a sample size of 5000 was selected, with a confidence interval of 95%.

4.5.2.1 Hypotheses Test of Mediating Effect for EID

Regarding the mediating effect of exploitative digital transformation, this study sequentially tests the three research hypotheses H2, H3, and H4 on the impact of design thinking on exploitative digital transformation, the impact of exploitative digital transformation on organizational innovation performance, and the mediating effect of exploitative digital transformation in the relationship between design thinking and organizational innovation performance.

Specifically, taking exploitative digital transformation as the dependent variable, after inputting control variables such as enterprise size, age, nature, and industry, the basic Model 3 including only control variables is obtained, and then design thinking is introduced into this model to obtain Model 4 for testing the relationship between design thinking and exploitative digital transformation; similarly, taking organizational innovation performance as the dependent variable, on the basis of Model 1 including only control variables, exploitative digital transformation is introduced to obtain Model 5 for testing its impact on organizational innovation performance, and then both design thinking and exploitative digital transformation are introduced to obtain Model 6 for testing the mediating effect of exploitative digital transformation, with specific results shown in Table 4.30. It is evident that design thinking has a positive and significant impact on exploitative digital transformation ($\beta=0.697$, $p<0.001$, Model 4), and exploitative digital transformation has a positive and significant impact on

organizational innovation performance (β=0.550, p<0.001, Model 5). Thus, H2 and H3 are accepted.

Compared with Model 2, after introducing the mediating variable, the regression coefficient of design thinking decreases (β=0.355, p<0.001, Model 6), while the regression coefficient of exploitative digital transformation remains significant (β=0.304, p<0.001, Model 6). Additionally, the model fit R^2 increases, indicating that exploitative digital transformation plays a mediating role between design thinking and organizational innovation performance.

Table 4.30 Results of the mediating effect test for EID

	Exploitative digital transformation (EID)		Organizational innovation performance (OIP)	
	Model 3	Model 4	Model 5	Model 6
Control variables				
Size	0.047	0.042	0.074	0.083
Nature	-0.075	-0.034	-0.047	-0.044
Age	-0.029	-0.070	0.108	0.080
Industry	0.075	0.011	-0.019	-0.034
Independent variable				
DT		0.697***		0.355***
Mediating Variable				
EID			0.550***	0.304***
R^2	0.011	0.489	0.333	0.397
Adjust R^2	0.002	0.483	0.325	0.389
F	*F* (4,424)=1.228, *p*=0.298	*F* (5,423)=81.093, *p*=0.000	*F* (5,423)=42.299, *p*=0.000	*F* (6,422)=46.351, *p*=0.000

To further confirm this mediating effect, this study employs the PROCESS macro program to conduct a Bootstrap test. As shown in Table 4.31, the indirect effect value of exploitative digital transformation between design thinking and organizational innovation performance is 0.263, with a confidence interval of [0.134, 0.258] that does not include zero. Thus, H4 is accepted.

Table 4.31 The Bootstrap test results of the mediating effect of EID

Path	Effect	S.E.	95% CI	
			LCI	UCI
Indirect effect: DT=>EID=>OIP	0.263	0.038	0.134	0.285
Direct effect: DT=>OIP	0.440	0.066	0.311	0.569
Total effect: DT=>OIP	0.702	0.049	0.606	0.798

4.5.2.2 Hypotheses Test of Mediating Effect for ERD

Regarding the mediating effect of exploratory digital transformation, this study sequentially tests the three research hypotheses H5, H6, and H7 on the impact of design thinking on exploratory digital transformation, the impact of exploratory digital transformation on organizational innovation performance, and the mediating effect of exploratory digital transformation in the relationship between design thinking and organizational innovation performance.

Specifically, taking exploratory digital transformation as the dependent variable, after inputting control variables such as enterprise size, age, nature, and industry, the basic Model 7 including only control variables is obtained, and then design thinking is introduced into this model to obtain Model 8 for testing the relationship between design thinking and exploratory digital transformation; similarly, taking organizational innovation performance as the dependent variable, on the basis of Model 1 including only control variables, exploratory digital transformation is introduced to obtain Model 9 for testing its impact on organizational innovation performance, and then both design thinking and exploratory digital transformation are introduced to obtain Model 10 for

testing the mediating effect of exploratory digital transformation, with specific results shown in Table 4.32. It is evident that design thinking positively affects exploratory digital transformation (β=0.677, p<0.001, Model 8), and exploratory digital transformation positively affects organizational innovation performance (β=0.570, p<0.001, Model 9). Thus, H5 and H6 are accepted.

Compared with Model 2, after introducing the mediating variable, the regression coefficient of design thinking decreases (β=0.333, p<0.001, Model 10), while the regression coefficient of exploitative digital transformation remains significant (β=0.344, p<0.001, Model 10). Additionally, the model fit R^2 increases, indicating that exploratory digital transformation plays a mediating role between design thinking and organizational innovation performance.

Table 4.32 Results of the mediating effect test for ERD

	Exploratory digital transformation (ERD)		Organizational innovation performance (OIP)	
	Model 7	Model 8	Model 9	Model 10
Control variables				
Size	0.050	0.045	0.071	0.080
Nature	-0.089	-0.050	-0.037	-0.038
Age	0.017	-0.023	0.083	0.067
Industry	0.075	0.012	-0.021	-0.034
Independent variable				
DT		0.677***		0.333***
Mediating Variable				
EID			0.570***	0.344***
R^2	0.016	0.467	0.354	0.413
Adjust R^2	0.006	0.461	0.347	0.405

	Exploratory digital transformation (ERD)		Organizational innovation performance (OIP)	
	Model 7	Model 8	Model 9	Model 10
Control variables				
F	*F* (4,424)=1.687, *p*=0.152	*F* (5,423)=74.106, *p*=0.000	*F* (5,423)=46.398, *p*=0.000	*F* (6,422)=49.552, *p*=0.000

To further confirm this mediating effect, this study employs the PROCESS macro program to conduct a Bootstrap test. As shown in Table 4.33, the indirect effect value of exploratory digital transformation between design thinking and organizational innovation performance is 0.289, with a confidence interval of [0.159, 0.304] that does not include zero. Thus, H7 is accepted.

Table 4.33 The Bootstrap test results of the mediating effect of ERD

Path	Effect	S.E.	95% CI	
			LCI	UCI
Indirect effect: DT=>ERD=>OIP	0.289	0.037	0.159	0.304
Direct effect: DT=>OIP	0.413	0.063	0.289	0.537
Total effect: DT=>OIP	0.702	0.049	0.606	0.798

4.5.3 Verification of Moderating Effects

The moderating effect examines whether the influence of X on Y is affected by the presence of a moderator variable Z. The principle of detecting moderating effects in quantitative analysis primarily involves using statistical models to evaluate how a moderator variable alters the strength or direction of the relationship between two other variables (the independent and dependent variables). In practice, this typically entails introducing an interaction term in statistical methods such as regression analysis, which is the product of the independent variable and the moderator variable. This allows for observing whether the effect of the independent variable on the dependent variable

changes when the moderator variable is present. If the coefficient of the interaction term is significant, it indicates that the moderator variable indeed changes the relationship between the independent and dependent variables, thereby confirming the existence of a moderating effect. Additionally, the specific mechanisms of the moderating effect can be further explained through methods such as plotting simple slopes graphs and calculating conditional effects at different levels of the moderator.

4.5.3.1 Testing the Moderating Effect of Regulatory Environment on the Relationship Between Design Thinking and Organizational Innovation Performance

The moderating effect of the regulatory environment was rigorously tested, as presented in Table 4.34. First, the independent variable Design Thinking was centered to minimize the impact of multicollinearity on regression results. Then, hierarchical regression analysis was conducted to examine the moderating role of regulatory environment in the relationship between Design Thinking and organizational Innovation performance. The results from Model 1 showed a significant path coefficient for Design Thinking, indicating a positive influence of Design Thinking on organizational innovation performance. In Model 2, after adding the moderator variable (regulatory environment), the path coefficient for the moderator was also significant, and the R^2 value increased from 0.328 to 0.424, suggesting that regulatory environment had an independent positive effect on organizational innovation performance. Further, in Model 3, when the interaction term between Design Thinking and regulatory environment was introduced, the interaction coefficient was not significant (p=0.111). This result indicates that the regulatory environment is unable to moderate the influence of Design Thinking on organizational innovation performance, meaning that H8 was not supported.

Table 4.34 Regression Analysis with Regulatory Environment as the Moderating Variable

	Model 1			**Model 2**			**Model 3**		
	t	***p***	***β***	***t***	***p***	***β***	***t***	***p***	***β***
Constant	156.195	***	-	168.488	***	-	157.315	***	-

	Model 1			Model 2			Model 3		
	t	***p***	***β***	***t***	***p***	***β***	***t***	***p***	***β***
DT	14.439	***	0.573	9.128	***	0.390	8.430	***	0.372
RE				8.418	***	0.360	8.419	***	0.359
DT*RE							-1.597	0.111	-0.061
R^2	0.328			0.424			0.427		
Adjusted R^2	0.327			0.421			0.423		
F	*F* (1,427)=208.499, *p*=0.000			*F* (2,426)=156.732, *p*=0.000			*F* (3,425)=105.718, *p*=0.000		
$\triangle R^2$	0.328			0.096			0.003		
$\triangle F$	*F* (1,427)=208.499, *p*=0.000			*F* (1,426)=70.856, *p*=0.000			*F* (1,425)=2.549, *p*=0.111		

Note: OIP is Dependent Variable; * $p<0.05$ ** $p<0.01$ *** $p<0.001$

Source: Researcher (2025)

4.5.3.2 Testing the Moderating Effect of Normative environment on the Relationship Between Design Thinking and Organizational Innovation Performance

The moderating effect of normative environment was rigorously tested, as presented in Table 4.35. Firstly, the independent variable Design Thinking was centered to minimize the impact of multicollinearity on regression results. Then, hierarchical regression analysis was conducted to examine the moderating role of normative environment in the relationship between Design Thinking and organizational innovation performance. The results from Model 4 showed a significant path coefficient for Design Thinking, indicating a positive influence of Design Thinking on organizational innovation performance. In Model 5, after adding the moderator variable (normative environment), the path coefficient for the moderator was also significant, and the R^2 value increased from 0.328 to 0.361, suggesting that normative environment had an independent positive effect on organizational innovation performance. Further, in Model 6, when the interaction term between Design Thinking and normative environment was introduced, the interaction

coefficient was significant (β=0.166, p<0.05), with the R^2 rising to 0.466 and an R^2 change of 0.104, significantly higher than 0.033 between Models 4 and 5. This result indicates that normative environment positively moderates the influence of Design Thinking on organizational innovation performance, meaning that as normative environment increases, the positive effect of Design Thinking on organizational innovation performance also strengthens.

