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The Impact of Digital transformation of Supply Chain on Competitive Advantage of Enterprises: A Case Study of Chinese Manufacturing Enterprises

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Abstract

This study takes the digital transformation of the supply chain of manufacturing enterprises as the entry point and focuses on the theme of "the impact of digital transformation of the supply chain of manufacturing enterprises on the competitive advantage of enterprises in an uncertain environment and the path of its effect", aiming to answer the following questions: First, why do manufacturing enterprises need to Firstly, why do manufacturing enterprises need to transform their supply chains digitally? What is the impact of supply chain digital transformation on the competitive advantage of enterprises? Secondly, what is the role of dynamic supply chain capabilities in the process of digital transformation of supply chains in manufacturing companies? Thirdly, how does environmental uncertainty affect the relationship between supply chain digital transformation, supply chain dynamic capabilities and firms' competitive advantage? This study draws on and refers to the mature scale of existing research and designs a questionnaire for this study. Reliability and validity test, descriptive statistical analysis, homology deviation analysis and confirmatory factor analysis are used to test the sample quality, and correlation analysis and regression analysis methods are used to verify the main effect, mediating effect and moderating effect of the research hypothesis, and finally the empirical analysis results are obtained and discussed.

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Introduction

Digital transformation is a new trend of integration and development of traditional manufacturing enterprises in the context of digitalization. In China, the added value of the manufacturing industry has developed from 17.98 trillion yuan in 2012 to 27.60 trillion yuan in 2020, accounting for a global increase of nearly 8%. The second issue of Seeking Truth in 2022 published General Secretary Xi Jinping's article "Continuously becoming stronger and better, and expanding China's digital economy", which emphasized that the development of the digital economy is an important direction for the country in the future. The "14th Five-Year" Digital Economy Development Plan newly issued by the State Council also clearly states that by 2025, China's digital economy will move towards a comprehensive and expanding period, and the added value of the core industries of the digital economy will account for 10% of GDP. At present, the whole country is actively promoting the development of digital industrialization and industrial digitization. In some parts of China, it is expected that the proportion of key links of manufacturing enterprises above designated size will be fully digitized by 2023. 65%. General Secretary Xi Jinping emphasized that "China is one of the important engines of the recovery of the world economy. It not only provides the world with growth opportunities with a huge market, but also an indispensable part of the global supply chain of many enterprises." The modernization level of the supply chain is an important manifestation of the degree of digital transformation of manufacturing enterprises. Therefore, accelerating the digital transformation of the supply chain is of great significance to promote the transformation and upgrading of traditional manufacturing enterprises. However, with the advancement of enterprise digital transformation, there are still problems that cannot be ignored. For example, although traditional manufacturing enterprises have a huge scale and foundation, there are still problems such as unreasonable industrial structure, insufficient talent supply and weak independent innovation capabilities. Research on how to improve the competitive advantage of enterprises has always been the focus of supply chain management research. In the context of digital transformation, exploring how to improve the competitive advantage of manufacturing enterprises is very practical research. Manufacturing is one of the most important industries in China, the foundation of the national economy, and plays an important role in national development. To better cope with the development and transformation of the new pattern of the world economy, China took the lead in proposing the "Made in China 2025" plan as early as 2015, striving to enter the ranks of manufacturing powerhouses by 2025, enter the middle level of manufacturing powerhouses in 2035, and reach the forefront of world manufacturing powerhouses in 2050. Since then, China's traditional manufacturing enterprises have begun to gradually carry out digital transformation and upgrading. " The Guiding Opinions on Deepening the Integrated Development of the New Generation of Information Technology and the Manufacturing Industry clearly pointed out that while the current manufacturing enterprises are facing new challenges, there are also huge opportunities. It is necessary to guide large manufacturing enterprises and medium and small manufacturing enterprises to adhere to independent innovation. The road integrates the new generation of information technology with the manufacturing industry to get out of the road of manufacturing enterprises with Chinese characteristics. China’s "14th Five-Year Plan" and the outline of the long-term goals for 2035 emphasize that the digital transformation of manufacturing enterprises is a key means to improve their efficiency and quality, which is conducive to strengthening the foundation to ensure the safety and stability of the industrial chain and supply chain, and effectively respond to major risks and external shocks. The COVID-19 epidemic has brought a huge impact on the development of the global manufacturing industry, and China is no exception. During the epidemic, Chinese manufacturing enterprises once faced a dilemma. On the one hand, to prevent the epidemic from intensifying and spreading, in the early stage of the epidemic, manufacturing enterprises completely stopped production and work; on the other

hand, after the resumption of production and work, the global supply chain was interrupted, resulting in limited supply of raw materials, which seriously affected production capacity and supply. However, while the epidemic has brought challenges to manufacturing enterprises, it has also promoted the digital transformation and upgrading of manufacturing enterprises. For example, Baosteel Group's "unmanned intelligent workshop" was put into use during this epidemic after several years of research.In the early days of the epidemic, when most companies were unable to resume production, Baosteel Group put this "unmanned intelligent workshop" into use, replacing traditional labor with robots, and conducting remote supervision and control through a digital platform. During the epidemic, the safety of production supply and employees was double guaranteed in such a special way. " "Unmanned Intelligent Workshop" represents a good start for the digital transformation of manufacturing enterprises. Therefore, how to promote and accelerate the high integration of digital technology and manufacturing in the context of digitalization, realize the "two-wheel drive" of digital economy and manufacturing, and insert "digital" wings for manufacturing powerhouses has become a hot topic of common concern in the industry and academia. (Arya et al., 2017; Attaran, 2020; Baker & Sinkula, 1999; Banalieva & Dhanaraj, 2019; Benerjee et al., 2021).

Problem Statement

This study found that globalization has brought more complexity and uncertainty to supply chains, which has also led to the fact that these issues are still major challenges facing supply chains today. Compared with 10 years ago, commodity competition in today's world is more intense, and the oversupply of commodities in the market is a common phenomenon. Consumers have increasing demand for product quality, after-sales services, customization, etc. The traditional supply chain can no longer meet the current market demand, and the supply chain industry is encountering unprecedented challenges. The research report "Social Digital Supply Chain Panorama" released by the National Industrial Information Security Development Research Center summarizes the supply chain and business development bottlenecks that China is still facing in 2021, as shown in Figure 1.1. The report pointed out that the repeated COVID-19 pandemic has increased the risk of instability in the supply chain, and also exposed many challenges and bottlenecks facing the development of China's supply chain: under the influence of repeated epidemics, market demand tends to diversify, business Scenarios are gradually complicated, and the uncertainty of the basis for corporate decision-making has increased, which makes the already fierce market competition even more brutal. Even leading companies cannot guarantee that they will always be able to occupy a leading position; in supply chain management, due to demand forecasts Inaccurate, price fluctuations, decision-making mistakes and other reasons cause the supply chain to pass from the bottom up, demand planning the phenomenon of step-by-step amplification of the deviation from the actual demand in the market is called the bullwhip effect. It is ubiquitous in the traditional linear supply chain, and today's increasingly complex market environment is bound to further amplify the bullwhip effect; the supply chain management of many enterprises is fragmented, The phenomenon of islands, the lack of information exchange between departments, enterprises and suppliers, enterprises and customers, and the opaque business process make the entire supply chain lack the ability to deal with risks and are prone to supply chain interruptions; in the traditional supply chain, the upstream and downstream of the supply chain are closely connected with the front and rear links through series. Once there is a problem in a certain link in the supply chain, it will cause the chain reaction of the entire supply chain, the interruption of a certain link can even cause the failure of the entire supply chain. This has been verified in several global supply chain interruptions in 2021, such as the interruption of some pharmacy supply chains in the world caused by the epidemic in India, the closure of all factories in the south in Vietnam due to the epidemic, resulting in the shutdown

of the global manufacturing industry, etc. Limited by scale and capacity, many small and medium-sized enterprises have low investment in the field of supply chain management. In today's competition, the fierce market needs to face the uncertainty of the supply chain, and it is easy to cause irreparable losses due to decision-making mistakes.

