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The Impact of C2M Enterprise Digital Transformation and Cross Border Cooperation on Sustainable Competitive Advantage

HE Xiaoqiang

Doctor of Management

Supervisors:
PhD Ricardo Godinho Bilro, Assistant Professor with Habilitation,
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University of Electronic Science and Technology of China

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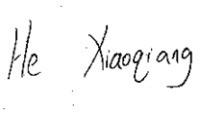
Signed:  Date: 2024.12.1

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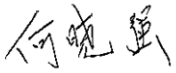
作者签名：  日期：2024.12.1

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Abstract

With the rapid development of digital economy, digital transformation of enterprises is imperative, and more and more manufacturers and e-commerce platforms have begun to introduce C2M (Customer to Manufacturer) mode for production and sales. Under this model, production enterprises can reduce costs, eliminate the overstocked inventory, and create their own brands. On the other hand, consumers can choose goods customized to their needs. Therefore, the C2M mode enables a win-win cooperation between supply and demand.

This study focuses on the following questions: first, how the digital transformation of C2M enterprises affects enterprises to gain sustainable competitive advantage; second, what role cross-border cooperation plays between digital transformation and sustainable competitive advantage; and third, whether enterprise size, enterprise region and management level play a role in the sustainable competitive advantage of enterprises during digital transformation.

This thesis uses empirical research methods such as expert interviews and questionnaire surveys to examine the hypothesized relationships between the variables. It was concluded that technology readiness, the degree of digital transformation, and the width of cross-border cooperation have a positive impact on the sustainable competitive advantage of enterprises; technology readiness and the degree of digital transformation have a positive impact on cross-border cooperation; and cross border cooperation plays a mediating role the relationships of technology readiness and the degree of digital transformation with the sustainable competitive advantage of enterprises.

Keywords: digital transformation, C2M, cross-border cooperation, value co-creation, competitive advantage

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Resumo

Com o rápido desenvolvimento da economia digital, a transformação digital das empresas tornou-se imperativa, e um número crescente de fabricantes e plataformas de comércio eletrónico começaram a introduzir o modelo C2M (consumidor-para-fabricante) para a produção e vendas. Neste modelo, os fabricantes reduzem custos, eliminam o excesso de stock e podem criar as suas próprias marcas. Os consumidores, por sua vez, escolhem bens personalizados que realmente correspondem às suas necessidades, promovendo uma cooperação mutuamente vantajosa entre a oferta e a procura.

Esta tese centra-se nas seguintes questões: primeiro, como é que a transformação digital das empresas C2M influencia a obtenção de uma vantagem competitiva sustentável; segundo, qual o papel da cooperação transfronteiriça na relação entre a transformação digital e a vantagem competitiva sustentável; e, terceiro, se o tamanho da empresa, a região onde se localiza e o nível de gestão desempenham algum papel na vantagem competitiva sustentável das empresas em transformação digital.

Esta dissertação utiliza métodos de investigação empírica tais como entrevistas com especialistas e inquéritos por questionário para verificar as relações hipotéticas entre as variáveis. Através da investigação conduzida, concluiu-se que a preparação tecnológica para a transformação digital, o grau de transformação digital e a extensão da cooperação transfronteiriça têm um impacto positivo na vantagem competitiva sustentável das empresas. A preparação tecnológica para a transformação digital e o grau de transformação digital também têm um impacto positivo na cooperação transfronteiriça. A cooperação transfronteiriça desempenhou um papel mediador entre a preparação tecnológica para a transformação digital, o grau de transformação digital e a vantagem competitiva sustentável das empresas.

Palavras-chave: transformação digital, C2M, cooperação transfronteiriça, cocriação de valor, vantagem competitiva

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摘要

随着数字经济的快速发展，企业数字化转型势在必行，越来越多的制造商和电商平台开始引入 C2M（Customer to Manufacturer）模式进行生产和销售。在这种模式下，生产企业降低了成本，并且消除了积压的库存，并创建了自己的品牌。反过来，消费者选用的是真正适合自己的定制化商品，实现供需双方的合作共赢。

本研究重点关注以下几个问题：第一，C2M 企业数字化转型如何影响企业获得可持续竞争优势；第二，跨界合作在数字化转型与企业获得可持续竞争优势之间发挥何种作用；第三，企业规模、企业地域、管理层级在数字化转型企业获得可持续性竞争优势中是否发挥作用。

本文采用专家访谈和问卷调研等实证研究方法，验证变量之间的假设关系。通过研究得出结论，数字化转型技术准备、数字化转型转型程度、跨界合作的合作广度对企业可持续竞争优势具有正向影响。数字化转型技术准备和数字化转型转型程度对跨界合作具有正向影响。跨界合作在数字化转型技术准备、数字化转型转型程度与企业可持续竞争优势之间发挥了中介作用。

关键词：数字化转型，C2M，跨界合作，价值共创，竞争优势

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My doctoral studies will come to an end. Looking back on my doctoral years, what impresses me most is the countless nights I spent looking up materials on the computer and the countless weekends I spent writing thesis in the library. The process of studying for a PhD is difficult, as it not only requires a lot of time but also faces and solves all kinds of academic problems that suddenly arise. In the face of a vast ocean of academic unknowns, we often feel small. Once upon a time, the conflict between study and work, as well as pressure from my family, occasionally made it difficult for me to persist in pain. However, the initial intention of studying and the support from schoolteachers, relatives, and friends made me calm down, calmly solve one academic problem after another, and overcome all kinds of difficulties brought by work and family. Looking back, in addition to the improvement of academic ability, is it not a process of coordinating resources and adjusting my mind to meet unknown challenges? In the early stages of graduation, I have so many thanks that I can only express my sincere gratitude in the simplest language.

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I will always miss every struggling day during my doctoral studies. No matter what difficulties I face or achievements I make in the future, my rigorous, practical, and tenacious academic experience will become a character quality that will accompany me for a lifetime!

Chengdu, Sichuan Province, November 2024

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时光如梭，转眼博士求学生涯即将结束。回想读博时光，我印象最为深刻的就是无数个夜晚在电脑旁查阅资料，无数个周末在图书馆撰写论文。读博过程是艰辛的，不止要付出大量的时间，还要面对和解决突如其来的各种学术问题。在学术未知的浩瀚海洋面前，时常会感到自己的渺小。曾几何时，学习和工作的冲突，和来自家庭的压力让我偶然有过难以坚持的痛苦，但是求学的初心和来自学校老师、亲朋好友的支持，让我沉下心来，冷静解决遇到的一个又一个学术问题，克服工作和家庭带来的种种困难。回首来看，博士期间学习除了学术能力的提升，何尝又不是一个协调资源、调整心态迎接未知挑战的过程呢？在毕业前期，我有太多的感谢想要表达，仅以最朴素的语言表达最真挚的感激之情。

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人生旅途上的各色风景。

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我永远怀念博士学习阶段里每一个奋斗的日子，无论将来面临困难或取得一些成绩，这段严谨、踏实、坚韧的学术经历内化成的性格品质将陪伴我一生！

四川成都 2024 年 11 月

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List of Abbreviations

AMT	Advanced Manufacturing Technology
API	Application Programming Interface
BPDM	Business Partner Digital Maturity
C2M	Customer to Manufacturer
CC	Cloud Computing
CMC	Change Management Capability
CRM	Customer Relationship Management
CSM	Cybersecurity Maturity
DRP	Digital Readiness Pre-assessment
DSNS	Digital Supply Networks
ESD	External Support for Digitization
FMC	Flexible Manufacturing Capabilities
GDP	Gross Domestic Product
GiMS	Graduate-style Intelligent Manufacturing System
HPC	High Performance Computing
IDTE	Information and Digital Technology Expertise
IDTR	Information and Digital Technology Readiness
IoT	Internet of Things
JIT	Just in Time
MCDT	Management Capability Digital Transformation
MDSR	Manufacturing Digitization Strategic Roadmap
MES	Manufacturing Execution Systems
OIP	Operational Improvement Platform
OTR	Operational Technical Readiness
RSA	Resource Availability
SME	Small and Medium-sized Enterprises
SOA	Service Oriented Architecture

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Chapter 1: Introduction

1.1 Research background

1.1.1 Practical background

With the rapid development of digital economy and the comprehensive popularization of information technology, digital transformation of enterprises is imperative, and more and more manufacturers and e-commerce platforms have begun to introduce C2M mode for production and sales (X. Chen et al., 2024). C2M refers to the direct connection between end users in the market and commodity manufacturers through digital means. The end user of the market puts forward the purchase demand of goods and then drives the business model of commodity manufacturers to manufacture and produce. Compared with the traditional post-production sales model, the C2M model has the unique characteristics of low production cost, low supplier inventory level, and highly personalized production of goods (Yuan et al., 2024).

Manufacturers can obtain customer preferences through distributors and sales channels, carry out small batch and agile production, and expand the market scale for manufacturers, especially for the long-tail market, to gain competitive advantages (G. Y. Liu et al., 2024). For the e-commerce platform, by collecting the personalized and differentiated commodity demand of customers on the platform, providing sales orders to upstream suppliers to obtain the price difference, it can also improve the richness of commodities on the e-commerce platform, and then promote the improvement of users' satisfaction and loyalty to the e-commerce platform (B. He et al., 2023). Because the trading behavior based on the C2M model is initiated by the end users in the market, and then carries out the product design through digital means, and then the final production and manufacturing, the C2M model can ensure that the goods traded are the needs of users. Since the manufacturer arranges the production after receiving the order from the end user, the C2M model can effectively reduce the backlog of inventory and provide opportunities for manufacturers to create their own brands. This model achieves a win-win situation for both consumers and manufacturers (Dai & Li, 2022).

As a new industry that only developed around 2013, C2M still has huge room for future development. According to data from Analysis Consulting, a third-party market research company, China's e-commerce transactions of factory-directed supply and sales-based

production totaled 17.5 billion yuan in 2019, and the e-commerce market penetration rate was only 4.1 percent. According to Analysis research results, there is still a lot of room for improvement in the above markets, and the transaction scale is expected to reach 50 billion yuan in 2025. According to the data of the National Bureau of Statistics, China's population was 1.41 billion in 2023. Under the neutral assumption, the long-term penetration rate of C2M e-commerce can reach 10% and its target population size is 140 million in China only. According to the data of existing platforms such as Biyao Mall and Jingdong, under the neutral assumption, the per capita single consumption is 200 yuan, and the average annual purchase times are nine times (once every 1.5 months on average). Based on the above data and assumptions, the long-term market space for C2M e-commerce is 251.1 billion yuan (Y. Liu, 2021).

The C2M digital model combines advanced digital technologies such as AI, big data, cloud computing, 5G and the Internet of Things, so that merchants in the market can quickly and accurately understand the needs of end consumers, thus improving the accuracy of decision-making. For consumers, the C2M model can better meet their pursuit of personalization and cost performance. For manufacturers, the C2M model can reduce costs and lower commodity prices by directly connecting terminal consumption in the market, helping enterprises gain more users and expand their brand influence. Alibaba, Pinduoduo, Jingdong and other large integrated e-commerce platforms have accumulated a large number of users and channel resources in the traditional business model, with strong capital and good consumer education effect, which plays a huge role in accelerating the digital transformation of the C2M industry. Manufacturers are responsible for receiving customer orders collected by the platform for product production, and the C2M model provides them with a way to destock and reduce production costs. At present, they are actively participating in digital C2M model reform. Small C2M platforms are industry explorers, such as Biyao Mall, Youbi, E-enterprise Hi Buy, etc., have accumulated rich experience so far. Companies that have achieved commercial success in the traditional C2M development stage are now actively implementing digital transformation.

Similar to many other enterprises, with the intensification of industry competition, C2M participating enterprises, whether they are manufacturers, large and medium-sized e-commerce platforms, or C2M vertical e-commerce enterprises, have gradually introduced new technologies into all aspects of enterprise production, management, sales, operation etc. (X. Y. Zhang et al., 2019). The traditional C2M enterprise business process, with the blessing of digital technology, has produced new changes, resulting in the digital C2M business model. Through the research and perspective of the existing C2M enterprises with relatively successful digital

transformation, it is found that most of the C2M enterprises with successful transformation have the ability to effectively integrate foreign technologies with the production process and organization management of the enterprise, and with the help of digital technology, constantly introduce the upstream and downstream enterprises in the supply chain of the enterprise, and finally form a sustainable competitive advantage of C2M enterprises.

Although there are numerous studies on the digital transformation of enterprises, there are still no in-depth studies or clear conclusions on the path and influencing factors of the digital transformation of C2M enterprises in academia and industry. Therefore, it is innovative to explore the influence mechanism between C2M enterprises' digital transformation and cross-border cooperation on enterprises' sustainable competitive advantage. No matter from the strategic perspective of national development of digital economy, or from the practice of C2M enterprises implementing digital transformation, this thesis will attract the attention of the industry and academia in the future and provide scientific and reasonable suggestions for C2M enterprises to obtain sustainable competitive advantages through digital transformation.

1.1.2 Theoretical background

In recent years, with the rapid development of digital technology, scholars have focused on how enterprises gain sustainable competitive advantages through digital transformation. In the era of digital economy, more and more scholars have realized that enterprises can gain sustainable competitive advantage by improving efficiency, achieving differentiation and increasing customer stickiness. Eisenmann et al. (2011) believed that the network effect in the platform market and the low conversion cost enabled the platform enterprises to quickly acquire a large number of market shares, thus promoting the establishment of unique competitive advantages. Song (2015) believes that enterprises can identify, create, optimize, and predict customer value from four aspects of network capabilities. These four aspects include network coordination, network vision, relationship management and relationship portfolio management. These capabilities will guide business strategy and operations, which in turn will build a sustainable competitive advantage for the platform business. Despite the rapid development of China's digital economy and the large number of digital enterprises such as high-end manufacturing and the Internet, the domestic research on the digital transformation mechanism of C2M enterprises is still relatively scarce. Empirical research based on theories is needed to explore the relationship and impact mechanism between the digital transformation of C2M enterprises and cross-border cooperation on enterprises' sustainable competitive advantage (G. Y. Liu et al., 2024).

According to the dynamic capability theory, by establishing specific dynamic capabilities, enterprises can effectively adapt to the rapid changes in the external environment and thus obtain unique competitive advantages (Teece et al., 1997). Through the digital transformation of enterprises, the manufacturing industry aims to achieve cost reduction and efficiency increase, improve product quality, save energy and reduce cost, solve the customized needs of customers, improve the added value of products, shorten the time to market of products, seek profitability from providing services, etc., and finally improve the core competitiveness and profitability of enterprises. Annarelli et al. (2021) believes that the digitalization level of C2M enterprises determines whether enterprises can form sustainable competitive advantages. Therefore, when building sustainable competitive advantages, C2M enterprises usually reconstruct enterprise resources and business processes with the help of digital technologies and capabilities. By referring to relevant literature, we find that the current research rarely involves the improvement of sustainable competitive advantage of manufacturing enterprises through enterprise digital transformation. In addition, there is still a lack of in-depth research on the technical preparation and transformation degree of enterprises' digital transformation under the C2M model, as well as the relationship between these two and the sustainable competitive advantage of C2M enterprises (Elidemir et al., 2020).

From the perspective of value co-creation theory, digital technology alone is not sufficient to ensure the long-term, sustainable and healthy development of C2M enterprises. It is necessary to use digital technology to extend the boundaries of enterprises, expand the participation of upstream and downstream partners in the supply chain, and realize the value co-creation among multiple entities by utilizing differentiated advantages and complementary capabilities of enterprises. According to the value co-creation theory, the scope of entities involved in the enterprise value creation directly affects the value created by the enterprise, while the value of the enterprise will affect its core competitiveness and competitive advantage (Teece, 2007). Digital capability is regarded as the key for traditional manufacturing enterprises to gain new competitive advantages through digital transformation, as well as the main source of sustained competitiveness (Annarelli et al., 2021). The value co-creation of user participation, the value co-creation of upstream and downstream enterprises in the supply chain, and the value co-creation of various types of service providers will all play an intermediary role between the digital transformation of C2M enterprises and the acquisition of sustainable competitive advantage, which scholars have not paid enough attention to. The research on how the digital transformation of C2M enterprises affects their acquisition of sustainable competitive advantage will help to deeply understand the relationship between the digital transformation of

manufacturing enterprises and their realization of sustainable competitive advantage.

From the perspective of competitive advantage theory, in the highly competitive market environment of high uncertainty and high risk, the core competitiveness of enterprises helps them develop collective learning and expertise, generate unique capabilities through organizational processes, and ensure the effective implementation of core business activities, which is crucial for the creation of strategic resources of enterprises (Porter, 1985). Information technology capability plays a strategic role in creating new products to meet customer needs, and it achieves a firm's competitive advantage by improving operational efficiency, minimizing costs and realizing automation (Elidemir et al., 2020). On the one hand, C2M enterprises are technically prepared for digital transformation, on the other hand, they adapt to digital change and enhance the transformation degree of enterprise digital transformation through organizational and business process transformation. In the above two aspects, the current research on the digital transformation of C2M enterprises lacks in-depth research. Therefore, it is of great significance to deeply explore the impact of technical preparation and transformation degree of C2M enterprises' digital transformation on C2M enterprises' sustainable competitive advantage.

In summary, in the era of rapid development of networking and digitalization, the digital transformation of C2M enterprises can jointly promote their sustainable competitive advantage of C2M enterprises through the value co-creation of upstream and downstream enterprises in the supply chain and various types of service providers. It is of great theoretical and practical value to study and discover the action path and mechanism of C2M enterprises' implementation of digital transformation to obtain sustainable competitive advantage.

1.2 Research significance

With the vigorous development of digital technologies represented by artificial intelligence, blockchain, Internet of Things, cloud computing, big data and 5G, accelerating their penetration into various fields, digital technologies are quietly promoting the transformation of the industrial structure of the manufacturing industry, and digital technologies will profoundly change the competitive advantages of various enterprises. With the application of various advanced manufacturing technologies and management methods in the manufacturing industry, there is an urgent need for a scientific and systematic methods and theories to guide manufacturing activities. This research focuses on the digital transformation of C2M enterprises to build a sustainable competitive advantage of the enterprise, interviews experts and conducts

a questionnaire survey. This thesis combines qualitative and quantitative research methods, and the conclusions drawn not only enrich the theoretical system of enterprise digital transformation, but also provide important practical guidance and reference value for C2M enterprises when they carry out digital transformation.

1.2.1 Theoretical significance

This study integrates dynamic capability, value co-creation and sustainable competitive advantage in a conceptual model and discusses the mechanism and conditions of digital transformation technology preparation, digital transformation degree, cooperation width and depth of cross-border cooperation on enterprises' sustainable competitive advantage to provide a rich perspective for the study of C2M enterprises' sustainable competitive advantage in the context of digital economy. The above theories provide theoretical guidance for the creation of conceptual model. C2M enterprises obtain technical resources and organizational resources through digital transformation, thus improving the enterprise capability. Enterprises carry out value co-creation by increasing the number of partners and improving the quality of cooperation, and obtain differentiated competitive advantages through digital transformation. The theoretical significance of this thesis includes the following three aspects:

First, this thesis studies the impact of digital transformation of C2M enterprises on enterprises to obtain sustainable competitive advantage, which enriches the existing research on digital transformation of enterprises. Under the background of the rapid development of digital economy, the technical preparation of enterprise digital transformation can promote enterprises to acquire and absorb the latest information technology and realize the improvement of enterprise competitiveness. The degree of enterprise digital transformation can promote the enterprise business process and management mechanism to adapt to the application of digital technology and influence the application effect of digital technology. The existing research are insufficient on the mechanism and influence path of enterprises to obtain sustainable competitive advantage. Most of them only discuss the influence of digital technology, ignoring the enterprises' adaptation to digital technology and the role played by both. Based on the introduction of the degree of digital transformation, this thesis deeply discusses the impact of enterprises' digital transformation on enterprises' sustainable competitive advantage, and the research conclusions expand the relevant research on dynamic capability theory.

Second, taking cross-border cooperation as the core variable, this thesis explores the mediating role of cross-border cooperation between the digital transformation of C2M enterprises and the sustainable competitive advantage of enterprises, further enriching the

research on the mechanism and conditions of enterprises' digital transformation on enterprises' sustainable competitive advantage. After reviewing the existing literature and research results, most studies focus on how enterprises create value by expanding the types and number of cooperative enterprises, so as to enhance the sustainable competitive advantage of enterprises in digital transformation; however, they ignore the in-depth cross-border research on cross-border cooperation, and few scholars pay attention to the impact of different factors of cross-border cooperation on the effect of cross-border cooperation (Lyu et al., 2023; Rianti et al., 2023). Will digital transformation of enterprises affect the sustainable competitive advantage through cross-border cooperation? To study this question clearly, this thesis considers cross-border cooperation as an intermediary variable and studies the mechanism of cross-border cooperation between enterprise digital transformation and sustainable competitive advantage. This thesis extends the application of value co-creation theory.

Third, this thesis introduces three variables, namely location, scale and management rank, and proposes and attempts to verify the moderating effects of the three variables on the relationship between digital transformation and sustainable competitive advantage. Under the background of the digital economy era, the regions where enterprises are located have different levels of informatization development, the enterprise scale represents different levels of enterprise informatization, and different management ranks have different levels of understanding on how digital transformation can promote enterprises to obtain sustainable competitiveness (Ko et al., 2022). Based on this, three variables, namely the region of the enterprise, the scale of the enterprise and the management rank, are incorporated into the conceptual model. The research results improve the boundary conditions for C2M enterprises to obtain sustainable competitive advantage and expand the theoretical research in this field.

1.2.2 Practical significance

Nambisan (2017) pointed out that the rapid development of digital technology is profoundly changing the way people produce and live, and fundamentally changing the business operation mode of enterprises. In the era of rapid development of digital economy, C2M enterprises have to face the problem of digital transformation in the case of rapid upgrading of digital technology. This thesis discusses the path for C2M enterprises to obtain sustainable competitive advantage in the process of digital transformation, which has important practical significance.

First, it provides practical reference for C2M enterprises to pay attention to the introduction and application of digital technology and obtain sustainable competitive advantage by using digital transformation of enterprises. Enterprise digital transformation means that C2M

enterprises build and form their digital capabilities through the introduction, absorption and use of information technology to help C2M enterprises improve the efficiency of information collection, processing and storage, improve the efficiency and accuracy of corporate decision-making, and simultaneously drive upstream and downstream enterprises and suppliers of the supply chain to participate in the platform construction. Based on the discussion of enterprise digital transformation, this thesis clarifies the positive role of C2M enterprises in acquiring and using digital technology. This has important practical guiding significance for C2M enterprises to obtain sustainable competitive advantage through digital transformation.

Second, it provides guidance for C2M enterprises to focus on multi-entity value co-creation, integrate enterprise customers, upstream and downstream enterprises in the supply chain, enterprise service providers and other entities, and use cross-border cooperation to create sustainable competitive advantages. Due to the rapid development of digital technology, the subject and boundary of enterprise value co-creation have changed dramatically. In this context, how to effectively exploit the advantages of different participants and jointly create new business value has become an important issue that digital transformation enterprises must consider deeply (X. Zhang & Chen, 2020). Through digital transformation, C2M enterprises can increase their ability to utilize information technology while simultaneously giving full play to the differentiation advantages of upstream and downstream enterprises in the supply chain and enterprise service providers, so as to enhance the sustainable competitive advantages of C2M enterprises.

Third, it provides practical directions for C2M enterprises to adapt to the external environment and enhance their competitiveness. C2M enterprises carry out value creation through various operations and management activities inside and outside the enterprise. The emergence of cross-border cooperation complicates the network relationship of value creation, and enterprises' obtaining sustainable competitive advantage gradually evolves into activities under the joint action of external partners. Enterprise customers continue to put forward new requirements for products and services, and C2M enterprises are increasingly close to upstream and downstream enterprises in the supply chain and service providers. The digital transformation of C2M enterprises is facing a large number of new problems (L. Li, 2012). Therefore, this thesis includes the environmental factors faced by C2M enterprises into the research framework, which provides practical guidance for C2M enterprises to absorb and digest information technology, adapt to the external business environment, realize value co-creation and promote sustainable competitive advantages.

1.3 Research context and problem

The digital transformation of enterprises will enhance the future competitiveness of enterprises and provide advantages for their survival. For example, improving manufacturing productivity, reducing operating costs, improving product quality and product innovation (C. Chen, 2019; Moeuf et al., 2018). However, there are few research on the mechanism of enterprises' digital transformation, especially the digital transformation of C2M enterprises, on enterprises' sustainable competitive advantage. In view of this theoretical gap, this thesis combines dynamic capability theory, value co-creation theory and competitive advantage theory to build a conceptual model of C2M enterprises' digital transformation technology preparation, digital transformation degree, cooperation width and depth of cross-border cooperation and enterprises' sustainable competitive advantage. The influence mechanism of enterprise digital transformation on enterprise sustainable competitive advantage is revealed, and theoretical support is provided for C2M enterprises to build digital capability and play the value co-creation role among enterprise partners. In summary, the research problem of this thesis is: How can digital transformation of C2M enterprises promote sustainable competitive advantage in the context of digital economy?

Based on the above research problem, the research questions of this thesis are as follows: (1) Does digital transformation and cross-border cooperation of enterprises have a significant impact on obtaining sustainable competitive advantages? (2) Does the digital transformation of enterprises have a significant impact on cross-border cooperation? (3) Does cross-border cooperation play a mediating role between digital transformation and sustainable competitive advantage for enterprises? (4) Do enterprise size, enterprise region and management level have a moderating effect on the relationship between digital transformation and sustainable competitive advantage of the enterprise?

1.4 Research methods in use

Combining qualitative research and quantitative research, this thesis analyses the relationship between digital transformation technology preparation, digital transformation degree, cross-border cooperation width, cross-border cooperation depth, and enterprises to obtain sustainable competitive advantage. In terms of research methods, this thesis undertakes an extensive literature review, conducts expert interviews and questionnaire survey methods. Detailed information about the methods and contents are shown in Annex Table 1.

The literature research first used the keywords related to this research, including but not limited to C2M, digital transformation, cross-border cooperation, value co-creation, intelligent manufacturing, competitive advantage to search in the literature database. At the same time, the latest research progress of the main theories on which this thesis is based is found in the literature. Through a systematic review and combination of related fields and theories, this study provides a solid theoretical foundation.

First, 27 experts with digital transformation experience were interviewed offline to obtain first-hand data. Then, based on the qualitative research method, the interview data is deeply analyzed to build the conceptual model of this thesis.

The empirical research uses questionnaire survey method, including questionnaire design, pre-survey and formal survey. First, relevant scales containing the most adequate variables was searched through literature, and after expert discussion and testing, a measurement scale containing 25 items was created. Second, the questionnaire was pre-tested, and the final questionnaire was formed by revising and improving the questionnaire according to the data of the collected samples. Finally, in the final research stage, we conducted research in Beijing, Shenzhen, Chengdu and Hangzhou, and collected a total of 301 valid questionnaires. In this study, SPSS 29.0 statistical software was used to analyze the formal survey data, including descriptive statistical analysis, reliability and validity tests, correlation analysis, regression analysis, etc. And based on the data analysis results, the research hypothesis of this thesis is tested, and finally a rigorous research conclusion is drawn. The technical roadmap of this research is shown in Figure 1.1.

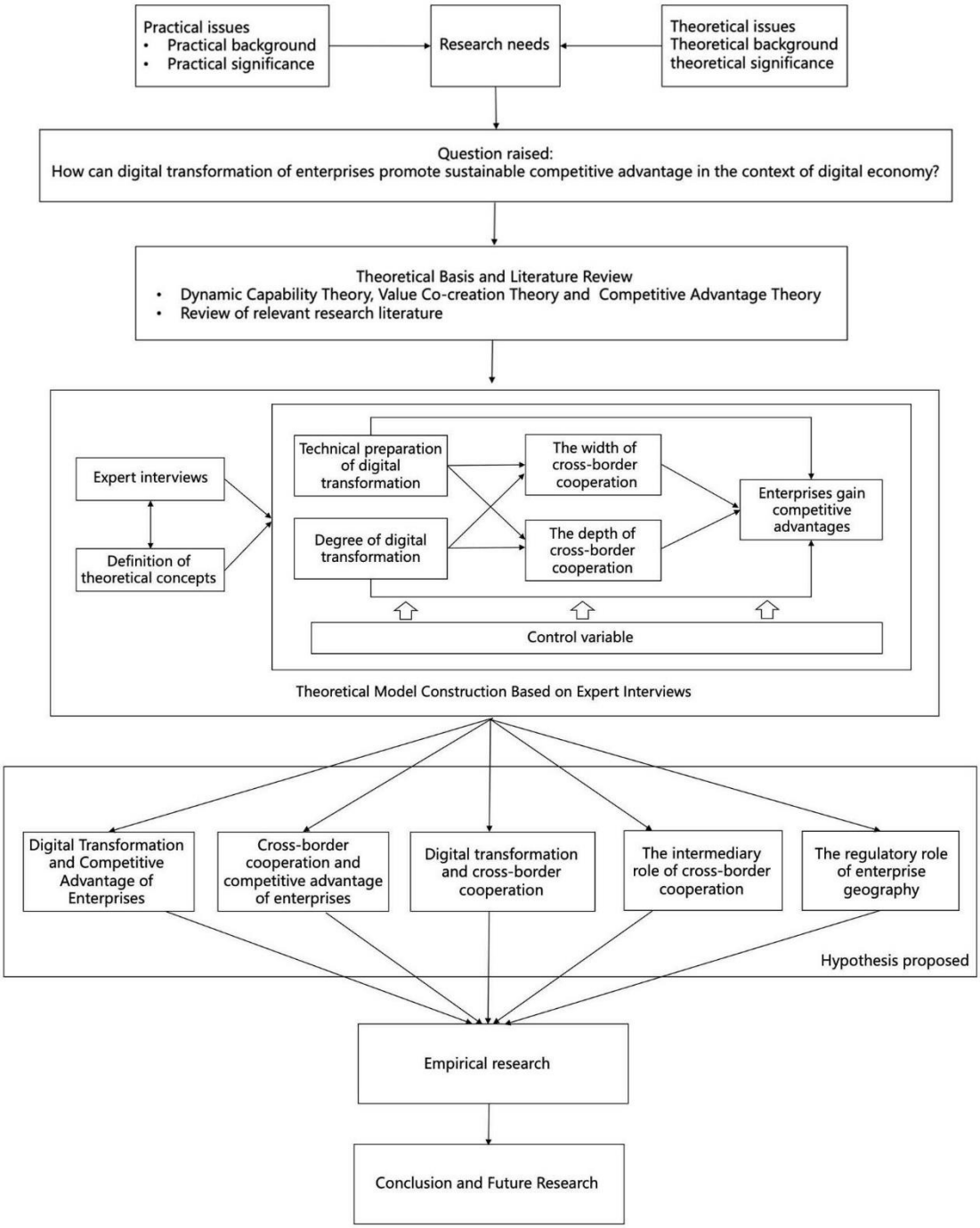

Figure 1.1 Research roadmap

1.5 Thesis structure

Based on clarifying the research background and significance, this thesis considers C2M enterprises as the research object and divides them into six chapters according to the following structure. The specific contents of each chapter are as follows:

Chapter 1, introduction. This chapter first introduces the background of the topic in detail,

focusing on the status quo and challenges faced by C2M enterprises in the process of survival and development. On this basis, the research question of this thesis is put forward, that is, to explore the relationship and mechanism between the digital transformation of C2M enterprises and the sustainable competitive advantage of enterprises. Second, this chapter also expounds the practical significance and theoretical value of this research and emphasizes its importance in related fields. At the end of this chapter, the research content of this thesis is comprehensively summarized, and the specific research methods and technical routes adopted in this research are introduced in detail.

