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공급망의 디지털 전환이 중국 자동차 제조기업의 환경성과에 미치는 영향 요인에 관한 연구

채옥결*, 심재연**
중국 광서재경학원 회계사*, 세한대학교 경영학과 교수**

A Study on the Factors that Influence the Digital Transformation of the Supply Chain on the Enterprise Environmental Performance of Chinese Automobile Manufacturers

Yujie Cai*, Jae yeon Sim**

Accountant ,Procurement Department, Guangxi University of Finance and Economics, China*
Professor, Dept. Of Management, Sehan University, Korea**

요 약 자동차 제조업은 에너지 소비가 많고, 오염물질을 많이 배출하는 전통적인 제조업으로 공급망의 디지털 전환을 통해 환경성과를 향상시킬 필요가 있다. 본 연구에서는 공급망의 디지털전환, 공급망 동적 역량 및 기업 환경성과를 바탕으로 13개의 가설을 제시하였다. 중국 7개 지역 자동차 제조기업의 경영자 및 종업원을 대상으로 설문조사를 실시한 결과 공급망의 디지털 전환이 공급망 동적 역량의 영향을 받아, 자동차 제조기업의 환경성과를 향상시키는 데에 영향이 있는 것으로 나타났다.

주제어 자동차제조업, 전통제조업, 공급망디지털전환, 기업환경성과, 공급망동적역량

Abstract Automotive manufacturing is a traditional manufacturing industry that consumes a lot of energy and emits a lot of pollutants, and needs to improve environmental performance through digital transformation of supply chains.In this study, 13 hypotheses were put forward based on supply chain digital transformation, supply chain dynamic capability and enterprise environmental performance. The results of the questionnaire survey on the managers and employees of automobile manufacturing enterprises in 7 regions of China show that the digital transformation of supply chain can help improve the environmental performance of automobile manufacturing enterprises under the influence of supply chain dynamic capability

Key Words Automotive manufacturing industry; Traditional manufacturing industry; Supply chain digital transformation; Enterprise environmental performance; Supply chain dynamic capabilities

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Corresponding Author: Jae yeon Sim
(Sehan University)
Email: simjy@sehan.ac.kr
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1. Introduction

1.1 Research Background

With the continuous deterioration of the ecological environment, human beings are extremely concerned about the survival of society[1]. The application of digital technology holds the promise of becoming a significant lever for supply chain digital transformation and environmental performance improvement in the automotive manufacturing industry[2].The entire process of automotive manufacturing generates data from different times, locations, and equipment, which is complex and diverse. Analyzing and utilizing this data are crucial means for the digital transformation of traditional manufacturing towards intelligent manufacturing[3]. Currently, there is abundant research on the factors influencing corporate environmental performance. However, studies from the perspective of the supply chain are still relatively limited[4].Carbon footprints may arise at every stage of the supply chain, hence it is necessary to implement carbon reduction targets across each supply chain entity, concentrating decision-making, and coordinating optimization throughout the supply chain[5]. Dynamic capability refers to the ability of an enterprise to establish, integrate, and reconfigure internal and external resources, enabling effective responses to rapidly changing environments[6]. The rapid progress of global economic integration and advancements in information technology have prompted enterprises to continuously transcend organizational boundaries, actively seeking collaboration with upstream and downstream companies in the supply chain to enhance performance[7]. At the same time, the dynamism and uncertainty of the external environment have spurred enterprises' desire for dynamic capabilities[8]. Automotive manufacturing enterprises leverage digital information technology to integrate critical data from upstream and downstream companies, thereby driving supply chain digital transformation. Dubey et al.analyzed the impact of big data analytics on environmental performance[9].Kamble et al. analyzed the impact of various Industry 4.0 technologies, such as big data analytics and the Internet of Things, under green supply chain management on sustainable performance[10].Belhadi et al.found that companies with strong capabilities in big data analytics can achieve better sustainable performance[11]. Digital transformation combines digital technology with environmental management to enable companies to better fulfill their environmental responsibilities [12]. Chen et al. [13] show that the improvement of information technology capabilities can significantly improve the environmental performance of enterprises.

1.2 Research Objectives

Currently, there is limited scholarly attention to how the automotive manufacturing industry utilizes digital technology to achieve supply chain digital transformation, particularly concerning environmental performance. This study aimsto explore the mechanisms through which supply chain digital transformation and dynamic capabilities influence enterprise environmental performance based on theories such as supply chain dynamic capabilities, resource-based theory.