Research objectives

Based on previous research results, this study takes the digital transformation of the supply chain of manufacturing enterprises as the starting point and focuses on the theme of "In an uncertain environment, the impact and action path of the digital transformation of the supply chain of manufacturing enterprises on the competitive advantage of enterprises". The specific goals are as follows: 1. Explore the impact and action path of manufacturing enterprises and supply chain digital transformation on the competitive advantage of enterprises. 2. Explore the impact of digital transformation of the supply chain of manufacturing enterprises on the dynamic capabilities of the supply chain. 3. Explore the impact of the dynamic capabilities of the supply chain of manufacturing enterprises on the competitive advantage of enterprises. 4. From the new perspective of digital supply chain, analyze the role of supply chain dynamic capabilities in the relationship between supply chain digital transformation and enterprise competitive advantage. 5. Explore the contingency role of environmental uncertainty in the relationship between supply chain digital transformation, supply chain dynamic capabilities and enterprise competitive advantage, to reveal the boundary conditions that supply chain digital transformation indirectly affects enterprise competitive advantage through supply chain dynamic capabilities.

Research questions

Based on the above problem statement, the specific questions of this study are as follows: 1. How does the digital transformation of the supply chain of manufacturing enterprises affect the competitive advantage of enterprises? 2. How does the digital transformation of the supply chain of manufacturing enterprises affect the dynamic capabilities of the supply chain? 3. What is the impact of the dynamic capabilities of the supply chain of manufacturing enterprises on the competitive advantage of enterprises? 4. Does the dynamic capability of the supply chain of manufacturing enterprises play an intermediary role between the digital transformation of the supply chain and the competitive advantage? 5. How does environmental uncertainty adjust the relationship between supply chain digital transformation, supply chain dynamic capabilities and enterprise competitive advantage?

Scope of study

This study takes Chinese manufacturing enterprises as the research object and will deeply explore how supply chain digital transformation and supply chain dynamic capabilities have an impact on the competitive advantage of manufacturing enterprises, and provide Chinese manufacturing enterprises with supply chain digital transformation and cultivation. Supply chain dynamic capabilities provide a theoretical basis, thereby promoting the rapid development of Chinese manufacturing enterprises and the entire industry. Digital transformation is a long-term transformation that requires enterprises to upgrade their strategies and invest heavily in resources. Supply chain digital transformation is the key direction for enterprises to carry out further digital transformation. It not only requires enterprises to have sufficient technology and resource accumulation, but also requires enterprises to have the ability to mobilize resources at each node of the supply chain. Therefore, supply chain digital transformation is a supply chain transformation dominated by the core enterprises in the supply chain and closely cooperated with other node enterprises.

Literature review

Independent variable

A digital supply chain as a value-oriented intelligent network that utilizes new technologies and methods to create new forms of revenue and business value through a central platform that captures and maximizes Utilize real-time information from various sources. All stages of a digital supply chain are interconnected, which enables robust data collection and intelligent decision-making based on real-time communication. A digital supply chain as an intelligently optimized technical system that performs functions such as massive data processing and excellent collaboration and communication with the help of digital hardware and software that synchronize and support interactions between organizations.

(Arya et al., 2017; Attaran, 2020; Baker & Sinkula, 1999; Banalieva & Dhanaraj, 2019; Benerjee et al. 2021) argue that a digital supply chain mediates the activities of partners in the supply chain through hardware, software, and communication networks to support interactions in processes such as purchasing, producing, storing, transporting, and selling goods between organizations around the world. The digital supply chain "Supply Chain 5.0". Enterprises develop supply chains in terms of transparency, predictability, scalability, adaptability, collaboration, integration, and customer-centricity. A digital supply chain requires enterprises to shift from stability to adaptability, from standardization to customization, from policy-driven to judgment-driven, and from isolation to collaboration. Institutions such as the Global Enterprise Center and the US Digital Supply Chain Research Institute define a digital supply chain as a customer-centric platform that captures real-time information from a variety of sources and maximizes its use, and optimizes performance through demand stimulation, matching, detection, and management to minimize risk. The digital supply chain with the SCOR model, defining it as a system based on emerging digital technologies such as big data analytics, CPS networks, and additive manufacturing, including functions such as plan execution, traceability, manufacturing, and delivery. A digital supply chain as a self-thinking supply chain that predicts and detects risks by analyzing large amounts of data collected from various sources, and actively takes preventive measures before risks occur, thereby enabling Continuous monitoring of performance. (Arya et al. ,2017; Attaran, 2020; Baker & Sinkula, 1999; Banalieva & Dhanaraj, 2019; Benerjee et al., 2021)

Dependent variable

The competitive advantage is the unique market position that an enterprise obtains over its competitors through resource allocation. A business has a unique market position and an excellent value proposition, the business has a competitive advantage because it can lead through lower cost leadership, differentiated product strategies, new market segments generate the best value proposition and customer satisfaction. (Arya et al., 2017; Attaran, 2020; Baker & Sinkula, 1999; Banalieva & Dhanaraj, 2019; Benerjee et al., 2021) regarded the return higher than the industry average as the competitive advantage of enterprises and believed that the fundamental reason for enterprises to improve financial performance is to obtain the competitive advantage of enterprises. Since then, many scholars have used financial-related indicators to measure the competitive advantage of enterprises. The competitive advantage of enterprises is equivalent to accounting performance; that is, when the accounting performance of enterprises is above the industry average level, it can be regarded as the competitive advantage of enterprises. When discussing the impact of the institutional environment of listed companies in China on the competitive advantage of companies, measured whether companies have it by measuring the relevant ratios in the return on assets, income statement and balance sheet of companies and comparing them with the industry average. Competitive Advantage.

The competitive advantage of companies into two dimensions: financial performance and market share, but because the result of increased market share is usually an increase in corporate revenue, both dimensions can be classified as financial related indicators. Although financial-related indicators can reflect the economic benefits of enterprises' production and operation activities, it is difficult to reflect other related contents. The competitive advantage of enterprises into three dimensions: efficiency, function, and sustainability, in which efficiency is a financial-related indicator, which refers to evaluating corporate behavior by measuring corporate costs, and function and sustainability are non-financial related indicators, respectively. The resource-based theory and the theory of dynamic capabilities should be combined to organically integrate the internal resources and dynamic capabilities of enterprises, to quickly respond to the external turbulent market environment (Arya et al., 2017; Attaran, 2020; Benerjee et al., 2021).

Mediating variables

Supply chain as a complex system. He took the lead in introducing dynamic capabilities into supply chain, and pointed out that supply chain dynamic capabilities are the response of this complex system to environmental changes and internal complexity. The ideal ability of relationships. Supply chain dynamic capabilities as the ability of enterprises to perceive and utilize internal and external resources to effectively enhance supply chain practices. They point out that supply chain dynamic capabilities should include information sharing, coordination, integration, and supply chain response capabilities. Supply chain, dynamic capabilities are the process of information exchange, supply chain adjustment and information technology integration, which can help companies meet customers, needs, and remain competitive in a dynamic environment that developing supply chain Dynamic capabilities play an important role in responding to the future needs of enterprises. By exploring the relationship between knowledge sharing and supply chain dynamic capabilities, the knowledge sharing is a process of knowledge flow and knowledge transfer between upstream and downstream enterprises in the supply chain, which has a strong positive impact on supply chain dynamic capabilities. The trust and relationship commitment between supply chain partners can effectively improve various capabilities including supply chain, operation ability, supply chain learning ability, etc., because supply chain management is based on business flow, capital flow, information flow and logistics, they are all processes of dynamic management, so these capabilities related to supply chain management can be regarded as the embodiment of supply chain dynamic capabilities in different dimensions. The increase and pairs of information technology investment by enterprises at each node of the supply chain, and the integration of information technology within and between enterprises will promote the improvement of the dynamic capabilities of the supply chain. Cross-organizational learning can help break the boundaries of supply chain dynamic capabilities. A descriptive case study of food processing companies based on second-hand data, and found that strategies such as corporate strategic positioning, supply chain network continuity, supply chain partner collaboration, and supply chain risk management can all promote the improvement of supply chain dynamic capabilities. When discussing the impact of executives' environmental awareness on the performance of enterprises' green innovation, found that environmental uncertainty significantly regulates the relationship between executives' environmental awareness and dynamic ability. The difference in corporate strategy positively affects the fluctuation of corporate operating performance, while environmental uncertainty and uncertainty play a positive regulatory role between the two, and at the same time prove that this the regulatory effect is more pronounced in small-scale enterprises (Arya et al., 2017; Attaran, 2020; Benerjee et al., 2021).