Chapter 2, theoretical background and literature review. First, it introduces the theoretical core of this thesis, including competitive advantage theory, dynamic capability theory and value co-creation theory. On this basis, it expounds the concept and meaning of each variable in the conceptual model of this study. For the main variables of digital transformation technology preparation, digital transformation degree, cross-border cooperation width, cross-border cooperation depth, enterprises to obtain sustainable competitive advantage, this thesis reviews the literature to understand scholars' views and research progress on the above concepts.

Chapter 3, qualitative research. Obtain first-hand research data through expert interviews, then use qualitative research method to analyze the conceptual model of this thesis from the text and form the main variables of digital transformation technology ability, digital transformation degree, cross-border cooperation width, cross-border cooperation depth, enterprises to obtain sustainable competitive advantage. The conceptual model of this thesis is constructed by combining the expert interviews, qualitative research method analysis results and academic research results.

Chapter 4, empirical quantitative research. This chapter describes the process of questionnaire design, sample selection and data collection based on the relevant variables and their interactions in the conceptual model. Determine the measurement scale of the core variables of this study (digital transformation technical ability, digital transformation degree, cross-border cooperation width, cross-border cooperation depth, enterprises to obtain sustainable competitive advantage). The questionnaire was modified and optimized through pre-research, and the final formal questionnaire was formed. After the questionnaire design is completed, the conceptual model is tested in this chapter. In this study, SPSS 29.0 statistical software was used to conduct descriptive statistical analysis, reliability test, validity test, correlation analysis, regression analysis and hierarchical regression analysis of the recovered data to verify the research hypothesis proposed in this thesis. According to the test results, an in-depth discussion and analysis of the results were conducted.

Chapter 5, conclusion and future research. In this chapter, the research results are systematically sorted out, from which the final research conclusions are extracted. Then, from the perspective of digital transformation of C2M enterprises, cross-border cooperation and enterprises to obtain sustainable competitiveness, the management enlightenment of this thesis is proposed. Finally, it points out some shortcomings in this study, and further puts forward a future research direction.

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Chapter 2: Theoretical Background and Literature Review

This chapter systematically reviews relevant literature to lay a good theoretical foundation for the follow-up research. First, the core variables of this thesis, such as enterprise digital transformation, intelligent manufacturing, value co-creation and enterprise obtaining sustainable competitive advantage, are explored and interpreted. Based on this, the theoretical connotations of dynamic capability theory, value co-creation theory and competitive advantage theory are reviewed, and the application of these theories in this thesis is introduced. Finally, this thesis explores the latest research progress of core variables, introduces the dimensions of digital transformation and the determinants of success, the types and behaviors of value co-creation, the evolution of intelligent manufacturing capabilities and the development of C2M model.

2.1 Core concepts

2.1.1 Digital transformation

Scholars have defined digital transformation from multiple perspectives. Digitalization is considered to be more about the use of digital technology to integrate and cross the manufacturing and sales processes of a company's products (Björkdahl, 2020). Ates and Acur (2022) believe that digital transformation is to mitigate the impact of obsolescence on enterprises by regularly developing adaptability and changing processes, showing resilience to cope with environmental fluctuations. From the perspective of digital technology application, Gamboa Quintanilla et al. (2016) emphasized the interaction between the physical world and the information world, including the virtualization of elements (such as products, orders and resources) that reflect reality in service-oriented architecture (SOA) for the integration of technology layer and business layer of enterprises.

On this basis, digital manufacturing is defined as the digitization of supply, production (including planning) and delivery operations by the company through the network, in which digital models and entities are intensively used (Suuronen et al., 2022). This establishes a broad, Internet-scale platform for gridded, intelligent production and efficient and scalable connectivity of various stakeholders (including manufacturing plants, supply chain service

providers, technology suppliers and service providers), thus creating a sustainable, customer-facing Internet economy for industrial logistics that is agile relative to the market (Borangiu, 2011). For SMEs, the academic community generally believes that the implementation of digital transformation by SMEs will enhance the future competitiveness of enterprises and provide advantages for their survival. For example, improving manufacturing productivity, reducing operating costs, improving product quality and product innovation (C. Chen, 2019; Moeuf et al., 2018).

The digital transformation in classical literature mostly involves the implementation of traditional information system projects, while the enterprise digital transformation described in this study is quite different. Digital transformation is not a technological innovation that an enterprise can implement as an information system project (Culot et al., 2020). Digital transformation is a strategic business transformation that relies on various combinations and integration of modern information and digital technologies, such as artificial intelligence, data analytics, digital twins, industrial robots, and blockchain. The process also involves adopting agility, customer orientation, and product personalization as core competencies (Fatorachian & Kazemi, 2018; Kagermann, 2015). Traditional measures of information system success, such as system usage or net revenue, can indicate the success of digital transformation within a manufacturer to some extent. The digital transformation that this thesis says includes selecting the right information technology, implementing the technology correctly, ensuring the satisfaction of the technology's end users, using the technology consistently and purposefully to support strategic business objectives, and deriving value from the implemented technology.

2.1.2 Intelligent manufacturing

The rapid development of technologies such as the Internet, cheap information processing, artificial intelligence, cloud technology and Internet of Things has not only shortened the product life cycle in many industries, but also spawned the emergence of modern manufacturing models (Suuronen et al., 2022). Smart manufacturing enables the digitization of the whole life cycle of products, establishing real-time connectivity and interaction between products, machines, production systems, enterprises, value chains, and even different industries (L. Wang et al., 2021).

Over the centuries, the industrial environment has changed, and the manufacturing sector has evolved accordingly through several paradigms, such as flexible manufacturing (Ezpeleta et al., 1995), reconfigurable manufacturing (Koren et al., 1999), lean manufacturing (Shah & Ward, 2002), wireless manufacturing (G. Q. Huang et al., 2009). These paradigms were all

triggered by the emerging technologies and changing markets of the time.

To explore intelligent manufacturing, D. Q. Guo et al. (2020) proposed a graduate-style Intelligent Manufacturing System (GiMS) to transform production management and operations into a new manufacturing paradigm. Under the smart manufacturing model, industrial internet of things and digital twin technologies are adopted. The industrial IoT and digital twin double enabling system (GiMS) consist of three layers: the physical space layer, the cloud space layer and the digital twin data layer that links the physical space and the cloud space together. In the physical space layer, manufacturing resources, manufacturing processes and production systems are modeled at the object level, product level and system level (D. Q. Guo et al., 2020). The object level focuses on manufacturing objects, and based on the internet of things technology, the manufacturing state of objects (such as attributes, status and service) can be captured and mapped in real time. The product level focuses on the manufacturing process of the product, which can visually trace lightweight 3D models and manufacturing processes of the product with the support of the Internet of Things, intelligent gateway and Web 3D technology. The system level focuses on production systems, which support human-centered interactive systems based on industrial wearables, acquiring and allocating limited resources to parallel and continuous activities to meet demand effectively. The digital twin data layer links physical and cloud Spaces together. In this layer, a mobile gateway operating system is developed through simple definition, configuration and execution (Barari et al., 2021).

This system aims to centrally manage digital twin data mapped from object level, product level and system level in physical space. Based on GiMS, the digital twin data can be mapped in the form of digital tickets and constantly updated as the physical space changes synchronously. In the cloud space, with the support of digital tickets, work task service, setup task service, logistics task service and operation task service are provided for managers and field operators to facilitate decision-making and daily operations in production planning, scheduling, execution and control. After being deployed in the cloud, managers and field operators can easily access these applications through fixed and mobile terminals, such as PCs, iPads, smartphones and wearables (D. Q. Guo et al., 2020).

2.1.3 Value co-creation

Ancona and Caldwell (1992) conducted influential research on team cross-border behavior. They define cross-boundary as the behavior of an organization to build relationships and maintain interactions with external stakeholders to achieve the overall objectives of the enterprise. These external-facing activities include managing changing customer needs,

negotiating project scope, and obtaining key sources of information from external sources. Catalano (2009, pp. 41) identifies cross-border behavior as "the behavior of an organization to reduce uncertainty or manage contingencies that may threaten the survival of the organization." Based on the existing literature and the research goal of this thesis, this thesis defines cross-border behavior as the behavior of an organization or department integrating different resources, crossing different boundaries, establishing contact and managing interaction with various parties in the environment, and then creating value for the enterprise.

Cross-boundary team cooperation for value co-creation has attracted increasing attention from enterprises seeking competitive advantage. Through successful management of value co-creation, enterprises can improve their market performance, strengthen the relationship with stakeholders, improve productivity and efficiency, and reduce business costs and risk failures (Payne et al., 2008; Roser et al., 2013; Saha et al., 2022).

Value co-creation is defined differently from different perspectives. McColl-Kennedy et al. (2012, pp. 2) defined value co-creation as "the effective integration of resources through activities and interactions with partners in the customer service network, so as to maximize the benefits of all parties." Russo-Spena and Mele (2012) refer to value co-creation as a process of integrating social and technical resources. When studying value co-creation in industrial digitalization, it usually describes the business interaction between various market participants (such as technology service providers, service system suppliers and customers), who jointly create business value with the same goal. The value mentioned here may refer to the intermediary of the service system itself or its beneficial terminal (end customer or customer satisfaction degree) (Sales-Vivó et al., 2020).

2.1.4 Competitive advantage

Different scholars have different understandings of competitive advantage. Scholars usually define competitive advantage from two aspects: result and source. Porter (1985) believed that a company's competitive position and competitive advantage meant that the value a company could create for its buyers exceeded the cost of creating value for the company. He proposed a framework based on the value chain to create and maintain competitive advantage. Competitive advantage can be seen as the specific market position that an organization obtains relative to its competitors by effectively deploying its resources (Hofer & Schendel, 1978). Chinese scholars generally include the market and financial performance of products and services into the comparative category in the study of enterprises' competitive advantage. Jiang (2002) believes that an enterprise's competitive advantage can be defined as the ability of an enterprise to

provide products or services with advantages over its competitors in an effectively competitive market, which not only helps an enterprise to win a larger market share, but also enables it to achieve profits beyond the average level of the industry.

Barney (1991), based on the definition of competitive advantage, incorporated replicability into the research category of competitive advantage and proposed the concept of sustainable competitive advantage of enterprises. Barney believes that when a company is implementing a value creation strategy and its current or potential competitors do not implement it at the same time, it is considered to have a competitive advantage. A company is considered to have a sustained competitive advantage when it is implementing a value creation strategy and current or potential competitors are not simultaneously implementing it, and these other companies are unable to replicate the benefits of the strategy.

In summary, there is no unified understanding and definition of what constitutes a firm's competitive advantage in academia. From the perspective of this thesis, the competitive advantage of an enterprise refers to the ability of an enterprise to create value compared with its competitors or the average level of the industry. This ability not only exceeds its own costs, but also provides higher value to customers, thus achieving better performance in the market than other companies in the same industry.

2.2 Theoretical background

2.2.1 Dynamic capability theory

2.2.1.1 The connotation of dynamic capability theory

The theory of dynamic capability was originated in the 1990s of last century and was developed by the extension of the enterprise resource view. The theory of enterprise resource view regards the enterprise as a collection of resources and believes that the resources and capabilities possessed by the enterprise are the origin of competitive advantage (Eisenhardt & Martin, 2000), and emphasizes the value, rarity, imitability and irreversibility of resources (Barney, 1991). However, in the face of diversified market demand and personalized customer demand, the competition of enterprises has become fiercer, and enterprises can no longer effectively build their competitive advantages by relying only on the traditional resource view. In the face of the problems encountered in theory and practice, scholars have gradually realized that in order to solve the problem of matching enterprise capability and environment, it is necessary to introduce a dynamic resource concept. Teece et al. (1997) was the first scholar to put forward

the concept of enterprise dynamic capability. He shifted the focus of promoting enterprise capability development to the environment of the enterprise and promoted the competitive advantage of the enterprise by helping the enterprise to achieve the adaptation, matching and reorganization of internal resources and external environment. The theory of dynamic capability emphasizes that enterprises must adapt to the dynamic changes of external environment when building competitive advantage.

The core connotation of this theory mainly includes three aspects: First, it discusses how the enterprise capability is created. Second, it analyzes how to use the enterprise capabilities. Finally, it studies how enterprises upgrade and develop their capabilities (Bowman & Ambrosini, 2003). In order to realize the dynamic capability of the enterprise, it is necessary to start from the three aspects of external resource acquisition, internal resource reorganization and internal and external resource integration, and form the dynamic capability of the enterprise through the integration of internal and external resources and capabilities (Helfat & Peteraf, 2003).

By referring to the relevant literature and analyzing the research results of scholars, the literature related to dynamic capability theory can be roughly divided into three aspects: first, the antecedent research focusing on the source of dynamic capability; second, focus on the mechanism of action, including mediating and regulating mechanism; The third is to focus on the effects of dynamic ability outcomes (Jiao et al., 2021; Schilke et al., 2018; Winter, 2003).

Regarding antecedents on the sources of dynamic capabilities, the existing literature identifies multiple levels of antecedents, including organizations, individuals, and environments. Organizational factors mainly include organizational experience, organizational structure, organizational culture, market orientation, organizational learning, information technology, etc. (Jiao et al., 2021). According to this study, resource-rich companies usually show stronger ability in formulating, implementing and continuously pushing forward strategic changes. Due to their abundant resources, these companies can carry out strategic planning more effectively and flexibly cope with various challenges in the execution process, so as to maintain competitive advantages in the changing market environment (Giudici & Reinmoeller, 2012).

As for the research on the mechanism of dynamic capability, the mediating variables mainly include innovation, operation capability and enterprise digital capability. Scholars' research shows that dynamic capability is conducive to the generation of new knowledge, and can promote the innovation of digital technology, digital service, process transformation and other aspects, which will have an impact on the competitiveness of enterprises. Variables such

as firm size, organizational culture, industry and region have been proved by scholars to be common regulatory factors. Studies on these relevant regulatory mechanisms have greatly improved the clarity and definition of boundary conditions. Research on dynamic capability is usually regarded as the focus of research in this field (Schilke et al., 2018). Dynamic capability confers a competitive advantage by adding unique value to the firm through systemic change, which may improve operational efficiency and enable greater alignment between the firm and the environment.

Winter (2003) conducted an in-depth analysis of the direct impact of dynamic capabilities on corporate performance excellence and viability. He pointed out that in a constantly changing business environment, enterprises lacking dynamic capabilities will not be able to sustain their competitive advantages and viability. Therefore, the existence of dynamic capabilities is crucial for the long-term success and development of an enterprise. Research on dynamic capability is usually regarded as the focus of research in this field.

2.2.1.2 The application of dynamic capability theory in this study

After more than 20 years of development, the dynamic capability theory has made remarkable progress. There is a consensus in academic circles that in the process of building competitive advantage, firms must possess unique resources and capabilities that are difficult to be imitated by competitors (Teece, 2007). With the rapid development of digital economy and digital technology, C2M enterprises have realized and regarded digital transformation as an important development direction for enterprises. Through digital transformation, they can improve the efficiency of enterprise resource use, enhance the in-depth insight of customers, partners and markets, and improve the ability to predict environmental changes. Therefore, enterprise digital transformation is a kind of enterprise capability in the context of the digital economy. Digital capability reflects not only the production capacity and operational efficiency of an enterprise, but also the ability of an enterprise to obtain external resources and information to compensate for the shortage of its own resources. In summary, the theory of dynamic capability is the basic theory for this thesis to study the digital transformation of C2M enterprises, and it is also an important part of the conceptual model for constructing the digital transformation path of C2M enterprises.

2.2.2 Value co-creation theory

2.2.2.1 Connotation of value co-creation theory

The value co-creation theory was proposed by Prahalad and Ramaswamy (2000). Until now,

through the research and development of academia and industry, the theory has developed into two main branches: one is the value co-creation theory focusing on user experience (Prahalad & Ramaswamy, 2000). The other is the value co-creation theory based on service-oriented logic (Vargo & Lusch, 2004).

Prahalad and Ramaswamy (2000) believe that with the development of digitalization, especially networking, users have become the main source of enterprise competitiveness. Activities such as conducting active dialogue around users, creating online communities, serving online users and satisfying user experience can promote the development of enterprise competitiveness. Prahalad and Ramaswamy (2004a) proposed the DART model for interpreting user experience, which includes dialogue, channel, transparency and risk. The DART model is illustrated in Figure 2.1.

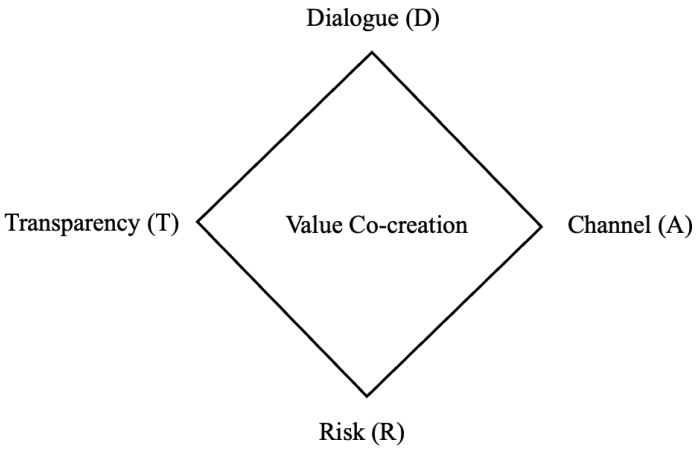

Figure 2.1 DART model of value co-creation

Source: Prahalad and Ramaswamy (2000)

Vargo and Lusch (2004) proposed the service-oriented logic. They defined the service ecosystem as a self-contained and self-adjusting resource integration system, which realizes value co-creation through shared institutions and service exchange. Service-led logic emphasizes the shift from a single enterprise-consumer relationship to a more complex network structure where all actors play a role in resource integration and service exchange. The emerging service-led logic creates value jointly by resource integrators and reciprocal service providers through rich experiences and is managed and evaluated through its institutional arrangements (Vargo & Lusch, 2004, 2008).

2.2.2.2 The application of value co-creation theory in this study

With the advancement of digitalization and the popularization of the network, the collaboration and cooperation between enterprises and users, enterprises and partners, enterprises and

suppliers have become increasingly close. In the process of digital transformation, C2M enterprises cooperate with upstream and downstream enterprises in the supply chain and various service providers to co-create value through production collaboration and information sharing, so as to build sustainable competitive advantages (B. He et al., 2023). The value co-creation theory points out that enterprises can significantly reduce production costs, enhance product functions, enhance product quality, and improve user experience by encouraging users to participate deeply in their business activities, thus helping enterprises to build sustainable competitive advantages (Ulaga, 2003). Value co-creation usually refers to the business interaction relationships established between different market participants. In this relationship, all parties work together to create greater business value based on common goals. These values may refer to the degree of service system itself and its end user satisfaction (Sales-Vivó et al., 2020). Therefore, in the context of digitalization, the theory of value co-creation provides theoretical support for studying the value co-creation behavior among C2M enterprises, customers, suppliers and partners, as well as the influence of co-creation behavior on enterprises to obtain sustainable competitive advantage.

2.2.3 Theory of competitive advantage

2.2.3.1 Connotation of competitive advantage theory

Porter proposed a theory of competitive advantage. Porter (1985) discusses the competitive advantage of enterprises by introducing the concept of value chain, which is composed of a series of value activities and profits, including product production, sales, transportation, after-sales service, technology development, human resource management. Value activities form the basis of an enterprise's competitive advantage. Each activity is the basic unit of competitive advantage, the source of creating customer value and the source of enterprise theory. Through the value chain, enterprises create alienated competition, which makes them have cost advantages compared with competitors, and thus obtain competitive advantages. Prahalad and Gary (1990) believed that for an enterprise, sustained competitive advantage should come from its own unique core competence. Therefore, in order to enhance competitiveness, enterprises should focus on developing and cultivating these core capabilities, rather than just focusing on the market performance and success of the final product in the short term.

Competitive advantage must be embedded in the memory and processes of the organization, rather than relying on individual talents (Azeem et al., 2021). This means building a body of knowledge that can be continuously passed on and reused, and designing systems, processes

and cultures to allow good experience and strategy to flow and accumulate within the organization. In this way, no matter how individual employees change, the core competence of the organization can still be maintained. At the same time, relying on the existing competitive advantages, enterprises should actively explore new opportunities and accumulate new resources, establish a good internal and external relationship network, in order to create new competitive advantages (Y. Y. Lee & Falahat, 2019). It is difficult for an enterprise to maintain its competitive advantage in the long run by relying only on simple promotional ideas or easily obtained equipment and technology. This advantage quickly disappears when competitors can copy it easily. Therefore, enterprises should pay more attention to the organization and systematization of competitive advantages and build a strong mechanism that can adapt to market changes and innovate continuously, rather than relying solely on individual talents and easily imitated strategies (Situ, 1997).

Martins et al. (2015) have conducted a series of research on how the established competitive advantages of enterprises change over time, in order to better understand the changes of enterprises' competitive advantages. In the process of competition with competitors, enterprises will use different technologies and methods to offset the competitive advantage of rivals. In the era of digital economy, enterprises usually adopt innovation and creativity to overcome their competitors' competitive advantages. No competitive advantage will exist forever. When the rival acquires and surpasses the advantage, the competitive advantage of the enterprise will no longer exist. See Figure 2.2 for details.

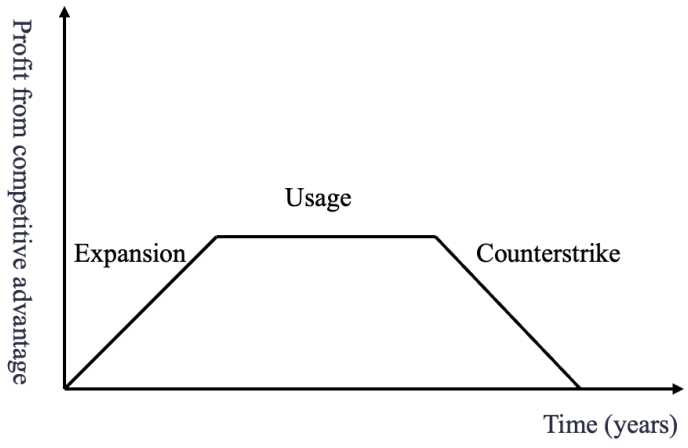

Figure 2.2 Changes in competitive advantage of enterprises

2.2.3.2 The application of competitive advantage theory in this study

The theory of competitive advantage states that an enterprise establishes its competitive position through the determinants of industrial competition and establishes sustainable

competitive advantage by developing or cultivating its core competence. The low cost, standardization and modularity features of digital technology will lower market entry barriers and intensify price competition, thus disrupting the traditional product and service market (Sousa & Rocha, 2019). C2M enterprises combine digital technology with business operation, management, products and services, identify the potential needs of users and the market through digital technology, and obtain real-time dynamic information of the market, and obtain resources through value-creation activities, thus forming a competitive advantage that is difficult for competitors to imitate. In summary, the theory of competitive advantage provides a theoretical basis for this thesis to study the relationship between the digital transformation of C2M enterprises and the acquisition of sustainable competitive advantage and provides theoretical support for in-depth analysis of the sources of sustainable competitive advantage.

2.3 Review of relevant literature

2.3.1 Digital transformation

2.3.1.1 Dimensions of digital transformation

Through long-term research on manufacturing enterprises, it is found that enterprises use digital technology to gain advantages from new technologies and become more advantageous in digital aspects, including product development, manufacturing production, improving products and services, and integrating value chains (Björkdahl, 2020; Porter & Heppelmann, 2014).

(1) Product development

Digitalization can improve the efficiency of product development in manufacturing enterprises, while the integrated use of digital technologies also makes products more complex (Björkdahl, 2020). On the one hand, due to the increasingly powerful functions of computer design software and visualization programs, and the strong human-machine interaction in the design process, the digital development of products requires fewer physical prototypes. This makes product design much easier. On the other hand, the convergence of digital technologies has made products more complex. Companies use software that can test products using models in a computer-aided environment to check the functionality and performance of products and can check various results. Product design and development cycles can be shortened with the help of these software testing programs. For many manufacturers, digitization has put an end to the costly, long design cycle of having to build a prototype, run different tests, and then modify the product based on the test results (Huang et al., 2022).

(2) Manufacturing

Most manufacturing enterprises make their production more competitive using digital means. They can increase the quantity and quality of manufacturing production and reduce the differences between products. And through the use of digital technology and more production data, making the production process more intelligent, the occurrence of failures and downtime is greatly reduced (Björkdahl, 2020). In the manufacturing process, access to new data and connection of different data sources can improve decision-making and achieve integration between machines, and companies can identify and analyze the data of abnormal conditions to find the causes of reduced operational efficiency. Other digitalization activities are being adopted by leading companies that are using machine learning algorithms to identify defects in the manufacturing process, thereby reducing the number of cases where products are manually removed from the production line and checked (Fu et al., 2022).

(3) Improving products and services

More and more manufacturing companies are integrating digital technologies into their products, making the products they produce smarter. Intelligent products will generate new data during use, which will be collected and analyzed by manufacturing enterprises through the network, which may improve the performance of products and generate new functions (Porter & Heppelmann, 2014). By using the data of products, manufacturing enterprises can enable enterprises to move to downstream customers and provide new operations and complementary services. This reduces the distance between the enterprise's end users while increasing the enterprise's revenue, which has been shown to improve the overall profitability of the enterprise (Baines et al., 2017; Lightfoot et al., 2013).

(4) Integrated value chain

Digitalization has made value chains more integrated, which has improved efficiency for all types of companies along the supply chain and reduced turnaround times. This integration manifests itself both in the sharing of data within the company, such as information sharing between systems and functions (Queiroz et al., 2019). It is also reflected in the sharing of data across company boundaries, such as between suppliers and customer companies, by integrating the customer's production and inventory management systems, a lot of time is saved in communicating with customers about supply issues. At the same time, digitization also offers easier traceability (Björkdahl, 2020).

2.3.1.2 Determinants of success in digital transformation

Ghobakhloo and Iranmanesh (2021), after cross-checking the identified determinants,

identified 11 determinants of success, namely: Business partner digital maturity, cybersecurity maturity, change management capability, Digital readiness Pre-assessment, digital external support, information and digital technology expertise, information and digital technology readiness, digital transformation management capability, strategic roadmap for manufacturing digitization, operational technology readiness, and resource availability. These determinants are described below.

(1) Digital maturity of business partners

SMEs in the manufacturing sector operate in a hypercompetitive environment characterized by reduced time to market and increasing product complexity (Masood & Sonntag, 2020). Thus, the survival of SMEs today depends on their ability to open their borders to value chain partners and implement the concept of digital supply networks (DSNS) (Queiroz et al., 2019). DSNS rely on the real-time interconnection and communication of intelligent machinery, equipment, assets, sensors and execution systems along the entire manufacturing chain (Ivanov & Dolgui, 2021).

(2) Cyber security maturity

Adding advanced digital technologies to existing operational technologies requires SMEs to have a certain level of cyber capability to ensure the security of critical manufacturing systems and operations (Moeuf et al., 2020). Unfortunately, the pace at which cybersecurity attacks are targeting manufacturing enterprises is accelerating (Kabanda et al., 2018). Therefore, the success of manufacturing digitization efforts depends on companies making cybersecurity a core corporate strategy (Ghobakhloo & Ching, 2019). Regardless of company size, every manufacturer seeking to digitalize should develop a comprehensive cybersecurity initiative based on the particularities of their IDT infrastructure, collaboration channels, and processes (Ani et al., 2017). The maturity of cyber security is therefore an undeniable component of the success of digitization in manufacturing.

(3) Pre-assessment of digital readiness

Organizations often fail to embrace innovative business models mandated by new digital technologies (Bibby & Dehe, 2018). Digitization of manufacturing often requires manufacturers (including SMEs) to implement disruptive business models (Müller et al., 2018). Manufacturers often do not fully understand the scope and features of Industry 4.0 and the potential for digital transformation (Mittal et al., 2018; Moeuf et al., 2020). A digital readiness pre-assessment can help manufacturing companies recognize whether they have the capabilities required to take initial steps, such as a digital cost-benefit analysis, strategic roadmap, or IDT-OT maturity assessment (Bibby & Dehe, 2018).

(4) External support for digitization

Industry reports indicate that the adoption rate of new digital technologies by manufacturing enterprises remains low (Castelo-Branco et al., 2019). This problem is largely due to the complex, expensive, and knowledge-intensive nature of new technologies, as well as the inherent limitations of manufacturing firms in terms of financial resources, human capital, and skills gaps (Mittal et al., 2020). Various supportive policies are being adopted by the government to facilitate the digitalization of enterprises. Regardless of the type of supportive policies, companies enjoy higher digitization of manufacturing in countries with government support (Klitou et al., 2020).

(5) Information and digital technology expertise

The successful implementation of digital transformation relies on the application of advanced digital and manufacturing technologies. This process requires not only the effective integration of the virtual and physical worlds, but also overcoming information silos and ensuring seamless integration of information, thereby increasing overall work efficiency and productivity (Frank et al., 2019). Therefore, software engineering, data analytics, business modeling, cybernetics and mechatronics skills are necessary to ensure the success of digital transformation in manufacturing (Kamble et al., 2018; Müller et al., 2018). However, most manufacturing firms lack the expertise needed to implement advanced IDT, which is rooted in the firm's informal skills development strategy, lack of financial resources, and failure to employ professional IT talent (Horváth & Szabó, 2019; Stentoft et al., 2021). Empirical evidence suggests that firms with a higher degree of IDT expertise enjoy higher levels of digitalization (Maroufkhani et al., 2020).

(6) Readiness of information and digital technologies

Digitization is not limited to the implementation of advanced digital technologies. IT depends on manufacturers' ability to seamlessly integrate new digital solutions into existing legacy networks, IT/OT infrastructure and processes to create a cohesive digital ecosystem capable of seamless and real-time data flow throughout the manufacturing process (Fatorachian & Kazemi, 2018; Shi et al., 2020). In reality, not all manufacturers are ready to strategically utilize digital technologies, IDT resources, talent, and existing OT (Stentoft et al., 2021). Developing digital readiness is incremental and hugely resource intensive (Mittal et al., 2018). SMEs with high digital readiness can prioritize smart manufacturing investments, perform digital risk management, and strategically align IDT resources for integration (Moeuf et al., 2018; Pirola et al., 2020).

(7) Management capability of digital transformation

A single manufacturer usually has limited financial resources, risk resilience, bargaining power with technology suppliers, and skill set (Masood & Sonntag, 2020). Therefore, the top management of enterprises should have the necessary strategic vision in order to more effectively guide the digital transformation efforts in the manufacturing industry (Agostini & Nosella, 2020). The success of digital manufacturing enterprises mainly depends on whether the management team has the necessary strategic vision and capability. This includes clarifying decision-making processes, being able to allocate required resources effectively, implementing appropriate digital strategies, addressing existing digital skills gaps, and attracting external support. Together, these factors influence the performance and outcomes of enterprises in the digital transformation process (Moeuf et al., 2020).

(8) Strategic roadmap for digitization of manufacturing industry

Enterprises need to achieve the maximum level of digitization, including vertical integration of every manufacturing function at the factory level, and horizontal integration of seamless data exchange with business partners and customers (Mittal et al., 2020). This level of complexity forces manufacturers to develop a strategic roadmap for digitization of manufacturing, creating a time-based action plan that defines the current state of digitalization of the organization and simulates the digital landscape of the future (Colli et al., 2019). The study proposes that a higher degree of digitization of manufacturing can be achieved in enterprises when the digitization strategic roadmap addresses key digital transformation areas such as IDT governance, supply chain integration, and IDT knowledge areas (Müller et al., 2018).