Table 4.35 Regression Analysis with Normative Environment as the Moderating Variable

	Model 4			**Model 5**			**Model 6**		
	t	***p***	***β***	***t***	***p***	***β***	***t***	***p***	***β***
Constant	156.195	***	-	160.034	***	-	150.419	***	-
DT	14.439	***	0.573	10.241	***	0.463	9.844	***	0.450
NE				4.716	***	0.213	4.747	***	0.214
DT*NE							1.671	0.026	0.166
R^2	0.328			0.361			0.466		
Adjusted R^2	0.327			0.358			0.461		
F	*F* (1,427)=208.499, *p*=0.000			*F* (2,426)=120.558, *p*=0.000			*F* (3,425)=81.641, *p*=0.000		
$\triangle R^2$	0.328			0.033			0.104		
$\triangle F$	*F* (1,427)=208.499, *p*=0.000			*F* (1,426)=22.245, *p*=0.000			*F* (1,425)=2.792, *p*=0.026		

Note: OIP is Dependent Variable

**** p*<0.05 ** *p*<0.01 *** *p*<0.001**

Source: Researcher (2025)

An interaction effect graph was plotted to validate the moderating effect further, as shown in Figure 4.6. The graph reveals that the strength of the positive effect of Design Thinking on organizational innovation performance varies with normative environment. Specifically, with the improvement of the normative environment, the positive effect of Design Thinking on organizational innovation performance is more significant. In summary, these results indicate the moderating role of normative

environment in the relationship between Design Thinking and organizational innovation performance, so H11 was supported.

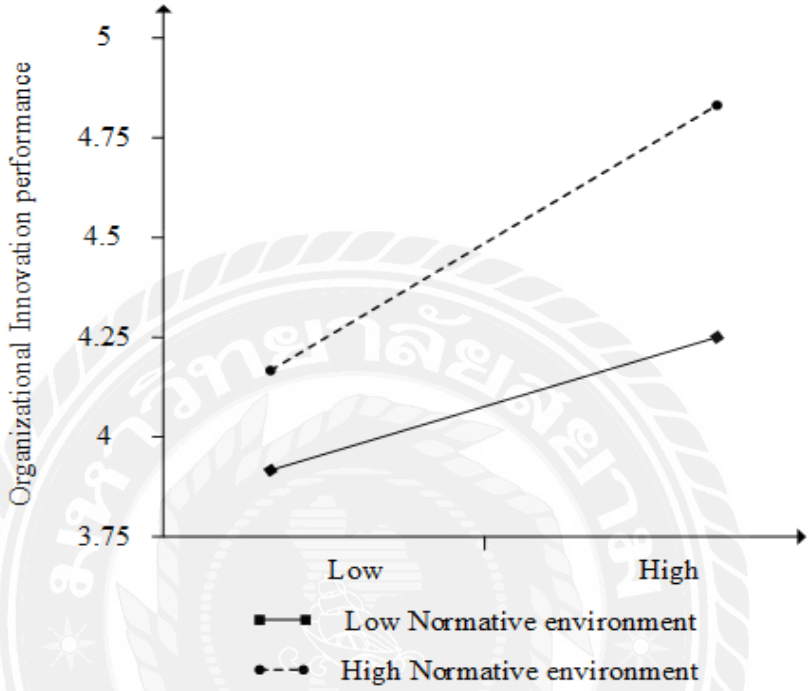

Figure 4.6 Moderating Effect of Normative environment on the Relationship Between Design Thinking and Organizational Innovation Performance
Source: Researcher (2025)

4.4.4.3 Testing the Moderating Effect of Cognitive Environment on the Relationship Between Design Thinking and Organizational Innovation Performance

The moderating effect of cognitive environment was rigorously tested, as presented in Table 4.36. Firstly, the independent variable Design Thinking was centralized to minimize the impact of multicollinearity on regression results. Then, hierarchical regression analysis was conducted to examine the moderating role of cognitive environment in the relationship between Design Thinking and organizational innovation performance. The results from Model 7 showed a significant path coefficient for Design Thinking, indicating a positive influence of Design Thinking on

organizational innovation performance. In Model 8, after adding the moderator variable (cognitive environment), the path coefficient for the moderator was also significant, and the R^2 value increased from 0.328 to 0.352, suggesting that cognitive environment had an independent positive effect on organizational innovation performance. Further, in Model 9, when the interaction term between Design Thinking and cognitive environment was introduced, the interaction coefficient was significant (β=0.172, p<0.05), with the R^2 rising to 0.558 and an R^2 change of 0.105, significantly higher than 0.024 between Models 7 and 8. This result indicates that normative environment positively moderates the influence of Design Thinking on organizational innovation performance, meaning that as normative environment increases, the positive effect of Design Thinking on organizational innovation performance also strengthens.

Table 4.36 Regression Analysis with Cognitive Environment as the Moderating Variable

	Model 7			**Model 8**			**Model 9**		
	t	***p***	***β***	***t***	***p***	***β***	***t***	***p***	***β***
Constant	156.195	***	-	158.917	***	-	153.323	***	-
DT	14.439	***	0.573	12.179	***	0.511	12.103	***	0.507
CE				4.001	***	0.168	3.953	***	0.165
DT*CE							2.856	0.014	0.172
***R* 2**	0.328			0.352			0.458		
***Adjusted R* 2**	0.327			0.349			0.453		
F	*F* (1,427)=208.499, *p*=0.000			*F* (2,426)=115.919, *p*=0.000			*F* (3,425)=78.872, *p*=0.000		
△*R* 2	0.328			0.024			0.105		
△*F*	*F* (1,427)=208.499, *p*=0.000			*F* (1,426)=16.011, *p*=0.000			*F* (1,425)=3.446, *p*=0.014		

Note: OIP is Dependent Variable

* p<0.05 ** p<0.01 *** p<0.001

Source: Researcher (2025)

An interaction effect graph was plotted to validate the moderating effect further, as shown in Figure 4.7. The graph reveals that the strength of the positive effect of Design Thinking on organizational innovation performance varies with cognitive environment. Specifically, with the improvement of the cognitive environment, the positive effect of Design Thinking on organizational innovation performance is more significant. In summary, these results indicate the moderating role of cognitive environment in the relationship between Design Thinking and organizational innovation performance, so H12 was supported.

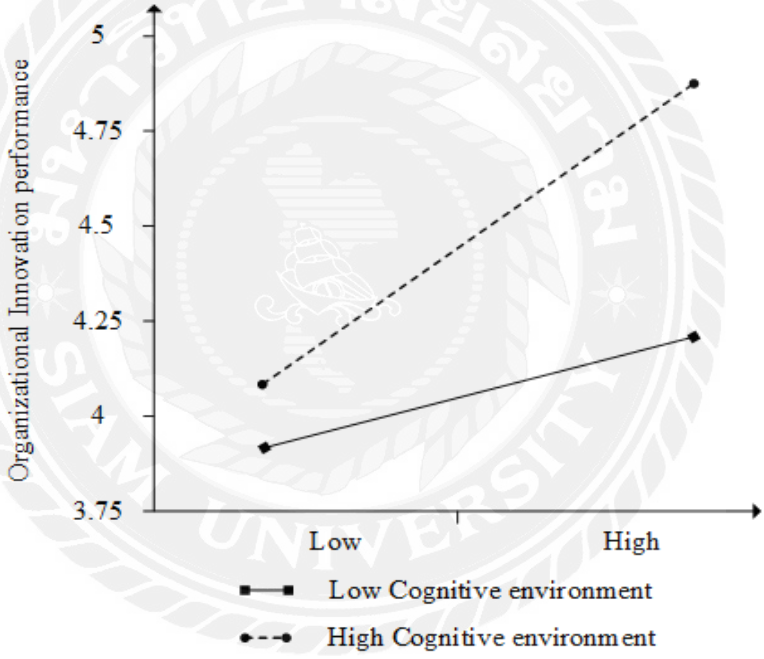

Figure 4.7 Moderating Effect of Cognitive Environment on the Relationship Between Design Thinking and Organizational Innovation Performance
Source: Researcher (2025)

4.5.4 Result of Hypotheses Testing

Based on the analysis of the above sections, the hypotheses testing is illustrated in Table 4.37.

Table 4.37 Result of hypotheses testing

	Hypothesis Content	Accepted / rejected
H1	Design Thinking positively affects organizational innovative performance.	√
H2	Design Thinking positively affects exploitative digital transformation.	√
H3	Exploitative digital transformation positively affects innovation performance.	√
H4	Design Thinking positively affects organizational innovative performance through the mediating effect of a chain of exploitative digital transformation and exploratory digital transformation.	√
H5	Design thinking positively affects exploratory digital transformation	√
H6	Exploratory digital transformation positively affects innovative performance.	√
H7	Design Thinking positively affects organizational innovative performance through the mediating effect of a chain of exploitative digital transformation and exploratory digital transformation.	√
H8	Design Thinking positively affects organizational innovative performance through the moderating effect of regulatory environment.	×
H9	Design Thinking positively affects organizational innovative performance through the moderating effect of normative environment.	√
H10	Design Thinking positively affects organizational innovative performance through the moderating effect of cognitive environment.	√

Note: (√) accepted hypothesis; (×) rejected hypothesis

Source: Researcher (2025)

4.6 Qualitative Data Analysis

This study employed interview methods to supplement the questionnaire survey, conducting further interpretation and in-depth analysis of the questionnaire data. By comparing interview data with questionnaire data, it examined whether there are inconsistencies or contradictions in the research results. This process helped researchers identify issues and make adjustments based on actual situations, thereby leading to more accurate and reliable research conclusions.

By summarizing the in-depth interviews of 16 participants including 3 government officials, 3 scholars and 10 managers of SMEs,this study obtained the following analytical results.

4.6.1 Interview opinions from In-depth Interview

The description in this part is to fulfill objectives number 1 to 3, that is, to test the relationships in SMEs in Guangxi province. The findings can be summarized into the following 7 opinions:

4.6.1.1 Opinion on five factors of design thinking

Based on literature review, design thinking had five factors including user-centered, abductive reasoning, team diversity, iteration & experimentation, and visualization & representation in this research.

1) User-centered

The participants from the Government emphasized that in the context of promoting the development of SMEs, a user-centered approach in design thinking was crucial. It helps SMEs better meet the diverse needs of the public, which in turn can enhance the overall competitiveness of the enterprise and contribute to the healthy development of the local economy. They believed that when SMEs focus on users, they were more likely to receive policy support as they were in line with the goal of promoting social and economic progress.

The scholars pointed out that a user-centered design thinking factor was the foundation of innovation. By deeply understanding user needs, SMEs can avoid developing products or services that are not in line with the market demand. It allows for the creation of more valuable offerings and promotes sustainable innovation within the enterprise. They also mentioned that it is important for SMEs to continuously update their understanding of users as user preferences change over time.

The participants from SMEs agreed that a user-centered approach was the key to their business success. It enabled them to tailor their products or services to specific customer segments, improving customer satisfaction and loyalty. For example, through user research methods such as surveys and interviews, they can identify pain points and develop solutions that truly address those issues. This had directly led to increased sales and market share for their enterprises.