Methodology

Research Design

1. Scale design

Through sorting out the relevant literature at home and abroad, combined with the concept definition of the relevant variables in this study, the connotation of each variable is clarified. Scholars at home and abroad have previously studied the scales of supply chain digital transformation, supply chain dynamic capabilities, environmental uncertainty, and enterprise competitive advantage, and most of them have good validity and reliability. By comparing the research scenarios, research objects and research purposes of domestic and foreign scholars, a mature scale close to paper research is selected from core journals with high citation rates.

2. Initial questionnaire design

This research designs the questionnaire based on the basic principles of questionnaire design. The whole structure consists of four parts: title, title, questionnaire text, and conclusion. The main body of the questionnaire is the most critical part of the questionnaire, which includes questions, measurements, items, and instructions for answering questions. Except for the relevant background questions of the respondents, the other measurement questions in the questionnaire designed in this study use the Likert Level 5 scale, of which 1 means "strongly disagree", 2 means "disagree", 3 means "unsure", 4 means "agree", 5 means "strongly agree", and the respondents need to fill in according to their own situation. Since the research objects selected in this study are all professionals in the field, the order of questions is sorted according to relevant variables. Compared with the body of the questionnaire, the other three parts of the questionnaire are equally important, and they have a great impact on the effective response rate of the questionnaire. The title of the questionnaire is to refine the content of the questionnaire in concise language, so that the respondents can understand the content of the questionnaire at a glance. The opening phrase is the "letter of introduction" of the questionnaire, which should contain the purpose, meaning, instructions and instructions for filling out the questionnaire, and a statement on the confidentiality of the survey. Provide guidance for the respondents to fill out the questionnaire smoothly, and eliminate their doubts about information leakage, thereby improving the reliability of the survey results. The closing remarks are the last part of the questionnaire, which usually express gratitude to the respondents for their active cooperation in short language.

3. Expert review to evaluate the quality of the questionnaire

To improve the quality of the questionnaire, experts in relevant fields need to be hired to evaluate the quality of the questionnaire and put forward suggestions for improvement before the pre-survey. Usually, experts will review the questionnaire from the following perspectives: whether the questionnaire misses important questions related to the research topic; whether the tone of the questions in the questionnaire is easy to accept, whether the opening and closing remarks of the questionnaire have an encouraging effect on the research object.

4. Pre-survey and return the questionnaire

Since most of the experts are from the perspective of the questioner, they cannot understand the response and understanding of the respondents to the question, so they can be evaluated through pre-survey. The pre-survey is to test the initial questionnaire, and a small-scale survey is used to check whether the questions of the questionnaire are appropriate, whether the questions are correct, whether the order of questions is reasonable, whether the respondents can understand the purpose and meaning of the questionnaire, and the time required to complete the entire questionnaire. The questionnaires recovered from the pre-survey are not included in the valid sample of the formal survey. According to the feedback from the pre-survey subjects, this study further improves the questionnaire to ensure that there are no unclear descriptions, difficult to understand, difficult or unwilling respondents to answer. After

completing the recovery of the pre-survey questionnaire, the reliability and validity of the results are tested to ensure the credibility and feasibility of the questionnaire.
5. Adjust and revise the questionnaire

According to the revisions and questions reported in steps (4) and (5), make final adjustments and revisions to the questionnaire to complete the design of the formal questionnaire.

6. Formal research

After the questionnaire was finalized, a formal survey began.

Data collection

The pre-survey subjects selected classmates from the on-the-job MBA class and the on-the-job DBA class of Asia Metropolitan University, and their occupations were limited to managers and practitioners of manufacturing enterprises. A total of 100 questionnaires were distributed and 90 questionnaires were recovered. After excluding the questionnaires with incomplete data and non-compliance requirements, a total of 93 valid pre-survey questionnaires were obtained, with a comprehensive effective collection rate of 93%.

Target population

This study has made it clear that the research objects are manufacturing companies of different sizes, types and ages located in China, and at the core of the end of the supply chain. Given that China is a big manufacturing country and has a large number of domestic manufacturing companies, in 2021, manufacturing companies will occupy 249 seats in China's top 500 companies, accounting for almost half. Due to the uneven economic development in various regions, the difference in the construction of supply chain system and the degree of digital development, the selection of the scope of the research object is too large, which not only consumes a lot of costs, but also makes it difficult to draw targeted conclusions. Therefore, this study selects the on-the-job MBA of Asia Metropolitan University and the classmates engaged in manufacturing among the on-the-job DBA students as the survey object. With the assistance of the China Program Center of Asia Metropolitan University, this study was conducted in the Beijing Curriculum Center of Asia Metropolitan University, the Shanghai Curriculum Center of Asia Metropolitan University, the Guangdong Curriculum Center of Asia Metropolitan University, the Shaanxi Curriculum Center of Asia Metropolitan University, the Zhejiang Curriculum Center of Asia Metropolitan University, and the Hubei Curriculum Center of Asia Metropolitan University., Asia Metropolitan University Hunan Teaching Center, and Asia Metropolitan University Shandong Curriculum Center each found a course leader to assist in finding eligible students for a questionnaire survey. Since Guangdong Province is a major manufacturing province in China, and there are a large number of students working in manufacturing enterprises, the Guangdong Curriculum Center issued 120 questionnaires, and the other 7 curriculum centers each issued 40 questionnaires. The assignment method is mainly to select a questionnaire star to assist in the distribution and collection of questionnaires in this study and send the questionnaire link to the person in charge of the course center through the WeChat group or personal WeChat. The distribution time is October-December 2022. After the end of all the investigation stages, 400 questionnaires were received, and the collected questionnaires were strictly screened to eliminate the questionnaires that did not meet the requirements. Finally, 368 complete and valid questionnaires were obtained, and the effective collection rate of the questionnaires was 92%.

Sampling frame and sampling location

There are 113 enterprises in Guangdong, accounting for 30.71% of the total, and 255 enterprises in other regions, accounting for 69.29% of the total; in terms of the age of the

enterprise, there are 56 enterprises established within 10 years, accounting for 16.2% of the total, 120 enterprises established in 10-15 years, accounting for 32.6% of the total, 125 enterprises established in 15-20 years, accounting for 35.0% of the total, and 67 enterprises established in more than 20 years, accounting for 18.2% of the total; considering that the financial information of most enterprises is not disclosed to the public, this study uses employees The number reflects the size of the enterprise. There are 95 enterprises with less than 300 people, accounting for 26.8% of the total, 178 enterprises with 300-2000 people, accounting for 48.4% of the total, and 65 enterprises with 2000-5000 people, accounting for 17.7% of the total. There are 30 enterprises with more than 5,000 people, accounting for 8.2% of the total; from the perspective of the nature of enterprises, there are 71 state-owned enterprises, accounting for 19.3% of the total, 125 private enterprises, accounting for 35.0% of the total, There are 108 joint ventures, accounting for 29.3% of the total, and 64 wholly foreign-owned enterprises, accounting for 17.4% of the total In terms of the main markets for final products downstream of the supply chain, there are 73 enterprises in the international market, accounting for 19.8% of the total. There are 214 enterprises in the domestic market, accounting for 58.2% of the total. There are 81 enterprises in both domestic and foreign markets, accounting for 22.0% of the total. Therefore, from the characteristics of the interviewed companies, it can be seen that there are many medium and large enterprises with a scale of more than 300 people and enterprises with a establishment time of more than 10 years, which is in line with the characteristics of China's manufacturing power. At the same time, the distribution of other characteristics of enterprises is relatively balanced. To sum up, the distribution of the selected sample companies conforms to the characteristics of Chinese manufacturing enterprises, has a good representation, and meets the design requirements of this study.