(9) Operational technology preparation

At the communication level, the intelligent execution system transforms the data collected at the control level into meaningful information for the intelligent resource-planning module, and vice versa (Q. Li et al., 2018). For manufacturing companies, this process tends to be resource intensive. Companies should evaluate the capabilities of existing OT, measure the integrability of existing equipment and machinery, design a technology roadmap to equip existing OT with sensors and intelligent controllers, and identify suitable technical preparations for replacing legacy redundant OT (Ghobakhloo, 2020; Stentoft et al., 2021).

(10) Change management capability

Change management is a strategic focus for digital success in manufacturing. In the process of digital transformation, enterprises must deeply reshape traditional business models to completely revolutionize the way the organization operates. This transformation involves not only the application of technology, but also comprehensive changes in management processes,

team collaboration and customer relationships (Dowell & Muthulingam, 2017). This means that the success of digital transformation also depends on the people who pay attention to the change process when implementing the digital transformation strategy (Sivathanu & Pillai, 2018). Therefore, change management policies should also manage the human resource aspects of change so that employees have sufficient capacity, willingness and knowledge to be part of the digital change process (Kagermann, 2015).

(11) Resource availability

The digitization process of basic manufacturing is characterized by dynamic development, and its process is extremely resource-dependent and resource-intensive. This process requires continuous capital investment and flexible allocation of human resources to adapt to the rapidly changing market environment and technological advances (Frank et al., 2019; Telukdarie et al., 2018; Tortorella & Fettermann, 2018). In the process of digital transformation, enterprises must provide adequate resource support at all stages of planning, implementation and institutionalization to ensure a smooth transition to digital manufacturing (Kumar et al., 2020; Mittal et al., 2020).

2.3.2 Value co-creation

2.3.2.1 Types of value co-creation

In the study of value co-creation among digital stakeholders, S. Y. Li et al. (2021) proposed four types of value co-creation, namely, strategic co-planning value, functional value, joint organizational learning value and customer experience value.

The value of strategic co-planning, discovered from the research, refers to the understanding of customer needs and the recognition of the business needs of the supply company, which is then translated into feasible system design and the overall use of digital systems to develop new products that meet customer needs. This type of value is co-created between the various companies involved in the company's digitization efforts and is reflected in the phase of digitization system development, as well as the use of digitization systems in the development of new products (Mathibe et al., 2023).

Functional value is the realization of the digital system in the day-to-day operations and cooperation between suppliers and customers. The main functions achieved through digital systems include data integration between suppliers and customers, sales forecasting by analyzing unstructured and structured marketing data, and automated problem solving of supply chain systems (X. M. S. Chen et al., 2023).

The value of intra-organizational and inter-organizational learning refers to the understanding of common goals and awareness of organizational conflicts of interest, as well as the process of finding solutions and reaching mutual agreements, formed both within organizations (i.e., intra-organizational conflict) and between different organizations (i.e., inter-organizational conflict). In collaboration with the help of digital systems, adaptation to common goals and organizational conflicts occurs more frequently (S. Y. Li et al., 2021).

The value of the customer experience can be seen as the success of the collaboration between the supplier, the digital system provider and the customer itself. In order to create a positive customer experience, suppliers and digital system providers need to analyze customer preferences, market trends and changes in the national and international environment. Another dimension of customer experience value focuses on understanding the concerns within the customer's company. The findings suggest that employees and workers vary widely from different perspectives in terms of expertise, education, previous experience, personality, behavior, and motivation. Understanding this difference and addressing the concerns that exist for customers is essential for a smoother introduction and use of digital technologies (Pee, 2016).

2.3.2.2 Value co-creation behavior

In the development and use of digital technology, the practice of creating value and promoting value co-creation requires the capability of enterprises. S. Y. Li et al. (2021) points out three capabilities owned by technology service providers, service system suppliers and customers that contribute to the practice of value co-creation.

The first is systems management capability, which focuses on applying technical knowledge and "hard" skills to solve practical technical problems that occur in developing, using and managing digital systems. This helps to create the functional value of digitized systems more efficiently. In addition, system management capabilities are also focused on long-term cooperation between suppliers and customers, helping to provide innovative technological solutions and facilitating the integration of digital capabilities into vendor-customer relationships and business activities (Sun & Zhang, 2022).

The second type of capability is commercialization capability, which refers to the application of knowledge, skills and available resources for the commercial activities of marketing and production. Research and development capability is a key indicator of the level of innovation in the vendor-customer collaboration. Commercialization capability also includes negotiating to achieve the agreed objectives. Research has found that negotiation is an integral part of mitigating inter-organizational conflicts and achieving mutually beneficial benefits. In

addition, the ability to expand markets and create new business opportunities is essential to facilitate strategic joint planning (S. Y. Li et al., 2021).

The third type of competence is interpersonal skills, which help to establish and maintain good relationships between partner companies with the aim of building trust, maintaining long-term partnerships and ultimately achieving marketing and business objectives. The application of interpersonal skills always involves two-way interactions, and building trust and interpersonal relationships is key to attracting business partners and mitigating conflicts within and between organizations (Ravazzani & Hazée, 2022).

2.3.2.3 Value co-creation dimension

(1) Value co-creation supported by consumers

Customer participation in the service and production activities of enterprises is not a new concept (Bendapudi et al., 1996). Input from the client is believed to play a decisive role in the process of designing the product or service. Consumer participation in these activities of the company can improve customer satisfaction (Acharya et al., 2018). This two-way interaction is related to a concept known as co-creation, which arises when companies and customers co-create value. Co-creation helps customers co-construct a service or product experience to meet their expectations (Prahalad & Ramaswamy, 2004a, 2004b). The idea has to do with customers and companies working together (Jaspers & Steen, 2020), which is also known as co-production (Dargahi et al., 2021). This way of involving consumers in business processes is value co-creation by mining economic value by involving more and more consumers in activities (M. Xiao et al., 2020). Therefore, co-production and the active participation of customers are helpful for co-creation activities (Hoyer et al., 2010). The intention of value co-creation activities will help to improve the business of the firm because the actual needs of the customers are expressed through their active input (José-Carlos & Jenny, 2019; Pani & Kumar Kar, 2011).

In order to study the value co-creation of consumer participation, scholars introduced the concept of value co-creation fit, that is, the match between consumers' expectation and experience level of value co-creation and explored its impact on consumer satisfaction. This further guide how firms should approach this process to determine the appropriate level of value co-creation (Chan et al., 2010). Undoubtedly, our research shows that customer satisfaction is maximized when the level of enterprise value co-creation experienced by consumers matches their expectations, and we conceptualize this matching as 'matching' (Venkatraman, 1989). Specifically, we distinguish between positive mismatches (i.e., consumers experience a higher-than-expected level of value co-creation) and negative mismatches (i.e., consumers experience

a lower-than-expected level of value co-creation). The results of post-mortem analysis show that positive mismatches have a greater negative impact on customer satisfaction than negative mismatches, providing further implications for producers to design the co-creation process. These effects hold true for both end customers and supply chain customers. Consequently, customer satisfaction increases when the company approaches the level of value co-creation desired by the customer, and the corresponding level of value co-creation is realized when the company matches the level of value co-creation expected by the customer.

(2) Value co-creation supported by IT

Although value co-creation is defined from different perspectives, these definitions all recognize that resource integration and social interaction are key processes leading to value co-creation. Resource integration has shifted from primarily utilizing a company's single product to combining various resources to use these products and services, providing a unique perspective on the use of products and services (Vargo & Lusch, 2004). In addition, the co-creation of value by multiple roles means that value is mutually influencing (Vargo & Lusch, 2016). Value co-creation is essentially a social process that requires social interaction. Resource integration and social interaction can also be said to be interdependent and dynamic in the process of value formation within a service system (Akaka et al., 2012). In order to study the value co-creation process, both social interaction and resource integration need to be discussed in the context of broader networks and relationships.

The elements of social interaction and resource integration that influence value co-creation and how they integrate resources remain unclear (Cabiddu et al., 2019). Addressing this research gap is important because the underlying elements of social interaction and resource integration can provide managers with practical and actionable insights when planning and developing IT tools as well as platform collaboration. Value co-creation does not happen by chance and can be seen as the way actors interact with each other and their decision consequences related to resource integration (Cabiddu et al., 2019). Therefore, studying the structure of IT-enabled value co-creation through social interaction and resource integration is critical, as IT can provide insights into the relevant actors, activities, and interlinked relationships.

(3) Value co-creation of social support

Value co-creation can be fostered in social media environments, such as social networking services, online brand communities and forums. Schau et al. (2009) observed that several successful brand communities have established a process of co-creating value with customers. Members participate in community activities by using social network tools to share brand usage

experience and manage brand impressions. Value co-creation through social networking requires user participation, trust and commitment. Social platforms provide a channel for organizations to communicate and help organizations enhance user engagement and interaction. It is obvious that social platforms cater to a wide range of audience groups and maintain a wealth of information, it also creates many opportunities for cooperation. Social platforms are virtual platforms where users can share their experiences and information and express themselves socially. At the same time, the social platform can be used as a collaborative tool to support a group of people to interact and work together, and the collaborators can use the platform to get shared results (Wallace et al., 2021).

In various types of social interactions, companies communicate and collaborate with users, partner companies, and other entities through social platforms, communities, and social tools. The value co-creation of social support creates value through four key elements: social platforms, customer engagement, organizational resources, and customer value creation (Edvardsson et al., 2011).

Social value is created through the co-creation of four key elements: social platform, customer engagement, organizational resources and customer value creation.

Social platforms, which are online platforms that integrate customer-facing social functions such as recommendations and ratings, are increasingly becoming an effective way to stimulate customer engagement. In a social environment with the Internet as the information transmission medium, social interaction takes place between users on social platforms (Y. Q. Wang et al., 2017). These social platforms enable businesses to interact with customers during shopping activities, thereby increasing their brand loyalty.

Customer engagement is a major driver of market-driven strategies and requires a unique set of competencies (Tuominen et al., 2004). Positive business logic becomes the market driving force of the enterprise, and by promoting its development, it creates new customer value (Berghman et al., 2006).

Organizational resources, as the basis of value co-creation, can bring new value to the enterprise. The service-oriented logic holds that these co-creators in the process of value creation are resource integrators who are able to integrate the resources of operators and operators to support the co-creation activities and interactions when services occur (Edvardsson et al., 2011; Lusch & Vargo, 2006). Actionable resources include tangible resources, such as economic resources and goods materials, while operational resources are composed of material, cultural and social resources (S. Baron & Warnaby, 2011). The effective way to create value is to acquire operational resources and operational resources and use them effectively (Normann,

2001).

Customers are considered to be co-creators of value. In brand communities, customers employ four methods to co-create value: social networking, impression management, community engagement, and brand usage. Customer brand communities focus more on value creation, and then they make more efforts to improve the perceived value (Schau et al., 2009).

(4) Enterprise value co-creation

Vargo and Lusch (2004) pointed out that service is the application of capabilities by suppliers to bring benefits to customers. Following this logic, industrial service can be defined as the application of a supplier's knowledge to improve the performance of a customer's production process (Kowalkowski, 2006). With the advent of Industry 4.0, this range of services becomes more diverse, as digital technologies provide improvements to existing services and the development of new industrial services, so-called smart services (Klein et al., 2018; Paschou et al., 2018). Intelligent industrial services are services based on data collection and analysis that can optimize customers' production processes (Töytäri et al., 2017).

According to Ramaswamy (2011), value co-creation is a collaborative practice that involves suppliers, other stakeholders and customers jointly participating in the development of a system, product or service. Therefore, when studying value co-creation in corporate relationships, in addition to the interaction between customers and suppliers, other stakeholders involved in partnerships should also be considered (Galvagno & Dalli, 2014).

In the digital environment, the co-creation of value takes place outside of the binary relationship between customer and supplier, and it takes place in an ecosystem involving different stakeholders. According to Lim and Maglio (2018), any type of socio-technical service system involves value co-creation, where different stakeholders work together to produce outcomes that have mutual value. In industrial intelligent service systems, value co-creation usually takes the following form. On the supply side, the enterprise's suppliers and the upstream and downstream enterprises in the supply chain jointly form a resource pool. This resource pool can meet the needs of customers for mass customization of products and services after integrating the capabilities and advantages of each enterprise. On the consumption side, when customers use digital products, a steady stream of data is generated, and intelligent terminals share the data with enterprises. Enterprises can improve the quality and performance of industrial services through data analysis, thus producing mutually beneficial results. This result benefits all parties involved, including customers, suppliers and other stakeholders.

2.3.3 Smart manufacturing

2.3.3.1 Evolution of manufacturing capability

Over the centuries, the industrial environment has changed, and the manufacturing sector has undergone several paradigms accordingly. Such as flexible manufacturing (Ezpeleta et al., 1995), reconfigurable manufacturing (Koren et al., 1999), lean manufacturing (Shah & Ward, 2002), wireless manufacturing (G. Q. Huang et al., 2009). These paradigms were all triggered by the emerging technologies and changing markets of the time. To explore intelligent manufacturing, D. Q. Guo et al. (2020) proposes a graduate-style Intelligent Manufacturing System (GiMS) to transform production management and operations into a new manufacturing paradigm. Under this new manufacturing paradigm, Industrial Internet of Things (IoT) and digital twin technologies are adopted. The Industrial IoT and Digital Twin Double Enabling System (GiMS) consists of three layers: the physical space layer, the cloud space layer and the digital twin data layer that links the physical space and the cloud space together.

At the physical space layer, manufacturing resources, manufacturing processes and production systems are modeled at the object level, product level and system level. The object level focuses on manufacturing objects, capturing and mapping the manufacturing state of objects (such as device ID, properties, status and services) in real time based on IOT technology. The product level focuses on the manufacturing process of the product and can visually trace the 3D model and manufacturing process of the product with the support of the Internet of Things, intelligent gateway and Web 3D technology. The system level focuses on production systems, which support human-centered interactive systems based on industrial wearables, acquiring and allocating limited resources to efficiently meet demands with parallel and continuous activities (D. Q. Guo et al., 2020).

The digital twin data layer links the physical and cloud Spaces together. In this layer, a mobile gateway operating system is developed through simple definition, configuration and execution. This system aims to centrally manage digital twin data mapped from object level, product level and system level in physical space. Based on GiMS, the digital twin data can be mapped in the form of digital tickets and constantly updated as the physical space changes synchronously (Barari et al., 2021).

In the cloud space, with the support of digital tickets, work task services, logistics task services and operational task services are provided for managers and field operators to facilitate decision-making and daily operations in the aspects of production planning, scheduling, execution and control. After being deployed in the cloud, managers and field operators can

easily access these applications through fixed and mobile terminals, such as PCs, iPads, smartphones and wearables (D. Q. Guo et al., 2020).

2.3.3.2 Smart manufacturing capabilities

Industries are focusing on strengthening their flexible manufacturing capabilities (FMC), which is widely recognized as the main way to upgrade enterprises' smart manufacturing capabilities and create competitive advantages. From a strategic perspective, FMC enhances a company's business strategy by reducing uncertainty and maintaining smooth production processes (Ibraimi et al., 2016; Q. Y. Zhang et al., 2006). Flexible manufacturing capabilities, such as volume and mixing flexibility, are external competitive capabilities valued by customers. Volumetric flexibility is described as the ability of an organization to modify volume levels to maintain profitability and minimal disruption in response to a changing socio-economic situation (Raj et al., 2008). Hybrid flexibility refers to the ability of a production system to respond to increasing product changes while maintaining system performance (Ullah & Narain, 2021). These external dimensions are valued by customers because these dimensions directly benefit them. FMC, which includes machines, labor, material handling, capacity and routing flexibility, is an important internal component of a customer's competitiveness. When a company focuses on improving its flexibility and does so successfully, the company is able to effectively handle fluctuations in the demand for its products in the market. However, in order to achieve this level, businesses need to identify and implement certain factors that can help them achieve better FMC (Ullah et al., 2012).

(1) Advanced manufacturing technology

Advanced Manufacturing Technology (AMT) refers to a collection of tools that automate and integrate various design, production, planning, and control processes (Cagliano & Spina, 2000). AMT reduces setup times, improves workflows, and increases the level of factory integration, allowing manufacturers to offer a wide variety of products in deliveries that meet varying volumetric flexibility and mixing flexibility (Mishra, 2020).

(2) Operational improvement methods

Operational Improvement Platform (OIP) are a collection of just-in-time (JIT) methods that emphasize continuous improvement in the manufacturing process, such as reduced setup time, preventive maintenance, cellular layout, pull production, total quality management, et al., helping to improve the volume flexibility and hybrid flexibility of an organization (Mishra, 2020). The deployment of AMT, combined with OIP, has a large impact on the flexibility of an organization (Da Silveira, 2006).

(3) Internal and external learning

Internal learning refers to situations in which employees acquire new skills and knowledge while performing routine and challenging tasks in teams or individually. External learning refers to the skills, knowledge, and experience that employees gain while working with suppliers, customers, and other third-party service providers (Okoro et al., 2021). Organizations that promote employee learning behaviors develop competitive capabilities to deal with a variety of situations that arise in both internal and external environments (Harryson et al., 2008).

(4) Adaptive human resources

Adaptability is a key trait of a person and refers to his ability to change himself as his environment changes. It is already very well established that adopting advanced technology is beneficial for an organization's FMC and competitiveness (Sabuhari et al., 2020). However, even the most advanced technologies cannot handle demand fluctuations single-handedly, they need the help of adaptive human resources. Adaptive human resources possess the ability to handle diverse, ambiguous and complex work environments and make effective decisions in different situations (Do et al., 2016).

(5) Absorptive capacity

Absorptive capacity is based on previous learning experiences and current knowledge, and it influences an organization's creative actions in the face of environmental disturbances in both active and passive ways (Y. Q. Wang et al., 2017). In other words, absorptive capacity refers to an organization's ability to manage internal innovation as well as to acquire and absorb external ideas, data and expertise. Organizations with absorptive capacity are better able to absorb and disseminate existing information and use this information to innovate and develop superior capabilities (Patel et al., 2012).

(6) Modularization of products and processes

Modularity of products is generally recognized as a goal of good design practice and is coming into focus as companies try to streamline their product lines and offer more variety at lower cost (Z. Q. Wang & Zhang, 2020). Increasing the modularity of products can lead to improvements in product flexibility (Ravi et al., 2005). Process modularization first standardizes the manufacturing sub-processes and then rearranges these sub-processes. At the same time, the standardized sub-processes support the rapid addition of modules to meet rapidly changing product and service needs.

(7) Time-based manufacturing

Time-based manufacturing is a production method that focuses on responding quickly to changing customer needs. In order to improve responsiveness and other competitive capabilities,

such as FMC, time-based manufacturing relies on methods that reduce time (Jin et al., 2021). These practices include active employee involvement in problem solving, process redesign, cellular production, total preventive maintenance, quality management, use of reliable suppliers, and build to order (Moges et al., 2011). Time-based manufacturing practices have resulted in a significant reduction in lead times, which in turn allows the organization to respond quickly to customer orders, which in turn allows the organization to demonstrate greater competitiveness.

(8) Capacity flexibility

Capacity flexibility refers to the ability to modify the quantity and variety of production. Enterprises need to create conditions and use fixed resources as much as possible. This factor can help organizations absorb short-term fluctuations in demand highly efficiently (Holtewert & Bauernhansl, 2016). Some practices that increase capacity flexibility are hiring temporary staff, making employees work overtime, installing new machinery, using subcontracting, et al.

(9) Delay in implementation

Delayed implementation is a strategy whereby a manufacturer creates a generic product that can be reconfigured at a later stage of production before it is finally delivered to the customer (Saghiri & Barnes, 2016). Delayed implementation allows the manufacturer to incorporate the diverse needs of the customer into the product without affecting existing production plans and operating procedures, thus achieving flexibility to respond to fluctuations in demand (Ferreira et al., 2018).

(10) Organizational structure

The system in which workflows through an organization is called the organizational structure. It enables groups or departments to form teams within their specific functional areas and manage different activities. Organizational structures can be formal or flexible, depending on the nature of the business (Sawhney, 2006). While they are relatively stable than informal or flexible organizational structures, formal organizational structures are somewhat limited in their ability to adapt to new or unforeseen situations. In this case, a flexible organizational structure is more suitable because it allows the organization to adapt to the changing course of events (Koçyiğit & Akkaya, 2020).

(11) Value chain management

Value chain management is the method of providing both supplier flexibility and procurement flexibility, allowing for rapid changes in production levels, raw material procurement, transportation capacity and schedules in response to changing business environments (Soon & Udin, 2011). Procurement flexibility represents the ability of manufacturers to respond to changing supply demands by quickly configuring supply nodes.

Supplier flexibility, on the other hand, refers to the ability of individual suppliers to adapt to changes in orders in terms of design, quantity, mix and delivery times (Siagian et al., 2022).

(12) Top management commitment

The dedication of top management is considered key to achieving organizational goals. Top management makes strategic decisions, and the outcomes of those decisions have an impact on the success of the business (Ullah & Narain, 2021). Managers are responsible for deciding how to use resources, what strategies need to be followed, and what changes need to be implemented. In other words, the pursuit of strengthening the FMC can only be achieved if top management is wholeheartedly committed to achieving this goal (Shukla et al., 2022).

2.3.3.3 Diffusion of IT innovation in smart manufacturing

(1) Manufacturing cloud services

Cloud services in manufacturing represent the evolution of networked and service-oriented manufacturing models that include reconfigurable shop floors and interchangeable project pools with access to shared pools of computing devices based on Cloud Computing (CC) principles (Kubler et al., 2016). The adoption of cloud service solutions in enterprise business and operations management helps enterprises to address global customer order management, matching capacity and demand, and increasing market share through customer segmentation (Thomas et al., 2012). Advanced cloud models allow for service-oriented product development and mass customization, where customers can order, configure, select, and use customized resources and services, ranging from computer-aided software tools to after-sales service (D. Z. Wu et al., 2015).

Cloud computing facilities are available for high-performance applications. Transform manufacturing resource pools (machines and their controllers and capabilities), products (accessories and customer needs) and orders (production patterns, schedules and business specifications) into on-demand manufacturing services (Kagermann et al., 2013). Enable pervasive and on-demand network access to shared pools of HPC resources that can be quickly configured and published as services to a wide variety of end users and require little administrative effort or service provider interaction (Governor, 2017).

(2) Virtualization of manufacturing resources

Resource virtualization is a key element of digital manufacturing. Through the virtualization of any type of production equipment (such as products, machines, tools, et al.), it can effectively balance local production capacity and global production capacity and complete the seamless integration of smart equipment. The virtualization of smart products allows a

portion of the processing power to be transferred from the smart parts embedded on the product to the cloud to dynamically optimize global view control and rapid local response capabilities to unexpected events.

The virtualization of manufacturing execution systems (MES) organizes and manages hardware and software resources in a pooling model, allowing for multiple customer benefits. Dynamic reconfiguration of shop floor equipment can be achieved through publicly available application programming interfaces (APIs) and service-oriented architecture (SOA) orchestration (N. Liu & Li, 2012; Nunes et al., 2014). This separation between hardware resources and software resources that implement controls provides flexibility and agility to manufacturing control systems.

(3) Digital intelligent decision making

The digital transformation of the manufacturing industry through cloud services and resource virtualization has enabled intelligent decision-making in line with flexibility and reality-consciousness theory (Valckenaers, 2019). These issues are addressed through three areas: big data analytics, machine learning, and digital twins.

Big data analytics and computing are currently integrated in one model: 1) collecting data, 2) connecting to create knowledge contexts, 3) reasons for making intelligent decisions, and 4) adaptation and preventive maintenance (Borangiu et al., 2019). The introduction of machine learning will address the need for big data aggregation and analysis for intelligent decisions and actions in digital manufacturing, including adaptive, reconfigurable, responsive, high availability, predictive behavior and contingency response and processing. Digital twins in digital manufacturing refer to a holistic view of the actual functions and characteristics of devices and products, including their digital representation, execution context, historical behavior and temporal evolution. Their physical counterparts remain the same even if they are not always online or in a connected state (Monostori et al., 2016; Oracle, 2017).

2.3.3.4 Supply chain digitization model: C2M

Digitalization has brought new challenges and opportunities to the development of supply chain, and the consumer-to-manufacturer model (C2M) is a new supply chain innovation model. C2M establishes a digital connection between end consumers and upstream manufacturers and product designers and provides a variety of strategies to shorten the information flow process in the supply chain. C2M usually acts as a virtual intermediary through e-commerce platforms. These links allow consumers to directly input not only demand forecasts, but even product and classification designs (D. Xiao et al., 2020). To a certain extent, C2M has been pioneered by e-

commerce platforms such as JD.com and Alibaba.

AAA supply chain has become one of the most influential concepts among practitioners and researchers in the field of supply chain management (H. L. Lee, 2004). It stipulates that supply chains should strive to improve along the dimensions of agility, adaptability and consistency, rather than focusing only on cost and efficiency improvements. While various strategies have been adopted by different industries to promote AAA, digitalization has brought new challenges and opportunities for AAA supply chain development.

(1) Evolution of agility

H. L. Lee (2004) defines agility as the ability to respond quickly to short-term changes in demand or supply and smoothly handle external disruptions. Having agility in the supply chain enables manufacturing companies to achieve a higher level of overall organizational agility. Supply chain agility enables the organization to react quickly and more effectively to market fluctuations and other uncertainties, thus enabling the company to establish a superior competitive position.

In the digital age, shortened product lifecycles and rapid responses to fickle consumer tastes require supply chains to become more agile than ever before. Fortunately, digital platforms unlock new possibilities for supply chains, extending agility further upstream by integrating manufacturing and product design functions. Jd.com uses its consumer data in the retail industry to learn and predict changes in consumption trends, and provides such forecasts digitally through the supply chain, allowing partners at different stages of the supply chain to take coordinated action.

(2) Evolution of adaptability

H. L. Lee (2004) defines adaptability as the ability to adjust supply chain design to meet structural changes in the market and to modify the supply network in response to strategies, products, and technologies. In contrast to agility, which is primarily concerned with decision-making at the tactical and operational levels, adaptability is an attribute at the strategic level of the supply chain.

Digitization brings new challenges and opportunities for the supply chain to explore new adaptive strategies. On the one hand, the width and depth of market and consumer data provided by digital platforms, coupled with advanced machine learning tools, give businesses the ability to detect and predict structural market trends as they occur (or even before). On the other hand, these capabilities are now largely pervasive, so businesses that fail to harness them to respond to and adapt to changes in the market are left behind.

(3) Evolution of consistency

H. L. Lee (2004) describes consistency as the ability to create incentives for better performance. This refers to aligning the incentives of different players in the supply chain to ensure that each stage optimizes its operations with the common goal of maximizing supply chain performance. In addition to aligning goals, all parties in the supply chain freely share knowledge and information, a practice that is particularly important in the digital age.

Coordination can often be achieved using supply chain intermediaries. In the digital age, intermediaries often take the form of digital platforms. A case in point is Chinese e-commerce giant Alibaba, which has launched its Cainiao smart logistics platform. The platform operates as a "digital control" to coordinate the delivery and fulfillment process. While the fulfillment process usually involves multiple independent players (sellers and one or more 3pls), the platform is designed to ensure tight digital integration between logistics and e-commerce platforms for efficiency and agility (Nikiforova, 2022). This model is in sharp contrast to JD's vertically integrated model, which has a large scale self-built logistics and distribution infrastructure.

2.3.4 Digital networks

2.3.4.1 Digital platform

The digital ecosystem is an extension of the business ecosystem, in which digital platforms play a leading role. A digital platform is a technological infrastructure that allows member companies to efficiently develop, configure, and deliver advanced services on an unprecedented scale (Ransbotham & Kane, 2011). Over the past decade, companies utilizing digital platform business models have experienced significant growth. For example, Apple, Microsoft, and Amazon are currently the most valuable companies in the world. At the same time, many manufacturers are actively considering how to utilize digital platforms (Cusumano et al., 2021). Only having a commercial ecosystem in the manufacturing industry does not promote collaboration among members of a digital ecosystem; there must also be a digital platform. Digital platforms are technological infrastructures that enable the efficient development, configuration, and delivery of advanced services (Yoo et al., 2012).

A digital platform is defined as a shared, universal service and architecture used to host complementary products and services, including digital assets (Tiwana et al., 2010). For example, Apple's iOS platform and Google's Android platform allow applications to run on their respective smartphones. Digital platforms provide entrepreneurs with abundant opportunities, which involve developing complementary products and services. Such digital

platforms are typically established by a single company, namely the platform leader, who is responsible for coordinating value creation and distribution. New enterprises are deeply involved in the professional construction of the platform, while developing the platform's marketing and distribution capabilities (P. Huang et al., 2009). Digital platforms allow a group of participants (including individuals and businesses) to jointly create value. New digital infrastructures, such as crowdsourcing and crowdfunding systems, digital manufacturing spaces, work execution forums, and dedicated social media, allow groups with common interests to create value.

Norman (1999) proposed the concept of accessibility. Accessibility is defined as the potential for action provided by an object (such as a digital platform) relative to a specific object (Majchrzak et al., 2013). In recent years, it has been used by scholars to study how digital platforms promote the innovation process of specific objects. In China, e-commerce platforms are developing rapidly and have strong digital platform capabilities. Famous e-commerce platforms include Alibaba, JD.com, and Pinduoduo. However, the digital platform capability is not limited to e-commerce enterprises, and production enterprises with open digital platforms also have strong digital platform capabilities. The existence of this capability enables production enterprises to respond more flexibly to market demand, providing new impetus for the innovation of their products and services. Manufacturing companies with powerful digital platforms include Huawei, Xiaomi, and BYD.

Digitization has fundamentally changed the concept of openness, including the degree, scale, and scope of openness. Digital technology has promoted the openness of digital platforms in several ways. The openness of digital platform technology architecture allows external entities to build and complement each other's capabilities (Tiwana, 2013). The openness of ecosystems or communities means that collectives, individuals, or organizations can collaborate to pursue innovation and participate in joint decision-making and governance (Bilro & Loureiro, 2023; Wareham et al., 2014). Therefore, digitalization has changed the openness in innovation and entrepreneurship. A series of rich open APIs on digital platforms enable third-party developers to take creative actions, thereby giving rise to new digital products or services. As Weitzman (1998) pointed out, the more assets of this type that can be recombined, the more opportunities for innovation.

The development based on digital platforms is beneficial for the growth and internationalization of enterprises (Nambisan et al., 2019). Obviously, technological capabilities related to digital platforms or infrastructure can help businesses achieve growth related goals. For example, common technical standards may help companies expand

internationally. This technological capability also makes it easy for businesses to achieve the goal of providing a consistent customer experience. When the digital background is considered, transaction attributes will change, and companies can conduct international business at lower costs and faster. Since the uncertainty of Internet exporters is lower than that of traditional enterprises, rapid internationalization brings more benefits than costs to enterprises. Owing to the lower risks they face and the fact that they do not commit to any specific market during the internationalization process, their specific location costs during the internationalization process are also lower. These combined factors indicate that exporters based on digital platforms may survive even if they maintain rapid internationalization. Through digitization, enterprises can manage information more effectively, thereby reducing the cost of finding potential business partners and maintaining stronger development resilience (Bilro et al., 2018; Bilro et al., 2023; H. Guo et al., 2020).