2) Abductive reasoning

The government officials saw abductive reasoning in design thinking as a way for SMEs to break away from traditional thinking patterns. In a rapidly changing economic environment, it allows SMEs to quickly identify new opportunities and potential solutions. This can help SMEs adapt to new policies and market trends more effectively, and the government encourages SMEs to develop this ability through relevant training and support programs.

The scholars argued that abductive reasoning was an important cognitive tool in design thinking. It helps SMEs make creative leaps and generate innovative ideas that are not easily obtained through traditional deductive or inductive methods. By using abductive reasoning, SMEs could connect seemingly unrelated elements to form unique value propositions, which was essential for standing out in a competitive market.

Those managers of SMEs mostly believed that abductive reasoning had enabled them to solve complex business problems. When faced with challenges such as resource constraints or fierce competition, they could use this way of thinking to come up with novel strategies. They might combine different technologies or business models in an unexpected way to create a new product or service offering.

3) Team diversity

The government officials recognized that team diversity in SMEs could bring in a wide range of perspectives and skills. It promoted innovation at the enterprise level and also contributes to the overall innovation ecosystem in the region. The government supports policies that encourage SMEs to hire a diverse workforce, including people from different educational backgrounds, genders, and cultural heritages.

The scholars emphasized that team diversity was a catalyst for design thinking. Different team members bring different knowledge, experiences, and ways of thinking, which can stimulate creativity and lead to more comprehensive problem-solving. They also noted that effective communication and collaboration within a diverse team are essential to fully realize the potential of team diversity.

Those managers of SMEs reported that having a diverse team has been beneficial for their design thinking process. It had allowed them to approach problems from multiple angles and has led to the development of more well-rounded solutions. They believed that a team with members from technical, marketing, and design backgrounds can combine their expertise to create a product that not only has excellent functionality but also meets market needs and has an attractive appearance.

4) Iteration & experimentation

The government officials believed that iteration and experimentation in design thinking could help SMEs reduce risks. By testing and refining their ideas in a step-by-step manner, SMEs were more likely to develop successful products or services. The government was willing to provide support for SMEs to carry out experimental projects, as it was in line with the goal of promoting innovation and economic development.

The scholars considered iteration and experimentation as essential processes in design thinking. They allowed SMEs to learn from failures and continuously improve their offerings. Through iterative processes, SMEs could gradually optimize their products or services to better meet user needs and market demands. This was a key factor in the long-term success of an enterprise.

Those managers of SMEs emphasized the practical importance of iteration and experimentation. They had experienced firsthand how these processes can transform an initial idea into a successful product or service. By conducting small-scale experiments and gathering feedback from users, they could make timely adjustments to their offerings, saving resources and improving the chances of success in the market.

5) Visualization & representation

The government officials thought that visualization and representation in design thinking could help SMEs better communicate their ideas to different stakeholders, including customers, investors, and partners. This could enhance the visibility and credibility of SMEs, which was beneficial for their development. The government encouraged SMEs to use visualization tools to showcase their innovative achievements.

The scholars pointed out that visualization and representation were powerful means of expressing complex ideas in design thinking. It helped team members better understand and collaborate on ideas, and also makes it easier for external stakeholders to grasp the value of the proposed products or services. Visualization could take various forms, such as sketches, prototypes, and digital models.

Those managers of SMEs agreed that visualization and representation have been very useful in their product development and marketing processes. By creating visual prototypes, they could get more accurate feedback from customers and make necessary improvements. In addition, visual representations could be used in marketing materials to attract potential customers and investors, which has a positive impact on the business growth of SMEs.

4.6.1.2 Opinion on digital transformation ambidexterity

The government officials agreed that digital transformation ambidexterity, with its exploitative and exploratory aspects, was vital for SMEs. It promoted short-term efficiency and long - term growth, and thus, merits policy support. Subsidies for adopting existing digital tech for exploitation and innovation funds for exploration can be provided. When SMEs succeed in this, it benefits the entire industry and regional economy.

The scholars argued that digital transformation ambidexterity combined complementary yet distinct strategies. SMEs faced resource, skill, and cultural barriers in achieving it. To overcome these, they need to develop suitable structures, invest in talent, build partnerships, and foster an innovative culture. This balance was essential for long - term viability, though its requirements may vary by industry and firm stage.

Those managers of SMEs argued that exploitative digital transformation was more straightforward, improving existing operations, while exploratory transformation was riskier. Resource allocation between the two was a major challenge. Some used a phased approach, while others formed cross-functional teams. Despite difficulties, digital transformation ambidexterity led to increased customer satisfaction, productivity, and competitiveness, crucial for long-term business success.

4.6.1.3 Opinion on the relationship between design thinking and innovation performance of innovative SMEs

The government officials concurred that design thinking serves as a catalyst for enhancing the innovation performance of innovative SMEs. They emphasized that design thinking encourages SMEs to be more attuned to market needs, especially those of end-users. By adopting a user - centered approach, which is a key aspect of design thinking, SMEs can develop products and services that are more relevant and appealing, directly boosting their innovation output. Moreover, they believed that design thinking - driven innovation can make SMEs more competitive, which in turn contributes to the overall economic development of the region. They saw the positive relationship as a win - win, where SMEs benefit from improved performance, and the local economy thrives due to increased innovation.

The scholars provided a more in-depth theoretical perspective on the relationship. They pointed out that design thinking provides a structured yet flexible framework for innovative SMEs to generate, test, and refine new ideas. The iterative and experimental nature of design thinking allows SMEs to quickly adapt to changing market dynamics, reducing the risk of failed innovation attempts. Additionally, the emphasis on team diversity within design thinking brings together different knowledge and viewpoints, fostering creative problem - solving. Through these mechanisms, design thinking not

only increases the quantity of innovative outputs but also improves their quality, thus having a significant positive impact on innovation performance. They also noted that this relationship is supported by previous research in organizational innovation and design theory.

Those managers of SMEs shared practical experiences that validated the positive relationship. They reported that implementing design thinking in their enterprises had led to tangible improvements in innovation performance. For example, by using design thinking techniques such as prototyping and user feedback collection, they were able to develop new products faster and with fewer errors. The abductive reasoning aspect of design thinking helped them identify unique market opportunities, which they translated into innovative offerings. They also found that design thinking improved internal communication and collaboration, enabling teams to work more effectively towards innovation goals. As a result, their companies experienced increased market share, revenue from new products, and overall business growth, all indicators of enhanced innovation performance.

4.6.1.4 Opinion on the relationship between design thinking and digital transformation ambidexterity

The government officials regarded design thinking as a powerful enabler for digital transformation ambidexterity in SMEs. They emphasized that design thinking's user-centered approach helps enterprises better understand market demands, which is crucial for both exploitative and exploratory digital transformation. For exploitative transformation, it enables SMEs to optimize existing digital processes based on user feedback, enhancing efficiency. In the context of exploratory transformation, design thinking encourages SMEs to explore new digital frontiers by identifying unmet user needs, thus promoting innovation in digital business models.

The scholars analyzed the relationship from a theoretical and systematic perspective. They pointed out that design thinking provides a structured yet flexible framework that aligns well with the dual requirements of digital transformation ambidexterity. The iterative and experimental nature of design thinking, such as prototyping and continuous refinement, supports the exploratory aspect of digital

transformation by allowing SMEs to test new digital ideas and technologies with relatively low risks. Meanwhile, its focus on problem-solving and process optimization can enhance the exploitative side, helping enterprises to make the most of existing digital resources. Additionally, the emphasis on team diversity in design thinking brings together different expertise, which is essential for handling the complex challenges of both types of digital transformation simultaneously.

Those managers of SMEs shared practical insights based on their experiences. They confirmed that design thinking has a positive impact on digital transformation ambidexterity. In their enterprises, design thinking techniques like user journey mapping and ideation workshops helped them identify areas for improving existing digital operations (exploitative transformation), such as streamlining online customer service processes. For exploratory transformation, design thinking inspired them to explore emerging digital trends, like using virtual reality in product marketing. They also noted that design thinking improved internal communication and collaboration, making it easier for different departments to work together on both types of digital transformation initiatives. As a result, they witnessed improvements in digital capabilities, increased agility in responding to digital market changes, and ultimately, a more balanced and effective digital transformation ambidexterity in their companies.

4.6.1.5 Opinion on the relationship between digital transformation ambidexterity and innovation performance of innovative SMEs

The government officials emphasized that digital transformation ambidexterity acts as a crucial driver for enhancing the innovation performance of innovative SMEs. They noted that when SMEs engage in exploitative digital transformation, such as optimizing existing digital - based business processes, it directly improves operational efficiency, which in turn provides a stable foundation for innovation. This efficiency allows enterprises to free up resources to invest in exploratory digital transformation, like venturing into new digital business models or adopting emerging technologies. By achieving a balance between the two, SMEs can more effectively identify market gaps, develop novel products and services, and contribute to the overall innovation - driven development of the local economy. They also believed that promoting digital

transformation ambidexterity in SMEs should be a key part of government policies to boost regional innovation capabilities.

The scholars provided a theoretical perspective, stating that digital transformation ambidexterity has a multi - faceted positive impact on innovation performance. Exploitative digital transformation enables SMEs to leverage existing digital assets, refine their products and services, and improve quality, which is an essential form of incremental innovation. Meanwhile, exploratory digital transformation encourages radical innovation by pushing SMEs to explore uncharted digital territories, such as artificial intelligence-powered solutions or blockchain-based applications. The synergy between these two aspects of ambidexterity creates a dynamic environment where SMEs can continuously adapt to market changes, experiment with new ideas, and ultimately increase their innovation output. Moreover, scholars pointed out that this relationship is bidirectional, as high innovation performance can also further drive SMEs to deepen their digital transformation ambidexterity efforts.

Those managers of SMEs shared practical experiences validating the positive relationship. They reported that through exploitative digital transformation, their companies had improved internal communication, data - driven decision - making, and supply - chain management, all of which enhanced the overall innovation ecosystem within the enterprise. For example, automating certain processes freed up employees' time to focus on creative tasks. Exploratory digital transformation, on the other hand, had opened up new markets and customer segments for them. By using emerging digital technologies to develop unique products or services, they had been able to stand out in the market, which was a clear indicator of improved innovation performance. Overall, they found that balancing both types of digital transformation was key to driving continuous innovation, increasing competitiveness, and achieving sustainable growth in their innovative SMEs.

4.6.1.6 Opinion on the mediating role of digital transformation ambidexterity in the influence of design thinking on innovation performance of innovative SMEs.

The government officials agreed the mediating role of digital transformation ambidexterity as a pivotal link between design thinking and the innovation

performance of innovative SMEs. They noted that design thinking provides the creative impetus and user-centered approach, but it is through digital transformation ambidexterity that these ideas can be effectively translated into practical innovations. For instance, the creative concepts generated by design thinking can be exploited via digital means, such as using existing digital platforms to optimize product features (exploitative digital transformation), or explored through new digital initiatives, like developing a blockchain-based supply chain system (exploratory digital transformation). This, in turn, directly impacts innovation performance. They emphasized that promoting this mediating mechanism in SMEs can boost the overall innovation capacity of the region, and thus, should be a focus of government - supported digital and innovation policies.