Sampling size

This study has made it clear that the research objects are manufacturing companies of different sizes, types and ages located in China, and at the core of the end of the supply chain. Given that China is a big manufacturing country and has many domestic manufacturing companies, in 2021, manufacturing companies will occupy 249 seats in China's top 500 companies, accounting for almost half. Due to the uneven economic development in various regions, the difference in the construction of supply chain system and the degree of digital development, the selection of the scope of the research object is too large, which not only consumes a lot of costs, but also makes it difficult to draw targeted conclusions. Therefore, this study selects the on-the-job MBA of Asia Metropolitan University and the classmates engaged in manufacturing among the on-the-job DBA students as the survey object. With the assistance of the China Program Center of Asia Metropolitan University, this study was conducted in the Beijing Curriculum Center of Asia Metropolitan University, the Shanghai Curriculum Center of Asia Metropolitan University, the Guangdong Curriculum Center of Asia Metropolitan University, the Shaanxi Curriculum Center of Asia Metropolitan University, the Zhejiang Curriculum Center of Asia Metropolitan University, and the Hubei Curriculum Center of Asia Metropolitan University., Asia Metropolitan University Hunan Teaching Center, and Asia Metropolitan University Shandong Curriculum Center each found a course leader to assist in finding eligible students for a questionnaire survey. Since Guangdong Province is a major manufacturing province in China, and there are a large number of students working in manufacturing enterprises, the Guangdong Curriculum Center issued 260 questionnaires, and the other 7 curriculum centers each issued 20 questionnaires. The assignment method is mainly to select a questionnaire star to assist in the distribution and collection of questionnaires in this study and send the questionnaire link to the person in charge of the course center through the WeChat group or personal WeChat. The distribution time is October-December 2022. After the

end of all the survey stages, 400 questionnaires were received, and the collected questionnaires were strictly screened, excluding the questionnaires that did not meet the requirements, and finally 368 complete and valid questionnaires were obtained, with a valid collection rate of 92%. According to previous research by scholars, multiple regression analysis usually requires the number of samples to be at least 15 times the number of variables, or more than 5 times the number of questions to meet the basic requirements of the analysis. No matter which standard is used to measure, the number of valid questionnaires collected in this study meets the requirements.

Questionnaire design and instrumentation

Questionnaire survey method is a scientific research method that collects data by means of written questions. The researcher compiles the questions to be studied into a question form, which is filled out by mail, electronic questionnaire, paper questionnaire or in-person answer. The data fed back by the respondents are sorted out and analyzed, and the corresponding conclusions are finally drawn.

Questionnaire design is a complex task, which requires researchers to have both professional knowledge and statistical knowledge in the field of study. According to previous research summaries, questionnaire design should follow the basic principles of completeness, reliability, clarity, simplicity, neutrality, etc. The principle of completeness is the primary principle of questionnaire design. It requires that the questionnaire meets the purpose of the survey, the design of the questions is consistent and complete, and it can cover the comprehensive research content, so as to improve the validity of the questionnaire and provide the required information for decision-making. The principle of reliability means that to ensure that the collected data remains stable under certain conditions, researchers should conduct multiple tests and adjustments to the first draft of the questionnaire to avoid ambiguous and easily ambiguous questions or options in the questionnaire, so as to ensure that the questionnaire Maintain stable reliability. The principle of clarity refers to the use of clear and easy-to-understand language in the questionnaire, and each question should be as easy to understand as possible to minimize the cognitive burden on respondents. The principle of simplicity refers to breaking down complex questions into multiple simple questions. Although this increases the total number of questions, it reduces the pressure on respondents by simplifying tasks and generally improves the efficiency of filling out questionnaires. The principle of neutrality refers to the use of neutral, objective statements when designing questionnaires and avoiding biased questions or options.

Reliability Analysis

1. Reliability test of supply chain digital transformation

The supply chain digital transformation contains a total of 8 measurement items, and the Cronbach's α coefficient is 0.901, which is higher than the critical value of 0.7. The CITC values of the 8 measurement items are distributed between 0.656-0.760, all of which are higher than the critical value of 0.4, and the Cronbach's α coefficient after deleting any one item has not been improved, which indicates that the reliability of the supply chain digital transformation measurement scale is high. The specific reliability indicators of supply chain digital transformation are shown in Table 3.11:

Table3- 1Reliability analysis of supply chain digital transformation

Variable	Measurement item	CITC	The α-value after deleting the	Cronbach's alpha
Supply chain digital transformation	SCDT1	0.760	0.880	0.901
	SCDT2	0.707	0.886	
	SCDT3	0.694	0.887	
	SCDT4	0.656	0.892	
	SCDT5	0.719	0.884	
	SCDT6	0.692	0.888	
	SCDT7	0.723	0.884	
	SCDT7	0.701	0.813	

2. Supply chain dynamic capability reliability test

The supply chain dynamic capability variable contains a total of 13 measurement items, which are divided into three dimensions. The Cronbach's α coefficients of each dimension are 0.798, 0.871, and 0.902 respectively, and the overall Cronbach coefficient of the variable is 0.805, all of which are higher than the critical value of 0.7. The CITC values of the 13 measurement items are distributed between 0.491-0.804, all of which are higher than the critical value of 0.4, and the Cronbach's α coefficients after deleting any one item have not been significantly improved, which indicates that the reliability of the supply chain dynamic capability measurement scale is high. The specific reliability indicators of supply chain dynamic capability are shown in Table 3.12:

Table3- 2Reliability Analysis of Formal Research Supply Chain Dynamic Capability

Variable	Dimension	Measurement	CITC	The α -value after	Dimension α value	Value of variable α
Supply chain dynamic capabilities	Supply chain learning and absorptive capacity	SCLA1	0.659	0.723	0.798	0.805
		SCLA2	0.632	0.737		
		SCLA3	0.491	0.801		
		SCLA4	0.674	0.714		
	Supply Chain Innovation Capability	SCIN1	0.746	0.827	0.871	
		SCIN2	0.716	0.839		
		SCIN3	0.724	0.836		
		SCIN4	0.714	0.840		
	Supply chain integration and optimization capabilities	SCIO1	0.804	0.869	0.902	
		SCIO2	0.698	0.892		
		SCIO3	0.730	0.886		
		SCIO4	0.754	0.881		
		SCIO5	0.797	0.871		

3. Environmental Uncertainty Reliability Test

The environmental uncertainty variable contains a total of 8 measurement items, which are divided into two dimensions. The Cronbach's α coefficients of each dimension are 0.887 and 0.914, respectively, and the overall Cronbach's α coefficients of the variables are 0.922, all of which are higher than the critical value of 0.7. The CITC values of the 8 measurement items are distributed between 0.712 and 0.860, all of which are higher than the critical value of 0.4, and the Cronbach's α coefficients after deleting any one item have not been improved, which indicates that the reliability of the environmental uncertainty measurement scale is high. The specific reliability indicators of environmental uncertainty are shown in Table 3.13:

Table3- 3Reliability Analysis of Environmental Uncertainty in Formal Research

Variable	Dimension	Measurement	CITC	The α -value after deleting	Dimension α Value	of
Environmental uncertainty	Environmental Dynamics	END1	0.790	0.840		
		END2	0.733	0.863		
		END3	0.782	0.844	0.887	
		END4	0.712	0.870		0.922
	Environmental hostility	ENH1	0.826	0.880		
		ENH2	0.764	0.901		
		ENH3	0.764	0.901	0.914	
		ENH4	0.860	0.867		