2.3.4.2 Digital ecosystem

The digital ecosystem can be defined as a distributed, adaptive, and open technology system with self-organizing, scalable, and sustainable characteristics, inspired by natural ecosystems. The digital ecosystem plays a crucial role in the digital transformation of enterprises. The digital ecosystem provides digital technological capabilities that enable the development of digital business systems in the manufacturing industry. In other words, without a digital ecosystem, the advantages of digital technologies such as artificial intelligence, digital twins, industrial Internet platforms, big data, and machine learning cannot be fully utilized (Loureiro et al., 2024; Stanley & Briscoe, 2010).

The architecture of a digital ecosystem can be divided into multiple levels, each dealing with different problems. The most basic level is the coordination layer, responsible for handling distributed coordination. In well sustained and centralized data centers, these coordination efforts are effective. Above the coordination layer is the resource layer. The resource layer provides platform-as-a-service and upper-level resources, such as the use of storage and computing resources. Finally, the service layer combines resources into services accessible to end-users, which may be further combined into more advanced services (Briscoe & Marinos, 2009). The digital ecosystem is located within the application layer.

Universal elements can be embedded into different layers of the digital ecosystem. The overall capability of the digital ecosystem cannot be defined solely by business capabilities. It is a combination of business capability, information capability, social capability, professional capability, application capability, data capability, platform capability, infrastructure capability,

spatial capability, energy capability, and auxiliary capability. All other elements of the digital ecosystem interact with each other in their environment, which involves political, economic, social, technological, environmental, and legal aspects (Anwar & Gill, 2019). In addition, the digital ecosystem also includes other elements, including service assets, service asset brokers, service asset providers, service asset consumers, and potential support providers. In the digital ecosystem, we refer to digital platforms as digital ecosystem platforms (Koch et al., 2022).

(1) Service assets

Service assets are any material or non-material goods that are valuable to both service asset providers and consumers. Service asset providers and consumers are natural or legal entities that provide or consume service assets, respectively. Service asset matching is a concrete example of core service activities aimed at connecting consumers with providers and their service assets (Koch et al., 2022).

(2) Service asset broker

Service asset brokers are positioned between service asset providers and consumers, assuming the specific responsibility of ecosystem service providers. We refer to this role as a service asset broker in the context of ecosystem services. Ecosystem services facilitate the transfer of service assets through asset brokers. This role is a key participant in the digital ecosystem, often playing a dominant role in software ecosystems (Iansiti & Levien, 2004).

(3) Service asset provider

Service asset providers can provide support to asset consumers through different services based on their experience and knowledge. Service asset providers can provide knowledge as a service to their customers, thereby offering new value to them. On the other hand, service asset providers may have more knowledge to build service capabilities than service asset brokers, as they are able to collect and analyze data from the environment (Kortelainen et al., 2019).

(4) Service asset consumers

A service asset consumer is a natural or legal entity that obtains expected results or benefits from service providers. The activities performed by service providers for service consumers include any activity that can generate economic value. Service providers are responsible for executing core service activities, which generate economic value. After the completion of core service activities, additional actions may be required. These behaviors are mainly related to physical goods, such as service consumers retrieving the goods they purchased from warehouses or supporting service providers in delivering goods to service consumers (Koch et al., 2022).

(5) Service support provider

Service delivery is either completed by the service provider or by the service supporter. Service supporters provide consumers with a way to join the service or a means for consumers to join on their own. For example, payment service provider PayPal, logistics service provider UPS, and cloud service provider Amazon serve as service support providers (Senyo et al., 2019).

2.3.4.3 Digital platform innovation

Digital platforms inject new creativity into innovation and entrepreneurship. Creativity refers to the overall ability of technology to drive change from a large, diverse, and uncoordinated audience without prompting (Zittrain, 2006). In the context of the digital economy, creativity refers to the ability of digital platforms to allow for element recombination, functional assembly, expansion, and redistribution. For example, when Apple injects new features into its digital platform, it creates a chain reaction where existing entrepreneurial opportunities change and generate new opportunities, thereby reshaping the boundaries of the relevant opportunity space. Digital platforms emphasize variability and flexibility. The creativity of digital platforms may stem from the characteristics of digital platform architecture and the governance of related ecosystems, indicating the role of digital technology in shaping the variable boundaries of entrepreneurial outcomes (Yoo et al., 2010).

(1) Innovation in digital technology

The most important feature in the innovation process of digital technology is that the platform becomes the core focus of innovation. The widespread penetration of digital technology and its flexible nature have enhanced the role of platforms and made them the core focus of many companies' innovation activities. We have observed this phenomenon occurring in multiple industries, including automotive, aerospace, media, telecommunications, and information technology. As a key element for innovation and popularization of digital technology, platforms are of great significance to organizational research. On the one hand, organizations must be able to manage a balance between platform innovation and control. When an organization exerts too much control over a digital platform, it may drive away third-party developers and stifle the platform's innovation. On the other hand, when organizations do not exert any control, digital platforms become too diverse and fragmented, making them less valuable to both developers and customers (West & Gallagher, 2006).

The enhancement of data processing capabilities has created new opportunities for innovation. This is because some things could now be presented digitally, which was previously impossible. Software transforms processing power into real-world applications, and the key factor in this technological advancement is the constantly increasing processing power. Another

fundamental change brought about by digitization is the active introduction of online digital platforms in various industries, as well as the increasingly important role of digital platforms in the economy and society (Kenney & Zysman, 2016). Online platforms are reshaping the business sector. Advanced digital technologies are applied by commercial companies to undertake non routine tasks beyond human behavior and thinking (Susskind & Susskind, 2016). Digital platforms standardize overall tasks to make them suitable for computer processing. After computers decompose non routine complex tasks into modular components, task processing becomes easier to automate. Reducing complexity and modularizing complex processes enables machines to replace, expand, and supplement human capabilities (O'Donovan & Smith, 2020; Simon, 2002).

With the ability of machines to perform non routine tasks and the emergence of substitutes between machines and humans, the complementarity between machines and humans has become more common. Especially with the unfolding of the Fourth Industrial Revolution, creative tasks (a large subset of non routine cognitive tasks) have become even more important. Machines can supplement humans in performing tasks that require processing large amounts of information and data, thereby supporting the experience and emotional judgment of professionals. For example, medical diagnosis based on dermatological images, which use biopsy results and can be done using AI based software, has a higher diagnostic accuracy than well-trained doctors (Esteva et al., 2017). Although computers can make mistakes, experienced doctors can also make different types of errors (Brynjolfsson & Mitchell, 2017).

(2) Distributed innovation

In the past few decades, organizational scholars have noticed that information technology has reduced communication and coordination costs, leading to the geographic decentralization of innovation activities (Dhanaraj & Parkhe, 2006). Not only is innovation increasingly shifting towards the edges of organizations, but the distributed innovation stimulated by digital technology has also increased the heterogeneity of knowledge resources. Innovation increasingly requires involving others, and this empowerment of others can be seen in new technological resources such as open data, application programming interfaces, and software development toolkits. Meanwhile, distributed innovation has led to the emergence of new industrial structures. This industrial structure cannot be easily explained by theories based on classical economic models or normal distribution assumptions (Andriani & McKelvey, 2009).

The concept of distributed innovation emphasizes cross organizational collaboration in a decentralized manner, as well as the participation of individuals, users, and communities in innovation activities. Unlike open innovation, distributed innovation emphasizes collaboration

across organizational boundaries to acquire resources for innovative products, services, business models, and processes. Based on this, distributed innovation in digital innovation has attracted widespread attention in global practice and academia. In practice, more and more companies are adopting distributed innovation strategies for digital innovation, such as LEGO's "Lego Ideas" and "Design by Me" platforms, Xiaomi's "Xiaomi Community", and Dell's "Idea Strom" Community. The establishment of these distributed interactive platforms or communities injects new vitality into the digital innovation of enterprises. Scholars believe that distributed innovation has become an important driving factor for digital innovation in enterprises (Choudhury, 2017; Rashid et al., 2019). Therefore, by restructuring and integrating knowledge from both internal and external sources, distributed innovation provides a powerful source of creativity for new ideas, services, and technologies for enterprises, thereby reducing communication and research and development costs for companies (Lyytinen et al., 2016). Undoubtedly, distributed innovation is an important driving factor for digital innovation in enterprises.

With the rapid development of digital technology, the speed of information storage and knowledge dissemination required for innovation has greatly increased. Owing to a significant decrease in communication and search costs, the focus of innovation is gradually shifting from within organizations to distributed entities that cannot be predefined (Kornberger, 2017). If a company cannot effectively filter out valuable information, it will harm innovation or have a negative impact on innovation (Karhade & Dong, 2021). Information technology capabilities can help businesses better absorb external knowledge and promote customer engagement in innovation. With the support of digital technology, distributed innovation provides a fertile ground for enterprises to obtain digital innovation opportunities. Through the process of opportunity discovery and creation, enterprises continuously expand the boundaries of digital innovation. Therefore, distributed innovation has become an important factor driving digital innovation (T. J. V. Saldanha et al., 2017). In fact, distributed innovation strategy plays a very important role in the innovation performance of enterprises. In the digital environment, the driving role of distributed innovation in enterprise digital innovation should be more prominent (Bilro & Loureiro, 2020).

(3) Combination innovation

More and more companies are creating new products or services by combining existing modules with embedded digital functions. Many software that follows standard interfaces can now easily connect with other modules that follow the same standards. For example, many web services now provide standardized interfaces for other developers to connect them with new

products or services. The tracking program related to running shoes can be combined with the map API to store the runner's running trajectory and visualize it on the network. They can also connect to the Facebook APIs to share running information with personal friends. We need to consider which features of digital tools can support valuable combinatorial innovation (Austin et al., 2012).

New digital solutions typically combine existing modules with embedded digital capabilities, or integrate different modules according to the same standards. This means that digital technology has generated a wide range of combinations, creating open innovation opportunities. In addition, the flexible nature of digital technology makes it possible to integrate modular components into digital platforms. Therefore, digital technology enables businesses to innovate by creating digital platforms rather than a single product. For example, many digital native companies, such as Facebook, Uber, and Airbnb, provide a digital technology platform with core features that can be expanded through contributions from external participants (Faraj et al., 2011).

Digital innovation is also characterized by generativity. The infinite combination of loosely coupled layers in a layered modular architecture has triggered continuous dynamic changes, as well as the increasingly inseparable relationship between innovation processes and outcomes. Therefore, knowledge is only a temporary combination, and finding new possibilities for combinations becomes a persistent effort (Yoo, 2010). The existing digital knowledge base of enterprises not only enables them to directly apply and combine this knowledge, but also increases their ability to accept new external knowledge. Therefore, establishing a digital knowledge base itself enables existing enterprises to absorb and utilize more external digital knowledge, thereby promoting the potential of digital innovation (Cohen & Levinthal, 1990). The essence of digital technology encourages experimentation and adaptation, which promotes the utilization and combination of knowledge.

Combination innovation increases the complexity of the innovation process. As the initially produced heterogeneous modules are combined to generate new innovations, organizations are increasingly facing complex system failures or other unexpected consequences. Products, tools, and subsystems originally built for specific contexts can now be easily transferred to other contexts through digital technology. As practitioners continue to construct new combinations based on complexity, combinatorial innovation will provide opportunities for research and bring uncertainty risks. The mobility of digital components and the complexity of digital capabilities increase the risk of organizational failure (Andriopoulos & Lewis, 2009; Smith & Lewis, 2011).

2.3.4.4 Impact of digital platform on performance

Digital platform plays a very important role in the performance of enterprises. In the digital environment, digital platform has the characteristics of platform, combination and distribution, and the positive effect of digital platform on enterprise performance is more prominent. Both open innovation across organizational boundaries and user innovation in cooperation with users can help enterprises acquire heterogeneous resources and diversified knowledge to improve enterprise innovation performance. From the perspective of the depth of cooperation, the closer and more stable the relationship between the organization and external interactive subjects, the more conducive it is to improve organizational performance by using external valuable resources (Tang et al., 2023).

In the digital age, customers increasingly expect the products of traditional enterprises to be associated with their digital daily lives. For example, the initial research on General Motors Company showed that digital innovation can successfully maintain the attractiveness of the core products of the industry's established enterprises in the digital era, thus ensuring the revenue flow of physical equipment, and can also create new revenue sources other than equipment sales through other aspects of the hierarchical module architecture. As in the case of General Motors Company, customers may directly pay subscription fees for in car digital services, while automobile manufacturers may provide a digital platform through which third-party service providers can promote applications to car drivers. General Motors Company can profit from the revenue sharing of these external partners (Hanelt et al., 2021; Yoo et al., 2010).

Digital network has accelerated the internationalization process of enterprises, especially through Internet export. In recent years, internet technology has developed at an unprecedented speed. The digital platform provides advanced services, such as integrated logistics services, professional training, interactive trading kits and customs clearance services (Ojala et al., 2018). In addition, the digital platform uses intelligent functions, such as search services and personalized recommendation algorithms. Rapid export through digital platforms has brought significant benefits to the survival and development of enterprises. The empirical results show that rapid internationalization through the Internet platform is conducive to the sustainable development of enterprises' exports (Deng et al., 2022). The digital platform reduces the transaction costs of exporters and provides them with unprecedented opportunities to understand market knowledge, after-sales services, marketing strategies and the best practices of competitors. Combined with these characteristics, enterprises can better cope with internationalization and improve enterprise performance with the help of digital platforms.

2.4 Conceptual model

Based on the above theories and literature, a conceptual model for this thesis has been preliminarily developed. The conceptual model includes concepts such as digital transformation, cross-border cooperation, and sustainable competitive advantage for enterprises. Among them, digital transformation includes two variables: the technological preparation for digital transformation and the degree of digital transformation. Cross-border cooperation includes two variables: the width of cooperation and the depth of cooperation. In addition, the conceptual model also introduces control variables, as shown in Figure 2.3 for details.

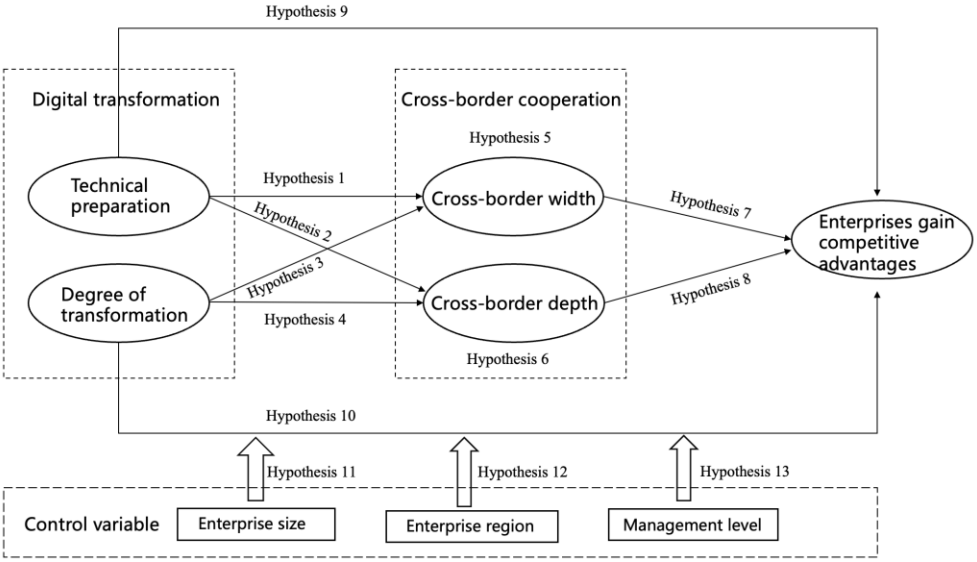

Figure 2.3 Proposed conceptual model

Table 2.1 Proposed hypothesis

Hypothesis	Hypothetical content
Hypothesis 1	Digital transformation technology readiness has a significant positive impact on the width of cross-border cooperation.
Hypothesis 2	Digital transformation technology readiness has a significant positive impact on the depth of cross-border cooperation.
Hypothesis 3	The degree of digital transformation has a significant positive impact on the width of cross-border cooperation.
Hypothesis 4	The degree of digital transformation has a significant positive impact on the depth of cross-border cooperation.
Hypothesis 5	The cooperation width of cross-border cooperation mediates the technological readiness of digital transformation, the degree of digital transformation, and the sustainable competitive advantage of enterprises.
Hypothesis 6	The cooperation depth of cross-border cooperation mediates the technological readiness of digital transformation, the degree of digital transformation, and the sustainable competitive advantage of enterprises.
Hypothesis 7	The cooperation width of cross-border cooperation has a significant positive impact on the sustainable competitive advantage of enterprises.
Hypothesis 8	The cooperation depth of cross-border cooperation has a significant positive impact on the sustainable competitive advantage of enterprises.

Hypothesis 9	Digital transformation technology readiness has a significant positive impact on sustainable competitive advantage of enterprises.
Hypothesis 10	The degree of digital transformation has a significant positive impact on the sustainable competitive advantage of enterprises.
Hypothesis 11	Enterprise size positively moderates the relationship between digital transformation technology preparation, digital transformation degree, cross-border cooperation width and cross-border cooperation depth on firm sustainable competitive advantage.
Hypothesis 12	Enterprise region positively regulates the relationship between digital transformation technology preparation, digital transformation degree, cooperation width and cooperation depth of cross-border cooperation on sustainable competitive advantage of enterprises.
Hypothesis 13	Management level positively moderates the relationship between digital transformation technology preparation, digital transformation degree, cross-border cooperation width and cross-border cooperation depth on sustainable competitive advantage of enterprises.

2.5 Summary of this chapter

This chapter mainly focuses on systematically sorting out, refining and summarizing the domestic and foreign research status of the main variables, and summarizes relevant theories and literature, which serves as the basis for the construction of conceptual model in this thesis. Specifically, this chapter first defines and clarifies basic concepts such as digital transformation, intelligent manufacturing, value co-creation and competitive advantage. On this basis, the research content and theoretical connotation of dynamic capability theory, value co-creation theory and competitive advantage theory, as well as the relationship between the theory and this research are expounded. In terms of literature review, this thesis systematically reviews, combs and refines the research on the conceptual connotation, evolution and influencing factors of the major variables involved in the research, such as enterprise digital transformation, value co-creation and intelligent manufacturing. The developmental context and theoretical boundaries of each variable were clarified, and on this basis, the conceptual model of this thesis was preliminarily constructed.

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Chapter 3: Qualitative Research

3.1 Research design

This thesis uses qualitative research methods to conduct in-depth interviews with several enterprise managers who have implemented or are implementing digital transformation. They included their own enterprises implementing digital transformation, and their own enterprises providing technology and consulting services to help other enterprises implement digital transformation. Two experts from universities also participated in the interview. The main purpose of inviting experts from universities is to observe the views and attitudes of the academic community towards the implementation of digital transformation in traditional enterprises, so as to avoid the problem of one-sidedness caused by only adopting the views of industry experts. The in-depth interview method is used because it can provide first-hand expert data and cover the different perspectives of experts, thus enabling researchers to discover the mechanisms and contributing factors of digital transformation.

In order to balance the validity of the data and the accuracy of the analysis results, this thesis uses qualitative research method to carry out the research. Qualitative research method is a theory derived from the data, rather than a theory that existed before the data. Qualitative research method describes and explains the system or behavior under study and is a research method for developing theories based on systematic collection and analysis of data. When conducting research using qualitative research method, open coding is first performed. In the process of open coding, the information in the data is broken down into small units, and these units are labeled. The researcher can extract the underlying theoretical concepts from the labels, laying the foundation for subsequent analysis and theoretical construction. Second, axial coding is carried out to recombine the concepts obtained from open coding, identify and establish the relationship between different categories. Finally, selective coding is performed. Through careful analysis of the collected data, researchers identify and sort out the key themes, patterns and concepts, so as to obtain the required conceptual model.

The qualitative data analysis software MAXQDA was used to analyze the results after the interview, so as to summarize the relevant information collected in the interview and summarize it into actionable knowledge by using qualitative research method. The whole process is based

on the following model, as shown in Annex Figure 1.

In the analysis stage of the collected data, the main line and main promoting factors of the traditional enterprise digital transformation mechanism are first determined through the interview records, and then the expert interview data is analyzed by the research method of qualitative research to further clarify the path and method of digital transformation. Qualitative research method is based on expert interview data. Researchers' own experience and academic background will inevitably have subjective influences on label setting, theme and concept extraction. In this thesis, in order to reduce the influence of researchers' subjective factors on the research results, MAXQDA software is used to improve the efficiency of interview data analysis by text mining, and MAXQDA's automatic coding function is used to generate keywords, thus reducing the subjectivity of the research. On this basis, the core themes and concepts of expert interviews are further summarized according to the theoretical basis, and the conceptual model is further derived, so as to make the research more objective and scientific.

3.2 Data collection

Interviews were conducted face-to-face. Most of the expert interviews were conducted offline face-to-face, while a few expert interviews were conducted online via video. In video interviews, webcam equipment and video software are used to ensure that the interview can be conducted smoothly and that the interview process is not interfered with by other things. The interviews were conducted using a semi-structured script with questions prepared in advance based on the specific topic of the thesis. During the interview, the focus of the interview and the order of questions can be flexibly adjusted according to the actual situation of the expert communication. This adjustment is more conducive to the discussion of specific topics and the acquisition of research data.

Using an interview script specifically designed for this study, we conducted one-on-one interviews with a total of 27 experts. The interviews were mostly with executives of listed or raised capital companies from different parts of China, including four cities: Beijing, Shenzhen, Hangzhou and Chengdu. Based on being familiar with the research topic, in order to ensure the reliability of the data, the experts interviewed came from different industries and management levels. The industries of the interviewed experts include Internet, software information services, science and technology extension and application services, business services, education, agriculture and animal husbandry. The positions held by the experts in the enterprises include senior managers, including chairman, chief technology officer, chief product officer and vice

president. There are also middle managers, including director of solutions, director of technology, director of operations, director of product and chief of staff. In addition, there are lower-level managers, including solution specialists, technical specialists, operations specialists, product specialists, and consultants. The 27 experts interviewed ranged from 30 minutes to 50 minutes, and the edited interview notes ranged from 8,000 Chinese characters to 14,000 Chinese characters.

The interviews involved experts who had experience in digital transformation in traditional enterprises, some who had implemented digital transformation in their own enterprises, and some who had helped other enterprises implement digital transformation through technology or consulting services provided by their enterprises. This helps to discover the path and mechanism of digital transformation in traditional enterprises. In addition to experts from enterprises, we also interviewed experts from universities.

After combing through the backgrounds of 27 experts, we made a descriptive analysis of the overall situation of the experts interviewed. The details are as follows:

A total of 11 low-ranked managers, 10 middle managers and 6 senior managers participated in this expert interview. The proportion of low-ranked managers, middle managers and senior managers was 40.7%, 22.2% and 37.1% respectively. The above data show that the interviewing experts are distributed at all levels of enterprise management and can discuss and evaluate the process of enterprises implementing digital transformation from different levels, which increases the credibility and representativeness of the samples.

In terms of the industry of experts, the Internet industry accounted for 51.9%, software and information technology service industry accounted for 25.9%, science and technology promotion and application service accounted for 7.4%, and other industries accounted for 14.8%. Other industries include education, business services and agricultural technology. As can be seen from the data, the interviewed experts are mainly concentrated on the Internet and software information technology industries. On the one hand, as the main body of digital transformation, these industries themselves are or have implemented digital transformation. On the other hand, with the help of their own information technology and digital transformation experience, enterprises in these industries provide digital transformation solutions for enterprises in other industries.

In terms of the regions where the experts are located, 55.6% of the experts are from Chengdu, 14.8% are from Beijing, 14.8% are from Shenzhen and 14.8% are from Hangzhou. Beijing, Shenzhen, Hangzhou and Chengdu are several cities with rapid development of information technology in China, and geographically located in the north, southeast, east and

southwest regions of China, with certain regional representation. Since the author is located in Chengdu, the proportion of experts from Chengdu is relatively high. However, the selection of experts should avoid the situation that many experts come from one enterprise. Since many large enterprises have branches in Chengdu, the business carried out by these branches is not limited to Chengdu, so the selection of experts in this way avoids the problem of regional concentration to a certain extent.

Among them, the non-listed enterprises have completed at least one round of financing. In the context of digital transformation research, mature enterprises are more effective to the study of transformation models. The specific sample distributions are listed in Table 3.1.

Table 3.1 Distribution of basic characteristics of samples

Categories	Options	Quantity	Percentage
Industry of experts	Internet	14	51.9%
	Software and information technology services	7	25.9%
	Science and technology extension and application services	2	7.4%
	Other	4	14.8%
Specialist job ranks	Senior management	6	22.2%
	Middle managers	10	37.1%
	Low-ranked managers	11	40.7%
Regional distribution of experts	Chengdu	15	55.6%
	Beijing	4	14.8%
	Shenzhen	4	14.8%
	Hangzhou	4	14.8%
Stage of enterprise development	Already listed	20	74.1%
	Unlisted	5	18.5%
	NGO	2	7.4%

3.3 Data analysis

According to the steps of data analysis (Eisenhardt, 1989), we first structured and classified the interview data, which laid the foundation for subsequent analysis. Second, we identified multiple relevant constructs and coded them to ensure the accuracy and consistency of the data in the subsequent analysis. Then, we compared the relevant literature to verify and supplement our data with the help of existing research results, so as to increase the credibility of the study. In addition, we also conducted a preliminary analysis of the interview data of each expert to establish the relationship between concepts. In order to further enhance the rigor of the study,

we also carried out cross-expert data comparison and verification, which helped us to identify the resonance and differences between different experts to ensure the comprehensiveness of the analysis results. Finally, through multiple comparisons and validations, we established the relationship between multiple concepts and developed with our findings.

Data analysis first converts the recording of expert interviews into text and then sorts and analyses the text. Then MAXQDA, a qualitative data analysis software, is used to encode the interview contents and establish categories, and then summarizes the mechanism and influencing factors of the digital transformation of C2M enterprises, as well as the competitive advantages gained by the digital transformation of enterprises.

3.3.1 Data coding

The first step is to reduce the data, delete the inconsistent data in different expert interviews, and then label the key data of the verified expert interviews. Then, combined with the concepts in the previous literature, the concept combinations in the expert interviews are identified, and the keyword combinations are abstracted.

When coding, first, the automatic coding function of MAXQDA software is used to extract keywords. Then, we extract keywords from the interview data, aiming to summarize the core ideas expressed by the interviewees. We then rigorously screened, modified, and supplemented these keywords and labeled them as themes, which accurately reflected the essence of the interview content. On this basis, we further cluster the topics, and we look for appropriate constructs from the relevant literature to conceptualize the clustering. Finally, we divide these conceptual categories into different dimensions, which further enhances the hierarchical and systematic data analysis. For example, in the dimension of digital transformation, we first get the experience themes of coding "e-commerce", "artificial intelligence", "digital twin", "blockchain", "cloud computing", "information transparency", "digital talent" and "integration of online and offline", and then aggregate these themes into two clusters of "digital transformation technology readiness" and "transformation degree". Finally, the two clusters are summarized under the dimension of "digital transformation". According to this method, the other two clustering dimensions of this thesis are summarized as "cross-border cooperation" in digital transformation and "enterprises gain competitive advantage" after digital transformation.

After the coding work is completed, the researchers exchange ideas and make modifications to form the final coding result. In this process, new connections between concepts are established by comparing the coding results with existing theories over and over again, ensuring that the coding data matches the existing theories (Eisenhardt & Graebner, 2007).

3.3.2 Reliability and validity

In order to ensure the reliability and validity of the research data, this thesis repeatedly compares and iterates the concepts derived from the analysis of interview data with existing theories. When there is a conflict between the two, the interview data is re-encoded and the relationship between concepts is reconstructed, so that the proposition of the relationship between digital transformation and enterprises' competitive advantage can conform to the literature theory. And it can improve the external validity of the research conclusions. In terms of internal validity, two professors with experience in the field of digital transformation and enterprise informatization were invited to participate in coding, and their coding data was repeatedly compared with their coding opinions, and finally coding consensus was reached. On this basis, the coding results of the interview and research propositions are collected to the interview expert representatives, who review the results, thus improving the internal validity of the results.

3.4 Analyzing the results

3.4.1 Subject data coding

In the topic data coding stage, the interview data of 27 experts were sorted out and imported into MAXQDA software. The MAXQDA software provides rich qualitative data processing functions. When conducting preliminary data analysis of the interview texts of experts, the MAXQDA automatic coding function can obtain the main meaning of each paragraph of the interview text, thus forming a free node. In the following analysis, the free node data is encoded to obtain new coding data, which is called the topic. Then, the subject data is stratified and clustered. Through literature comparison and analysis, the coding nodes will be added and deleted continuously. In this process, two professors who study digital transformation will be invited to participate in the modification of the node coding results. Through the above steps, a coding tree is finally formed, in which the root node is the topic, the second-level tree node is the subtopic, and the third-level tree node is the keyword. Finally, matrix analysis is carried out on the theme classification results, and then the main themes in the field of enterprise digital transformation and the relationship between them are obtained.

Through the coding analysis of the interview data of 27 experts, 207 free nodes are automatically encoded by MAXQDA. Through data coding, three root nodes, five leaf nodes and 72 free nodes are finally obtained, as shown in Annex Figure 2.

The above coding results were sorted out and modified, and after several discussions with two professors in the field of digital transformation and enterprise informatization, as well as consulting relevant literature and theories, a consensus was reached on the topic coding, indicating that the coding results of this study were credible.

Table 3.2 summarizes the final topics, subtopics, and free nodes. From Table 4.2, we can intuitively see the number and hierarchical relationship of topics, sub-topics and free nodes encoded by expert interview data. As shown in the table, the three themes are digital transformation, cross-border cooperation, and enterprises gaining competitive advantages. The five sub-topics are: technical preparation for digital transformation, degree of digital transformation, cross-border width of cross-border cooperation, cross-border depth of cross-border cooperation, and competitive advantages gained by enterprises. The 79 free nodes are: Data warehouse, CRM, supply chain, warehousing services, financial services, e-commerce, production and marketing planning collaboration, developing new products, big data, cloud computing, artificial intelligence, Internet of Things, 5G, full chain services, Open AI, commodity digitization, channel material management, store standardization, intelligent customer service, scheduling algorithm, recommendation algorithm, coordinate positioning, user profile, ERP, mobile technology, image recognition, electronic signature, digital twin, OA, blockchain, 3D printing, one-bit engineering, organizational change, process transformation, assessment system, information transparency, long-term investment, digital culture, management standardization, digital talent, transformation target positioning, online and offline integration, product matrix, regulatory authorities, institutions, consulting service providers, technology service providers, suppliers, channel operators, terminal stores, human resources service providers, logistics and transportation service providers, financial service providers, solution service providers, customers, e-commerce platforms, distributors, real estate developers, construction parties, join Business, foreign trade companies, joint ventures, cooperation efficiency improvement, tax growth, data collection growth, first-hand information, system docking, skills training, supply chain competitiveness improvement, common growth, business consulting, on-site services, revenue growth, net profit growth, market expansion, cost reduction and efficiency, investment, policy support, market value growth.