The scholars elaborated on the theoretical significance of digital transformation ambidexterity's mediating role. They explained that design thinking offers a cognitive and methodological framework for generating innovative ideas, but the dual nature of digital transformation ambidexterity serves as the operational bridge. Exploitative digital transformation helps in refining and implementing these ideas based on existing digital infrastructure, ensuring immediate improvements in products or services, which is an important aspect of innovation performance. Exploratory digital transformation, on the other hand, allows SMEs to pursue more radical innovation by leveraging emerging digital technologies, expanding the scope of what can be achieved. Together, these two dimensions of digital transformation ambidexterity ensure that the potential of design thinking is fully realized in terms of innovation output. Scholars also pointed out that understanding this mediating role can help in developing more targeted strategies for promoting innovation in SMEs.

Those managers of SMEs provided practical evidence supporting the mediating role. They shared that when their teams applied design thinking to identify customer needs and generate innovative concepts, it was the subsequent efforts in digital transformation ambidexterity that made these ideas actionable. They used design thinking to come up with a new mobile app concept for their customers. Then, through exploitative digital transformation, they optimized the app's user interface based on existing digital development tools and user feedback. Exploratory digital

transformation enabled them to integrate emerging technologies like augmented reality into the app, giving it a competitive edge. These digital transformation efforts directly led to increased user engagement, positive market reception, and ultimately, improved innovation performance for their enterprises. They emphasized that without effectively implementing digital transformation ambidexterity, the innovative potential of design thinking would remain unfulfilled.

4.6.1.7 Opinion on the moderating role of institutional environment partially in the relationship between design thinking and innovation performance of innovative SMEs.

The government officials acknowledged the varied moderating roles of the institutional environment. Regarding the regulatory environment's inability to moderate the impact of design thinking on organizational innovation performance, they suggested that existing regulations might be too generic or rigid, failing to adapt to the dynamic nature of design-thinking-driven innovation. Governmental financial resources were limited, allowing only symbolic rewards and subsidies to be given to a select few outstanding enterprises to create exemplary models. Therefore, the moderating role of the regulatory environment was debatable. In contrast, they emphasized the positive moderating role of the normative and cognitive environments. The normative environment, shaped by industry standards and social values, can encourage SMEs to align their design-thinking-based innovation efforts with broader societal expectations. Norms promoting sustainability can guide SMEs to use design thinking to create more environmentally friendly products. The cognitive environment, influenced by shared beliefs and knowledge within the industry, helps SMEs better understand and apply design thinking principles, thereby enhancing its impact on innovation performance. They proposed that the government could play a role in shaping more conducive normative and cognitive environments through public - private partnerships and industry - wide initiatives.

The scholars provided a more in-depth theoretical explanation for the partial moderating role of the institutional environment. They pointed out that the regulatory environment, with its focus on compliance and standardization, may not be well - suited to support the creative and flexible aspects of design thinking. Regulations often aim to ensure stability and fairness, which might inadvertently limit the freedom

required for radical innovation. On the other hand, the normative environment acts as a soft constraint that encourages SMEs to innovate in socially and ethically acceptable ways. It provides a framework of values that can enhance the effectiveness of design thinking by directing innovation efforts towards more meaningful and relevant goals. The cognitive environment, as a collective knowledge base, influences how SMEs perceive and implement design thinking. A rich cognitive environment, with access to diverse ideas and best practices, can strengthen the relationship between design thinking and innovation performance. Scholars also suggested that future research could explore how to reform the regulatory environment to better support design - thinking - enabled innovation.

Those managers of SMEs shared practical insights into the partial moderating role. They experienced firsthand the lack of influence of the regulatory environment on their design - thinking - led innovation initiatives. Existing regulations, such as those related to product safety certifications, often added administrative burdens without directly contributing to the creative process. In addition, the protection of intellectual property rights still lacks sufficient strength. However, they saw significant benefits from the normative and cognitive environments. Industry norms regarding user-centered reinforced the importance of the user-centered approach in design thinking, leading to more successful product innovations. The cognitive environment, influenced by industry conferences and peer-to- peer learning, helped their teams better understand advanced design-thinking techniques and how to apply them effectively. They noted that while the regulatory environment remained a hurdle, the positive moderating effects of the normative and cognitive environments were crucial for maximizing the impact of design thinking on their organizations' innovation performance.

4.6.1.8 Integrating the results from qualitative and quantitative research

Table 4.38 presents the combination of quantitative findings from questionnaire data and qualitative insights from interviews to validate hypotheses about the relationships between design thinking, digital transformation, institutional environment, and innovation performance. Quantitative results (accepted/rejected hypotheses) are consistently supported or contextualized by qualitative data. For instance, all accepted hypotheses (H1–H7, H9–H10) show alignment, with interviews

providing granular explanations (e.g., how design thinking drives exploitative/exploratory digital transformation or how normative/cognitive environments enhance its impact on innovation). The rejected hypothesis (H10) is corroborated by both methods, as participants did not recognize the moderating effect of the regulatory environment. The synthesis reveals that design thinking influences innovation performance through mediating digital transformation pathways, while normative and cognitive environments amplify this effect, which is strengthened by the triangulation of statistical significance and practical narratives. This integration underscores the robustness of mixed-method research, offering a holistic understanding of complex organizational mechanisms.

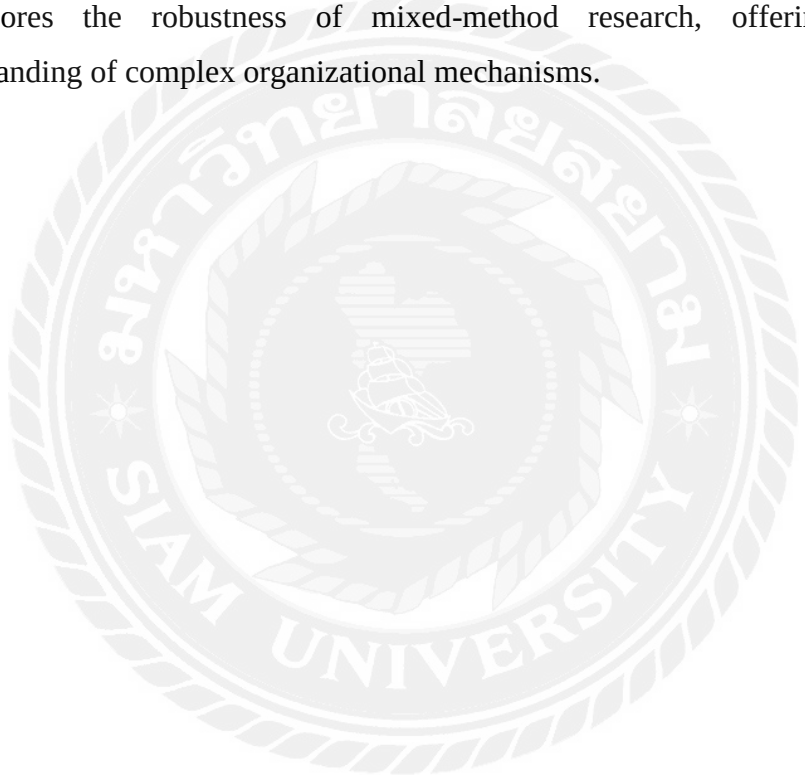

Table 4.38 Collaborating Quantitative & Qualitative Results

Hypothesis	Quantitative Results (Based on Questionnaire)	Qualitative Results (Based on Interviews)	Juxtaposition Insights
H1: Design Thinking positively affects organizational innovative performance	Accepted. Statistical analysis from the questionnaire shows a significant positive correlation between design thinking and organizational innovative performance.	Participants, including government officials, scholars, and managers, unanimously supported this relationship. Government officials noted that design thinking enables SMEs to better meet market needs, scholars elaborated on its theoretical framework for idea generation, and managers shared practical examples of improved innovation after implementing design thinking.	Both quantitative and qualitative methods validate H1. The quantitative data provides statistical significance, while the qualitative data offers rich, real - world examples and different perspectives on how this relationship works.
H2: Design Thinking positively affects exploitative digital transformation	Accepted. Questionnaire data indicates a positive link, suggesting that design thinking drives efforts to optimize existing digital processes.	Interviews revealed that managers used design thinking techniques to identify areas for improving existing digital operations, such as streamlining online customer service processes. Scholars also explained how design thinking's problem - solving approach supports exploitative digital transformation.	The two methods converge, with quantitative data confirming the relationship and qualitative data providing in - depth understanding of the mechanisms at play.
H3: Exploitative digital transformation positively affects innovation performance	Accepted. Questionnaire results demonstrate a positive impact of exploitative digital	Managers shared that improving internal processes through exploitative digital transformation, like automating certain tasks, freed up resources for	Both methods support H4, with quantitative data providing the statistical evidence and qualitative data

Hypothesis	Quantitative Results (Based on Questionnaire)	Qualitative Results (Based on Interviews)	Juxtaposition Insights
	transformation on innovation performance.	more innovative activities, thereby enhancing innovation performance.	explaining the practical implications.
H4: Design Thinking positively affects organizational innovative performance through the mediating effect of exploitative digital transformation	Accepted. Statistical analysis from the questionnaire supports the mediating role of exploitative digital transformation.	Managers described how design thinking - generated ideas were first implemented through exploitative digital transformation, which then led to improved innovation performance, providing real - life examples of the mediating process.	Both methods confirm the mediating role, with quantitative data proving the statistical significance and qualitative data illustrating the process.
H5: Design Thinking positively affects exploratory digital transformation	Accepted. Questionnaire analysis shows a positive association, indicating that design thinking encourages exploration of new digital technologies and business models.	Participants reported that design thinking inspired them to explore emerging digital trends. For example, managers used it to develop new products with emerging technologies, and scholars pointed out how design thinking's flexibility promotes exploration.	Quantitative and qualitative results are consistent. The quantitative data shows the relationship, and the qualitative data gives context and examples of the exploratory activities.
H6: Exploratory digital transformation positively affects innovative performance	Accepted. Questionnaire analysis shows a positive connection, suggesting that venturing into new digital frontiers improves innovation performance.	Participants provided examples of how exploratory digital transformation, such as integrating new technologies into products, led to increased market share and competitiveness, which are indicators of improved innovation performance.	The two types of data complement each other, validating the hypothesis from different angles.