4. Enterprise competitive advantage reliability test

The enterprise competitive advantage variable contains a total of 13 measurement items, which are divided into three dimensions. The Cronbach's α coefficients of each dimension are 0.906, 0.816, and 0.866 respectively, and the overall Cronbach's α coefficient of the variable is 0.845, all of which are higher than the critical value of 0.7. The CITC values of the 13 measurement items are distributed between 0.593-0.823, all of which are higher than the critical value of 0.4, and the Cronbach's α coefficient after deleting any one item has not been improved, which indicates that the reliability of the enterprise competitive advantage measurement scale is high. The specific reliability indicators of enterprise competitive advantage are shown in Table 3.14:

Table3- 4 Reliability Analysis of Competitive Advantage of Formal Research Enterprises

Variable	Dimension	Measurement	CITC	The α -value after deleting	Dimension α	Value of variable α
Enterprise competitive advantage	Economic benefits Competitive advantage	ECCA1	0.823	0.873	0.906	0.845
		ECCA2	0.736	0.891		
		ECCA3	0.723	0.894		
		ECCA4	0.812	0.875		
		ECCA5	0.735	0.892		
	Environmental Benefits Competitive Advantage	EBCA1	0.603	0.785	0.816	
		EBCA2	0.695	0.740		
		EBCA3	0.660	0.758		
		EBCA4	0.593	0.789		
	Social benefit Competitive advantage	SBCA1	0.722	0.828	0.866	
		SBCA2	0.734	0.821		
		SBCA3	0.705	0.833		
		SBCA4	0.709	0.833		

Correlation analysis of variables

Validity tests focus on evaluating the validity of the questionnaire, that is, the extent to which the scale can measure variables. In this study, KMO values and Bartlett sphere tests were performed on each variable data using SPSS26.0 software. The results are shown in Table 3.15:

Table3- 5Factor analysis of various variables in formal research

Variable	KMO value.	Bartlett's spherical test		Precipitation factor	Cumulative
		Approximate	Significance level		
Supply chain digital	0.927	1064.242	0.000	1	62.669%
Supply chain dynamic	0.852	1878.781	0.000	3	69.367%
Environmental uncertainty	0.914	1698.747	0.000	2	77.267%
Enterprise competitive	0.861	1956.873	0.000	3	69.975%

It can be seen from Table 3.15 that the KMO of all variables is close to 1, the significance level of the Bartlett sphere test is less than 0.01, and the results are significant. Therefore, the

relevance of factor analysis of each variable is good. In factor analysis, this study uses principal component analysis to extract factors with eigenvalues greater than 1, and uses the maximum variance method to rotate. The analysis results show that the digital transformation of the supply chain can precipitate 1 common factor, the dynamic capability of the supply chain can precipitate 3 common factors, the environmental uncertainty can precipitate 2 common factors, and the competitive advantage of enterprises can precipitate 3 common factors. From the perspective of cumulative explanation variance, the cumulative explanation variance of supply chain digital transformation is 62.669%, the cumulative explanation variance of supply chain dynamic capability is 69.367%, the cumulative explanation variance of environmental uncertainty is 77.267%, and the cumulative explanation variance of enterprise competitive advantage is 69.975%. From the above analysis results, it can be seen that each common factor has a high ability to explain the variance of the original scale items, which preliminarily proves that the scale formally investigated in this study has good validity. On this basis, this chapter uses AMOS25.0 software to conduct confirmatory factor analysis on the data collected by the formal survey to accurately test the relationship between each latent variable and the index. On the one hand, confirmatory factor analysis can test the aggregate validity of the scale based on various fitting indicators, and on the other hand, confirmatory factor analysis measures the discriminative validity and intrinsic quality level of the scale by calculating the average variance extraction AVE value and the combined reliability CR value. Referring to the research of Fornell & Larcker (1981), the AVE value needs to be greater than 0.5, and the CR value needs to be greater than 0.7. Currently, the scale has good aggregation validity. When the square root of the AVE value of all variables is greater than the correlation coefficient with other variables, the scale has good discriminative validity. In this study, the factor loads of each variable were calculated by maximum likelihood estimation, and chi-square/degree of freedom x2/df, goodness of fit index GFI, comparative fit index CFI, canonical fit index NFI, Tucker-Lewis index TLI, adjusted fit index AGFI, normalized root mean square residual SRMR, estimation error square root RMSEA and other fitting indicators were used to evaluate the aggregate validity of the scale. According to the research of Wu, M,L(2009), this study sorted out the evaluation criteria of the above fitting indicators, as shown in Table 3.16:

Table3- 6Evaluation criteria for each fitting index

Fitting index	Evaluation Criteria
χ2/df	Between 1-3, the closer to 1 the better
GFI	> 0.8, the closer to 1 the better
CFI	> 0.8, the closer to 1 the better
NFI	> 0.8, the closer to 1 the better
TLI	> 0.8, the closer to 1 the better
AGFI	> 0.8, the closer to 1 the better
SRMR	< 0.05, the closer to 0 the better
RMSEA	< 0.08 acceptable, < 0.05 fits well, the closer to 0 the better

1. Validity test of supply chain digital transformation

The validity index values of supply chain digital transformation are shown in Table 3.17. It can be seen from the table that the factor load distribution range of the eight items of supply chain digital transformation is 0.696-0.807, all of which are greater than 0.7, indicating that each item is effectively converged on the variable. The variable CR value is 0.901, which is greater than the critical value of 0.7, and the AVE value is 0.565, which is greater than the critical value of 0.5. The above results show that the aggregate validity of the supply chain digital transformation variable in this study is effective.

Table3- 7Validity analysis of formal supply chain digital transformation

Variable	Measurement item	Factor load	CR	AVE	Fitting index
Digital transformation of supply chain	SCDT1	0.807			χ2/df=1.152
	SCDT2	0.767			GFI=0.984
	SCDT3	0.739			CFI=0.998
	SCDT4	0.735			NFI=0.985
	SCDT5	0.763	0.901	0.565	TLI=0.997
	SCDT6	0.696			AGFI=0.969
	SCDT7	0.751			SRMR=0.019
	SCDT8	0.725			RMSE=0.023

2. Validity test of supply chain dynamic capabilities

The validity index values of supply chain dynamic capabilities are shown in Table 3.18:

Table3- 8Validity Analysis of Formal Research Supply Chain Dynamic Capability

Variable	Dimension	Measurement	Factor load	CR	AVE	Fitting index
Supply chain dynamic capabilities	Supply chain learning and absorptive	SCLA1	0.764			
		SCLA2	0.723			
		SCLA3	0.551	0.801	0.507	χ2/df
		SCLA4	0.785			=0.975
	Supply Chain Innovation Capability	SCIN1	0.827			GFI=0.970
		SCIN2	0.781	0.871	0.629	CFI=0.992
		SCIN3	0.786			NFI=0.968
		SCIN4	0.777			TLI=0.991
	Supply chain integration and optimization capabilities	SCIO1	0.862			AGFI=0.957
		SCIO2	0.738			SRMR=0.037
		SCIO3	0.772	0.903	0.651	RMSE=0.013
		SCIO4	0.802			
		SCIO5	0.852			

As can be seen from Table 3.18, the factor load distribution range of the 13 items of supply chain dynamic capability is 0.551-0.862, All are greater than 0.7, indicating that each item is effectively converged in each dimension. The CR values of supply chain learning and absorption capacity, supply chain innovation capacity, and supply chain integration and optimization capacity are 0.801, 0.971, and 0.903, respectively, all greater than the critical value of 0.7, and the AVE values are 0.507, 0.629, and 0.651, respectively, all greater than the critical value of 0.5. The above results show that the aggregation validity of the three dimensions of supply chain dynamic capability in this study is valid.