2. Theoretical Background

2.1 Supply Chain Management Theory

The concept of supply chain management emerged with the transition from "vertical integration" to "horizontal integration" management models, and its earliest research can be traced back to Drucker's "economic chain" and then to Porter's "value chain."Harrison (1999) [14] defines the supply chain as a functional network that involves the procurement of raw materials, their transformation into intermediate products/final products, and their ultimate sale to consumers. Ogden et al. (2005) [15] define the supply chain as all activities related to processes and goods transportation. Zhuang et al.(2010) [16]emphasize the value of the supply chain in closely coordinating various nodes and seamlessly connecting various processes. Maet al.(2022) [17] illustrate the supply chain as a functional network structure that integrates suppliers, manufacturers, distributors, retailers, and ultimately end-users through the control of information flow, logistics, and capital flow. Chen (2012) [18] suggests that the goal of supply chain management is to maximize the net present value of supply chain cooperation profits. For instance, Walton et al. (1998) [19]argue that conducting eco-design in supply chain management can generate significant ecological and economic benefits. Liu et al. (2023) [20] indicate that research has extended green technology innovation to the field of supply chain management, leading to a focus on green supply chain management. As a data and information-driven supply chain management model, digital supply chains, as researched by Lopez-Morales et al.(2023)[21], embed digitalization in three aspects: digital technology, digital foundation, and digital culture, which contributes to enhancing supply chain competitiveness.

2.2 Resource-Based Theory

In 1959, Penrose identified the importance of organizational resources to the success of anenterprise, and then Wernerfelt (1984) [22]pointed out that internal factors, namely resources and capabilities of a company, really determine the profits of a company. Resources can be divided into value dimension, rare dimension and imitative dimension. First, the value dimension of resources enables firms to increase net revenues and reduce net costs (Barney & Arikan, 2001) [23], helping firms capitalize on opportunities and minimize threats (Barney & Hesterly, 2012) [24]. Secondly, the rarity dimension refers to the fact that resources are owned by a few firms to achieve competitive advantage. Third, the imitative dimension indicates that firms cannot directly copy or replace these resources because imitation is expensive. Barney[25] explanation of corporate competitiveness is expanded. The resource-based theory holds that the different competitive advantages of enterprises come from the differences of the resources they own. Each link in the supply chain enterprises have their own advantages of resources, including some exclusive resources. These resources can be physical resources such as raw materials and products, or non-physical resources such as capital, information, manpower and technology. Moreover, these resources are complementary to each other and are the driving factors for enterprises to cooperate in the supply chain[26].The source of different core competence of enterprises is the different allocation of accessible resources.

2.3 Dynamic Capability Theory

Dynamic capability theory was developed in the changing market environment of the 1990s, where high environmental uncertainty, market volatility, and frequently changing conditions raised questions about the rate at which business capabilities eroded and ceased to provide competitive gains. Dynamic capability refers to the ability of an enterprise to integrate, build and transform internal and external capabilities to cope with a rapidly changing environment (Teece et al., 1994) [27]. Teece (2014) [28] proposed the concept of DC based on three main dimensions: perception capability, that is, the ability of a specific organization to identify and evaluate technological opportunities that meet customer needs and business opportunities; The ability of the organization to mobilize the resources needed to meet identified customer needs and business opportunities and thus capture the resulting business value: This includes all activities that "restructure resources and capabilities" to "innovate and respond to changes in the more general market and business environment." Wilhelm et al. (2015) [29] also elaborated the three dimensions of DC (perception ability, learning ability and reconfiguration ability). Enterprises supported by strong data analysis capabilities are more likely to participate in both agile and adaptive supply chains, thereby gaining a competitive advantage and improving corporate environmental performance. Liu Hua et al.divided supply chain dynamics into environmental awareness and adaptation, learning and innovation, and resources.Integration and reconstruction capabilities, relationships and coordination capabilities[30].

3. Research Method

3.1 Research Object

In this study, 412 questionnaires were collected from managers of automobile manufacturing enterprises in 7 regions of China,focuses on the specific impact of supply chain digital transformation on enterprise environmental performance, and further explores the mediating role of supply chain dynamic capability [31].The key information providers of this study are the senior, middle and grass-roots managers of automobile manufacturing enterprises. They have a clear understanding of the actual operation and future development trend of the supply chain, can accurately grasp the benefit improvement brought by the improvement of the supply chain technology to the enterprise, and give effective suggestions. Questionnaires are conducted through wechatand Wenxing.

3.2 Research Models

This study is based on previous studies on supply chain digital transformation, dynamic capability, environmental performance and other variables [32], and establishes a research model based on supply chain management theory and dynamic capability theory, as shown in Figure 1.