Hypothesis	Quantitative Results (Based on Questionnaire)	Qualitative Results (Based on Interviews)	Juxtaposition Insights
H7: Design Thinking positively affects organizational innovative performance through the mediating effect of exploratory digital transformation	Accepted. Questionnaire results support the mediating role of exploratory digital transformation.	Participants shared cases where design thinking inspired exploratory digital transformation efforts, such as developing new digital business models, which ultimately enhanced innovation performance.	The two data sources align, validating the mediating hypothesis and showing how it occurs in practice.
H8: Design Thinking positively affects organizational innovative performance through the moderating effect of regulatory environment	Rejected. Questionnaire data does not support a moderating role of the regulatory environment.	Participants, especially managers, reported that existing regulations added administrative burdens without directly influencing the design thinking - innovation performance relationship. Government officials also acknowledged the rigidity of regulations in this context.	Both quantitative and qualitative results are in agreement, showing that the regulatory environment does not play a moderating role as hypothesized.
H9: Design Thinking positively affects organizational innovative performance through the moderating effect of normative environment	Accepted. Questionnaire analysis shows a positive moderating effect of the normative environment.	Interviews showed that industry norms, such as customer-centred, reinforced the positive impact of design thinking on innovation performance, providing practical illustrations of the moderating role.	The two types of data validate the hypothesis, with quantitative data offering statistical proof and qualitative data giving examples.
H10: Design Thinking positively affects organizational innovative performance through the	Accepted. Questionnaire results support the positive moderating effect of the cognitive environment.	Participants, including scholars and managers, explained how a rich cognitive environment, influenced by industry knowledge sharing, enhanced	Quantitative and qualitative data converge, confirming the moderating role and the factors involved.

Hypothesis	Quantitative Results (Based on Questionnaire)	Qualitative Results (Based on Interviews)	Juxtaposition Insights
moderating effect of cognitive environment		the effectiveness of design thinking in improving innovation performance.	

4.6.2 A Design Thinking application Model in SMEs

According to the interview data, the application of design thinking and digital transformation among SMEs in China had already attracted widespread attention. If SMEs want to survive in the fierce market competition, they must establish innovative models, deeply cultivate niche markets, and meet the real needs of customers. In the operation of SMEs, there are many pain points, and the application of design thinking can help SMEs identify these pain points and propose reasonable solutions. The implementation of digital transformation can help SMEs make quick responses based on data analysis. The combination of design thinking and digital transformation is a powerful tool for SMEs to maintain sustainable development and enhance their competitive advantage.

Figure 4.8 presents a structured design-thinking practice model for SMEs, organized around a "Capability - Action - Performance" logic. At the "Capability" stage, Design Thinking is characterized by elements such as a user-centered approach, abductive reasoning, team diversification, iteration & experimentation, and visualization & representation. These capabilities drive the "Action" stage, which comprises two types of digital transformation: exploitative (e.g., leveraging digital tech trends, optimizing existing products via digital tools) and exploratory (e.g., creating innovation incentive systems, increasing digital investment). Finally, these actions lead to "Performance," where organizational innovative performance is evident in a more flexible business model, improved internal processes, enhanced external resource-integration ability, and reduced average business operating costs. This model illustrates how design-thinking-driven actions translate into measurable innovative outcomes for SMEs.

In the era of the digital economy, design thinking can have a positive impact on the innovation performance of SMEs, with the mediating role of digital transformation ambidexterity. The digital transformation of SMEs should not be implemented blindly. Instead, it should be carried out from the perspective of design thinking, planned at a systematic level, adopting a problem-oriented mechanism, and advanced step by step

steadily. Exploitative digital transformation is the basic step for SMEs to move towards digitalization; it is incremental and gentle, reducing employees' technical anxiety, with the main purpose of optimizing internal processes and maintaining the reliable operation of existing businesses. Exploratory digital transformation is more radical, mainly used for opening up new markets and customers.

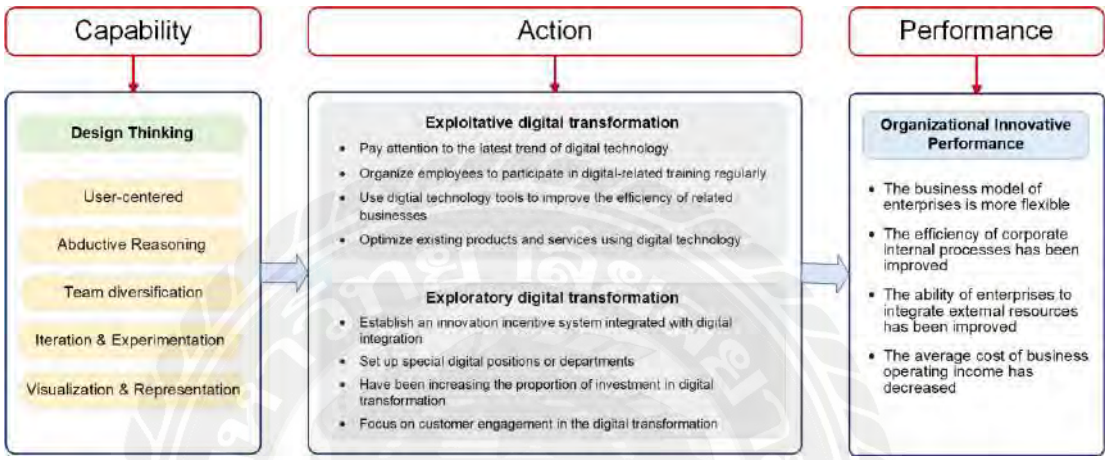

Figure 4.8 A Design Thinking Practice Model in SMEs
Source: Researcher (2025)

4.7 Conclusion

This chapter achieved the research objectives outlined in Chapter One. Through the use of SPSS and AMOS software tools for empirical analysis of the survey questionnaire, this study first confirmed the reliability and validity of the scale through exploratory factor analysis and confirmatory factor analysis, then employed structural equation modeling (SEM) as a quantitative method to examine the relationships between Design Thinking (DT), Exploitative Digital Transformation (EID), Exploratory Digital Transformation (ERD), Organizational Innovation Performance (OIP), Regulatory Environment (RE), Normative Environment (NE), and Cognitive Environment (CE). Additionally, this study tested the hypotheses proposed in Chapter Two and measured the mediating role of digital transformation and the moderating role of the institutional environment. Finally, through interview data, this study conducted a qualitative analysis of the corresponding influence relationships between the model variables.

In summary, design thinking positively impacts digital transformation in SMEs; its application can address the pain points associated with digital transformation. In the impact pathway of design thinking on the organizational innovation performance of SMEs, digital transformation can function as a mediating variable. The institutional environment partially moderated the relationship between design thinking and corporate innovation performance. The moderating role of the regulatory environment was debatable, while the normative and cognitive environments can moderate the relationship between design thinking and corporate innovation performance.

Finally, this study summarized the in-depth interviews of 16 participants, which included government officials, scholars, and managers of SMEs. These interviews were rich in detail, as each participant brought unique perspectives and real - world experiences to the table. Through a meticulous process of transcription, coding, and thematic analysis, the researchers carefully sifted through the vast amount of qualitative data. They looked for commonalities, discrepancies, and emerging trends within the responses.

By cross - referencing and triangulating the information obtained from different participants, the study was able to enhance the reliability of the findings. This comprehensive approach helped to weed out any potential outliers or idiosyncratic views that might have skewed the results. The synthesis of these interviews was not a simple aggregation but a thoughtful integration of diverse insights.

As a result, the study obtained some believable results. These results were grounded in the real - life situations and expert opinions shared by the interviewees. They have withstood the scrutiny of a rigorous analytical process, making them credible contributions to the body of knowledge in this area. The findings can be used to inform future research, policy - making, and practical strategies for SMEs aiming to enhance their innovation performance through design thinking and digital transformation.

CHAPTER 5
RESEARCH CONCLUSION, DISCUSSION AND RECOMMENDATION

This chapter synthesizes and contextualizes the empirical findings derived from the analytical processes outlined earlier. By applying structural equation modeling and regression analysis techniques, the study systematically evaluates the hypothesized relationships among variables, enabling rigorous validation of the proposed theoretical framework. The results are then critically examined through the lens of existing scholarly discourse, identifying convergences and divergences with prior literature. Building on these insights, the chapter concludes by offering actionable recommendations for stakeholders and delineating potential avenues for future scholarly exploration to address unresolved questions and methodological limitations. This chapter is divided into four parts as follows:

5.1 Research Conclusion

5.2 Discussion

5.3 Recommendation

5.1 **Research Conclusion**

The dissertation focuses on presenting the research findings, employing a comprehensive range of analytical methods to explore the relationships among design thinking, digital transformation ambidexterity, institutional environment, and organizational innovation performance of innovative SMEs in Guangxi.

5.1.1 Questionnaire Results

A total of 429 valid samples were collected from middle and senior managers of some innovative SMEs in Guangxi.

1) Descriptive Statistics from The Survey Questions

Among the 429 respondents with detailed demographic data, 70.63% were male, and 29.37% were female. Middle managers constituted 67.13%, while senior managers accounted for 32.87%. In terms of enterprise size, 14.92% had under 20

employees, 42.66% had 20 - 299 employees, and 42.42% had 300 or more employees. Regarding ownership structure, 16.32% were state - owned, 72.26% were private, 4.9% were foreign - invested, and 6.53% fell into other categories. Industry - wise, 41.03% were in traditional manufacturing, 14.69% in services, 30.77% in high - tech industries, and 13.52% in other industries. The years of enterprise establishment showed that 16.08% were under 5 years old, 23.08% were 5 - 10 years old, 27.51% were 10 - 15 years old, and 33.33% were more than 15 years old.

The survey covered 44 items related to various aspects such as design thinking, digital transformation, and innovation performance. Using SPSS for measurement, the mean values of all items were greater than 3.40, indicating that all measurement items were rated at or above the 'Agree' level. The skewness of each item was less than 0, suggesting an asymmetric data distribution with a higher concentration of larger values and the presence of extreme small values. Kurtosis values greater than 0 indicated a more peaked distribution than the normal distribution, with thicker tails and more outliers in some cases.

2) Reliability

The Cronbach's α coefficient was measured for the 44 - item questionnaire using SPSS. The α values for all factors exceeded 0.7, demonstrating that the reliability of the data met the study's standards, ensuring the data's dependability for further analysis.

3) Validity

Content validity was initially ensured by customizing measurement items based on previous scholars' scales and seeking expert opinions. The KMO and Bartlett's tests were then conducted for each variable. For example, for design thinking, the KMO value was 0.936, greater than 0.6, and the data passed the Bartlett's test of sphericity ($p < 0.05$), indicating its suitability for factor analysis. Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were performed subsequently. EFA extracted appropriate factors for each variable, and CFA confirmed good convergent and discriminant validity. For instance, in the measurement of design thinking, the

standardized factor loadings of items were greater than 0.7, and the AVE and CR values met the requirements, validating the construct's measurement.

4) Correlation Analysis

Correlation analysis was carried out on seven key variables: Design Thinking (DT), Exploitative digital transformation (EID), Exploratory digital transformation (ERD), Organizational Innovation performance (OIP), Regulatory environment (RE), Normative environment (NE), and Cognitive environment (CE). The results showed that DT had a significant positive correlation with EID, ERD, OIP, RE, NE, and CE at the significance level of $p < 0.001$, with correlation coefficients of 0.675, 0.653, 0.573, 0.509, 0.516, and 0.369 respectively. Other variables also exhibited positive correlations with each other, indicating inter - relationships among these factors.