3. Validity test of environmental uncertainty

The validity index values of environmental uncertainty are shown in Table 3.19. It can be seen from the table that the factor load distribution range of the eight items of environmental uncertainty is 0.767-0.924, all greater than 0.7, indicating that each item is effectively converged in each dimension. The CR values of environmental dynamics and environmental hostility are 0.888 and 0.914, respectively, both greater than the critical value of 0.7, and the AVE values are 0.665 and 0.728, respectively, both greater than the critical value of 0.5. The above results show that the aggregation validity of the two dimensions of environmental uncertainty in this study is effective.

Table3- 9 Validity Analysis of Environmental Uncertainty in Formal Research

Variable	Dimension	Measurement	Factor load	CR	AVE	Fitting index
Environmental uncertainty	Environmental Dynamics	END1	0.843	0.888	0.665	χ2/df=1.296
		END2	0.790			GFI=0.981

		END3	0.859			CFI=0.997
		END4	0.767			NFI=0.985
	Environmental hostility	ENH1	0.870	0.914	0.728	TLI=0.995
		ENH2	0.803			AGFI=0.963
		ENH3	0.810			SRMR=0.023
		ENH4	0.924			RMSE=0.031

4. Validity test of enterprise competitive advantage

The validity index values of enterprise competitive advantage are shown in Table 3.20. The factor load distribution range of the 13 items of enterprise competitive advantage is 0.665-0.880, all greater than 0.7, indicating that each item is effectively converged in each dimension. The CR values of economic benefit competitive advantage, environmental benefit competitive advantage, and social benefit competitive advantage are 0.907, 0.818, and 0.867, respectively, all greater than the critical value of 0.7, and the AVE values are 0.662, 0.530, and 0.620, respectively, all greater than the critical value of 0.5. The above results show that the aggregation validity of the three dimensions of enterprise competitive advantage in this study is effective.

Table3- 10Validity Analysis of Competitive Advantage of Formal Research Enterprises

Variable	Dimension	Measurement	Factor load	CR	AVE	Fitting index
Enterprise competitive advantage	Economic benefits Competitive advantage	ECCA1	0.880	0.907	0.662	
		ECCA2	0.772			
		ECCA3	0.761			$\chi 2/df$
		ECCA4	0.871			=1.122
		ECCA5	0.776			GFI=0.972
	Environmental Benefits Competitive Advantage	EBCA1	0.674	0.818	0.530	CFI=0.993
		EBCA2	0.802			NFI=0.971
		EBCA3	0.761			TLI=0.993
		EBCA4	0.665			AGFI=0.960
	Social benefit Competitive advantage	SBCA1	0.791	0.867	0.620	SRMR=0.027
		SBCA2	0.813			RMSE=0.017
		SBCA3	0.767			
		SBCA4	0.777			

Findings

Demographic Profile

Table4- 1 Characteristics of formal survey samples (N = 368)

Basic Features	classification	frequency	ratio	classification	frequency	ratio
Business location	Guangdong	113	30.71%	Zhejiang	38	10.32%
	Beijing	39	10.61%	Hubei	34	9.22%
	Shanghai	39	10.61%	Hunan	33	8.96%
	Shaanxi	33	8.96%	Shandong	39	10.61%
Enterprise age	<10 years	56	16.2%	15-20 years	125	35.0%
	10-15 years	120	32.6%	>20 years	67	18.2%
Number of employees in the enterprise	<300	95	26.8%	2000-5000	65	17.7%
	300-2000	178	48.4%	>5000	30	8.2%
Nature of business Main market	State-owned enterprise	71	19.3%	Joint venture	108	29.3%
	Private enterprise	125	35.0%	Wholly foreign-owned	64	17.4%

	International market	73	19.8%	National and international	81	22.0%
	Domestic market	214	58.2%			

Note: N is the number of samples

Table4- 2 Linear regression of supply chain digital transformation to enterprise competitive advantage

Variable	Enterprise competitive advantage	
	Model 1-1	Model 1-2
Control variables		
Enterprise age	0.014	-0.005
Enterprise size	-0.006	0.069
Enterprise nature	0.072	0.021
Product main market	0.124	0.121
Independent variable		
Supply chain digital transformation		0.263**
R^2	0.014	0.189
Adjusted R^2	0.011	0.174
F value	1.628	16.776**

Note: ** means significance level p < 0.01, * means significance level p < 0.05

Table4- 3 Linear regression of supply chain digital transformation to three dimensions of enterprise competitive advantage

	Economic benefits Competitive advantage	Environmental Benefits Competitive Advantage	Social benefit advantage	Competitive
Variable	Model 1-3	Model 1-4	Model 1-5	
Control variables				
Enterprise age	0.013	-0.004	-0.021	
Enterprise size	0.020	0.122*	0.019	
Enterprise nature	-0.053	0.082	0.042	
Product main market	0.053	0.069	0.133	
Independent variable				
Supply chain digital transformation	0.156**	0.215**	0.198**	
R^2	0.130	0.176	0.150	
Adjusted R^2	0. 114	0.161	0.134	
F value	6.778**	5.849**	5.799**	

Note: ** means significance level p < 0.01, * means significance level p < 0.05

Table4- 4 Linear regression of supply chain dynamic capability by supply chain digital transformation

Variable	Supply chain dynamic capabilities	
	Model 2-1	Model 2-2
Control variables		

Enterprise age	0.030	0.001
Enterprise size	0.095	0.090
Enterprise nature	0.066	0.028
Product main market	0.105	0.102
Independent variable		
Supply chain digital transformation		0.397**
R^2	0.024	0.179
Adjusted R^2	0.011	0.165
F value	1.794	12.79**

Note: ** means significance level p < 0.01, * means significance level p < 0.05

Table4- 5 Linear regression of supply chain digital transformation to three dimensions of supply chain dynamic capability

Variable	Supply chain learning and Model 2-3	Supply Chain Innovation Model 2-4	Supply chain integration and Model 2-5
Control variables			
Enterprise age	0.025	0.006	-0.021
Enterprise size	0.052	0.012	0.104
Enterprise	0.009	0.007	0.035
Product main market	0.129	0.066	0.022
Independent variable			
Supply chain digital	0.302**	0.323**	0.181**
R^2	0.113	0.110	0.096
Adjusted R^2	0.098	0.095	0.080
F value	7.498**	7.262**	6.842*

Note: ** means significance level p < 0.01, * means significance level p < 0.05

Table4- 6 Linear Regression of Supply Chain Dynamic Capability to Enterprise Competitive Advantage

Variable	Enterprise competitive advantage			
	Model 3-1	Model 3-2	Model 3-3	Model 3-4
Control variable				
Enterprise age	-0.001	-0.000	0.003	0.016
Enterprise size	0.024	0.055	0.066	0.037
Enterprise nature	0.013	0.035	0.033	0.029
Product main market	0.071	0.084	0.099	0.116
Independent variable				
Supply chain dynamic	0.505**			
Supply chain learning and		0.304**		
Supply Chain Innovation			0.357**	
Supply chain integration and				0.326**
R^2	0.270	0.112	0.148	0.126
Adjusted R^2	0.258	0.097	0.134	0.111
F value	21.782**	7.390**	10.246**	8.483**

Note: ** means significance level p < 0.01, * means significance level p < 0.05

Table4- 7 Multiple Regression of Three Dimensions of Supply Chain Dynamic Capability to Enterprise Economic Benefit Competitive Advantage

Variable	Enterprise economic benefits Competitive advantage		
	Model 3-5	Model 3-6	Model 3-7

Control variable			
Enterprise age	0.014	0.016	0.026
Enterprise size	0.009	0.017	0.003
Enterprise nature	-0.047	-0.049	-0.047
Product main market	0.026	0.035	0.051
Independent variable			
Supply chain learning and	0.220**		
Supply Chain Innovation		0.285**	
Supply chain integration and			0.174**
R^2	0.053	0.086	0.037
Adjusted R^2	0.042	0.070	0.021
F value	4.261**	6.530**	2.141*