Table 3.2 Coding and hierarchical relationship of interview data

Topics	Number of Nodes	Subtopics	Number of nodes	Keywords and number of nodes under the subtopic
Digital transformation	339	Technical Preparation	179	Data Warehouse (17), CRM (7), Supply Chain (5), Warehouse Services (3), Financial Services (5), e-commerce (6), Coordination of production and marketing planning (2), Development of new products (2), Big Data (5), Cloud computing (4), Artificial intelligence (17), Internet of Things (13), 5G (2), full chain services (2), Open AI (3), Commodity digitalization (4), Channel material management (2), store standardization (6), Intelligent customer service (11), scheduling algorithm (8), Recommendation algorithm (12), coordinate positioning (8), User Portrait (4), ERP (6), Mobile technology (10), Image recognition (2), Electronic signature (3), digital twin (5), OA (2), Blockchain (2), 3D Printing (1)
		Degree of transformation	160	Position 1 Engineering (15), Organizational Change (19), Process transformation (28), Appraisal system (13), Information transparency (9), long-term investment (20), Digital culture (11), standardized management (7), Digital talent (18), transformation target positioning (10), Online and offline integration (7), Product matrix (3)
Cross-border cooperation	214	Cross-border cooperation Cross-border width	124	Regulatory authorities (6), public institutions (3), consulting service providers (6), Technical service provider (17), supplier (21), channel provider (13), Terminal stores (6), human resource service providers (10), Logistics service provider (6), Financial service provider (4),

			Solution service provider (3), Customer (9), e-commerce platform (6), Distributor (6), real estate developer (3), construction party (1), Franchisee (1), Foreign trade company (1), Joint venture company (2)
	Cross-border cooperation	90	Increased cooperation efficiency (25),
	Cross-border depth		tax revenue growth (2), Growth rate of data collection (9), first-hand information (6), System docking (12), Skill training (4), Supply chain competitiveness improvement (10), Common growth (17), Business Consultant (4), On-site Service (1)
Gaining a competitive edge	52		Revenue growth (9), net profit growth (4), market expansion (2), Reducing costs and increasing efficiency (31), obtaining investment (3), policy support (2), Increase in market value (1)

After the above data coding is obtained, it is necessary to extract the core categories and core concepts and establish the relationship between them at different levels. The coding results are shown in Table 3.3. In the process of building the concepts, high-frequency words and word combinations in the interview should be used as much as possible, thus effectively reducing the subjectivity of concept extraction.

Table 3.3 Summary of coding results

Core Categories	Secondary Categories	Core concepts	Coding Examples
Digital Transformation	Technical readiness	Software technology, hardware technology, technology application, artificial intelligence	CRM, User profiling, Internet of Things, 3D printing, supply chain, e-commerce， Smart customer service, smart customer service,
	Degree of transformation	Business process, corporate culture, management model	Organizational change, process transformation, Digital culture, appraisal system,
Cross-border cooperation	Width of cross-border cooperation	Type of partner, business	Regulatory authorities, technology service providers, Suppliers, customers，
	Cross-border depth	Ecosphere, value creation,	Enhancing cooperation efficiency,

	Resource sharing	Synergizing systems and skills，Supply chain competitiveness, common growth
Gain Competitive advantage	Financials, performance reviews	Revenue growth, market expansion, Reduce costs and increase efficiency

By summarizing the coding results, we can basically summarize the digital transformation value creation process of C2M enterprises and the relevant content of enterprises to obtain competitive advantages. The summary is as follows:

Enterprises conducting digital transformation refers to the selection of the right information technology, the correct implementation of the technology, ensuring the satisfaction of the technology end users, the continuous and purposeful use of the technology to support strategic business objectives, and obtaining value from the implemented technology. In terms of technical preparation, C2M enterprises introduce software technology and hardware technology into the relevant links of enterprise management. Enterprises use relevant technology application achievements to improve the production efficiency of each production links and reduce production costs through artificial intelligence and other technical methods. First, in terms of software technology, data warehouse, CRM, cloud computing, digital twin and other software technologies are introduced; Second, in terms of hardware technology, hardware technologies such as the Internet of Things, 5G, 3D printing and mobile technology are introduced; Third, in terms of technology application, the introduction of supply chain, e-commerce, production and marketing plan coordination, standardized store management and other mature technology integration solutions to verify under specific business scenarios; The fourth is to introduce artificial intelligence technology and apply it in intelligent applications such as intelligent customer service, scheduling algorithm and recommendation algorithm.

The digital transformation of C2M enterprises measures the degree to which digital technology is used to create value in product development, manufacturing, improving products and services, integrating value chains and other links, including the improvement of business processes, corporate culture, management mode. In order to achieve the desired results of the digital transformation, the attention of the first position has guaranteed resources for the transformation and provided the support of the management. Organizational change provides institutional support for organizations to adapt to the introduction of technology and play the value of technology. Digital culture refers to the company's cultural reconstruction of digital technology, digital talent and digital operation to support the enterprise's digital transformation.

Cross-border cooperation in enterprise digital transformation, in terms of the width of cross-border cooperation, refers to the types and quantities of cross-border cooperation adopted

by C2M enterprises and digital cooperation with other enterprises. It covers the upstream and downstream links of enterprise operation, as well as government regulatory departments. There are also service providers that support the operation of specific links of enterprises, such as logistics and transportation service providers, financial service providers, foreign trade companies.

Cross-border cooperation of enterprise digital transformation, in terms of the depth of cross-border cooperation, refers to the degree of digital cooperation between C2M enterprises and other enterprises in the upstream and downstream of the supply chain, sales, after-sales, service and other links. The higher the degree of cooperation, the more obvious the value co-creation effect. The resource sharing among the participating cooperative enterprises is also more sufficient. It is reflected in the process of enterprise operation, including the improvement of cooperation efficiency, the acquisition of first-hand data, and the common growth.

The effect of an enterprise's implementation of digital transformation is ultimately reflected in the competitive advantages obtained by the enterprise. The combination of enterprise financial indicators and management performance reflects the competitive advantages obtained by the implementation of digital transformation and provides a basis for enterprise operations and decision makers. It includes revenue growth, profit growth, market scale expansion, efficiency improvement, etc.

3.4.2 Thematic cluster analysis

After completing open coding, the next step will be axial coding. Axial coding is a further generalization of preliminary concepts and topics based on open coding. Axial coding can help to explore the relationship between each node and finally find out the relationship between the factors of the research object.

The MAXQDA software and matrix analysis can be used to further investigate the correlation between various topics and perform cluster analysis. The results of matrix analysis are shown in Table 3.4 Node matrix.

Table 3.4 Node matrix

	Digital Transformation Technical readiness	Digital transformation Degree of transformation	Cross-border cooperation width of cross-border cooperation	Cross-border cooperation Cross-border depth	Companies gain competitive advantage
Digital transformation Technical	179				

readiness					
Digital Transformation	67	160			
Degree of transformation					
Cross-border cooperation					
width of cross-border cooperation	23	20	124		
Cross-border cooperation	26	21	51	90	
Boundary depth					
Companies gain competitive advantage	33	26	4	14	52

Through the node matrix list, it is possible to view the situation of the intersection points between the various topics derived from the expert interviews. The presence of multiple topics in the same paragraph of the expert interview text data indicates that there are intersections between multiple topics in the expert description. In our statistics, if multiple intersections of the same topic occur in the same paragraph, we count only one intersection. This minimizes the impact of repetitive descriptions by experts on the relevance of topics.

The more intersections of topics, the closer the relationship between topics. As can be seen from Table 3.4, what is closely related to the preparation of digital transformation technology is the degree of digital transformation, the width of cross-border cooperation, the depth of cross-border cooperation, and the competitive advantage of enterprises. What is closely related to the degree of digital transformation and transformation is the width of cross-border cooperation, the depth of cross-border cooperation, and the competitive advantage of enterprises. The depth of cross-border cooperation is closely related to the depth of cross-border cooperation, and the competitive advantage obtained by enterprises is closely related to the depth of cross-border cooperation.

3.4.3 Conceptual model of digital transformation of C2M enterprises

Next, we will model the topics obtained by open coding. Based on the literature research, the above results of open coding are analyzed, and combined with the research focus of this thesis, the five core themes of open coding are further simplified into three concepts: digital transformation, cross-border cooperation and competitive advantage. Among them, digital transformation corresponds to the digital transformation technology preparation and the degree of digital transformation in the open coding stage; Cross-border cooperation corresponds to the width and depth of cross-border cooperation in the open coding stage; Competitive advantage

corresponds to enterprises in the open coding stage gaining competitive advantage.

The topic of open coding obtained through expert interviews is summarized into relevant concepts. We can draw the following conclusions: (1) In the context of digital transformation, the implementation of digital transformation by C2M includes two aspects: technical preparation and transformation degree. Technology preparation for digital transformation provides technical reserves for enterprises to implement digital transformation and provides technical means for tapping digital potential. The degree of digital transformation reflects the degree to which digital technology is used to create value in every link of production and operation of an enterprise. It is the changes made by an enterprise in many aspects such as rules and regulations, performance appraisal, business process, talent introduction and management system in order to adapt to digital transformation, so as to achieve better digital transformation effect. (2) Under the background of digital transformation, C2M enterprises' cross-border cooperation not only focuses on the number of digital cooperation enterprises, but also on the depth of digital cooperation with other enterprises. In this thesis, the width of cross-border cooperation is used to measure the number of digital partners. The depth of cross-border cooperation is used to measure the closeness of digital cooperation between C2M enterprises and other enterprises in the upstream and downstream, sales, after-sales, service and other links of the supply chain. (3) Enterprises implement digital transformation with the goal of enhancing the competitiveness and performance of the organization through the introduction of digital technologies. Technology is the internal driving force for enterprise business growth and efficiency improvement, and digital transformation is the driving force for the sustainable development of individual enterprises, and the key element to promote the industrial transformation and upgrading of C2M enterprises.

3.4.4 Research on influencing factors of digital transformation of C2M enterprises

After in-depth analysis of the five themes of digital transformation technology preparation, digital transformation degree, cross-border cooperation width, cross-border cooperation depth, and enterprise gain competitive advantage obtained by spindle coding, three concepts of induction and leadership are obtained, including digital transformation, cross-border cooperation, and competitive advantage. Based on the original data obtained in the form of expert interviews, university expert discussions and return visits of some experts, further comparison is made to summarize the influencing factors of digital transformation, cross-border cooperation and competitive advantage at three levels, which lays a theoretical foundation for exploring the mechanism and influence path of the implementation of digital transformation by

C2M enterprises on the acquisition of competitive advantage. The conceptual model of the implementation of digital transformation in C2M enterprises is proposed. See Figure 3.1 for details.

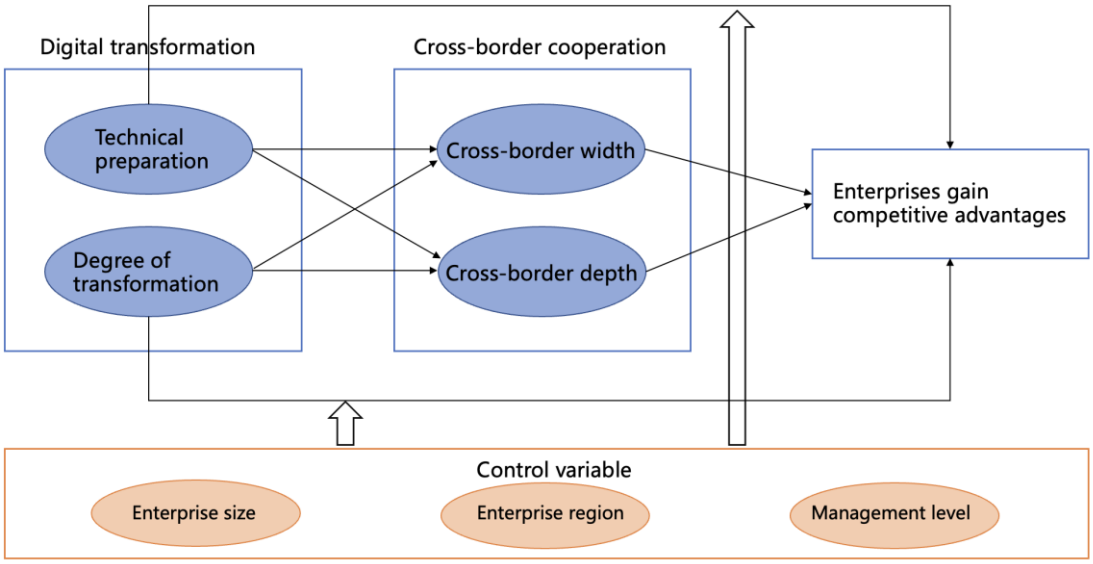

Figure 3.1 Conceptual model of C2M enterprises implementing digital transformation

3.4.4.1 Digital transformation

In the digital transformation of C2M enterprises, the technical readiness and transformation degree of digital transformation play a leading role. Only when there is a breakthrough in the introduction, absorption, application and transformation of digital technology, the enterprise comprehensively uses a variety of reasonable technical means, and effectively combines the production and operation of the enterprise to realize the upward change of the production and operation of C2M enterprises, can the C2M enterprises transform from traditional manufacturing enterprises to new digital manufacturing enterprises.

The degree of digital transformation is the result of the introduction of digital technology and the integration of all aspects of production and operation. For digital transformation enterprises, the introduction of technology will never be permanent. In order for technology to have a positive effect, the organic combination of organization and technology should be achieved. This requires enterprises, in order to make digital technology produce value, should build the mechanism, process and culture of enterprise digitalization based on technology introduction. Through the integration and absorption of digital technology by organizations and talents, the technology can exert its value in the enterprise, improve the production efficiency of the enterprise, and finally realize the increase of the competitiveness of the enterprise and the enhancement of the ability to create value. Since the purpose of implementing digital

strategy is to obtain incremental value, at the level of digital transformation, the incremental value obtained by relevant parties inside and outside the enterprise through digital transformation has become a key factor.

3.4.4.2 Cross-border cooperation

In the process of digital transformation of C2M enterprises, cross-border cooperation plays a role of connecting the past and the next. To undertake the digital transformation, through the cross-border cooperation of enterprises, guided by value co-creation, leading the value creation process between enterprises. Through the participation of the whole process, the cooperative enterprises use digital means to strengthen the cooperation between enterprises, improve the efficiency of cooperation, effectively integrate the resources between enterprises, jointly formulate digital collaborative plans and discuss and solve the problems existing in mutual cooperation, use digital technology to build a value co-creation system, and finally transform and upgrade the traditional manufacturing enterprises into digital manufacturing enterprises.

To carry out cross-border cooperation in digital transformation, on the one hand, enterprises with the potential of value co-creation need to carry out digital cooperation in every link of production and operation; On the other hand, cooperation between enterprises needs to identify cooperation points, and carry out digital cooperation between enterprises in the direction of significantly improving cooperation efficiency, promoting data transmission between enterprises, interworking between systems, and enhancing cooperation between upstream and downstream enterprises in the supply chain. Cross-border cooperation is carried out in the two dimensions of width and depth, which promotes digital technology to help C2M enterprises gain competitive advantages.

3.4.4.3 Competitive advantage

In the process of digital transformation of C2M enterprises, competitive advantage plays the role of transformation effect evaluation and goal measurement. It is the result of the implementation of digital transformation by enterprises and the integration of cross-border cooperation with enterprises.

In the aspect of enterprise management, digital transformation will help enterprises reduce costs and increase efficiency. In terms of market scale, digital transformation will promote the expansion of enterprises' market share. In terms of financial indicators, digital transformation will promote the growth of business turnover and net profit. In the secondary market, digital transformation will help increase the market value of enterprises. In terms of government cooperation, digital transformation will help enterprises obtain corresponding policy support

from the government. All in all, the competitive advantages gained by enterprises through digital transformation will realize the value appreciation and win-win situation of enterprises in digital transformation and cooperative enterprises. Competitive advantage should be an important direction to evaluate the effect of digital transformation of enterprises.

3.4.4.4 Geographical region, enterprise scale and management rank

China is a vast country, and different provinces and regions have different levels of economic development. Although the experts did not clearly discuss the impact of region or economic development level on the digital transformation of C2M enterprises during the interview, there may be differences in the acceptance degree of digital technology and the willingness of enterprises to carry out cross-border cooperation based on digitalization under the influence of economic development. In addition, differences in the size of enterprises and the rank of the interviewed experts may also lead to differences in attitudes towards digital transformation.

Therefore, this thesis introduces geographic region, firm size and management rank as control variables, and plans to further investigate the possible impacts of geographic region, firm size and management rank on the digital transformation of C2M enterprises in the questionnaire survey in the following chapters.

3.5 Summary of this chapter

In this chapter, based on the data and content obtained from the interviews of 27 experts, the preliminary research findings of this study are obtained through the three-level coding analysis program. In the context of digital transformation, following the research and analysis ideas of value co-creation, a conceptual model of digital transformation of C2M enterprises is constructed, and three open coding concepts of "digital transformation", "cross-border cooperation" and "competitive advantage" are proposed. The digital transformation of C2M enterprises is driven by these three concepts, and the promoting role and influence of these three concepts on the digital transformation of C2M enterprises are analyzed.

On this basis, it also discusses the potential impact of expert region, enterprise scale and management on the digital transformation of C2M enterprises and introduces the conceptual model of controlling variables to improve the digital transformation of C2M enterprises. The above model provides a theoretical foundation for the follow-up research. In the following chapters, empirical quantitative research on the conceptual model is conducted based on the survey questionnaire.

Chapter 4: Empirical Quantitative Research

Based on the conceptual model of C2M enterprises implementing digital transformation constructed by expert interviews, this chapter adopts quantitative empirical research methods to verify the conceptual model by issuing questionnaires. The empirical research method design of this study is introduced, including the following contents: 1) Design the survey questionnaire; 2) Determine the measurement scale of each variable in the conceptual model; 3) Carry out a pre-test to improve and modify the measurement scale. On this basis, this chapter uses formal survey questionnaire to conduct an empirical test. First, the sample selection and distribution process of formal survey questionnaire are described, and the descriptive characteristics of the sample are analyzed. Then SPSS 29.0 statistical software was used to test the reliability and validity of the questionnaire survey data, so as to test the validity of the collected samples. Finally, the conceptual model and research hypothesis are tested, and regression analysis and hierarchical regression analysis are used to verify them. According to the results of the empirical test, the thesis discusses the relationship between the technical preparation of digital transformation, the transformation degree of digital transformation, the cross-border width of cross-border cooperation, the cross-border depth of cross-border cooperation, and the sustainable competitive advantage of enterprises.

4.1 Research hypothesis

In the previous chapter, experts with extensive experience in digital transformation were invited to conduct interviews. Through interviews, the conceptual model of this thesis is further improved, and the practice of C2M enterprise digital transformation is added to the conceptual model, so as to make the conceptual model more accurate and complete.

After the qualitative research was completed, we developed an expert-validated conceptual model for the digital transformation of C2M enterprises. In order to further verify the conceptual model, the research hypothesis of this thesis is proposed based on the conceptual model, and the quantitative research method is used for verification. Based on the conceptual model obtained from the expert interviews above and the research purpose of this thesis, the following hypothesis tests are obtained. See Figure 4.1 and Table 4.1 for details.

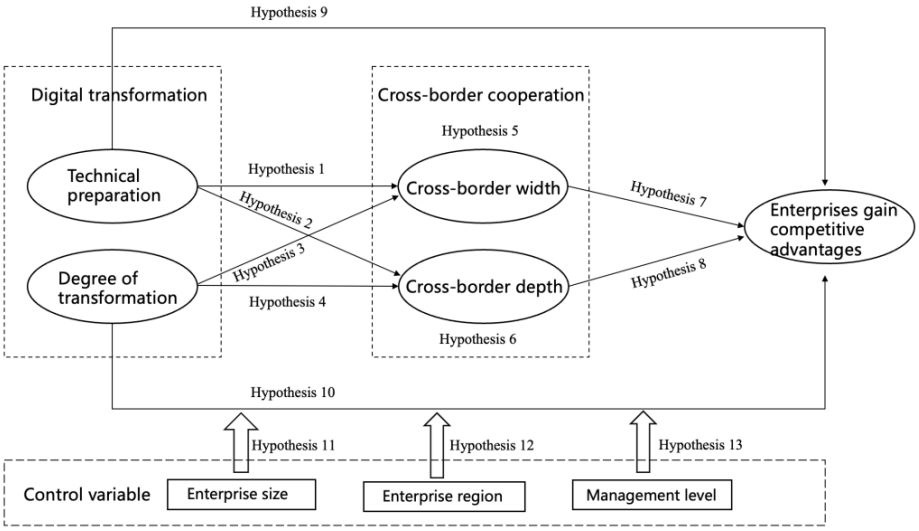

Figure 4.1 Hypothesis on the implementation of digital transformation in C2M enterprises

Table 4.1 Hypothesis testing

Hypothesis	Hypothetical content
Hypothesis 1	Digital transformation technology readiness has a significant positive impact on the width of cross-border cooperation.
Hypothesis 2	Digital transformation technology readiness has a significant positive impact on the depth of cross-border cooperation.
Hypothesis 3	The degree of digital transformation has a significant positive impact on the width of cross-border cooperation.
Hypothesis 4	The degree of digital transformation has a significant positive impact on the depth of cross-border cooperation.
Hypothesis 5	The cooperation width of cross-border cooperation mediates the technological readiness of digital transformation, the degree of digital transformation, and the sustainable competitive advantage of enterprises.
Hypothesis 6	The cooperation depth of cross-border cooperation mediates the technological readiness of digital transformation, the degree of digital transformation, and the sustainable competitive advantage of enterprises.
Hypothesis 7	The cooperation width of cross-border cooperation has a significant positive impact on the sustainable competitive advantage of enterprises.
Hypothesis 8	The cooperation depth of cross-border cooperation has a significant positive impact on the sustainable competitive advantage of enterprises.
Hypothesis 9	Digital transformation technology readiness has a significant positive impact on sustainable competitive advantage of enterprises.
Hypothesis 10	The degree of digital transformation has a significant positive impact on the sustainable competitive advantage of enterprises.
Hypothesis 11	Enterprise size positively moderates the relationship between digital transformation technology preparation, digital transformation degree, cross-border cooperation width and cross-border cooperation depth on firm sustainable competitive advantage.
Hypothesis 12	Enterprise region positively regulates the relationship between digital transformation technology preparation, digital transformation degree, cooperation width and cooperation depth of cross-border cooperation on sustainable competitive advantage of enterprises.
Hypothesis 13	Management level positively moderates the relationship between digital transformation technology preparation, digital transformation degree, cross-border cooperation width and cross-border cooperation depth on sustainable competitive advantage of enterprises.

4.2 Research design

4.2.1 Questionnaire design

After consulting relevant data, it is found that the variables in this study, such as technical preparation for digital transformation, transformation degree of digital transformation, cooperation width and depth of cross-border cooperation, and competitive advantage obtained by digital transformation, cannot be directly measured using publicly available secondary data. Based on the scale, questionnaire survey can measure the above core variables by issuing survey questionnaires. Therefore, this study adopts the empirical research method of questionnaire survey to collect data and measure variables.

First, an initial survey questionnaire was developed. In order to meet the reliability and validity requirements of the survey questionnaire, the validated scale containing the above variables was selected and used by referring to the existing literature. Second, to optimize the initial survey questionnaire, a pre-test was conducted before the formal survey, and industry experts were invited to modify the contents of the questionnaire. After completing the above steps, the final survey questionnaire will be obtained. This chapter describes the questionnaire, which includes the technical preparation of digital transformation, the degree of digital transformation, the width of cross-border cooperation, the depth of cross-border cooperation, and the acquisition of sustainable competitive advantage through digital transformation.

4.2.1.1 Principles of questionnaire design

In order to ensure the scientific and effectiveness of the questionnaire design, the questionnaire design in this thesis will strictly follow the statistical principle and the following questionnaire design principles: First, scientific. In order to ensure that the core indicators are accurate and clear, the measurement questions in the questionnaire should arise from the existing validated scales as far as possible. When selecting the questionnaire analysis method, we also choose to use the scientific analysis method with perfect theoretical basis and practical verification. Second, maneuverability. In order for the interviewees to accurately understand the meaning of the question and then collect the real questionnaire information. When describing the questionnaire topics, try to make the description easy to understand, minimize or avoid using academic language. Third, authenticity. People with in-depth knowledge of the interview questions and practical work experience in relevant fields should be selected as the research group, and the interviewees are willing to provide real feedback on the research questions. In

the design of the questionnaire, avoid the use of leading and tendentious language and expression. Fourth, logic. Considering the answering habits of the respondents, the questions before and after the measurement are correlated, but they will not interfere with each other. The questions are arranged in the order of easy first and then difficult.

4.2.1.2 Questionnaire design process

The survey respondents in this study are located in Beijing, Shenzhen, Chengdu and Hangzhou respectively. The questionnaire design of this research strictly follows the above principles, which can be divided into the following five steps:

The first step is to select the initial scale. In this study, we first consulted the literature in related fields to develop an initial scale. This process involved an in-depth collation and analysis of the literature on digital transformation, cross-border cooperation and their competitive advantages. This enables us to identify key concepts and their interrelationships, laying the foundation for subsequent scale design. In addition, we also refer to some mature scales, and combined with the definition of related concepts, to improve and modify the existing scales. Through literature research and scale adjustment, we formed an initial scale that is more in line with the research question.

The second step is to adapt the initial scale. First, focus on the research materials in the fields of digital transformation, cross-border cooperation, and digital transformation to gain competitive advantage. Second, by comparing the researcher's research situation with the research background, research objects and research questions in this thesis, the scale is further screened to determine a mature scale with high reliability and validity. Finally, for the scales derived from English literature, this study adopts the method of translation between Chinese and English to reduce the comprehension bias caused by language problems. During the study, we invited experts in the field of management to translate the English questionnaire and found some significant differences in the language during the process, so we revised the translation results in a timely manner. Subsequently, we invited some Internet executives who are familiar with digital transformation to discuss the contents of the questionnaire in detail. Through this professional exchange, we revised the questionnaire accordingly. The purpose of this is to improve the rationality and understandability of the questionnaire, and to ensure that participants can accurately understand each question when filling out the questionnaire. The active participation of experts and executives will significantly improve the overall quality and effectiveness of the questionnaire, so that it can better reflect the actual situation.

The third step is to design the questionnaire structure. The questionnaire consists of the

background of the survey, the basic information of the interviewees and the body of the questionnaire from front to back. The first part is the research background, which mainly explains the purpose of the survey, contains the main content of the survey, and provides the participants with the promise of confidentiality. In addition, we also express my gratitude to the interviewees. The second part is the basic information of the interviewee, which is divided into company information and personal information. The former requires respondents to provide basic information such as enterprise name, location, enterprise scale, industry, enterprise digital transformation attitude, implementation stage of enterprise digital transformation, cooperation experience of partners, number of partners, etc., while the latter requires respondents to provide personal job information such as job rank. The third part is the body of the questionnaire, which mainly includes the technical preparation for digital transformation, the degree of digital transformation, the width of cross-border cooperation, the depth of cross-border cooperation, and the measurement items of variables such as enterprises' digital transformation to obtain sustainable competitive advantage. In this study, 5-level Likert scale was used as a scoring tool in order to evaluate the attitudes and cognition of respondents more systematically and objectively. The scale ranges from 1 to 5, with specific meanings being "strongly disagree," "disagree," "neutral," "agree," and "strongly agree." Using this rating system, we can obtain a clear picture of the extent to which respondents agree with each issue. On the scale, the higher the score, the stronger the respondents' agreement with the question, whereas the opposite indicates a lower degree of agreement. This design not only improves the reliability and validity of the questionnaire, but also provides a clear quantitative basis for the subsequent data analysis. This quantitative evaluation method improves the scientific research and makes the results more convincing and valuable for reference purposes.

The fourth step involved pre-research and questionnaire refinement. Before the formal investigation, we sent a pre-survey questionnaire to 94 respondents and analyzed the reliability and validity of the questionnaire results to identify problems in the question setting and modified the description of the questionnaire questions. In addition, we also invited three enterprise managers with experience in digital transformation to conduct in-depth interviews. Through the communication with these three managers, we collected feedback from experts, and further improved and modified the questionnaire to form the final interview questionnaire.

The fifth step involved conducting a formal questionnaire survey. The formal survey will be based on the above survey questionnaires, and the questionnaire distribution and data collection will be conducted for the target groups. In this process, in order to ensure the accuracy of data entry, we use a person to enter the data, and another person to cross-check the method.

In addition, the researchers involved in the questionnaire issuing and recycling process were systematically trained to ensure that the process was in line with norms and the data was accurate and effective. See the appendix B for the final version of the questionnaire.

4.2.2 Measurement of variables

This study involves five variables: technical preparation for digital transformation, transformation degree of digital transformation, cooperation width of cross-border cooperation, cooperation depth of cross-border cooperation, and competitive advantage gained through digital transformation. We draw on the existing validated scale and make appropriate modifications according to the actual needs, so as to ensure the reliability and validity of the survey questionnaire used. Through in-depth analysis of the practice of digital transformation enterprises, we finally formed a set of formal measurement scale specifically for enterprise digital transformation. The construction of this scale not only enhances the scientific research tool but also provides a more effective measurement basis for the subsequent research. The scales used to measure the variables in this thesis are presented in Annex Table 2.

4.2.2.1 Technical preparation for digital transformation

Digital transformation is a strategic business transformation that relies on various combinations and integration of modern information and digital technologies, such as artificial intelligence, big data, digital twins, industrial robots, machine learning, cloud computing, Internet of Things, 5G mobile communications and blockchain. The process also includes the adoption of agility, customer orientation and product personalization as core competencies (Fatorachian & Kazemi, 2018; Kagermann, 2015). Digital transformation is measured from two dimensions, including the technical readiness of digital transformation and the degree of transformation.

Zhou and Wu (2010) developed a scale of technological readiness for digital transformation from the perspective of the role of technological capability in innovation, with a total of five items. On this basis, K. Zhang (2019) developed the item about the integration of manufacturing enterprises and the Internet to measure the technical readiness of digital transformation. This study modifies the scale designed by Jain (2007), which is used in the field of dynamic IT capabilities of organizations, based on the actual situation of C2M enterprises. According to the interview results obtained from the expert interviews in this thesis, the technical preparation for digital transformation includes: "Strong ability of enterprises to obtain important technical information", "strong ability of enterprises to identify new technological opportunities", "strong ability of enterprises to cope with technological changes", "strong ability of enterprises to

master advanced technologies", and "enterprises to continuously carry out a series of innovations". This study regards the technological readiness of digital transformation as the core variable and explores its impact on the development of enterprises in depth. Based on the mature scale, combined with the opinions of expert interviews, and according to the actual situation of China's C2M enterprises, the items in the scale were modified and adjusted accordingly. After repeated discussion and verification, five items were finally determined in order to more accurately measure the level of technical readiness for digital transformation. The specific scale items are listed in Table 4.2.

Table 4.2 Technical readiness measurement scale for digital transformation

Variables	Number	Item content
Technical preparation for digital transformation	101	The enterprise has a strong ability to obtain important technical information.
	102	The enterprise has a strong ability to identify new technological opportunities.
	103	The enterprise has a strong ability to respond with technological changes.
	104	The enterprise has a strong ability to master advanced technologies.
	105	The enterprise continuously carries out a series of innovations.

4.2.2.2 Degree of transformation of digital transformation

At present, the academic community has not reached a consensus on the measurement scale of the transformation degree of digital transformation. Through consulting domestic and foreign literature, the transformation degree of digital transformation is generally divided into three dimensions, namely R&D and manufacturing, sales, service and organization (X. He, 2015; H. Li & Chen, 2011). This study believes that the degree of transformation of digital transformation refers to the degree of value creation by digital technology in product development, manufacturing, improvement of products and services, integration of value chain and other links in digital transformation enterprises. Z. Li et al. (2022), a domestic scholar, took high-end manufacturing industry as an example and developed a scale for measuring the degree of digital transformation through literature review and enterprise practice investigation. Lenka et al. (2017) developed a measurement scale of the degree of digital transformation based on the research in the process of service-oriented strategy of manufacturing enterprises. In the development of enterprise digital transformation based on the case, the scale was appropriately modified in combination with the practical situation of C2M enterprises.