5) The Structural Equation Model and Hypotheses Test

The proposed structural equation model was constructed using AMOS. The main fit indices, including $\chi 2=202$, df=113, $\chi 2/df=1.79$, GFI=0.9435, CFI=0.983, NFI=0.963, TLI=0.980, IFI=0.984, and RMSEA=0.045, met the requirements, suggesting that the model was reasonable and could effectively represent the relationships among variables.

In the process of hypothesis testing, this study adopted enterprise size, enterprise nature, enterprise age and industry as control variables to ensure the reliability and stability of the research results. The hypothesis test used the hierarchical regression analysis, indicated that Design thinking positively affected organizational innovation performance ($\beta = 0.566$, $P < 0.001$), so H1 was significant.

About hypotheses testing of mediating effects of exploitative digital transformation, this study adopted the hierarchical regression analysis with control variables, and the research results indicated that Design thinking positively affected exploitative digital transformation ($\beta = 0.697$, $P < 0.001$), exploitative digital transformation positively affected organizational innovation performance ($\beta = 0.550$, $P < 0.001$), and exploitative digital transformation had a mediating effect between the above two variables ($\beta = 0.304$, $P < 0.001$). Furthermore, the Bootstrap method had

been used to verify the mediating effect of exploitative digital transformation(Effect =0.263). So H2-H4 were significant.

About hypotheses testing of mediating effects of exploratory digital transformation, this study adopted the hierarchical regression analysis with control variables, and the research results indicated that Design thinking positively affected exploratory digital transformation ($\beta = 0.677$, $P < 0.001$), exploratory digital transformation positively affected organizational innovation performance ($\beta = 0.570$, $P < 0.001$), and exploratory digital transformation had a mediating effect between the above two variables ($\beta = 0.344$, $P < 0.001$). Furthermore, the Bootstrap method had been used to verify the mediating effect of exploratory digital transformation(Effect =0.289). So H5-H7 were significant.

About verification of moderating effects, hierarchical regression analysis was used. The regulatory environment was unable to moderate the influence of Design Thinking on organizational innovation performance (H8 not supported). In contrast, the normative environment ($\beta= 0.166$, $p < 0.05$) and cognitive environment ($\beta= 0.172$, $p < 0.05$) positively moderated this relationship (H9 and H10 supported). Interaction effect graphs further validated these findings.

In summary, the results of hypotheses testing indicated H1 - H7 and H9 - H10 were accepted, while H8 was rejected.

5.1.2 Qualitative Results

1) Interview opinions from In-depth Interview

Through in-depth interviews with 16 participants including 3 government officials, 3 scholars, and 10 managers of SMEs, seven main opinions were obtained. All parties recognized the importance of design thinking factors including user-centered, abductive reasoning, team diversification, iteration & experimentation, and visualization & representation, in promoting enterprise development. They also agreed on the significance of digital transformation ambidexterity for SMEs, and the positive relationship between design thinking and innovation performance. The mediating role

of digital transformation ambidexterity and the partial moderating role of the institutional environment were also discussed.

2) Developing a design thinking application model in SMEs

In current developed economies, product as a service (PaaS) , the proportion of the service industry is gradually increasing, with service-based economies emphasizing the importance of user experience and a large number of SMEs belonging to the service sector. Among innovative SMEs, while the majority are in manufacturing, an increasing number belong to producer services. Design thinking serves as a core capability of enterprises, as capabilities form the foundation for action, and digital transformation can be viewed as an organizational change initiative—capabilities are a prerequisite for action, meaning that when corresponding capabilities are lacking, actions may struggle to be effectively implemented, and similarly, enterprises lacking design thinking have a low success rate in digital transformation. Successful digital transformation can bring outstanding innovation performance to enterprises, such as more flexible business models, improved efficiency of corporate internal processes, enhanced ability to integrate external resources, and reduced average cost of business operating income.

5.2 Discussion

This section explained the effects between the variables in this research.

5.2.1 The effect of design thinking on organizational innovation performance

A critical mechanism linking Design Thinking to innovation performance is its capacity to overcome cognitive and structural inertia within organizations. Despite its strengths, Design Thinking's indirect financial impact and resource intensity pose challenges. While Design Thinking enhances operational creativity and idea generation, its direct correlation with short-term financial metrics is weak, as benefits materialize through long-term brand equity and customer loyalty (Teerayout Wattanasupachoke, 2012). This study is conducted at the organizational level, while most existing research focuses on the individual and team levels. In SMEs, due to their relatively single-line business operations, closer organizational collaboration, and dynamic role changes

among personnel, organizational-level research is more suitable. At the organizational level, the focus is on innovation performance, not on corporate performance.

In this study, Design Thinking directly enhances SMEs innovation performance. Design Thinking and organizational innovation performance elucidates a multifaceted relationship wherein Design Thinking acts as a catalytic framework for fostering innovation through user-centered problem-solving, iterative experimentation, and cross-functional collaboration. Rooted in its core principles, including empathy, ideation, prototyping, and testing, Design Thinking enhances innovation performance by systematically aligning organizational outputs with latent user needs while mitigating risks associated with market misalignment.

In this study, quantitative and qualitative results demonstrate that design thinking positively impacts organizational innovative performance. The five factors of design thinking, namely user - centeredness, abductive reasoning, team diversification, iteration & experimentation, and visualization & representation, each contribute to different aspects of organizational innovation performance. User - centeredness helps enterprises make their business models more flexible by focusing on customer needs and enabling the discovery of new market opportunities. Abductive reasoning allows companies to break away from traditional thinking patterns, thereby improving the efficiency of internal processes as it encourages creative problem - solving and optimization. Team diversification enhances enterprises' ability to integrate external resources because diverse teams can draw on a wider range of knowledge and connections. Iteration & experimentation reduces the average cost of business operating income by identifying and correcting problems early, minimizing waste and inefficiencies. Visualization & representation supports all these aspects of organizational innovation performance. It facilitates communication and understanding within the organization, ensuring that ideas can be effectively conveyed and implemented, thus contributing to a more flexible business model, improved internal process efficiency, enhanced external resource integration, and reduced operating costs.

5.2.2 The effect of design thinking on digital transformation

The relationship between design thinking and digital transformation in SMEs is characterized by a symbiotic interplay that addresses the inherent challenges of digital transformation "wicked problem" while enabling SMEs to navigate resource constraints and organizational inertia. Quantitative findings confirm that Design Thinking positively influences digital transformation outcomes in SMEs, a relationship further elaborated through qualitative insights. For SMEs, digital transformation presents a unique challenge due to their limited budgets, technical expertise, and need to prioritize critical pain points over large-scale, all-encompassing solutions.

Design thinking, as a human-centered, iterative framework, provides a structured yet flexible approach to tackle these challenges. Its emphasis on empathetic problem-solving helps SMEs clarify user needs and internal circumstances, aligning technological adoption with strategic goals rather than pursuing technologies blindly—a critical factor in avoiding misallocated investments. The "experimentation and iteration" principle of Design Thinking enables SMEs to adopt gradual, phased digital transformation strategies, mitigating risks of disruptive failure and ensuring alignment with their operational realities. Beyond technical adoption, Design thinking addresses organizational barriers: by fostering cross-departmental collaboration through visualization tools (e.g., journey maps, prototypes), it resolves siloed decision-making and aligns stakeholders around shared objectives. Senior executives, when equipped with Design thinking methodologies, can drive cultural change by modeling innovative behaviors, enhancing leadership influence, and improving organizational synergy. The "visualization" aspect of Design thinking further supports SMEs in establishing clear data governance frameworks and quantifiable metrics, enabling evidence-based decision-making. Crucially, Design thinking empowers SMEs to confront digital transformation uncertainties by focusing on problem essence, strengthening their innovation capabilities, and building value systems rooted in organizational competencies rather than mere technological adoption.

Digital transformation is a prolonged process requiring strategic foresight, resource allocation for targeted goals, and sustained Design thinking integration to avoid deviations from core development trajectories (Habicher et al., 2022； Oliveira et al., 2024). By prioritizing user-centered, incremental progress, and adaptive

governance, Design thinking not only resolves immediate pain points but also cultivates a sustainable innovation core, enhancing competitive advantage. This study underscores Design thinking as indispensable for SMEs, offering a bridge between digital transformation abstract challenges and actionable, context-specific solutions—transforming digital transformation from a risky, resource-draining endeavor into a coherent, value-driven process aligned with organizational capabilities. The alignment of quantitative and qualitative findings reinforces Design thinking's role as both a strategic tool and a cultural catalyst, enabling SMEs to harness digital transformation potential without overextending their limitations.

5.2.3 The mediating role of digital transformation ambidexterity

Quantitative and qualitative studies collectively demonstrate that design thinking practices positively influence the innovation performance of SMEs, mediated by digital transformation ambidexterity. This ambidexterity comprises two dimensions: exploitative digital transformation, which involves refining and optimizing existing digital resources, and exploratory digital transformation, which focuses on pursuing emerging technological opportunities (Zhang et al., 2023). Research results indicate that design thinking indirectly enhances innovation capabilities by enabling SMEs to harmonize these dual pathways. Grounded in user-centered methodologies, design thinking guides organizations to identify critical operational challenges and strategically prioritize digital initiatives, thereby balancing short-term efficiency gains with long-term innovation goals under resource constraints. Exploitative digital transformation, supported by iterative experimentation inherent to design thinking, facilitates incremental improvements such as process optimization and cost reduction. For example, rapid prototyping and continuous feedback loops allow SMEs to refine existing digital systems and improve resource efficiency. Concurrently, design thinking mitigates risks in exploratory digital transformation, which involves experimenting with novel technologies, business models, or markets. Through collaborative workshops and user journey mapping, design thinking ensures alignment between technological exploration and genuine user needs, thereby reducing speculative investments.

Qualitative insights further highlighted that the organizational culture fostered by design thinking alleviates tensions between exploitative and exploratory activities. By establishing a shared commitment to user value, SMEs can synergize efficiency-driven optimization with breakthrough innovation, transforming potential conflicts into complementary strategies. This dynamic equilibrium in ambidextrous capabilities enabled SMEs to sustain operational stability while cultivating future-oriented digital competitiveness. Crucially, the mediating role of digital transformation ambidexterity underscores the path-dependent nature of innovation performance enhancement. Rather than directly driving outcomes, design thinking reshapes strategic cognition and execution patterns in digital transformation, fostering organizational adaptability that bridges incremental refinement and radical change. These findings provide actionable guidance for SMEs, emphasizing the integration of design thinking into ambidextrous capability development. By embedding continuous user-centered insights and agile iteration into digital transformation processes, SMEs can achieve sustainable innovation growth despite resource limitations, positioning themselves competitively in evolving markets.

5.2.4 The moderating role of institutional environment

This study investigated how institutional environments moderate the relationship between design thinking and organizational innovation performance. Results demonstrate that the regulatory environment fails to exert a significant moderating effect, suggesting that compliance-focused frameworks may lack the flexibility needed to enhance the influence of design thinking. Regulatory rigidity, often tied to prescriptive mandates and bureaucratic limitations, appears incompatible with the iterative and user-centered nature of design thinking, which requires environments that prioritize experimentation and adaptive problem-solving. In contrast, both normative and cognitive environments positively moderate this relationship. The normative environment, rooted in industry standards and collaborative practices, establishes a cultural framework that validates design thinking as a strategic imperative, enabling organizations to integrate its principles with operational goals. The cognitive environment, shaped by shared knowledge systems and collective learning, strengthens

organizational capacity to interpret and implement design thinking methodologies, translating abstract ideas into actionable strategies.