Note: ** means significance level p < 0.01, * means significance level p < 0.05

Table4- 8Multiple Regression of Three Dimensions of Supply Chain Dynamic Capability to Enterprise Environmental Benefit Competitive Advantage

Variable .	Enterprise environmental benefits Competitive advantage		
	Model 3-8	Model 3-9	Model 3-10
Control variable			
Enterprise age	0.001	0.006	0.014
Enterprise size	0.001	0.122	0.091
Enterprise nature	0.094	0.095	0.086
Product main market	0.052	0.069	0.075
Independent variable			
Supply chain learning and	0.235**		
Supply Chain Innovation		0.198**	
Supply chain integration and			0.319**
R^2	0.085	0.071	0.135
Adjusted R^2	0.070	0.055	0.120
F value	6.458**	5.413**	8.876**

Note: ** means significance level p < 0.01, * means significance level p < 0.05

Table4- 9Summary of research hypopaper test results

No.	Hypothetical content	Result
H1	The digital transformation of the supply chain of manufacturing enterprises has a positive impact on the competitive advantage of enterprises;	support
H1a	The digital transformation of the supply chain of manufacturing enterprises has a positive impact on the competitive advantage of enterprises' economic benefits;	support
H1b	The digital transformation of the supply chain of manufacturing enterprises has a positive impact on the competitive advantage of enterprises' environmental benefits;	support
H1c	The digital transformation of the supply chain of manufacturing enterprises has a positive impact on the competitive advantage of enterprises' social benefits;	support
H2	The digital transformation of the supply chain of manufacturing enterprises has a positive impact on the dynamic capabilities of the supply chain;	support
H2a	The digital transformation of the supply chain of manufacturing enterprises has a positive impact on the learning and absorption capacity of the supply chain;	support
H2b	The digital transformation of the supply chain of manufacturing enterprises has a positive impact on the innovation capability of the supply chain;	support
H2c	The digital transformation of the supply chain of manufacturing enterprises has a positive impact on the integration and optimization capabilities of the supply chain.	support

H3	The supply chain dynamic capability of manufacturing enterprises has a positive impact on the competitive advantage of enterprises;	support
H3a	The supply chain learning and absorption capacity of manufacturing enterprises have a positive impact on the competitive advantage of enterprises;	support
H3aa	The supply chain learning and absorption capacity of manufacturing enterprises have a positive impact on the competitive advantage of economic benefits;	support
H3ab	The supply chain learning and absorption capacity of manufacturing enterprises have a positive impact on the competitive advantage of environmental benefits;	support
H3ac	The supply chain learning and absorption capacity of manufacturing enterprises have a positive impact on the competitive advantage of social benefits;	support
H3b	The supply chain innovation ability of manufacturing enterprises has a positive impact on the competitive advantage of enterprises;	support
H3ba	The supply chain innovation ability of manufacturing enterprises has a positive impact on the competitive advantage of economic benefits;	support
H3bb	The supply chain innovation ability of manufacturing enterprises has a positive impact on the competitive advantage of environmental benefits;	support
H3bc	The supply chain innovation ability of manufacturing enterprises has a positive impact on the competitive advantage of social benefits;	support
H3c	The supply chain integration and innovation ability of manufacturing enterprises have a positive impact on the competitive advantage of enterprises;	support
H3ca	The supply chain integration and optimization ability of manufacturing enterprises has a positive impact on the competitive advantage of economic benefits;	support
H3cb	The supply chain integration and optimization ability of manufacturing enterprises has a positive impact on the competitive advantage of environmental benefits;	support
H3cc	The supply chain integration and optimization ability of manufacturing enterprises has a positive impact on the competitive advantage of social benefits.	support
H4	The dynamic capability of the supply chain plays a mediating role in the relationship between digital transformation of the supply chain in manufacturing enterprises and their competitive advantage.	support
H41	The learning and absorption ability of the supply chain plays a mediating role in the relationship between digital transformation of the supply chain in manufacturing enterprises and their competitive advantage.	support
H42	The innovation capability of the supply chain plays a mediating role in the relationship between digital transformation of the supply chain in manufacturing enterprises and their competitive advantage.	support
H43	The capability of supply chain integration and optimization plays a mediating role in the relationship between digital transformation of the supply chain in manufacturing enterprises and their competitive	support
H5	Environmental uncertainty positively regulates the relationship between supply chain digital transformation and enterprise competitive advantage;	Not supported
H5a	Environmental dynamics positively regulates the relationship between supply chain digital transformation and enterprise competitive advantage;	Not supported
H5b	Environmental hostility positively regulates the relationship between supply chain digital transformation and enterprise competitive advantage;	Not supported
H6	Environmental uncertainty positively regulates the relationship between supply chain digital transformation and supply chain dynamic capabilities;	support
H6a	Environmental dynamics positively regulates the relationship between supply chain digital transformation and supply chain dynamic capabilities;	support
H6b	Environmental hostility positively regulates the relationship between supply chain digital transformation and supply chain dynamic capabilities;	support
H7	Environmental uncertainty positively regulates the relationship between supply chain dynamic capability and enterprise competitive advantage;	support
H7a	Environmental dynamics positively regulates the relationship between supply chain dynamic capabilities and enterprise competitive advantage;	support
H7b	Environmental hostility positively regulates the relationship between supply chain dynamic capabilities and enterprise competitive advantage;	support
H8	Environmental uncertainty has a positive moderating effect on the indirect relationship between supply chain digital transformation and enterprise competitive advantage through supply chain dynamic	support
H8a	Environmental dynamics has a positive regulating effect on the indirect relationship of supply chain digital transformation affecting the competitive advantage of enterprises through supply chain dynamic	support
H8b	Environmental hostility has a positive moderating effect on the indirect relationship between supply chain digital transformation and enterprise competitive advantage through supply chain dynamic	support

Reliability and Validity

Reliability analysis of the scale

In addition to Cronbach's α coefficient, this study also uses the Corrected Item Total Correlation Coefficient (CITC, Corrected Item Total Correlation) to judge the internal consistency between

a question item and the overall scale of its variables. If the CITC value of a question item is less than 0.4, and the Cronbach coefficient is significantly improved after deleting this question item, it is considered that there is a low internal consistency between this question item and the overall scale of structure, and this question item should be considered for deletion. This study uses SPSS 26.0 software to test the reliability of the pre-survey scale. The test results are shown in Table 3.7:

Table3- 11Reliability Analysis of Pre-survey Scale

Variable	Question item	CITC	The value of a after the item is	Cronbach's alpha coefficient
Supply chain digitization	SCDT1	0.797	0.883	
	SCDT2	0.764	0.887	
	SCDT3	0.728	0.891	
	SCDT4	0.596	0.905	0.906
Transforming SCDT	SCDT5	0.697	0.895	
	SCDT6	0.717	0.893	
	SCDT7	0.740	0.890	
	SCDT8	0.718	0.882	
Supply chain learning and absorptive capacity SCLA	SCLA1	0.667	0.747	
	SCLA2	0.674	0.744	
	SCLA3	0.427	0.814	0.802
	SCLA4	0.475	0.803	
	SCLA5	0.739	0.721	
Supply Chain Innovation Capability SCIN	SCIN1	0.722	0.843	
	SCIN2	0.720	0.844	0.875
	SCIN3	0.719	0.845	
	SCIN4	0.764	0.827	
Supply chain integration and optimization capabilities SCIO	SCIO1	0.750	0.878	
	SCIO2	0.689	0.891	
	SCIO3	0.745	0.880	0.900
	SCIO4	0.763	0.875	
	SCIO5	0.814	0.864	
Environmental Dynamics END	END1	0.805	0.877	
	END2	0.816	0.876	
	END3	0.790	0.885	0.911
	END4	0.774	0.889	
Environmental hostility ENH	ENH1	0.847	0.872	
	ENH2	0.740	0.909	0.913
	ENH3	0.766	0.901	
	ENH4	0.863	0.866	
Economic benefits Competitive advantage ECCA	ECCA1	0.805	0.872	
	ECCA2	0.742	0.886	
	ECCA3	0.733	0.888	0.903
	ECCA4	0.814	0.870	
	ECCA5	0.714	0.892	
Environmental Benefits Competitive Advantage EBCA	EBCA1	0.618	0.827	
	EBCA2	0.709	0.788	0.844
	EBCA3	0.768	0.761	
	EBCA4	0.627	0.824	
Social benefit Competitive advantage SBCA	SBCA1	0.728	0.831	
	SBCA2	0.764	0.815	0.869
	SBCA3	0.690	0.845	
	SBCA4	0.706	0.839	