According to the results of the expert interviews in this thesis, The degree of transformation of digital transformation includes "enterprises are able to identify big data sources to meet technology needs", "enterprises are able to rely on big data to identify new technology

development opportunities", "enterprises have the ability to connect digital products through wireless communication networks", "enterprises are increasingly using digital technologies to connect people, systems, companies, products and services", "enterprises are able to connect people, systems, companies, products and services" Data is applied to research and development to automatically collect storage device parameters, "" Enterprises are able to apply data to equipment manufacturing to monitor equipment operating status in real time," and "enterprises have improved the efficiency of business intelligence decision-making through digital tools and components." This study regards the degree of transformation of digital transformation as the core variable and explores its impact on the development of enterprises in depth. On the basis of the mature scale, combined with the opinions of expert interviews, and according to the actual situation of China's C2M enterprises, the items in the scale were modified and adjusted accordingly. After repeated discussion and verification, seven items were finally determined in order to more accurately measure the transformation degree level of digital transformation. The specific scale items are listed in Table 4.3.

Table 4.3 Measurement scale of transformation degree of digital transformation

Variables	Number	Item content
The transformation degree of digital transformation	201	The enterprise can identify big data sources that meet technical requirements.
	202	The enterprise can rely on big data to identify new technological development opportunities.
	203	The enterprise has the ability to connect digital products through wireless communication networks.
	204	The enterprise is increasingly using digital technologies to connect people, systems, companies, products and services.
	205	The enterprise can use data in research and development to automatically collect storage device parameters.
	206	The enterprise can apply the data to the production and manufacturing of the equipment to monitor the running status of the equipment in real time.
	207	The enterprise improves the efficiency of business intelligence decision making through digital tools and components.

4.2.2.3 Cooperation width of cross-border cooperation

Cross-border cooperation is the act of integrating different resources of an organization or department, crossing different borders, establishing contacts and managing interactions with various parties in the environment, and thus creating value. Cross-border cooperation means that an organization achieves its overall goal of cross-border cooperation by establishing relationships and interactions with external stakeholders. This type of external-oriented activity covers many aspects, such as effectively managing customer needs, conducting project-scope negotiations and obtaining critical information (Ancona & Caldwell, 1992). Some scholars

have pointed out that cross-border cooperation is regarded as an organizational behavior, the main purpose of which is to reduce uncertainty or effectively manage the unexpected events that may pose a threat to the survival of the organization. Cross-border cooperation is measured from two dimensions, including the width and depth of cross-border cooperation.

Based on the study of enterprise alliance, Sarkar et al. (2009) developed a scale of cooperation width of cross-border cooperation, with a total of 5 items. Sullivan (2004) conducted field research on cross-border cooperation behaviors within organizational groups, developed an item to measure the cooperation width of cross-border cooperation through the study of cross-border cooperation behaviors among organizations, and obtained good empirical results. According to the interview results obtained by the experts in this thesis, the cooperation width of cross-border cooperation includes: "Enterprises actively monitor cooperation opportunities in the market", "enterprises regularly collect information about potential partners from various channels", "enterprises actively establish cooperative relations with potential partners", "enterprises strive to gain competitive advantages by cooperating with major companies", "enterprises often take the initiative to contact companies with cooperation intentions". This thesis considers the width of cross-border cooperation as the core variable and explores its impact on the development of enterprises in depth. On the basis of the mature scale, combined with the opinions of expert interviews, and according to the actual situation of China's C2M enterprises, the items in the scale were modified and adjusted accordingly. After repeated discussion and verification, five items were finally determined in order to more accurately measure the width of cross-border cooperation. The specific scale items are listed in Table 4.4.

Table 4.4 Cooperation width measurement scale of cross-border cooperation

Variables	Number	Item content
The width of cross-border cooperation	301	The enterprise actively monitors our environment to identify partnering opportunities.
	302	The enterprise routinely gathers information about prospective partners from various forums.
	303	The enterprise is alert to market developments that create potential alliance opportunities.
	304	The enterprise strives to preempt our competition by entering into alliances with key firms before they can.
	305	The enterprise often takes the initiative in approaching firms with alliance proposals.

4.2.2.4 Cooperation depth of cross-border cooperation

In contrast to research on the width of cooperation in cross-border cooperation, scholars mostly use case studies to study the depth of cooperation in cross-border cooperation. There are few

scales for measuring the depth of cooperation in cross-border cooperation. At present, the academic community often uses the scale developed by Ranjan and Read (2016), which is modified and improved according to the actual situation of the research. This thesis believes that the cooperation depth of cross-border cooperation refers to the degree of digital cooperation between an enterprise and other enterprises in the upstream and downstream, sales, after-sales, service and other links of the supply chain. The cooperation depth of cross-border cooperation reflects the ability of an enterprise to absorb information and resources in its environment. This depth is reflected in the enterprise's ability to master and integrate internal or external resources, the degree to which enterprises rely on information sources to achieve innovation, and the ability to control the required resources in cross-border activities (Zahra, 2012). Feng (2012), a domestic scholar, studied the cross-border cooperation involved in the promotion of quality improvement by domestic enterprises, and developed a scale for measuring the depth of cross-border cooperation based on the practice of domestic digital enterprises, which has been used for reference by many scholars.

The items of cooperation depth of cross-border cooperation include: "For existing products or the development of new products, the partner is willing to accept our ideas and suggestions", "the partner has provided us with sufficient information and materials", "We are willing to spare time and energy to share ideas and suggestions with the partner. To help them further improve their products and processes", "the partner provides us with a suitable environment and opportunity to put forward suggestions and ideas". This study combines domestic and foreign digital enterprise management practices, draws on mature measurement scales developed by domestic and foreign scholars such as Ranjan and Read (2016) and Feng (2012), considers the cooperation depth of cross-border cooperation as the core variable, and deeply discusses its impact on enterprise development. Based on the mature scale, combined with the opinions of expert interviews, and according to the actual situation of Chinese C2M enterprises, the items in the scale were modified and adjusted accordingly. After repeated discussion and verification, four items were finally determined in order to more accurately measure the depth of cross-border cooperation. The specific scale items are listed in Table 4.5.

Table 4.5 Cooperation depth measurement scale of cross-border cooperation

Variables	Number	Item content
The depth of cross-border cooperation	401	The partner is open to my ideas and suggestions about its existing products or towards developing a new product.
	402	The partner provides sufficient illustrations and information to me.
	403	I would willingly spare time and effort to share my ideas and suggestions with the partner in order to help it improve its products and processes further.

404	The partner provides suitable environment and opportunity to me to offer suggestions and ideas.

4.2.2.5 Enterprises gain sustainable competitive advantage

To obtain sustainable competitive advantage through digital transformation is the goal that enterprises hope to achieve when implementing digital strategy. Sustainable competitive advantage refers to the lasting value that an enterprise possesses relative to its competitors. In today's highly competitive market environment, to stand out from the pack, companies must achieve competitive advantage by implementing a unique digital transformation strategy. This strategy involves the use of unique products, advanced technologies and quality services to help companies build a clear advantage over their competitors. In addition, enterprises need to take advantage of cost, scale, differentiation and speed to further enhance their competitiveness. By effectively integrating these resources and capabilities, companies can maintain their competitive position in a changing market environment. Analyzing the results of the expert interviews, it is clear that if enterprises want to achieve a sustainable competitive advantage in digital transformation, they must continuously invest resources to enhance their digital capabilities. In addition, enterprises should also actively attract multiple entities to participate in order to form a unique and comprehensive competitive advantage.

Morgan and Berthon (2008) developed a scale for enterprises to obtain sustainable competitive advantage through digital transformation based on the key role that innovation strategy plays in enterprise performance, with a total of four questions. Chinese scholar Tan et al. (2017) studied the effect of digital transformation on enterprise innovation in international subcontracting enterprises and developed a scale to measure enterprises' sustainable competitive advantage by studying the effect of digital transformation on enterprise performance improvement. According to the results obtained from the expert interviews in this thesis, the sustainable competitive advantages obtained by enterprises include: "enterprise sales increased", "enterprise average profit per customer increased", "enterprise return on investment increased", and "enterprise overall performance improved".

The sustainable competitive advantage obtained by enterprises through the implementation of digital transformation is regarded as the core variable, and its impact on the development of enterprises is deeply discussed. Based on the mature scale, combined with the opinions of expert interviews, and according to the actual situation of China's C2M enterprises, the items in the scale were modified and adjusted accordingly. After repeated discussion and verification, four items were finally determined in order to more accurately measure enterprises' sustainable competitive advantage through the implementation of digital transformation. The specific scale

items are listed in Table 4.6.

Table 4.6 Measurement scale for enterprises to obtain sustainable competitive advantage

Variables	Number	Item content
Enterprises gain sustainable competitive advantage	501	Business sales increases.
	502	The average profit earned by the enterprise per customer increases.
	503	The return on investment increases.
	504	The overall performance of the enterprise improves.

4.2.2.6 Selection and measurement of control variables

In order to avoid the impact of firm-level differences on the research results, it is necessary to control the characteristics of firm differences. In this thesis, the scale of C2M enterprises, the geographical location of enterprises and the management level of respondents were taken as control variables to reduce the impact on the research results.

C2M enterprises of different sizes show different characteristics in terms of resource acquisition ability. Larger enterprises usually have more abundant resource channels and higher bargaining power, and can obtain capital, technology and human resources more effectively, while smaller enterprises face more challenges in resource acquisition. In addition, the difference in the size of enterprises will also have a significant impact on the number and types of players participating in the platform. Larger firms may attract more partners to participate in the platform, forming a rich and diverse ecosystem, whereas smaller firms may result in a single number and type of platform participants due to their relatively limited influence (Annarelli et al., 2021). Larger enterprises generally have more abundant human resources, which provide corresponding human support for enterprises to cultivate digital capabilities and carry out cross-border cooperation. Compared with smaller enterprises, larger enterprises tend to have richer market experience and pay more attention to the introduction of digital technology and internal transformation of technology. Therefore, in this study, firm size is included in the category of control variables.

In terms of the region where enterprises are located, the industrial agglomeration of China's digital economy has achieved rapid growth with an average annual growth rate of about 21.50% from 2000 to 2020, and the agglomeration scale shows a trend of "absolute dominance in the east, simultaneous progress between the East and the West, and widening gap between the north and the south" (Zeng et al., 2016). The eastern region of China is more economically developed than the central and western regions, and enterprises in the eastern region have earlier access to digital technology than enterprises in the central and western regions, and the resources required by enterprises in the eastern region for digital transformation are more adequate than those in

the central and western regions. Therefore, enterprises in the eastern region tend to have more sufficient technology and resource reserves for digital transformation, so the region of the enterprise is included in the category of control variables.

In terms of the management level of the respondents, by promoting the digital transformation, the human capital of the enterprises not only effectively improves the production efficiency and information disclosure level of the enterprises, but also inhibits the short-sighted behavior of the management level to a certain extent. Relevant studies clearly prove that human capital plays an important role in promoting digital transformation (W. F. He & Yao, 2023). An increasing number of enterprises are focusing on the important role of human capital in digital transformation. Human resources with experience and ability of digital transformation provide human support for enterprises to break technical barriers, improve production efficiency and create competitive advantages, and provide intellectual support for enterprises to digital transformation. Therefore, the management level of the interviewee is included in the category of control variables.

In summary, the scale of C2M enterprises, the region of the enterprises and the management level of the respondents are included in the category of control variables. In terms of enterprise size, 1 means 1-100 employees, 2 means 101-500 employees, 3 means 501-2000 employees, and 4 means more than 2000 employees. In terms of the region where the enterprise is located, according to the urban GDP of the latest natural year, 1 means less than 2 trillion, 2 means 2-3 trillion, 3 means 3-4 trillion, and 4 means more than 4 trillion (the units of the above amount are RMB); In terms of the management level of the respondents, 1 means low-ranked managers, 2 means middle managers, 3 means senior managers, and 4 means others.

4.2.3 Pre-survey and questionnaire correction

Pre-survey is a small-range survey conducted with a questionnaire containing 25 items before the formal release of the survey questionnaire. In terms of the selection of research objects, enterprise management and business experts who have a deep understanding of the technical preparation for the digital transformation of C2M enterprises, the degree of transformation of digital transformation, the width and depth of cross-border cooperation, and the situation of enterprises obtaining sustainable competitive advantages were selected. The enterprises where the experts work should meet the following requirements: (1) have a digital platform and system; (2) capable of exporting digital products or services; And (3) have implemented digital transformation themselves or helped other enterprises to implement it. In order to avoid the aversion caused by too many questions, before the pre-survey, three experts in the field of

digital transformation of Internet companies were invited to complete in the survey questionnaire. The average time for the experts to complete in the questionnaire was 11 minutes, indicating that the questionnaire was acceptable to the respondents. The pre-survey was conducted in digital transformation enterprises in Beijing and Chengdu. A total of 94 questionnaires were collected, of which 78 were valid, with an effective response rate of 82.98%. The above data indicated that the survey questionnaire met the requirements of the research design.

Next, exploratory factor analysis was used to test the reliability and validity of the scale at the same time (M. L. Wu, 2010b). Annex Table 3 shows the KMO values and Bartlett sphericity test criteria. First, KMO value and Bartlett sphericity test were performed by SPSS 29.0 statistical software. The KMO value is 0.852, between 0.8 and 0.9, the Bartlett sphericity test is 1604.439, and the Sig of the test. The value is 0.000<0.01, which was considered significant. It indicates that the scale used in this thesis is suitable for factor analysis, and the specific results are shown in Annex Table 4.

Second, the scale reliability test was conducted by SPSS 29.0 statistical software (Nunnally, 1978), with the criteria shown in Annex Table 5. The reliability test is to evaluate whether the sample data of the scale are real and reliable. Cronbach's α coefficient was used as the test index of internal consistency in this thesis.

The Cronbach's Alpha value calculated by SPSS 29.0 statistical software indicates that the reliability of variables such as technical preparation for digital transformation, transformation degree of digital transformation, cooperation width and depth of cross-border cooperation, and enterprises' obtaining sustainable competitive advantage are good. Cronbach's Alpha values of all variables exceeded 0.7, and the values were 0.858, 0.848, 0.755, 0.709, and 0.835, respectively.

Finally, a validity test is conducted. Validity test is to evaluate whether the scale can effectively measure variables, that is, to measure whether the scale questions are accurate and valid. The exploratory factor load was obtained by using the "orthogonal rotation method of maximum variance" in SPSS 29.0 statistical software. The factor load values of 25 items are all greater than 0.5, which is consistent with the research design. Principal component analysis was continued with SPSS 29.0 statistical software. The data showed that the cumulative explanatory variance of the five common factors was 68.117%, and a value greater than 50% indicated that the scale had good explanatory power, which was also consistent with the study design. In summary, the scale used in this study has good validity, as shown in Table 4.7.

Table 4.7 Test of reliability and validity

Variables	Item	Factors 1	2	3	4	5	Cumulative explanatory variance	Cronbach's Alpha
Digital Transformation Technical Preparation	101	0.766					12.902%	0.858
	102	0.904						
	103	0.917						
	104	0.707						
	105	0.504						
Digital transformation degree	201		0.571				30.158%	0.848
	202		0.604					
	203		0.574					
	204		0.523					
	205		0.636					
	206		0.886					
	207		0.953					
Width of cross-border cooperation	301			0.689			44.611%	0.755
	302			0.597				
	303			0.769				
	304			0.856				
	305			0.501				
Depth of cross-border cooperation	401				0.842		54.498%	0.709
	402				0.572			
	403				0.647			
	404				0.566			
Enterprises gain sustainable competitive advantages	501					0.769	68.117%	0.835
	502					0.854		
	503					0.874		
	504					0.661		

In summary, after the scale design, initial scale pre-survey, reliability and validity test and data analysis, a formal survey questionnaire was developed in this thesis. For details, see the appendix.

4.3 Empirical research results

4.3.1 Data collection and sample characteristics

4.3.1.1 Sample selection

This study focuses on C2M enterprises implementing digital transformation. Owing to the rapid development of China's digital industry in recent years, there are more types of enterprises related to the implementation of digital transformation. In order to make the theoretical research more universal and explore the common problems of C2M enterprises implementing digital transformation, this research selected C2M platform enterprises, e-commerce platforms, digital transformation technology service platforms and other types of platform enterprises as the

sample selected objects.

Combined with the research situation and research questions of this thesis, this research mainly distributes questionnaires in Beijing, Shenzhen, Chengdu and Hangzhou, which are regions with relatively concentrated and developed digital economy and Internet platforms. Compared with other cities, these cities not only have relatively developed digital industries, but also are located in different geographical regions of China, and the economic development levels of these cities are different. Therefore, the selection of platform enterprises in these cities as research samples can draw general research conclusions, and thus have a general demonstration role for other C2M enterprises implementing digital transformation.

In the process of questionnaire survey, respondents are required to have certain industry experience in enterprise digital transformation. The respondents are either managers or technical experts of enterprises implementing digital transformation, or practitioners of cooperative enterprises providing technology or consulting services for enterprises implementing digital transformation. Therefore, the managers at all levels of the above enterprises, the backbone of digital transformation technical experts, product managers with digital transformation experience, and project managers with rich digital transformation project experience are the main research objects of this study.

4.3.1.2 Data collection

The formal questionnaire issuance began in July 2024 and ended in August 2024, and the questionnaire data collection took nearly two months. A total of 420 online questionnaires were distributed through WeChat, QQ, email and other social platforms. The targets of the questionnaires were mainly managers and experts of enterprises meeting the requirements. Before the respondents completed the questionnaire, we introduced the purpose of the survey and the impact of the study on the future development of the enterprise to them in detail through face-to-face or online communication, so as to encourage them to complete the questionnaire carefully and ensure the quality of the questionnaire.

In the end, a total of 420 questionnaires were distributed and 366 questionnaires were recovered, accounting for 87.14% of the total. If "no relevant experience" is selected among the questions about digital transformation experience in the questionnaire, all the scale questions have the same score, and the questionnaire answering time is less than 5 minutes, they are regarded as invalid questionnaires. There are 65 invalid questionnaires were included. After eliminating the above-mentioned invalid questionnaires such as incomplete data and information, 301 valid questionnaires were finally returned, with an effective rate of 82.2%,

which met the efficiency requirements of questionnaire research.

4.3.1.3 Sample characteristics

The 301 valid questionnaires were sorted out and the sample descriptive statistical analysis was carried out. The basic data characteristics of the samples are listed in Table 4.8. The details are as follows:

Table 4.8 Distribution of basic characteristics of samples (N=301)

Basic characteristics	Item	Sample size	Sample percentage (%)
City in which the business is located	GDP < 2 trillion	70	23.3%
	2 trillion ≤GDP < 3 trillion	68	22.6%
	3 trillion ≤GDP < 4 trillion	78	25.9%
	4 trillion ≤GDP	85	28.2%
Enterprise size	Under 100 people	76	25.2%
	101-500 people	65	21.6%
	501-2,000 people	76	25.2%
	2,000 +	84	27.9%
Business age	Less than 5 years	31	10.3%
	5-10 years	139	46.1%
	10-20 years	99	32.8%
	20 + years	32	10.8%
Management levels	Lower-level managers	99	32.9%
	Middle managers	106	35.2%
	Top managers	96	31.9%

Regarding the cities where the surveyed enterprises are located, enterprises account for 23.3% of the cities with a GDP less than 2 trillion yuan, 22.6% of the cities with a GDP between 2 trillion yuan and 3 trillion yuan, 25.9% of the cities with a GDP between 3 trillion yuan and 4 trillion yuan, and 28.2% of the cities with a GDP greater than 4 trillion yuan.

From the perspective of the scale of platform enterprises, enterprises with less than 100 employees accounted for 25.2%, enterprises with 100-500 employees accounted for 21.6%, enterprises with 500-2,000 employees accounted for 25.2%, and enterprises with more than 2,000 employees accounted for 27.9%.

In terms of the time of their establishment, 10.3% were under 5 years old, 46.1% were between 5 and 10 years old, 32.8% were between 10 and 20 years old, and 10.8% were over 20 years old. This also shows that most of the enterprises engaged in digital transformation are young enterprises, more than 50% of the enterprises have been established for less than 10 years, and nearly 90% of the enterprises have been established for less than 20 years.

A total of 99 low-ranked managers, 106 middle-level managers and 96 senior managers participated in the questionnaire survey. In general, managers of different levels account for a similar proportion of respondents, which makes the conclusion more representative and improves the credibility of sample data.

4.3.2 Reliability and validity tests

In this study, SPSS 29.0 statistical software was used to test the reliability and validity of the questionnaire survey data to ensure the data validity of the empirical test of the model.

4.3.2.1 Reliability test

Reliability test describes the reliability of the measured object, focusing on the stability and consistency of the scale measurement. Common reliability testing methods include internal consistency, broken half reliability, parallel reliability etc. In this study, Cronbach's α coefficient was used as the test index of internal consistency. Generally speaking, the larger the Cronbach's α coefficient is, the better the reliability of the questionnaire (Nunnally, 1978). SPSS 29.0 statistical software was used to calculate Cronbach's α coefficient of variables, and the results were shown in Table 4.9.

Table 4.9 Cronbach's α coefficient of variables (N=301)

Variables	Number of topics	Cronbach's alpha
Technical preparation for digital transformation	5	0.895
The degree of transformation of digital transformation	7	0.911
The width of collaboration across borders	5	0.897
The depth of cross-border cooperation	4	0.874
Enterprises gain sustainable competitive advantage	4	0.878

Cronbach's α calculated by SPSS 29.0 statistical software indicates that the reliability performance of variables such as technical preparation for digital transformation, transformation degree of digital transformation, cooperation width and depth of cross-border cooperation, and enterprises' obtaining sustainable competitive advantage is good. Cronbach's α value of all variables exceeded 0.7. The Cronbach's α coefficient values of technological preparation for digital transformation, transformation degree of digital transformation, cooperation width and depth of cross-border cooperation, and enterprises obtaining sustainable competitive advantage were 0.895, 0.911, 0.897, 0.874 and 0.878, respectively, all above 0.8. This indicates that all variables have good reliability, and the corresponding scale has high consistency and reliability, meets the empirical analysis standards, and can be used for follow-up data verification.

4.3.2.2 Validity test

Validity test reflects whether the scale items truly and accurately measure the study variables, focusing on the validity of the scale measurements. Validity tests can be divided into two types:

content validity and structure validity. Content validity is concerned with the degree of fit between the measured content and the concept to be measured, emphasizing whether the measurement tool used can fully and appropriately represent the research topic or construct. In contrast, structural validity focuses more on the consistency between the definition of the variable and the measured content, which requires the measurement tool not only to accurately measure the defined variable, but also to ensure that the relationship between these variables can be reasonably explained. The measurement scale used in this study is based on the full review of relevant literature in the industry, and the maturity scale suitable for the research situation is selected. The final scale was modified and improved based on the problems found in the pre-survey and was issued under the guidance of experienced managers and experts in the industry, so the content validity of the survey questionnaire could meet the requirements of the research.

In this study, SPSS 29.0 software was used to test the structural validity of each variable, and the test results are listed in Table 4.10. Bartlett sphericity test results of the five variables in this study, namely, technical preparation for digital transformation, transformation degree of digital transformation, cooperation width of cross-border cooperation, cooperation depth of cross-border cooperation, and enterprise obtaining sustainable competitive advantage, show that KMO values are all greater than 0.8, ranging from 0.8 to 0.9, and Sig values are tested. The KMO value was 0.000<0.01, which reached the significance level, and the data indicated that the variable was suitable for factor analysis (M. L. Wu, 2010a, 2010b). The exploratory factor load was obtained by using the "orthogonal rotation method of maximum variance" in SPSS 29.0 statistical software. The factor load values of the 25 items are all greater than 0.5, and the corresponding relationship with each variable is clear, indicating that the scale has good structural validity. Principal component analysis was carried out by SPSS 29.0 statistical software. The data showed that the cumulative explanatory variance of the five common factors was 71.670%, and a value greater than 50% indicated that the scale had good explanatory power. The above information indicates that the questionnaire meets the empirical analysis criteria and can be verified using subsequent data.

Table 4.10 Validity test table of variable structure (N=301)

Variables	Item	Standardized factor load	KMO
Digital transformation technical preparation	101	0.718	0.877
	102	0.820	
	103	0.742	
	104	0.778	
	105	0.669	

Digital transformation degree	201	0.526	0.920
	202	0.610	
	203	0.726	
	204	0.641	
	205	0.688	
	206	0.703	
	207	0.532	
Width of cross-border cooperation	301	0.658	0.883
	302	0.730	
	303	0.710	
	304	0.603	
	305	0.625	
Depth of cross-border cooperation	401	0.508	0.832
	402	0.670	
	403	0.775	
	404	0.758	
Enterprises gain sustainable competitive advantages	501	0.756	0.803
	502	0.823	
	503	0.691	
	504	0.544	

4.3.3 Descriptive statistics and correlation analysis

In this study, SPSS 29.0 software was first used for descriptive statistical analysis of all variables, the mean and standard deviation of variables were calculated, and Pearson coefficient was calculated for pound-wise correlation analysis of variables, so as to detect the overall data quality. The test results are listed in Table 4.11.

Table 4.11 Descriptive statistical analysis and correlation coefficient matrix (N=301)

Variables	1	2	3	4	5
Digital transformation technical preparation	1				
Digital transformation degree	0.719 * *	1			
Cross-border cooperation Width of cooperation	0.639 * *	0.756 * *	1		
Cross-border cooperation Depth of cooperation	0.591 * *	0.718 * *	0.786 * *	1	
Enterprises gain sustained Competitive advantage	0.597 * *	0.679 * *	0.715 * *	0.647 * *	1
Mean	4.213	4.168	4.155	4.142	3.209
Standard deviation	0.813	0.748	0.742	0.746	0.630

Note: ** means significance level p<0.01 (two-tailed test)

As shown in Table 4.11, the mean values of all variables are consistent with the research context, and the standard deviations of all variables meet the research requirements. The correlation analysis of the data shows that there is a significant correlation between the five variables: technical preparation for digital transformation, transformation degree of digital transformation, cooperation width of cross-border cooperation, cooperation depth of cross-border cooperation, and enterprises' acquisition of sustainable competitive advantage, and the coefficient is positive, indicating that there is a significant positive correlation between the variables. The better the technical preparation for digital transformation, the deeper the transformation degree of digital transformation, which is conducive to broadening the width of cross-border cooperation, deepening the depth of cross-border cooperation, and creating a sustainable competitive advantage of enterprises. The correlation between the variables of the model is good, which preliminarily validates the theoretical hypothesis.

In the statistical analysis, when multicollinearity exists between variables, the verification results will be adversely affected. Variance inflation factor VIF (Variance inflation factor) can be used to analyze the multicollinearity between variables. The VIF value of each variable is less than 3.5 (the critical value is 10), indicating that multicollinearity does not appear among the variables in this study (M. L. Wu, 2010a, 2010b).

4.3.4 Hypothesis testing

This section mainly uses the empirical research method, taking the city where the enterprise is located, the scale of the enterprise and the level of management as the control variables, to explore the relationship between the technical preparation of digital transformation, the degree of digital transformation, the width and depth of cross-border cooperation, and the sustainable competitive advantage of the enterprise. The main test methods used in this study include the main effect test, intermediary effect test, and regulatory effect test, and a difference analysis is performed based on the regulatory effect test.

4.3.4.1 Test the relationship between the technical preparation of digital transformation, the degree of digital transformation, the width and depth of cross-border cooperation and the sustainable competitive advantage of enterprises

In the main effect analysis, taking the enterprise's sustainable competitive advantage as the dependent variable, the independent variables of digital transformation technology preparation, digital transformation degree, cross-border cooperation width and cross-border cooperation depth were brought into the multiple linear regression equation, and the influence of the above

four independent variables on the dependent variables was tested, as shown in Table 4.12.

Table 4.12 Tests the relationship between enterprises to obtain sustainable competitive advantage

Model	Unstandardized coefficients		Standardized coefficient	t	Significance	Collinearity statistics	
	B	Standard error	Beta			Tolerances	VIF
(Constant)	0.284	0.151		1.879	0.061		
Digital transformation technical preparation	0.103	0.044	0.133	2.366	0.019	0.461	2.170
Digital transformation degree	0.181	0.057	0.215	3.155	0.002	0.313	3.193
Width of cross-border cooperation	0.315	0.059	0.371	5.310	<.001	0.299	3.348
Depth of cross-border cooperation	0.104	0.055	0.123	1.890	0.060	0.345	2.896
Adjusted R square				0.564			
F				97.862			

Note: The dependent variable is the firm's sustainable competitive advantage

The results of data analysis show that the regression coefficient of technological readiness for digital transformation is 0.133 (P<0.05), that of the degree of digital transformation is 0.215 (P<0.01), and that of the width of cross-border cooperation is 0.371 (P<0.001). In other words, digital transformation technology readiness, digital transformation degree and cross-border cooperation width all have significant positive effects on enterprises' sustainable competitive advantage. Among them, the cooperation width of cross-border cooperation has the greatest impact on enterprises' sustainable competitive advantage. We assume that H7, H9 and H10 pass the test. The P-value of the cooperation depth of cross-border cooperation on the sustainable competitive advantage of enterprises is greater than 0.05, indicating that the cooperation depth of cross-border cooperation has no significant impact on the sustainable competitive advantage of enterprises. It is assumed that H8 does not pass the test. In the multiple linear regression model, the adjusted R square is 0.564, indicating that these four factors can explain 56.4% of the sustainable competitive advantage of enterprises, and the model fits well. The Durbin-Watson coefficient of the model is 1.909, which is close to 2, indicating that there is no autocorrelation problem between the data. Among the three hypotheses that pass the test, the VIF value of digital transformation technology preparation is 2.170, the VIF value of digital transformation degree is 3.193, and the VIF value of cross-border cooperation width is 3.348. The above VIF values are all less than five, indicating that there is no multi-collinearity problem in the data.

4.3.4.2 Technical preparation of digital transformation and the degree of digital transformation test the relationship between the width of cross-border cooperation

Taking the cooperation width of cross-border cooperation as the dependent variable, the technology readiness of digital transformation and the degree of transformation of digital transformation as independent variables were included in the multiple linear regression equation, and a model was constructed to test the impact of independent variables on the cooperation width of cross-border cooperation, as shown in Table 4.13.

Table 4.13 Relationship test of cooperation width in cross-border cooperation

Models	Unstandardized coefficients		Standardized coefficient	t	Significance	Collinearity statistics	
	B	Standard error	Beta			Tolerances	VIF
(Constant)	0.859	0.162		5.292	<.001		
Digital transformation technical preparation	0.180	0.049	0.198	3.711	<.001	0.483	2.069
Digital transformation degree	0.609	0.053	0.614	11.525	<.001	0.483	2.069
Adjusted R square				0.588			
F				215.247			

Note: The dependent variable is the cooperation width of cross-border cooperation

The results of data analysis show that the regression coefficient of digital transformation technology readiness is 0.198 (P<0.001), and that of digital transformation degree is 0.614 (P<0.001), that is, both digital transformation technology readiness and digital transformation degree have a significant positive impact on the cooperation width of cross-border cooperation. Moreover, the degree of digital transformation has a greater impact on the cooperation width of cross-border cooperation, assuming that H1 and H3 both pass the test. In the multiple linear regression model, the adjusted R square is 0.588, indicating that these two factors can explain 58.8% of the cooperation width of cross-border cooperation, and the model fits well. The Durbin-Watson coefficient of the model is 1.929, which is close to 2, indicating that there is no autocorrelation problem between the data. Among the two hypotheses that passed the test, the VIF value of the digital transformation technology preparation and the VIF value of the digital transformation degree were both 2.069, and the above VIF value was less than five, indicating that the data had no multicollinearity problem.