These findings emphasize the inadequacy of regulatory-heavy approaches in driving innovation, particularly for SMEs operating in rapidly evolving markets. While SMEs remain cautious about policy alignment, their focus on supply chain collaboration reflects a pragmatic emphasis on institutional frameworks that bolster operational resilience. This caution may stem from perceived risks of regulatory instability or mismatches between policy incentives and SME resource constraints (Peng, 2003). Policymakers should therefore prioritize adaptable and inclusive institutional designs. Strengthening normative alignment through cross-sector partnerships could institutionalize design thinking as a collaborative practice, while enhancing cognitive cohesion via knowledge-sharing networks would help SMEs implement design thinking to their specific challenges.

The study contributes theoretically by delineating the distinct roles of regulatory, normative, and cognitive environments in shaping innovation outcomes. Practically, it advocates transitioning from rigid regulatory interventions to ecosystem-oriented strategies that nurture shared norms and cognitive synergies. For SMEs, successfully embedding design thinking into innovation strategies demands not only methodological adoption but also active engagement with industry networks to co-develop standards and assimilate domain expertise. Policymakers can support this shift by incentivizing collaborative innovation through grants for cross-organizational projects or tax benefits for workforce training in design thinking competencies. Ultimately, the synergy between organizational agility and supportive institutional ecosystems emerges as pivotal for sustainable innovation. By aligning the user-driven principles of design thinking with robust normative and cognitive infrastructures, SMEs can effectively navigate institutional complexities while maximizing their innovation potential in an increasingly interconnected digital landscape.

5.2.5 Limitations of the study

While this study offers valuable insights into innovation management for SMEs, several limitations should be acknowledged.

(1) Geographic Region

The research sample focuses exclusively on innovative SMEs in Guangxi, where regional economic characteristics, policy environments, and cultural contexts may limit the generalizability of findings. Actually, the industrial structure and digital transformation maturity of Guangxi differ from other regions in China. Guangxi Province belongs to the Western Region of China and shows a significant gap compared to Guangdong Province in the eastern part.

(2) Time relevance

The data collection period for this study was from January to May 2025. Given the rapid development of disruptive technological revolutions, such as the accelerated evolution of AI technology, and the dynamic changes in the institutional environment, such as tariff issues, the findings of this study have strong timeliness and represent research achievements at specific time nodes.

(4) Cultural context

Rooted in Western innovation management theories, design thinking encounters significant adaptation challenges when aligning its core principles with the Chinese cultural context. Moreover, as a subjective management philosophy, the measurement of design thinking relies on self-assessments by managers of SMEs through survey questionnaires, which may involve potential cognitive biases.

5.3 Recommendation

5.3.1 Policy recommendation for development of SMEs

1) Regulatory Framework Optimization

The regulatory environment has not significantly influenced the link between design thinking and innovation performance. Therefore, policymakers should review and improve the current regulatory systems for SMEs. They should simplify administrative processes related to digital transformation and innovation. This includes improving the business environment, reducing administrative workloads, and

enhancing intellectual property protection. By doing so, SMEs can save resources and focus more on innovation driven by design thinking.

2) Normative and Cognitive Environment Cultivation

Policymakers should enhance the development of normative and cognitive environments. In terms of the normative environment, they should promote industry standards that encourage innovation based on design thinking. For instance, they can create awards or recognition programs for SMEs that successfully apply design thinking in an environmentally friendly and socially responsible manner. Regarding the cognitive environment, policymakers should organize industry - wide knowledge - sharing platforms, such as regular seminars or workshops. These platforms enable SMEs to learn advanced design - thinking methods and successful practices.

3) Financial and Resource Support

Governments should offer more targeted financial assistance to SMEs. They can provide tax benefits specifically for research and development (R&D) activities related to design thinking and digital transformation. For example, SMEs that invest in design - thinking training programs or adopt digital technologies can receive tax reductions. Additionally, more funds should be allocated for digital infrastructure development in areas with a high concentration of SMEs. This ensures that these enterprises have access to the essential digital resources they need.

5.3.2 Recommendation for action

1) For SMEs Leaders

Design Thinking Adoption: SMEs leaders should make design thinking a core part of their organizational strategy. They need to create a corporate culture that values creativity, empathy, and iterative problem - solving. This can be achieved by training all employees in design - thinking methodologies, from basic user - centered design concepts to advanced abductive reasoning techniques.

Digital Transformation Balance: SMEs leaders should recognize the importance of balancing exploitative and exploratory digital transformation. Allocate resources strategically between improving existing digital processes (exploitative) and

exploring new digital business models (exploratory). For example, set up cross-functional teams to work on both types of transformation simultaneously, ensuring that short-term efficiency improvements support long-term innovation goals.

Alignment with Environmental Norms: SMEs leaders should align innovation strategies with industry standards and ethical expectations. Stay updated on the latest normative trends in the industry and adjust the company's design-thinking-based innovation efforts accordingly. Foster a cognitive environment that encourages continuous learning and adaptability among employees, so they can better implement design - thinking principles.

2) For Government Officials

Policy-Making and Promotion: In addition to regulatory improvements, government officials should play an active role in promoting design thinking and digital transformation in SMEs. Organize workshops, seminars, and training programs across different regions to disseminate knowledge about these methodologies. Benchmark and recognize innovative SMEs at a regional or national level to create a competitive environment that drives further innovation.

Resource Provision: Government officials should ensure that SMEs have access to digital resources and infrastructure. This can be done by subsidizing digital tools and technologies, offering low-interest loans for digital transformation projects, and establishing innovation hubs. These hubs can serve as collaborative spaces where SMEs can share resources, exchange ideas, and collaborate on design - thinking - related projects.

5.3.3 Recommendation for future study

1) Expanding Research Scope

Researchers should conduct studies using a wider geographical sample. They should compare SMEs in different economic regions of China or even in various countries. This approach will help clarify how differences in institutions, such as policy stability and market openness, influence the relationship between design thinking, digital transformation, and innovation performance.

2) Longitudinal and Multi-source Data

Researchers need to adopt mixed-methods designs that combine longitudinal data. They should track the joint development of design thinking, digital flexibility, and innovation performance over time. Additionally, researchers should use multi-source datasets, including corporate annual reports, digital investment records, and objective performance indicators like the number of patents, to make research findings more reliable.

3) In-depth Exploration of Institutional Mechanisms

Researchers should further explore the institutional mechanisms involved. They should study how regulatory environments have different impacts during various policy cycles, for example, the effects of technology subsidy periods compared to times when regulations become stricter. Also, researchers should investigate how SMEs use design thinking to deal with conflicting institutional requirements.

4) Model Expansion

Researchers can expand the current research model by adding more mediators, such as organizational learning abilities, or moderators, like digital leadership and supply chain cooperation. Doing this will reveal more ways that design thinking can help SMEs improve their innovation performance.

5) Methodological Improvements

Researchers should develop measurement tools for design thinking that fit specific situations. They should carry out more case studies and experiments to understand the difficulties of implementing design thinking in SMEs and find effective ways to resolve conflicts within organizations.

6) Policy-oriented Research

Researchers should focus on policy-oriented research. They should analyze how local governments can strengthen the institutional support systems for SMEs. This includes actions like offering design thinking training programs for employees, setting industry-specific innovation standards, and promoting digital transformation when

resources are limited. Such research will contribute to creating both theoretical frameworks and practical strategies for building regional innovation ecosystems.

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APPENDIX

A: IOC Test Of Questionnaire

Items of Design Thinking

		IOC from Experts						
Question item		1	2	3	4	5	Total	Avg.
User-centered								
UC1	Can take the initiative to communicate with customers to understand the special needs of customers	1	1	1	1	1	5	1
UC2	Can increase customer demand over other positions	1	1	1	0	1	5	0.8
UC3	Can actively ask customers about the real reasons behind the specific needs	1	1	1	1	1	5	1
UC4	Customer business scenarios are integrated to determine whether the proposed solution is working	1	1	1	1	1	5	1
Abductive reasoning								
AR1	When facing a problem, you can quickly form a variety of possible explanations, and choose the most reasonable explanation	1	0	1	1	1	4	0.8
AR2	Regularly collectively share and evaluate the collected information and verify various hypotheses	1	1	1	1	1	5	1
AR3	Efficient consensus in the face of uncertainty	1	1	0	1	1	4	0.8
AR4	Encourage employees to think backwards and try different assumptions	1	1	1	1	1	5	1
Team diversification								
TD1	Encourage employees from different professional backgrounds to conduct in-depth exchanges and cooperation	1	1	1	1	1	5	1
TD2	Employees on different resumes in a company team can work deeply together	1	1	1	1	1	5	1

		IOC from Experts						
Question item		1	2	3	4	5	Total	Avg.
TD3	Employees from different cultural backgrounds in the company team can work together	1	1	1	1	1	5	1
TD4	Employees with different personalities in the company team can work together	1	1	1	1	1	5	1
Iteration and Experimentation								
IT1	Understanding of requirements is changing increasingly during product / service design development	1	1	1	1	1	5	1
IT2	As organizational learning deepens, the final solution is redefined	1	1	1	1	1	5	1
IT3	Experiments use different concepts and techniques, and directions are constantly being corrected	1	1	1	1	1	5	1
IT4	Believing the problem-solving process needs to be productive and has no ultimate standard	1	1	1	1	0	4	0.8
Visualization and Representation								
VI1	Emphasis on the training and promotion of visual tools in the company	1	1	1	0	1	4	0.8
VI2	Employees are good at using visual tools to share ideas	1	1	0	1	1	4	0.8
VI3	Good at using visualization tools in all aspects of project management	1	1	1	1	1	5	1
VI4	Be good at using visualization tools or design prototypes to the customer	1	1	1	1	1	5	1

Items of Digital transformation

		IOC from Experts						
Question item		1	2	3	4	5	Total	Avg.
Exploitative digital transformation								
EIDT1	Actively learn about digital content	1	1	1	1	1	5	1
EIDT2	Organize employees to participate in digital-related training regularly	0	1	1	1	1	4	0.8

		IOC from Experts						
Question item		1	2	3	4	5	Total	Avg.
EIDT3	Be able to use information technology tools to assist in the work to improve the efficiency of related businesses	1	1	1	1	1	5	1
EIDT4	Be able to slightly optimize existing products and services using digital technology	1	1	1	1	1	5	1
Exploratory digital transformation								
ERDT1	Establish an innovation incentive system for key businesses integrated with digital integration	1	1	1	1	1	5	1
ERDT2	Set up special digital positions or departments	1	1	1	1	1	5	1
ERDT3	Have been increasing the proportion of investment in digital transformation	1	1	1	1	1	5	1
ERDT4	Focus on customer engagement in the digital transformation	1	0	1	1	1	4	0.8