Validity analysis of the scale

After the reliability test is passed, it is necessary to further test the validity of the scale. Validity test is to test the validity of the questionnaire, that is, to analyze whether the items of the scale are reasonable and whether the questionnaire data can truly reflect the research purpose. Validity is divided into three categories: content validity, criterion validity and structural validity. Content validity tests whether the items of the questionnaire meet the research purpose. Criterion validity refers to the degree of correlation between measurement results and criteria, and structural validity refers to the consistency between measurement results and theory. Since this study uses a tested maturity scale and has been reviewed by experts in the

field of supply chain management, this study will no longer test the content validity. Since the research on digital supply chain is still in its infancy, there is no authoritative research on related research. Scale data, this research scale is not suitable for criterion validity testing, so this study conducts structural validity testing on pre-survey measurement scales, and the field of management usually uses factor analysis to test structural validity. Before testing the validity, it is also necessary to test the simple correlation coefficient and partial correlation coefficient between the variables through the KMO value and the Bartlett spherical test to determine whether the scale is suitable for factor analysis. The range of KMO values is divided as shown in Table 3.8.

Table3- 12 Range division of KMO values

KMO value	Factor analysis relevance
>0.9	excellent
0.8-0.9	Good
0.7-0.8	Moderate
0.6-0.7	General
0.5-0.6	Unsatisfactory
<0.5	Unacceptable

The KMO value is between 0 and 1. As can be seen from Table 3.8, the closer the KMO value is to 1, indicating that the correlation between the items is stronger, and the questionnaire data is more suitable for factor analysis. The minimum requirement for KMO value is 0.6. The Bartlett spherical test takes the absence of correlation between variables as the null hypothesis. When the chi-square value of the Barlett spherical test is large and reaches the significance level ($P < 0.05$), the null hypothesis can be rejected, indicating that the variables are related, and the data can be used for factor analysis. The KMO values of the pre-survey scale and the results of the Bartlett spherical test are shown in Table 3.9:

Table3- 13KMO values and Bartlett spherical test for pre-survey scales

Kaiser-Meyer-Olkin Measure of Sampling Sufficiency	0.763
Bartlett Spherical Test, Approximate Chi Square	2853.842
df	861
Sig.	0.000

It can be seen from Table 3.9 that the approximate chi-square value of the Bartlett spherical test is 2853.842, the degrees of freedom are 861, and the significance level is $0.000 < 0.05$, indicating that the 43 items of the pre-survey scale have high correlation, and the KMO value is 0.763., the relevance of factor analysis is moderate, indicating that the pre-survey data is suitable for factor analysis.

Conclusion

China's "14th Five-Year Plan" and the outline of its long-term goals for 2035 list accelerating the digital transformation of the whole industry and the whole society as one of the key strategies, and strive to seize the opportunity when the wave of the fourth industrial revolution is approaching, and comprehensively promote the digital transformation at the enterprise level, industry level, and social level. As a pillar industry of China's national economy, manufacturing should become the main battlefield of digital transformation. Many scholars have proposed that the key to the digital transformation of manufacturing enterprises lies in the digital transformation of the supply chain, but the mechanism of the digital transformation of the supply chain of manufacturing enterprises on the competitive advantage of enterprises

has not been effectively answered. Based on China's historical journey from a manufacturing power to a manufacturing power, this study aims to reveal the impact mechanism of supply chain digital transformation and supply chain dynamic capabilities on the competitive advantage of enterprises and the contingency factors played by environmental uncertainty. First of all, this study conducted an exploratory multi-case analysis of four manufacturing enterprises, so as to propose a preliminary theoretical model; then, on the basis of theoretical analysis, formally constructed including supply chain digital transformation, supply chain dynamic capabilities, environmental uncertainty and, Theoretical models of variables such as corporate competitive advantage, and put forward 37 research hypotheses; finally, a formal questionnaire was formed on the basis of expert review and pre-investigation. This study selected Chinese manufacturing enterprises as the research object and collected questionnaire data from middle and senior managers of enterprises or related employees, and conducted empirical tests. The results show that there are 34 items in total Assumption is supported.
Based on this, the main conclusions of this study are as follows:
1. The digital transformation of the supply chain of manufacturing enterprises has a positive impact on the competitive advantage of enterprises. Drawing on previous studies on the competitive advantage of enterprises, this study divides it into three dimensions: the competitive advantage of enterprises' economic benefits, the competitive advantage of enterprises' environmental benefits, and the competitive advantage of enterprises' social benefits. The results show that there is a significant positive relationship between the digital transformation of the supply chain of manufacturing enterprises and the competitive advantage of enterprises.
2. Supply chain dynamic capabilities play a complete intermediary role between supply chain digital transformation and enterprise competitive advantage. Supply chain digital transformation brings rich information to enterprises. The application of many digital technologies and the introduction of digital management methods have greatly improved the efficiency of enterprise information processing, enabling enterprises to fully understand the needs of customers from the upstream of the supply chain, suppliers all the way to the end point. Therefore, this study draws on the theory of dynamic capabilities and focuses on the role of supply chain dynamic capabilities, which focus on information, knowledge, experience sharing, innovation and resource integration, in the relationship between supply chain digital transformation and enterprise competitive advantage.The research results show that digital transformation of supply chain positively affects the three dimensions of supply chain dynamic capability, including supply chain learning and absorption capability, supply chain innovation capability and supply chain integration and optimization capability; supply chain dynamic capability and its three dimensions all positively affect the competitive advantage of enterprises; supply chain learning and absorption capability, supply chain innovation capability and supply chain integration and optimisation capability each play a partly mediating role in the relationship between digital transformation of supply chain and the competitive advantage of enterprises, and together they constitute the supply chain dynamic capability playing a fully mediating role.
3. Environmental uncertainty plays an important contingency role in the model of this study: environmental uncertainty positively regulates the impact of supply chain digital transformation on supply chain dynamic capabilities, environmental uncertainty positively regulates supply chain dynamic capabilities on enterprises The impact of competitive advantage, environmental uncertainty positively regulates the mediating effect of supply chain dynamic capabilities. Environment and uncertainty affect the competition and market environment faced by enterprises. Therefore, starting from contingency theory, this study discusses the relationship between environment and uncertainty on supply chain digital transformation and supply chain dynamic capabilities, supply chain dynamic capabilities and

enterprises. The influence of competitive advantage relationship and the mediating effect of supply chain dynamic capabilities. The research results show that environmental uncertainty and its two dimensions, environmental dynamics and environmental hostility, positively regulate the relationship between supply chain digital transformation and supply chain dynamic capabilities, supply chain dynamic capabilities and enterprise competitive advantages. At the same time, environmental uncertainty and its two dimensions also play a moderating role in the entire process of supply chain digital transformation affecting the competitive advantage of enterprises through supply chain dynamic capabilities, that is, when the environmental uncertainty is high (or environmental dynamics), environmental hostility is high), with a high degree of supply chain digital transformation, manufacturing enterprises are more likely to enhance their competitive advantages through supply chain dynamic capabilities.

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