4.3.4.3 Technical preparation of digital transformation, the degree of transformation of digital transformation and the relationship between the depth of cross-border cooperation

With the cooperation width of cross-border cooperation as the dependent variable, the technical readiness of digital transformation and the degree of transformation of digital transformation as independent variables were incorporated into the multiple linear regression equation, and a model was constructed to test the impact of independent variables on the cooperation depth of cross-border cooperation, as shown in Table 4.14.

Table 4.14 Cooperation depth relationship test of cross-border cooperation

model	Unstandardized coefficients		Standardized coefficient	t	Significance	Collinearity statistics	
	B	Standard error	Beta			Tolerances	VIF
(Constant)	1.022	0.176		5.823	<.001		
Digital transformation technical preparation	0.142	0.053	0.154	2.694	0.007	0.483	2.069
Digital transformation degree	0.605	0.057	0.607	10.596	<.001	0.483	2.069
Adjusted R square				0.524			
F				166.110			

Note: The dependent variable is the depth of cooperation in cross-border cooperation

The data analysis results show that the regression coefficient of digital transformation technology readiness is 0.154 (P<0.01), and that of digital transformation degree is 0.607 (P<0.001), that is, both digital transformation technology readiness and digital transformation degree have a significant positive impact on the cooperation depth of cross-border cooperation. Moreover, the degree of digital transformation has a greater impact on the depth of cross-border cooperation, assuming that both H2 and H4 pass the test. In the multiple linear regression model, the adjusted R square is 0.524, indicating that these two factors can explain 52.4% of the cooperation depth of cross-border cooperation, and the model fits well. The Durbin-Watson coefficient of the model is 1.959, which is close to 2, indicating that there is no autocorrelation problem between the data. Among the two hypotheses that passed the test, the VIF value of the digital transformation technology preparation and the VIF value of the digital transformation degree were both 2.069, and the above VIF value was less than 5, indicating that the data had no multicollinearity problem.

4.3.5 Mediation effect test

The mediation effect test is divided into three steps: First, the independent variable has a significant effect on the dependent variable; Second, the test independent variable has a significant impact on the mediating variable; Finally, the independent variable and the intermediary variable are added to the model at the same time to test whether the independent variable and the intermediary variable are significant to the dependent variable, to judge whether the intermediary effect exists, and to determine the type of the intermediary effect according to the size change of the regression coefficient. In the research, when the presence of the intermediary variable causes the regression coefficient of the independent variable to the dependent variable to decrease, but still maintains significance, we call it partial mediation. This situation shows that the influence of the independent variable on the dependent variable through some mediating variable is still present, although its influence is reduced. In addition, complete mediation means that the regression coefficient of the independent variable to the dependent variable decreases to zero after the addition of the mediating variable, indicating that the influence of the independent variable on the dependent variable is completely realized through the mediating variable (R. M. Baron & Kenny, 1986).

4.3.5.1 In the relationship between the technological preparation of digital transformation and the degree of digital transformation on the sustainable competitive advantage of enterprises, the mediation effect test of the cooperation width of cross-border cooperation

According to the above mediation test method, this thesis conducted a mediation effect test on the cooperation width of cross-border cooperation. The first two steps of the mediation effect test have been completed in the above thesis. Next, the cooperation width of cross-border cooperation of intermediary variables is added into the multiple linear models to obtain a new model, and the results are shown in Table 4.15. The data analysis results show that both the independent variable and the intermediary variable are significant after the addition of the intermediary variable (p value is less than 0.05), indicating the existence of the intermediary effect. At the same time, the regression coefficient of digital transformation technology preparation on enterprise sustainable competition decreased from 0.225 to 0.138, and the regression coefficient of digital transformation degree on enterprise sustainable competition decreased from 0.517 to 0.247, indicating that the intermediary type was partial intermediary. After adding the intermediary variable, the adjusted R square of the model increases from 0.482 to 0.560, indicating that the interpretation degree of the model is improved, and it is meaningful to add the intermediary variable to the model. Therefore, assume that H5 passes the test.

Table 4.15 Cooperation width intermediation effect test for cross-border cooperation

Models	Unstandardized coefficients		Standardized coefficient	t	Significance	Adjusted R square	F
	B	Standard error	Beta				
(Constant)	0.661	0.155		4.272	<.001	0.482	140.527
Digital transformation technical preparation	0.174	0.046	0.225	3.766	<.001		
Digital transformation degree	0.435	0.050	0.517	8.651	<.001		
(Constant)	0.340	0.149		2.282	0.023	0.560	128.181
Digital transformation Technical preparation	0.107	0.044	0.138	2.454	0.015		
Digital transformation degree	0.208	0.056	0.247	3.735	<.001		
The width of cooperation in cross-border cooperation	0.373	0.051	0.439	7.331	<.001		

Note: The dependent variable is the firm's sustainable competitive advantage

4.3.5.2 In the relationship between the technological preparation of digital transformation and the degree of digital transformation on the sustainable competitive advantage of enterprises, the mediation effect test of cooperation depth of cross-border cooperation

According to the above mediation test method, this thesis conducted a mediation effect test on the cooperation depth of cross-border cooperation. The first two steps of the mediation effect test have been completed above. Next, the cooperation depth of cross-border cooperation of intermediary variables is added into the multivariate linear model to obtain a new model, and the results are shown in Table 4.16. The data analysis results show that both the independent variable and the intermediary variable are significant after the addition of the intermediary variable (P value is less than 0.01), indicating the existence of the intermediary effect. At the same time, the regression coefficient of digital transformation technology preparation on enterprise sustainable competition decreased from 0.225 to 0.179, and the regression coefficient of digital transformation degree on enterprise sustainable competition decreased from 0.517 to 0.334, indicating that the intermediary type was partial intermediary. After adding the intermediary variable, the adjusted R square of the model increases from 0.482 to 0.524, indicating that the interpretation degree of the model is improved, and it is meaningful to add

the intermediary variable to the model. Therefore, we assume that H6 passes the test.

Table 4.16 The mediation effect test of cooperation depth in cross-border cooperation

Models	Unstandardized coefficients		Standardized coefficient	t	Significance	Adjusted R square	F
	B	Standard error	Beta				
(Constant)	0.661	0.155		4.272	<.001		
Digital transformation Technical preparation	0.174	0.046	0.225	3.766	<.001	0.482	140.527
Digital transformation degree	0.435	0.050	0.517	8.651	<.001		
(Constant)	0.400	0.156		2.557	0.011		
Digital transformation Technical preparation	0.138	0.045	0.179	3.078	0.002		
Digital transformation degree	0.281	0.057	0.334	4.965	<.001	0.524	110. 926
The depth of cooperation in cross-border cooperation	0.255	0.049	0.302	5.206	<.001		

Note: The dependent variable is the firm's sustainable competitive advantage

4.3.6 Adjustment effect test

X. P. Chen et al. (2012) pointed out that in the adjustment effect test, in order to reduce multicollinearity, the independent variable and the regulating variable should be standardized first, and then the product term of the independent variable and the regulating variable will affect the regression coefficient of the dependent variable. Suppose that H11, H12 and H13 respectively predict the moderating effects of firm size, firm region and management level on the relationship between digital transformation technology preparation, digital transformation degree, cooperation width and cooperation depth of cross-border cooperation on sustainable competitive advantage of enterprises. This study verifies the moderating effects of firm size, region and management level on the sustainable competitive advantage of enterprises, and the results are shown in Table 4.17. The data analysis results show that after adding three moderating variables to the H1 hypothesis model to build the hypothesis model, firm size, firm region and management level have no significant influence on the sustainable competitive advantage of enterprises (P values are all greater than 0.05), indicating that the moderating effects of the three variables do not exist, and hypothesis H11, H12 and H13 fail the test.

Table 4.17 Test on the moderating effects of firm size, region and management level

Model	Unstandardized coefficients		Standardized coefficient	t	Significance	Collinearity statistics	
	B	Standard error	Beta			Tolerances	VIF
(Constant)	0.332	0.172		1.929	0.055		
Digital transformation technology preparation	0.106	0.044	0.136	2.394	0.017	0.453	2.209
Digital transformation degree	0.182	0.059	0.216	3.095	0.002	0.302	3.306
Width of cross-border cooperation	0.313	0.06	0.368	5.214	<.001	0.294	3.4
Depth of cross-border cooperation	0.1	0.055	0.118	1.802	0.073	0.341	2.934
Company size (2)	0.056	0.072	0.037	0.779	0.437	0.658	1.521
Company size (3)	-0.015	0.069	-0.01	-0.216	0.829	0.647	1.545
Company size (4)	0.004	0.068	0.003	0.061	0.951	0.623	1.605
Company Region (2)	-0.119	0.072	-0.079	-1.65	0.1	0.643	1.554
Company Region (3)	-0.072	0.07	-0.05	-1.02	0.309	0.609	1.642
Company Region (4)	-0.039	0.069	-0.028	-0.57	0.569	0.602	1.662
Management level (2)	0.04	0.06	0.03	0.669	0.504	0.715	1.399
Management Level (3)	-0.018	0.061	-0.014	-0.302	0.763	0.727	1.376
Adjusted R square				0.559			
F				32.718			

Note: The dependent variable is the firm's sustainable competitive advantage

When the adjustment effect is not established, the differential influence of five variables, namely firm size, firm region and management level on the technical preparation of digital transformation, the transformation degree of digital transformation, the width of cross-border cooperation, the depth of cross-border cooperation and the sustainable competitive advantage of enterprises, is studied through the difference analysis. Univariate variance method was used for analysis. The data analysis results showed that firm size and firm region had no significant impact on the above five variables (P values were all greater than 0.05), while management level had no significant impact on the three variables (P values were all greater than 0.05) : technology readiness for digital transformation, degree of digital transformation and width of cross-border cooperation. Management level has significant differences on the two variables of cross-border cooperation depth and sustainable competitive advantage of enterprises (P values are all less than 0.05). Through multiple comparisons, it is found that in the depth of cross-border cooperation, compared with senior managers, middle managers are more likely to

recognize the depth of cross-border cooperation. Regarding the sustainable competitive advantage of enterprises, compared with senior managers, middle managers are more likely to recognize sustainable competitive advantage of enterprises, as shown in Table 4.18.

Table 4.18 Difference analysis of each variable at the management level

Variables	Options	N	Average	Standard Deviation	F	Significance	Multiple comparisons
Digital transformation technology preparation	Low-ranked managers	99	4.22	0.84	1.749	0.176	/
	Middle managers	106	4.31	0.64			
	Top managers	96	4.10	0.94			
Digital transformation Degree of transformation	Low-ranked managers	99	4.22	0.82	1.73	0.179	/
	Middle managers	106	4.22	0.57			
	Top managers	96	4.05	0.84			
Width of cross-border cooperation	Low-ranked managers	99	4.12	0.81	2.674	0.071	/
	Middle managers	106	4.28	0.56			
	Top managers	96	4.05	0.83			
Cross-border cooperation depth	Low-ranked managers	99	4.11	0.84	3.432	0.034	2 > 3
	Middle managers	106	4.29	0.55			
	Top managers	96	4.02	0.81			
Corporate sustainable competitive advantage	Low-ranked manager	99	3.20	0.66	2.946	0.044	2 > 3
	Middle managers	106	3.32	0.56			
	Top managers	96	3.10	0.66			

Note: In the results of multiple comparisons, 1 represents junior managers, 2 represents middle managers, and 3 represents senior managers

4.3.7 Result analysis and discussion

This study invited 27 experts with extensive experience in digital transformation to conduct in-depth interviews and proposed conceptual models and research hypotheses on the relationship between the technical preparation for digital transformation, the degree of transformation of digital transformation, the width and depth of cross-border cooperation and the acquisition of sustainable competitive advantage by enterprises. A total of 301 valid questionnaires were collected in the formal research phase. Then, SPSS 29.0 statistical software was used to conduct

in-depth analysis of the survey questionnaire data. Descriptive statistical analysis, reliability test, validity test, correlation analysis, regression analysis, hierarchical regression analysis and other methods were used successively. The test results are presented in Figure 4.2 and Table 4.19. The results show that nine of the 13 hypotheses pass the test, whereas four hypotheses fail the test.

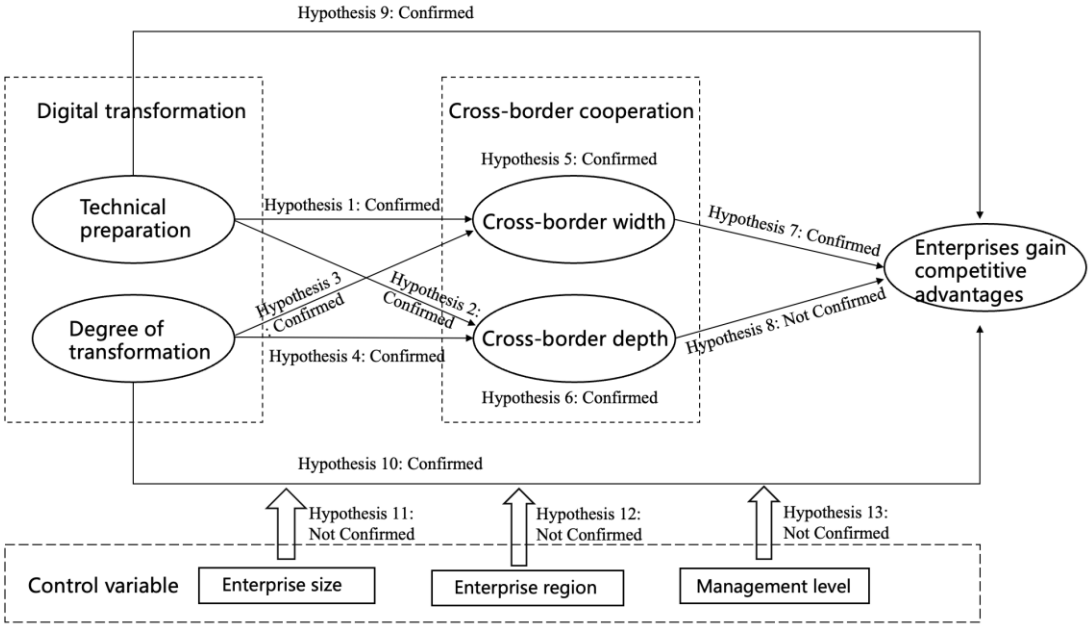

Figure 4.2 Hypothesis results of the implementation of digital transformation in C2M enterprises research

Table 4.19 Statistics of hypothesis test results

Hypothesis	Hypothetical content	Test results
Hypothesis 1	Digital transformation technology readiness has a significant positive impact on the width of cross-border cooperation.	Confirmed
Hypothesis 2	Digital transformation technology readiness has a significant positive impact on the depth of cross-border cooperation.	Confirmed
Hypothesis 3	The degree of digital transformation has a significant positive impact on the width of cross-border cooperation.	Confirmed
Hypothesis 4	The degree of digital transformation has a significant positive impact on the depth of cross-border cooperation.	Confirmed
Hypothesis 5	The cooperation width of cross-border cooperation mediates the technological readiness of digital transformation, the degree of digital transformation, and the sustainable competitive advantage of enterprises.	Confirmed
Hypothesis 6	The cooperation depth of cross-border cooperation mediates the technological readiness of digital transformation, the degree of digital transformation, and the sustainable competitive advantage of enterprises.	Confirmed
Hypothesis 7	The cooperation width of cross-border cooperation has a significant positive impact on the sustainable competitive advantage of enterprises.	Confirmed
Hypothesis 8	The cooperation depth of cross-border cooperation has a	Not

	significant positive impact on the sustainable competitive advantage of enterprises.	Confirmed
Hypothesis 9	Digital transformation technology readiness has a significant positive impact on sustainable competitive advantage of enterprises.	Confirmed
Hypothesis 10	The degree of digital transformation has a significant positive impact on the sustainable competitive advantage of enterprises.	Confirmed
Hypothesis 11	Enterprise size positively moderates the relationship between digital transformation technology preparation, digital transformation degree, cross-border cooperation width and cross-border cooperation depth on firm sustainable competitive advantage.	Not Confirmed
Hypothesis 12	Enterprise region positively regulates the relationship between digital transformation technology preparation, digital transformation degree, cooperation width and cooperation depth of cross-border cooperation on sustainable competitive advantage of enterprises.	Not Confirmed
Hypothesis 13	Management level positively moderates the relationship between digital transformation technology preparation, digital transformation degree, cross-border cooperation width and cross-border cooperation depth on sustainable competitive advantage of enterprises.	Not Confirmed

4.3.7.1 Digital transformation technology preparation, digital transformation degree, cross-border cooperation width, cross-border cooperation depth and enterprise sustainable competitive advantage relationship discussion

The research results of this thesis show that digital transformation technology preparation has a significant positive impact on enterprises to obtain sustainable competitive advantage, assuming that H9 is verified. C2M enterprises implementing digital transformation, based on artificial intelligence, Internet of things, cloud computing, big data, robots, 5G and other technologies, build their own digital application scenarios, and continuously accumulate digital technical capabilities, so that enterprises can obtain external information and resources in a timely manner, and carry out flexible resource arrangement. Thus, the competitive advantage of enterprises can be quickly formed (H. C. Wang et al., 2020).

The research results of this thesis show that the degree of digital transformation has a significant positive impact on enterprises to obtain sustainable competitive advantage. H10 is assumed to be verified. C2M enterprises implementing digital transformation, in order to achieve a successful digital transformation to carry out organizational and process mechanism changes, such as the implementation of digital transformation No.1 project, publicity and guidance of digital culture, the introduction of digital talents. These successful enterprises can widely transform existing business processes into corresponding digital solutions at the company level (Verhoef et al., 2021; Yoo et al., 2012).

The results of this thesis show that the cooperation width of cross-border cooperation has

a significant positive impact on the sustainable competitive advantage of enterprises, assuming H7 is verified. On the one hand, C2M enterprises implementing digital transformation unite upstream and downstream enterprises of the supply chain, such as e-commerce platforms, channel providers and terminal stores; On the other hand, integrate service providers that provide various services to enterprises, such as technology service providers, human resources service providers, logistics and transportation service providers. In order to achieve sustainable competitive advantage, enterprises must transform traditional IT capabilities into interactive capabilities that can co-create user experience with partners, which is a new strategic capability for enterprises (Ramaswamy & Ozcan, 2018).

The results of this thesis show that the cooperation depth of cross-border cooperation has no significant positive impact on the sustainable competitive advantage of enterprises, assuming that H8 is not valid. There are many reasons that lead to the non-significant relationship between variables. From the actual scenario of this study, there are two main reasons: (1) Some practical measures of cross-border cooperation depth, such as skill training, business consulting, on-site service, and system interconnection, are not necessarily related to enterprises' creation of sustainable competitive advantage. (2) Limited by the scope of cooperation, high-level in-depth cooperation may not be widely carried out among value co-creation enterprises, so it does not play an obvious role in improving the competitive advantage of enterprises.

4.3.7.2 Discuss the relationship between digital transformation technology preparation, digital transformation degree and cross-border cooperation width

The results of this thesis show that digital transformation technology readiness has a significant positive impact on the cooperation width of cross-border cooperation, assuming H1 is verified. The widespread use of digital technology by C2M enterprises in all aspects of manufacturing and commodity circulation will effectively expand the enterprise scope of value co-creation. With advances in IT, the trajectory of value creation has shifted from single enterprises to supply chains and, more recently, to complex and fragmented ecosystems (Bitran et al., 2007).

The results of this thesis show that the degree of digital transformation has a significant positive impact on the width of cooperation in cross-border cooperation, assuming H3 is verified. With the deepening of the transformation degree of C2M digital transformation enterprises, the organizational ability and resource utilization ability will be significantly improved. Organizational capacity and relationship resources will seek to promote value within the organization or in a close partnership (Vial, 2019), thus contributing to the width of

cooperation across borders.

4.3.7.3 Discuss the relationship between digital transformation technology preparation, digital transformation degree and cooperation depth of cross-border cooperation

The results of this thesis show that digital transformation technology readiness has a significant positive impact on the cooperation depth of cross-border cooperation, assuming that H2 is verified. In the field of intelligent manufacturing, scholars generally believe that the use of technology, despite certain limitations at present, will support the integration of manufacturing resources in the entire industry (Kaartemo & Helkkula, 2018), and other technologies will also have a similar promotion effect on the integration of resources in cross-border cooperation.

The results of this thesis show that the degree of digital transformation has a significant positive impact on the cooperation depth of cross-border cooperation, assuming that H4 is verified. In the process of organizational resource allocation, the transformation of basic operational resources into higher-order resources improves the sustainability of organizational competitive advantages (Paredes et al., 2014). The integrated resources are more valuable and less likely to be imitated than the pre-integrated resources, and organizations can benefit from this synergistic effect (Hadaya & Cassivi, 2012), thus promoting the cooperation depth of cross-border cooperation.

4.3.7.4 Discuss the mediating role of cooperation width in cross-border cooperation

This thesis discusses the relationship between technological preparation for digital transformation, transformation degree of digital transformation, width of cross-border cooperation and sustainable competitive advantage of enterprises, and holds that cooperation width of cross-border cooperation plays an intermediary role between technological preparation for digital transformation, transformation degree of digital transformation and sustainable competitive advantage of enterprises, corresponding to hypothesis H5. The empirical results show that hypothesis H5 passes the verification.

Against the background of digital transformation, expanding the cooperation width of cross-border cooperation between C2M enterprises can help enterprises find more market opportunities and improve their market competitiveness, so that C2M enterprises and value co-creation enterprises can achieve win-win value and help enterprises form sustainable competitive advantages. On the one hand, more partners can help enterprises obtain more market information from different channels, so that enterprises can obtain the latest information about external markets and customer needs and promote the formation of competitive advantages of enterprises. On the other hand, the rich types of partners can provide enterprises

with more abundant and professional services, so that the operation efficiency and cost of enterprises can be continuously optimized and improved (Yao et al., 2023). The mediating effect of the width of cross-border cooperation is also reflected in the research process of this study. For example, in the survey of an expert in a Hangzhou gas energy company, the expert believed that when the traditional energy industry was undergoing digital transformation, the introduction of digital technology was accompanied by an increase in the number of partners. Simultaneously, in order to adapt to a series of changes in management methods and production processes, enterprises also need professional consulting and technical service providers to participate. After the above partners and service providers bring high-quality products and services to the energy company, the digital transformation of the enterprise can be carried out smoothly, and ultimately help the enterprise to establish a sustainable competitive advantage.

Therefore, from both theoretical and practical points of view, the width of cooperation of cross-border cooperation plays an intermediary role between the technical readiness of digital transformation, the degree of transformation of digital transformation and the sustainable competitive advantage of enterprises.

4.3.7.5 Discuss the mediating role of cooperation depth in cross-border cooperation

This thesis discusses the relationship between technological preparation for digital transformation, transformation degree of digital transformation, depth of cross-border cooperation and sustainable competitive advantage of enterprises, and holds that cooperation depth of cross-border cooperation plays a mediating role between technological preparation for digital transformation, transformation degree of digital transformation and sustainable competitive advantage of enterprises, corresponding to hypothesis H6. The empirical results show that hypothesis H6 passes the verification.

In the context of digital transformation, increasing the cooperation depth of cross-border cooperation between C2M enterprises can help explore the potential cooperation opportunities and improve the cooperation efficiency among enterprises, so that C2M enterprises and value co-creation enterprises can achieve win-win value and help enterprises form sustainable competitive advantages. On the one hand, more in-depth corporate communication and information exchange enable C2M enterprises to obtain more information and business opportunities from partners. On the other hand, in-depth cooperation can help C2M enterprises examine all aspects of production and operation, so that enterprises can find and solve the problems in production management and promote the creation of competitive advantages of enterprises (Yang et al., 2023). The intermediary role of the depth of cross-border cooperation

is also reflected in the research process of this study. For example, in the survey of an expert on an e-commerce platform, the expert believed that when C2M enterprises use the e-commerce platform to sell, the e-commerce platform can enable the cooperative enterprises to obtain first-hand information through real-time data transmission. Simultaneously, through the processing and transmission of real-time data, the accuracy of the production plan of C2M enterprises is improved, the inventory turnover cycle is reduced, and the operating efficiency of C2M enterprises is improved. After the above C2M enterprises and the e-commerce platform connect the commodity, order, inventory, logistics and other data in real time, the digital transformation of the enterprises can be carried out smoothly, and finally help the enterprises to establish sustainable competitive advantages.

Therefore, from both a theoretical and practical point of view, the depth of cross-border cooperation plays an intermediary role between the technical preparation of digital transformation, the degree of digital transformation and the sustainable competitive advantage of enterprises.

4.3.7.6 The moderating effects of firm size, firm region and management level are discussed

This thesis introduces three variables, namely enterprise scale, enterprise region and management level, to analyze the moderating effects of these three variables on the relationship between the technical preparation for digital transformation, the transformation degree of digital transformation, the cooperation width and depth of cross-border cooperation and the sustainable competitive advantage of enterprises. The empirical research results show that firm size does not play a moderating role in the relationship between firms' acquisition of sustainable competitive advantage, and the data results do not support hypothesis H11. The region of the firm does not play a moderating role in the relationship between the firm's acquisition of sustainable competitive advantage, and the data results do not support hypothesis H12. Management level does not play a moderating role in the relationship between enterprises to obtain sustainable competitive advantage, and the data results do not support hypothesis H13.

There are many reasons that lead to the insignificant relationship between variables. From the actual scenario of this study, there are two main reasons: (1) C2M industry is an emerging industry developed in recent years. The industry itself has the characteristics of networking, and its employees have a high level of informatization. Intelligent manufacturing includes a human-centered production system and a scientifically designed production process, and uses advanced technology, particularly collaborative technology (Fantini et al., 2020). Therefore,

regardless of the size of the enterprise and the city where the enterprise is located, C2M enterprises have digital characteristics, and this inherent similarity of the industry exceeds the influence of enterprise size and enterprise region. (2) Due to production needs, C2M enterprises have high requirements on technical capabilities of employees, and regardless of the level of employees, they need to have network and digital capabilities. Employees of C2M enterprises participate in complex assembly, planning, scheduling production processes and decision-making tasks (W. H. Zhang, 2017). Although senior managers are responsible for the development of digital strategy, while junior employees are responsible for the implementation of digital strategy, employees' views on digital transformation are not significantly different according to different job levels.

Through the difference analysis, it is found that there are significant differences between the management level in two variables: the depth of cross-border cooperation and the sustainable competitive advantage of enterprises. Through multiple comparative analyses, it is found that middle managers are more likely than senior managers to agree on the depth of cross-border cooperation and the sustainable competitive advantage of enterprises. As the link between the low-ranked and the senior management, the middle managers have a comprehensive and in-depth understanding of the development and implementation of the digital strategic direction. Compared with senior managers, middle managers have a clearer and more comprehensive understanding of the in-depth development of cross-border cooperation and the acquisition of sustainable competitiveness of enterprises through digital transformation. Therefore, middle managers have a more positive attitude towards the above two variables.

Therefore, the three variables, enterprise scale, enterprise region and management level, have no significant moderating effect on the relationship between the technical preparation of digital transformation, the transformation degree of digital transformation, the cooperation width and the cooperation depth of cross-border cooperation and the sustainable competitive advantage of enterprises.

4.4 Summary of this chapter

This chapter first combines the conceptual model obtained from the in-depth interview with 27 digital transformation experts and proposes the research hypothesis of this thesis. Next, we design and test the conceptual model by using rigorous questionnaire survey method. During the design process, we strictly followed the relevant design principles and steps and explained the design process in detail. The initial questionnaire consisted of 25 items in the construction

stage. After translation, in-depth discussion with experts and selection of items, the scale was improved and modified for several rounds to make the contents of the questionnaire more scientific and reasonable.

In the stage of empirical research, we carried out pre-survey and data analysis to confirm that the scale of core variables can meet the requirements of testing the conceptual model. Based on the results of the pre-survey, we improved the content of the questionnaire and obtained a formal survey questionnaire. We then used formal questionnaires to conduct empirical research. We conducted questionnaires among experts with digital transformation experience in Beijing, Shenzhen, Chengdu and Hangzhou, and collected 301 valid questionnaires. For the questionnaire survey data, this thesis uses SPSS 29.0 statistical software to conduct in-depth analysis of the data, and successively uses descriptive statistical analysis, reliability test, validity test, correlation analysis, regression analysis, hierarchical regression analysis and other methods. Combined with the conceptual model and research hypothesis, the thesis analyzes the relationship between the technical preparation of digital transformation, the transformation degree of digital transformation, the cooperation width and depth of cross-border cooperation and the sustainable competitive advantage of enterprises.

The results show that 9 of the 13 hypotheses pass the test, and 4 hypotheses fail the test. Among them, the technical preparation of digital transformation, the degree of digital transformation and the width of cross-border cooperation have a significant positive impact on the sustainable competitive advantage of enterprises. The depth of cross-border cooperation has no significant effect on the sustainable competitive advantage of enterprises. Digital transformation technology preparation and digital transformation degree have a significant positive impact on the width and depth of cross-border cooperation. The width and depth of cross-border cooperation play a mediating role between digital transformation technology preparation, digital transformation degree and sustainable competitive advantage of enterprises. Enterprise size, enterprise region, and management level have no regulatory effect on enterprises' sustainable competitive advantage in terms of digital transformation technology preparation, digital transformation degree, width of cross-border cooperation, and depth of cross-border cooperation. Finally, this chapter discusses and analyzes the empirical research results in depth to reveal the reasons for the validity of the research hypothesis. This lays the foundation for the management enlightenment in the following chapters.

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Chapter 5: Conclusion and Future Research

Based on the background of the rapid development of the current digital economy, this study considers C2M enterprises as the research object and discusses the impact mechanism of enterprise digital transformation and enterprise cross-border cooperation on C2M enterprises to obtain sustainable competitive advantage. The relationship between the technical preparation of enterprise digital transformation, the transformation degree of digital transformation, the cooperation width and depth of cross-border cooperation and the sustainable competitive advantage of C2M enterprises is analyzed. Based on the above empirical analysis, this thesis systematically reviews the mechanism of technological preparation for digital transformation, the degree of transformation of digital transformation, the width and depth of cooperation of cross-border cooperation and the sustainable competitive advantage of C2M enterprises and summarizes the research conclusions of this thesis. In the last part of this thesis, we elaborate on the innovative contribution of this thesis and the implications for management practices. At the same time, we also point out the limitations of this study, and the future direction of research is prospected.

5.1 Theoretical contributions

This study considers the C2M enterprises implementing digital transformation as the research object, uses the dynamic capability theory, value co-creation theory and competitive advantage theory, and based on expert interviews, proposes the research model and theoretical hypothesis of the impact of enterprise digital transformation and enterprise cross-border cooperation on C2M enterprises' acquisition of sustainable competitive advantage. By introducing the variables of cooperation width and cooperation depth of cross-border cooperation, this thesis deeply reveals the effects of cooperation width and cooperation depth of cross-border cooperation on the digital transformation of C2M enterprises and enterprises' acquisition of sustainable competitive advantage.