Organizational innovation performance

		IOC from Experts						
Question item		1	2	3	4	5	Total	Avg.
IP1	The business model of enterprises is more flexible	1	1	1	1	1	5	1
IP2	The efficiency of corporate internal processes has been improved	1	1	1	1	1	5	1
IP3	The ability of enterprises to integrate external resources has been improved	1	0	1	1	1	4	0.8
IP4	The average cost of business operating income has decreased	1	1	1	1	1	5	1

Institutional environment

	IOC from Experts						
Question item	1	2	3	4	5	Total	Avg.
Regulatory Environment							

		IOC from Experts						
Question item		1	2	3	4	5	Total	Avg.
RE1	The government and relevant institutions provide financial support and tax incentives to innovative SMEs	1	1	1	1	1	5	1
RE2	The government provides special policies for SMEs in financing loans, intellectual property protection and government procurement	1	1	1	1	1	5	1
RE 3	The government builds platforms such as entrepreneurship parks and incubators to provide office space, facilities and consulting services for SMEs.	1	1	1	1	1	5	1
RE 4	The government provides personnel training and personnel introduction assistance for SMEs.	1	0	1	1	0	3	0.6
Normative Environment								
NE1	Enterprises know how to legally maintain a competitive edge	1	1	1	1	1	5	1
NE2	Enterprises have a clear understanding of the risk of innovation	1	1	1	1	1	5	1
NE3	Enterprises have a mechanism to deal with innovation risks	1	1	1	1	1	5	1
NE4	Companies can obtain business development information from the market	1	1	1	1	1	4	0.8
Cognitive Environment								
CE1	Enterprises praise employees for their ideas and practice in their work	1	1	1	1	1	4	0.8
CE2	Innovation is an important part of our corporate culture	1	1	1	1	1	5	1
CE3	Innovative talents are respected in the enterprise	1	1	1	1	1	5	1
CE4	Enterprise employees all take innovative talents as role models.	1	1	1	1	1	5	1

B: Survey Questionnaire

Dear Miss/Mr:

Hi, Thank you very much for participating in this questionnaire survey on the impact of SMEs' innovation performance through digital transformation. This questionnaire is filled out anonymously. The data of this survey is only used for academic research, and will not involve the trade secrets of you and your company. I solemnly promise that your company and your personal information will be completely confidential and the research data will not be used for commercial purposes. There are no right or wrong answers to the questionnaire, please rest assured to answer. If you feel that a question does not fully represent your opinion, please choose the answer closest to your idea. Your truthful filling is of great significance to my research. If you need to consult the academic results of this research, you can contact me for it. Thank you again for your support!

Contact: Email: sunnywq@foxmail.com

The following is a description about your business. Please choose according to your actual situation and the answer, the greater the degree is the number, 1 said "completely not" or "worse than most companies", "2 said" or "worse than most companies," 3 "said" average "or" medium level, "4" more "or" better than most companies ", 5" fully meet "or" better than most companies ", please check the options you think right.

Mrs. Wang Qin, Ph.D. Candidate

Siam University

TIPS: Please do not proceed with this survey if your enterprise is not classified as an innovative SME in Guangxi.

Part I: Basic information

number	item
1	Your gender A. man B. woman
2	Your position in the company A. middle managers B. senior manager
3	Size of your enterprise: A. is less than 20 people B. 20-299 people C. 300-1,000 people
4	The nature of your business A. state-owned enterprise B. private enterprises C. foreign company D. other
5	Industry you are in A. Traditional manufacturing industry (including chemical industry, automobile, electronics, food, machinery, textile, construction, etc.) B. Service industry (including transportation, communications, trade, consulting, finance, catering, retail, education and training, etc.) C. High-tech industries (Passing the certification of high-tech enterprise qualification) D. other
6	The term of the establishment of your enterprise A. less than 5 years B. 5-10 years C. 10-15 years D. More than 15 years

Part two: Items of Design Thinking

Question item	1	2	3	4	5

User-centered						
UC1	Can take the initiative to communicate with customers to understand the special needs of customers					
UC2	Can increase customer demand over other positions					
UC3	Can actively ask customers about the real reasons behind the specific needs					
UC4	Customer business scenarios are integrated to determine whether the proposed solution is working					
Abductive reasoning						
AR1	When facing a problem, you can quickly form a variety of possible explanations, and choose the most reasonable explanation					
AR2	Regularly collectively share and evaluate the collected information and verify various hypotheses					
AR3	Efficient consensus in the face of uncertainty					
AR4	Encourage employees to think backwards and try different assumptions					
Team diversification						
TD1	Encourage employees from different professional backgrounds to conduct in-depth exchanges and cooperation					
TD2	Employees on different resumes in a company team can work deeply together					
TD3	Employees from different cultural backgrounds in the company team can work together					
TD4	Employees with different personalities in the company team can work together					
Iteration and Experimentation						
IT1	Understanding of requirements is changing increasingly during product / service design development					
IT2	As organizational learning deepens, the final solution is redefined					

IT3	Experiments use different concepts and techniques, and directions are constantly being corrected					
IT4	Believing the problem-solving process needs to be productive and has no ultimate standard					
Visualization and Representation						
VI1	Emphasis on the training and promotion of visual tools in the company					
VI2	Employees are good at using visual tools to share ideas					
VI3	Good at using visualization tools in all aspects of project management					
VI4	Be good at using visualization tools or design prototypes to the customer					

Part three: Items of Digital transformation

Question item		1	2	3	4	5
Exploitative digital transformation						
EIDT1	Actively learn about digital content					
EIDT2	Organize employees to participate in digital-related training regularly					
EIDT3	Be able to use information technology tools to assist in the work to improve the efficiency of related businesses					
EIDT4	Be able to slightly optimize existing products and services using digital technology					
Exploratory digital transformation						
ERDT1	Establish an innovation incentive system for key businesses integrated with digital integration					

ERDT2	Set up special digital positions or departments					
ERDT3	Have been increasing the proportion of investment in digital transformation					
ERDT4	Focus on customer engagement in the digital transformation					

Part four: Organizational innovation performance

Question item		1	2	3	4	5
IP1	The business model of enterprises is more flexible					
IP2	The efficiency of corporate internal processes has been improved					
IP3	The ability of enterprises to integrate external resources has been improved					
IP4	The average cost of business operating income has decreased					

Part five: Institutional environment

Question item		1	2	3	4	5
Regulatory Environment						
RE1	The government and relevant institutions provide financial support and tax incentives to innovative SMEs					
RE2	The government provides special policies for SMEs in financing loans, intellectual property protection and government procurement					
RE 3	The government builds platforms such as entrepreneurship parks and incubators to provide office space, facilities and consulting services for small and medium-sized enterprises.					

RE 4	Small and medium-sized enterprises of the government will provide personnel training and personnel introduction assistance.					
Normative Environment						
NE1	Enterprises know how to legally maintain a competitive edge					
NE2	Enterprises have a clear understanding of the risk of innovation					
NE3	Enterprises have a mechanism to deal with innovation risks					
NE4	Enterprises can obtain business development information from the market					
Cognitive Environment						
CE1	Enterprises praise employees for their ideas and practice in their work					
CE2	Innovation is an important part of our corporate culture					
CE3	Innovative talents are respected in the enterprise					
CE4	Enterprise employees all take innovative talents as role models.					

C: Interview Protocol

Interview Protocol of the Topic" Design Thinking and Innovation Performance Through the Mediating Effects of Digital Transformation Ambidexterity: A Case Study of Innovative SMEs in Guangxi, China "

Hello,

Thank you for accepting my invitation to be interviewed in your capacity as a recognized scholar and subject matter expert in the business intelligence subject area.

Today, SMEs are challenged to gain sustainability and competitive market advantage by their larger-sized competitors' rapid adoption of innovative business models. Leaders, engineers, and designers must cooperate to build cross-functional team collaboration to successfully embed the design-thinking process in SMEs to enhance innovation.

The results of the study may contribute to processes for SMEs leaders to enhance organizational development and implement change management strategies to address market conditions and maintain business competitiveness. This study may also contribute to the effective practice of SMEs by leaders implementing design thinking as an organizational development strategy and addressing change for the business.

Are we ready to begin?

Q1	Do you agree that design thinking has five factors including user-centered, abductive reasoning, team diversification, iteration & experimentation, and visualization & representation? Why?

Q2	Do you agree that digital transformation ambidexterity, which divides into exploitative and exploratory digital transformation? Why?
Q3	Do you agree that design thinking is positively associated with the innovation performance of innovative SMEs? Why?
Q4	Do you agree that design thinking is positively associated with digital transformation ambidexterity of innovative SMEs? Why?
Q5	Do you agree that digital transformation ambidexterity is positively associated with innovation performance of innovative SMEs? Why?
Q6	Do you agree that digital transformation ambidexterity plays a mediating role in the influence of design thinking on the innovation performance of innovative SMEs? Why?
Q7	Do you agree that institutional environment plays a moderating effect on the influence of design thinking on innovation performance of innovative SMEs? Why?
Q8	How can implementing design thinking enhance the innovation performance of an innovative SME?

Debrief:

Thank you for assisting me with this research study. I will contact you via email once the transcription from our interview is finalized. I will provide a summary of the interview, and I would like you to review the summary to confirm that I have captured the essence of what you have shared with me. If any discrepancies are found, I will correct the interpretations. Do you have any questions? Please contact me at any point if you have any questions.

D: Ethics Approval Certification

ใบรับรองจริยธรรมการวิจัยในมนุษย์
สถาบันการจัดการปัญญาภิวัฒน์

หมายเลขใบรับรอง: PIM-REC 008/2568

ข้อเสนอการวิจัยนี้ และเอกสารประกอบของข้อเสนอการวิจัยตามรายการแสดงด้านล่าง ได้รับการพิจารณาจากคณะกรรมการจริยธรรมการวิจัยในมนุษย์ สถาบันการจัดการปัญญาภิวัฒน์แล้ว คณะกรรมการฯ มีความเห็นว่าข้อเสนอการวิจัยที่จะดำเนินการมีความสอดคล้องกับหลักจริยธรรมสากล ตลอดจนกฎหมายข้อบังคับและข้อกำหนดภายในประเทศ จึงเห็นสมควรให้ดำเนินการตามข้อเสนอการวิจัยนี้ได้

ชื่อข้อเสนอโครงการ: Design Thinking and Innovation Performance of Small and Medium-sized Enterprises in Guangxi: the Mediating Effects of Digital Transformation Ambidexterity

รหัสข้อเสนอการวิจัย (ถ้ามี): -

หน่วยงาน: Siam University

ผู้วิจัยหลัก: Wang Qin

ลงนาม.....

(อาจารย์ ดร.พิเชษฐ์ มุสิกะโปตก)
ประธานคณะกรรมการจริยธรรมการวิจัยในมนุษย์
สถาบันการจัดการปัญญาภิวัฒน์

วันที่รับรอง: 4 มีนาคม 2568 **วันหมดอายุ:** 4 มีนาคม 2569

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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