In the stage of empirical research, this thesis uses a questionnaire survey to verify the hypothesized relationship between the variables. Questionnaires were distributed to C2M enterprises in Beijing, Shenzhen, Chengdu and Hangzhou with different economic sizes. After deleting invalid samples such as identical answers, incomplete response data and short response

time, 301 valid questionnaires were obtained. According to the questionnaire survey data, this study used SPSS 29.0 statistical software to conduct in-depth analysis of the data, and successively used descriptive statistical analysis, reliability test, validity test, correlation analysis, regression analysis, hierarchical regression analysis and other methods. The results show that among the 13 hypotheses, nine hypotheses pass the test, and four hypotheses fail the test. The findings are as follows:

5.1.1 Digital transformation technology preparation, digital transformation degree and cross-border cooperation width have a positive impact on enterprises' sustainable competitive advantage

First, digital transformation technology preparation has a significant positive impact on sustainable competitive advantage of enterprises. According to the existing literature and theories, digital technology promotes the arrangement and reorganization of data resources and builds the business model of online and offline linkage (T. Saldanha et al., 2017). Digital technology can realize the collection, processing and insight of the internal and external data of C2M enterprises through various ways and means, optimize the business model through the intelligent analysis of data, and guide business decisions. The empirical research results show that digital transformation technology preparation has a significant positive impact on sustainable competitive advantage of enterprises.

Second, the degree of digital transformation has a significantly positive impact on enterprises' sustainable competitive advantage. The deepening of the transformation degree can help C2M enterprises to more accurately grasp the pain points of customer demand, obtain real market information more quickly, lead consumption and create real demand. The in-depth application of digital technology enables C2M enterprises to provide diversified products and services for different enterprises and customers in many business links such as procurement, production, manufacturing, consumption and service, establishing a competitive advantage for C2M enterprises. The empirical results show that the degree of digital transformation has a significantly positive impact on the sustainable competitive advantage of enterprises.

Finally, the width of cross-border cooperation has a significant positive impact on enterprises' sustainable competitive advantage. The increase in the width of cross-border cooperation between C2M enterprises will promote C2M enterprises to form a close cooperative relationship with more enterprises, which is conducive to transforming traditional IT capabilities into the ability to jointly create enterprise and user value with partners, and then give play to the network effect and complementary effect between enterprises and cooperative

subjects. Cross-border cooperation effectively expands the scope of enterprise activities, enriches the business types of enterprises, and establishes its own competitive advantages for enterprises. The empirical results show that the width of cross-border cooperation has a significant positive impact on the sustainable competitive advantage of enterprises.

5.1.2 Digital transformation technology preparation and digital transformation degree have a positive impact on the width of cross-border cooperation

Technological readiness and degree of digital transformation have a significant positive impact on the width of cross-border cooperation. This thesis deeply discusses how C2M enterprises can expand the scope of cooperation and the number of partners in the process of deepening the technical preparation and transformation degree of digital transformation. In this way, the perception and insight of C2M enterprises to the market environment can be improved, and the application of digital technology to identify and grasp market opportunities can be promoted, and the width of cross-border cooperation can be expanded. The research shows that digital transformation technology preparation and digital transformation degree have a significant positive impact on the width of cross-border cooperation.

5.1.3 Digital transformation technology readiness and digital transformation degree have a positive impact on the cooperation depth of cross-border cooperation

Digital transformation technology preparation and digital transformation degree have a significant positive impact on the depth of cross-border cooperation. This thesis deeply discusses how C2M enterprises can expand the depth and mutual influence of inter-enterprise cooperation in the process of deepening technological preparation and transformation degree of digital transformation. In order to promote the more in-depth application of digital technology among cooperating enterprises, digital technology and digital process can play a driving role in improving the cooperation efficiency of enterprises, and then realize the deepening of cross-border cooperation. The research shows that the preparation of digital transformation technology and the degree of digital transformation have a significant positive impact on the depth of cross-border cooperation.

5.1.4 The cooperation width of cross-border cooperation plays a mediating role between digital transformation technology readiness, digital transformation degree and sustainable competitive advantage of enterprises

In the current context of the rapid development of the digital economy, C2M enterprises actively implement digital transformation, introduce digital technologies and digitally transform management mechanisms and business processes, to achieve good digital transformation results and sustainable competitive advantages (Yao et al., 2023). However, it is obviously not enough to rely only on the introduction of digital technology and the adjustment of organizational process mechanism. Without the participation of a rich number and types of partners, it is difficult for C2M enterprises to achieve sustainable competitive advantage (Du et al., 2024). This thesis analyzes that after the introduction of digital technology and the digital transformation of the management mechanism and business process of C2M enterprises, the introduction of many cooperative enterprises can make the cooperative enterprises benefit each other, and the introduction of a rich variety of cooperative enterprises can improve the efficiency of cooperative enterprises. The width of cross-border cooperation is a bridge connecting the technological readiness of digital transformation, the degree of digital transformation and the sustainable competitive advantage of enterprises. This thesis verifies the mediating effect of cooperation width of cross-border cooperation through empirical research. The data show that cooperation width of cross-border cooperation plays a mediating role between digital transformation technology preparation, digital transformation degree and sustainable competitive advantage of enterprises.

5.1.5 The cooperation depth of cross-border cooperation plays a mediating role between digital transformation technology preparation, digital transformation degree and sustainable competitive advantage of enterprises

In order to achieve a good digital transformation effect and sustainable competitive advantage, it is not sufficient to rely only on the introduction of digital technology and the adjustment of organizational process mechanisms. If there is no deep participation and effective cooperation of partners, it is difficult for enterprises to achieve sustainable competitive advantage (Yang et al., 2023). Based on the dynamic capability theory and value co-creation theory, this thesis analyzed that after the introduction of digital technology and the digital transformation of the management mechanism and business process of C2M enterprises, the cooperative enterprises can jointly create value by utilizing their respective advantages, which can significantly

improve the efficiency of enterprises. The cooperation depth of cross-border cooperation is a bridge connecting the digital transformation technology preparation, the degree of digital transformation and the sustainable competitive advantage of enterprises. This thesis verifies the mediating effect of cooperation depth of cross-border cooperation through empirical research. The data show that cooperation depth of cross-border cooperation plays a mediating role between digital transformation technology preparation, digital transformation degree and sustainable competitive advantage of enterprises.

5.2 Research on innovation points

With the rapid development of digital economy, scholars have paid increasing attention to the mechanism research of enterprise digital transformation. Digital transformation is affected by many factors, and the process of transformation is very complicated. In the existing research, the analysis on how digital transformation can help enterprises gain competitive advantages mainly focuses on the application of digital technology and the promotion of digital technology among cooperative enterprises, and there is few research on the mechanism of digital transformation enterprises adapting to digital technology (Sandkuhl et al., 2020). In view of the above gaps in the research, this thesis builds a research model and hypothesis on the impact of digital transformation and cross-border cooperation on enterprises' sustainable competitive advantage by referring to the relevant research on the technical preparation of digital transformation, the degree of transformation of digital transformation, the width and depth of cross-border cooperation and enterprises' sustainable competitive advantage. It provides a new perspective for enterprises to implement digital transformation and enriches the relevant theoretical research on the mechanism of enterprise digital transformation. Compared with previous research, this research is innovative in the following aspects:

First, it reveals the mechanism of technological preparation and degree of digital transformation for enterprises to obtain sustainable competitive advantage and extends the development of enterprise competence theory. Most of the previous studies only discussed the single factor of enterprise digital transformation technology preparation and enterprise digital transformation degree (S. G. Li & Tian, 2023). In the context of the rapid development of digital economy, enterprise digital transformation includes two aspects: digital transformation technology preparation and digital transformation degree. Providing the necessary technological upgrading and organizational change preparation for the implementation of digital transformation enterprises is the booster for enterprises to obtain sustainable competitive

advantages. In this thesis, the two aspects are incorporated into the same conceptual model. Empirical research confirms that both have a significant positive impact on enterprises to obtain sustainable competitive advantage. This shift from a single-factor perspective to a more comprehensive interactive perspective not only deepens the understanding of the underlying mechanisms of digital transformation, but also enables researchers to more accurately assess the interactions between different factors. On this basis, the research reveals the specific influence mechanism of technology readiness and transformation degree on enterprises' sustainable competitive advantage, which provides a valuable reference for enterprises to implement digital transformation. In addition, this study has further enriched the relevant research on enterprise capability theory and clarified the multi-dimensional and dynamic nature of enterprise capability construction under the digital context. These research results provide a new perspective and theoretical support for enterprises to understand the opportunities for digital transformation.

Second, by introducing the intermediary variable of cross-border cooperation, this study opens the "theoretical black box" of the relationship between enterprises' technological preparation for digital transformation, the degree of digital transformation and enterprises' acquisition of sustainable competitive advantage and expands the research on the mechanism of the interaction between the above-mentioned variables. Specifically, although technological readiness for digital transformation and degree of digital transformation work together, transformational enterprises can apply digital technologies and organizational processes adapted to digital transformation to their enterprises, it is difficult for transformational enterprises to succeed solely on their own (O'Cass & Sok, 2013). Only by joining the partners of the enterprise in the process of digital transformation can the value of the whole value chain be amplified, thus forming a sustainable competitive advantage of the enterprise. Therefore, cross-border cooperation is a bridge connecting the relationship between digital transformation technology preparation, digital transformation degree and enterprises to obtain sustainable competitive advantage and is an important means to promote digital transformation enterprises to obtain sustainable competitive advantage. Most of the existing research focus on how enterprises can gain sustainable competitive advantage by expanding the width of cross-border cooperation, but often neglect the depth of cross-border cooperation. This study focuses on the impact of cross-border cooperation on enterprises' digital transformation and reveals its important role in improving enterprises' technological readiness, promoting transformation degree and obtaining sustainable competitive advantage. The results show that cross-border cooperation plays a key intermediary role in the process of enterprises obtaining sustainable

competitive advantage, which opens a new development path for enterprises. This study also provides a new research perspective for cross-border cooperation.

Third, this thesis defines the concept and connotation of enterprise value co-creation of cross-border cooperation in the process of enterprise digital transformation, integrates the upstream and downstream cooperation subjects of enterprise supply chain and various types of service providers, and deconstructs cross-border cooperation into the cooperation width and depth of cross-border cooperation. Research on value co-creation often ignores many enterprises in the upstream and downstream of enterprise supply chain. However, with the continuous development of digital economy, fundamental changes have taken place in the way, process and participants of enterprise value co-creation. Through the establishment of internal digital platforms, enterprises actively attract all kinds of participants to join, forming a multi-party collaborative ecology, and jointly create enterprise value (Parker et al., 2017). This thesis focuses on the value co-creation process between the upstream and downstream of the supply chain and various service providers of enterprises in digital transformation. Through in-depth analysis of these interactions, this thesis aims to establish a systematic understanding of the various cross-border partners in order to better understand their roles and contributions in value co-creation. Finally, this study not only provides a new perspective to examine the value co-creation mechanism of digital transformation enterprises, but also provides valuable theoretical support for subsequent academic research.

This thesis deconstructs the process of technological preparation and degree of digital transformation for enterprises to obtain sustainable competitive advantage, and deeply explores the way in which the depth of cross-border cooperation plays a role. Digital transformation technology preparation and degree of digital transformation not only promote enterprises in transformation to establish connections with different value co-creators, but also by building a reasonable value distribution system, value sharing between different entities can be realized, so that these entities can continue to provide services for enterprises in digital transformation. This not only helps to enhance the cooperative relationship among the participants, but also promotes the digital transformation enterprises to obtain lasting competitive advantages (Tiwana et al., 2010; Wacker et al., 2016). The above research reveals the sources of sustainable competitive advantage of digital transformation enterprises and also enriches the multiple intermediary paths of enterprise digital transformation technology preparation and digital transformation degree to promote C2M enterprises to build sustainable competitive advantage.

5.3 Managerial implications

In the context of the rapid development of the digital economy, the development of enterprises has ushered in unprecedented opportunities, but also faced with severe challenges. In this process, C2M enterprises, with their unique digital advantages, can seize the opportunity in the trend of enterprise digital transformation, so as to conform to the trend of The Times and achieve more effective market competition. Under the "Internet +" strategy, digital transformation enterprises show their vitality that they never had before (Shao et al., 2001). Through digital transformation, C2M enterprises connect the upstream and downstream enterprises of the supply chain with a variety of service providers to achieve value co-creation among multiple entities, so that enterprises can obtain sustainable competitive advantages. Through the research on the relationship between the technical preparation of enterprises' digital transformation, the transformation degree of digital transformation, the cooperation width and depth of cross-border cooperation and the sustainable competitive advantage of C2M enterprises, it provides guidance for C2M enterprises to adapt to and use emerging technologies to enhance their market competitiveness in the context of digital economic transformation. Simultaneously, it provides practical management suggestions for the digital transformation of C2M enterprises.

5.3.1 Develop the basic digital capabilities of enterprises

In the digital era, vigorously developing enterprises' digital basic capabilities and building enterprise digital platforms are the basis for C2M enterprises to establish competitive advantages. In the process of implementing digital transformation, C2M enterprises apply artificial intelligence, cloud computing, internet of things, 5G and other technologies to all aspects of enterprise production and operation to achieve a high degree of integration with enterprise activities such as research and development, procurement, production, sales and service. The absorption and use of digital technologies have promoted the interconnection between C2M enterprises and other cooperative enterprises (Cirillo et al., 2023). By enhancing the interconnection of information, data and ideas between C2M enterprises and their partners, cooperation processes can be effectively simplified, costs reduced, and overall operational efficiency improved, bringing sustainable development momentum to enterprises.

5.3.2 Attach importance to the establishment of value co-creation of inter-enterprise cooperation

By building a digital platform, C2M enterprises can form a connection network with many users, upstream and downstream enterprises in the supply chain, and various types of service providers. A large number and a rich variety of cross-border partners have instant interaction, resource sharing and close contact based on the digital platform, becoming a value community formed with value creation as the starting point. Value co-creation is an important criterion for evaluating the success of an enterprise's digital transformation. In this process, enterprises must integrate multiple stakeholders such as internal employees, users and suppliers to ensure that the true value of digital transformation is realized. In addition, it is crucial to put the needs of users first, and only by deeply understanding the needs and feedback of users can companies develop and optimize digital products and services in a targeted manner (Miric et al., 2019). Therefore, C2M companies should attach great importance to and actively promote the co-creation of value among various entities. This includes not only the value co-creation within the enterprise, but also the value co-creation process with users and suppliers. Through this multi-agent cooperation mechanism, we will give full play to the important role of value co-creation in the digital transformation process of enterprises, thereby enhancing the sustainable competitive advantage of C2M enterprises.

5.3.3 Strengthen the establishment of a mechanism for the collaborative development of digital transformation and enterprises' cross-border cooperation capabilities

In the era of digital economy, there is a mutually reinforcing relationship between enterprises' digital transformation and cross-border cooperation capabilities, especially in C2M enterprises. This collaborative trend has prompted C2M companies to re-examine and re-structure their business activities to improve overall operational efficiency by updating management models and innovating business processes (Hendrawan et al., 2024). Digital transformation can not only maximize the positive impact of cross-border cooperation, but also provide a foundation to support the establishment and deepening of all kinds of partnerships. With digital technology and cross-border cooperation reinforcing each other, C2M companies can better adapt to market changes, thereby enhancing their sustainable competitive advantage. Therefore, C2M companies should attach great importance to the combination of digital transformation and cross-border cooperation in order to maximize the value it brings and further enhance their long-term competitiveness.

5.3.4 Attach importance to the transformation, cultivation, development and enhancement of digital transformation capabilities of enterprises, and promote the creation of sustainable competitive advantages of enterprises

By improving the digital capability of enterprises and the value co-creation ability among cooperative enterprises, it will have a positive impact on the digital transformation of enterprises and provide strategic guidance for digital transformation enterprises to obtain sustainable competitive advantages. C2M enterprises that are attempting digital transformation need to strive to transform external digital technologies into internalized enterprise digital capabilities and cultivate and enhance enterprise digital capabilities and value co-creation capabilities (Warner & Wäger, 2019). Whether enterprises can gain sustainable competitive advantages from digital transformation largely depends on the cultivation of enterprises' digital capabilities and the implementation of cross-border cooperation. Within the enterprise, C2M enterprises, with their technology and data and other resources, can help C2M enterprises to carry out business collaboration and digital operation and management, and help enterprises to optimize products and services. Externally, cross-border cooperation can help C2M companies establish new connections with external stakeholders, gain insight into value co-creation opportunities, and improve value creation methods. This can provide a sustainable competitive advantage.

5.4 Research limitations and future research

Based on the dynamic capability theory, value co-creation theory and competitive advantage theory, this thesis explores the influence mechanism of enterprise digital transformation and enterprise cross-border cooperation on C2M enterprises to obtain sustainable competitive advantage and deconstructs the intermediary role of cooperation width and cooperation depth of cross-border cooperation, which has high theoretical value. Owing to the limitations of the authors' abilities, this thesis has shortcomings in several aspects. These limitations prevented the depth and width of the study from reaching the desired level, thus affecting the comprehensiveness and accuracy of the study conclusions. More in-depth and comprehensive research is needed in this field in the future, so as to provide more powerful support for theoretical development and practice.

First, this thesis studies the digital transformation of C2M enterprises using the data of a certain point in time, and then examines the relationship between the digital transformation of

enterprises, cross-border cooperation of enterprises and the acquisition of sustainable competitive advantage of C2M enterprises. Digital transformation is a dynamic development, and enterprise digital transformation strategies and cross-border cooperation modes have different characteristics at different stages and time points. Follow-up research can adopt the tracking method to conduct long-term research on C2M enterprises and conduct cross-time research based on data at different time points, so as to strengthen the dynamic research of the model.

Second, this thesis deeply explains the impact of enterprise digital transformation technology preparation and enterprise digital transformation degree on C2M enterprises to obtain sustainable competitive advantage and introduces the cooperation width and cooperation depth of cross-border cooperation as intermediary variables. The influence of technological preparation and degree of digital transformation on the sustainable competitive advantage of C2M enterprises is further analyzed. Although it is measured from the width and depth of cross-border cooperation, it does not deeply analyze the mechanism of enterprise digital transformation technology readiness, enterprise digital transformation degree and their interaction terms to promote the cooperation width and depth of cross-border cooperation. Future research needs to further explore the influencing conditions and ways of the interaction between the two on the cooperation width and depth of cross-border cooperation and deepen the understanding of the promoting role of enterprise digital transformation technology preparation and enterprise digital transformation degree on the cooperation width and depth of cross-border cooperation.

Finally, in the process of exploring the relationship between technological preparation for enterprise digital transformation, transformation degree of digital transformation, cooperation width of cross-border cooperation, cooperation depth of cross-border cooperation, and the sustainable competitive advantage of C2M enterprises, this thesis uses the research method of combining expert interview research and empirical research. First of all, preliminary data were obtained through expert interviews, which provided empirical support for the construction of the relationship chain between data. After in-depth analysis of the collected data using qualitative research method, the researcher further clarified the logical relationship between the model variables and proposed a series of research hypotheses accordingly. Finally, through the design of a survey questionnaire, these hypotheses are tested empirically. Although the sample of expert interview research and questionnaire research in the empirical research, including different regions, different sizes and job levels of respondents can bring a wide range of sample representation, the above research scheme cannot compensate for the shortcomings of a single

industry research, the universality of the research conclusions thus obtained needs to be further improved. Therefore, the future research should consider expanding the scope of industries covered, so as to further explore the logical relationship between variables in a wider range of fields. This will help to enrich and expand the existing research field and provide more perspectives and insights for related research.

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Annex A: Interview Script

Introduction

Description of the interview process (no right or wrong answers). Introduction to the subject of research (the value of implementing digital strategy in C2M Enterprises).

Opening

Can you please tell us your name, age, highest level of education attained, and how long you have been in your current position at your firm?

Transition

1) Could you briefly describe your current role? Does your role and\or firm could be impacted by digital transformation strategies in C2M?

The company's digital transformation

2) Could you please share your understanding of digital transformation? Based on your company's practice, do you think the company needs to perform a digital transformation process?

3) Please consider your company's business. Has the company already made any digital transformation process, or are you preparing a digital transformation process?

4) Now, think about the industry in which you are working. Which digital transformation processes do you think have been successful and why?

5) And now, which digital transformation processes do you think have not been successful and why?

6) How do you view the firm's potential and opportunities for the digital transformation process in your field and\or industry?

Cross-border partnerships of the company

7）Please discuss the relationship between cross-border partnerships and company development.

8） What types of partners does your company have?

9） Could you please talk about how different partners participate in these partnerships? What kind of value has it generated for the company?

10） What is the relationship quality between the company and its partners? What are the

prospects for partnerships?

11) How can digital transformation be helpful in developing existing partnerships or establishing new partnerships?

Conclusion

We are currently researching the key features of implementing digital strategy in C2M Enterprises. Do you consider adding anything that could help us?

Annex B: Questionnaire

Dear Sir/Madam:

Thank you sincerely for participating in this survey. The purpose of this survey is to explore how C2M enterprises can promote digital transformation. The survey questionnaire includes the following contents: filling in basic information; Regarding the technological preparation and degree of digital transformation of the company; The width and depth of cross-border cooperation among enterprises; The competitive advantage gained from enterprise digital transformation. The results of the questionnaire survey are for academic research purposes only, and all questionnaire information will be strictly kept confidential. Your objective answer is crucial to us, and we would like to express our sincere gratitude once again!

Part 1: Basic information

Your company name: _____

Region where your company is located: _____Province_____City

1.Date of establishment of your company:

☐≤ 5 years ☐6-10 years ☐11-20 years ☐ > 20 years

2. Number of employees in your company:

☐≤ 100 people ☐101-500 people ☐501-2000 people ☐ > 2000 people

3. Your company's (annual) operating income is (unit: RMB yuan):

☐≤5 million ☐5-30 million ☐30-100 million ☐above 100 million

4. The nature of your enterprise is:

☐Private enterprises ☐State owned enterprises ☐Foreign funded enterprises

☐Joint ventures ☐Other

5. Industry category of your company:

☐Agriculture, forestry, animal husbandry, fisheries ☐Finance, insurance ☐Manufacturing

☐Information technology ☐Service industries

☐Energy and environmental protection industry ☐Biopharmaceuticals

☐Textiles, clothing ☐Transportation industry

☐Metal or mineral products industry

☐Other industries_____

6. Do you think it is necessary for your company to undergo digital transformation:

☐It's necessary. ☐It's not necessary. ☐I'm not sure.

7. Has your company implemented digital transformation:

☐Not yet prepared for implementation.

☐Preparing to implement digital transformation.

☐Currently in progress.

8. Have your company and partners had any cooperation experience:

☐Yes ☐No

9. Number of partners of your company:

☐≤ 10 companies ☐11-30 companies ☐31-100 companies ☐>100 companies

10. Your job level within the company is:

☐Low-ranked management personnel ☐Middle-level management personnel

☐Senior management personnel ☐Others_____

Part 2: Information on Enterprise Digital Transformation

The following questions are based on the background of enterprise digital transformation. Please put a check mark on the number you think conforms to your actual feelings.

1. Technical preparation for enterprise digital transformation		**Very inconsistent**				**Very consistent**
1.1	**The enterprise has a strong ability to obtain important technical information.**	**1**	**2**	**3**	**4**	**5**
1.2	**The enterprise has a strong ability to identify new technological opportunities.**	**1**	**2**	**3**	**4**	**5**
1.3	**The enterprise has a strong ability to respond with technological changes.**	**1**	**2**	**3**	**4**	**5**
1.4	**The enterprise has a strong ability to master advanced technologies.**	**1**	**2**	**3**	**4**	**5**
1.5	**The enterprise continuously carries out a series of innovations.**	**1**	**2**	**3**	**4**	**5**
2. The degree of digital transformation in enterprises		**Very inconsistent**				**Very consistent**
2.1	**The enterprise can identify big data**	**1**	**2**	**3**	**4**	**5**

	sources that meet technical requirements.	
2.2	**The enterprise can rely on big data to identify new technological development opportunities.**	**1 2 3 4 5**
2.3	**The enterprise has the ability to connect digital products through wireless communication networks.**	**1 2 3 4 5**
2.4	**The enterprise is increasingly using digital technologies to connect people, systems, companies, products and services.**	**1 2 3 4 5**
2.5	**The enterprise can use data in research and development to automatically collect storage device parameters.**	**1 2 3 4 5**
2.6	**The enterprise can apply the data to the production and manufacturing of the equipment to monitor the running status of the equipment in real time.**	**1 2 3 4 5**
2.7	**The enterprise improves the efficiency of business intelligence decision making through digital tools and components.**	**1 2 3 4 5**
3. The width of cross-border cooperation among enterprises		**Very inconsistent Very consistent**
3.1	**The enterprise actively monitors our environment to identify partnering opportunities.**	**1 2 3 4 5**
3.2	**The enterprise routinely gathers information about prospective partners from various forums.**	**1 2 3 4 5**
3.3	**The enterprise is alert to market developments that create potential alliance opportunities.**	**1 2 3 4 5**
3.4	**The enterprise strives to preempt our**	**1 2 3 4 5**

	competition by entering into alliances with key firms before they can.	
3.5	**The enterprise often takes the initiative in approaching firms with alliance proposals.**	**1 2 3 4 5**
4. The depth of cross-border cooperation among enterprises		**Very inconsistent Very consistent**
4.1	**The partner is open to my ideas and suggestions about its existing products or towards developing a new product.**	**1 2 3 4 5**
4.2	**The partner provides sufficient illustrations and information to me.**	**1 2 3 4 5**
4.3	**I would willingly spare time and effort to share my ideas and suggestions with the partner in order to help it improve its products and processes further.**	**1 2 3 4 5**
4.4	**The partner provides suitable environment and opportunity to me to offer suggestions and ideas.**	**1 2 3 4 5**
5. Sustainable competitive advantage of enterprises		**Very inconsistent Very consistent**
5.1	**Business sales increases.**	**1 2 3 4 5**
5.2	**The average profit earned by the enterprise per customer increases.**	**1 2 3 4 5**
5.3	**The return on investment increases.**	**1 2 3 4 5**
5.4	**The overall performance of the enterprise improves.**	**1 2 3 4 5**

Annex C: Annex Tables and Figures

Annex Table 1 Research methods and contents

Methodology	Research Method	Research Content
Literature Review	Literature Review	The method of collecting, identifying, and organizing documents to form a scientific understanding of facts through the study of documents.
Qualitative Research	Expert Interviews	A method of studying the psychology and behavior of an interviewee through in-depth conversation with them. Based on respondents' responses to questions related to digital transformation, the conceptual model of enterprise digital transformation was explored.
Quantitative Research	Questionnaire Survey	Design a detailed and structured questionnaire, so that the respondents can answer the questions in the questionnaire, so as to effectively collect the required data. By analyzing the results of the questionnaire survey, the conceptual model proposed in this thesis is verified.

Annex Table 2 Measurement scale of each variable

Variables	Scale source
Technical preparation for digital transformation	Technological capability, strategic flexibility, and product innovation (Zhou & Wu, 2010)
The transformation degree of digital transformation	Dimension exploration and scale development of digital empowerment structure (Z. Li et al., 2022)
The width of cross-border cooperation	Process capabilities and value generation in alliance portfolios (Sarkar et al., 2009)
The depth of cross-border cooperation	Value co-creation: concept and measurement (Ranjan & Read, 2016)
Enterprises gain sustainable competitive advantage	Market orientation, generative learning, innovation strategy and business performance inter-relationships in bioscience firms (Morgan & Berthon, 2008)

Annex Table 3 KMO values and Bartlett sphericity test criteria

Range of KMO values	Whether it is suitable to do factor analysis
> 0.9	Great fit
0.8-0.9	Fit
0.7-0.8	More suitable
0.6-0.7	Barely fit
0.5-0.6	Not a good fit
< 0.5	Totally inappropriate

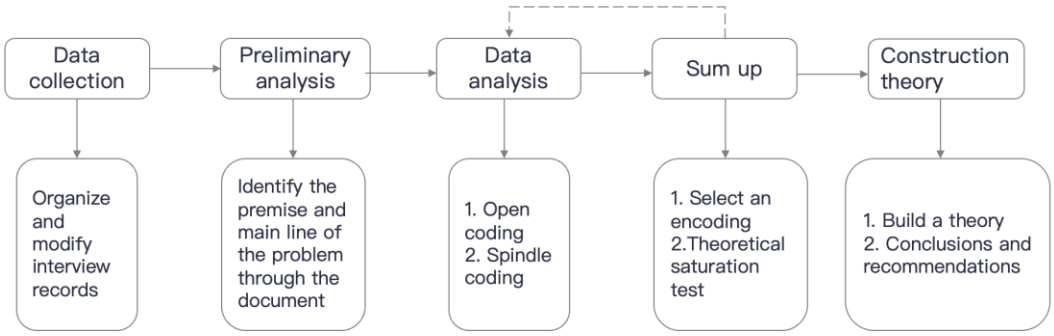
Source: M. L. Wu (2010b)

Annex Table 4 KMO values and Bartlett sphericity test

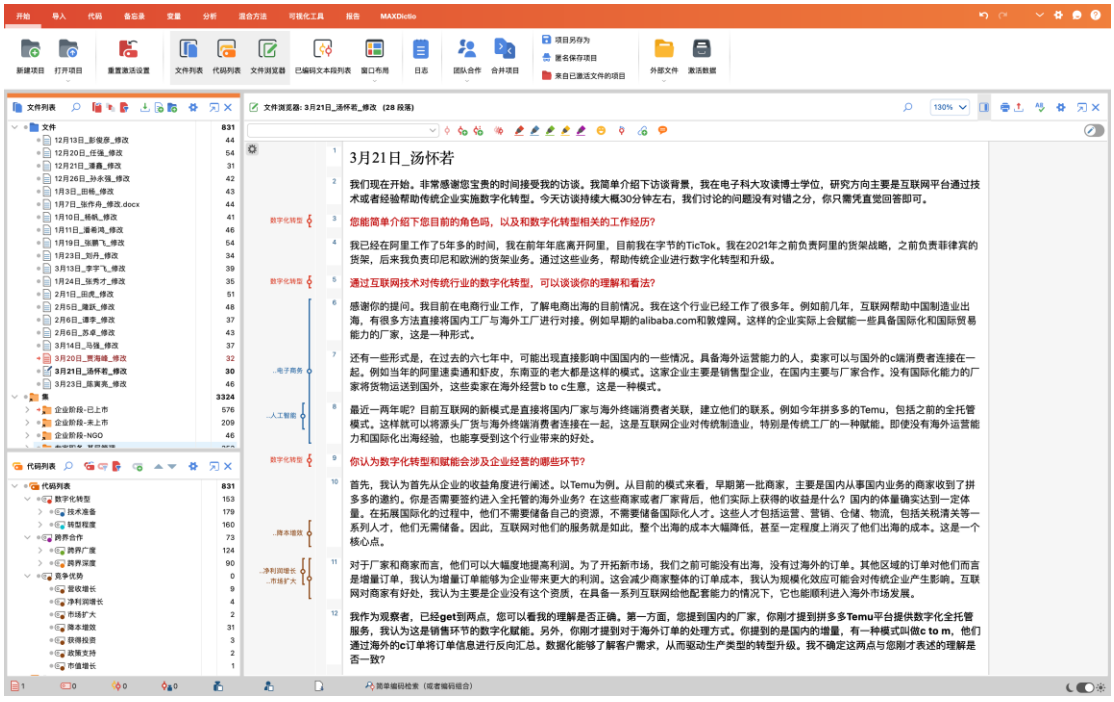
Kaiser-Meyer-Olkin measure of sampling adequacy		0.852
Bartlett's sphericity test	Approximate Chi-square	1604.439
	df	91.000
	Sig.	0.000

Annex Table 5 Cronbach's α test criteria

Cronbach's α value range	Internal consistency
>0.8	Good
0.7-0.8	Better
0.65-0.7	Acceptable
<0.65	Unacceptable



Annex Figure 1 Flowchart of the research scheme



Annex Figure 2 MAXQDA node coding