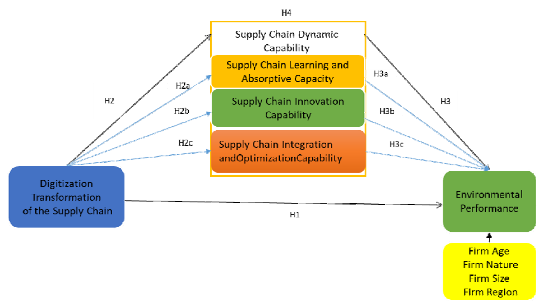

Fig. 1. Research model diagram

3.3 Research Design

3.3.1 Operational Definition of Variables

(1) Explanation of variables

Supply chain digital transformation (SCDT) refers to the optimization and upgrading of traditional supply chains through the Internet, Internet of Things, big data, artificial intelligence and other technologies to improve supply chain efficiency and flexibility.This study uses Nasiri et al.'s scale to measure supply chain digital transformation by designing 10 topics from three dimensions: core enterprise digital transformation, supply chain digital platform construction and empowerment of suppliers.

(2) Intermediary variables

Supply chain dynamic capability (SCDC) is a composite capability to configure, integrate and optimize supply chain resources to adapt to the external environment, effectively manage supply chain networks and resources.In this study, Huo et al., Najar, Duong et al. designed 13 questions to measure supply chain dynamics from three dimensions: supply chain learning and absorption, supply chain innovation, supply chain integration and optimization.

(3) Explained variables

Enterprise Environmental Performance (EP) refers to the achievements and effects of enterprise management activities on environmental protection and environmental pollution control. Using a scale developed by Singh et al., 12 questions were designed to measure corporate environmental performance from three dimensions: waste discharge, resource utilization and ecological conservation management.

(4) Control of variables

This study chose Firm Age, Firm Nature, Firm Size and Firm Region as the control variables, but they affect supply chain dynamics and environmental performance. Therefore, this study strives to strip these variables and control their possible effects on regression results.

3.3.2 Research Hypotheses

(1) Supply Chain Digital Transformation and Environmental Performance

With human attention to environmental issues, the future development of automobile manufacturing enterprises needs to add environmental efficiency indicators to their business goals. Wu et al. propose that supply chain digitization can reduce non-essential human involvement by using "machine replacement." Xu Xiangyun and Li Jinxiu believe that the introduction of digital technologies such as the industrial Internet in supply chain management will reduce enterprises' carbon emissions. Faisal et al. found that digital transformation of enterprise supply chains has a long-term impact on reducing carbon intensity. Faruquee et al. pointed out that through digital transformation of the supply chain, enterprises can achieve real-time monitoring of the ecological environment in the production process, thus effectively controlling the source of pollution and reducing pollutant emissions. Therefore, the following assumptions are made:

H1: Digital transformation of enterprise supply chain has a positive impact on enterprise environmental performance.

(2) Supply Chain Digital Transformation and Supply Chain Dynamics Capabilities

Supply chain dynamic capabilities of manufacturing enterprises change with the continuous integration of digital technology and supply chain management. This study divides supply chain dynamic capability into three dimensions: supply chain learning and absorption capability, supply chain innovation capability, supply chain integration and optimization capability. Chen believes that the digital transformation of the supply chain has led to the convergence of enterprises and industries, access to more information in the industry, and improve their supply chain ecosystem through continuous learning. According to Hanelt and others, digital transformation can combine integration and innovation, emphasizing that digital transformation can not only change the way things are made, but also introduce novelty into strategy and supply chain operations. Jangga et al. found that in the complex and volatile market environment, enterprises need to introduce new digital technologies to adapt to changing market needs, and the application of digital technology can enhance the flexibility, flexibility and responsiveness of enterprise supply chain. Kollmann et al. believe that enterprises respond to the complexity and flexibility of the external environment through digital transformation, and enhance the ability of business integration and optimization to adapt quickly to external changes. Qi and Xiao Xu believe that digital transformation enhances the ability to integrate and optimize internal and external business processes. Digital technologies can help companies reshape supply chains and improve their environmental performance. Therefore, the following assumptions are made:

H2: The digital transformation of the enterprise supply chain has a positive impact on the dynamic capabilities of the supply chain;

H2a: Digital transformation of enterprise supply chain has a positive impact on supply chain learning and absorption capabilities;

H2b: Digital transformation of enterprise supply chain has a positive impact on supply chain innovation capabilities;

H2c: Digital transformation of enterprise supply chains has a positive impact on supply chain integration and optimization capabilities.

(3) Supply Chain Dynamics and Environmental Performance

Silvestre et al. believe that supply chain learning and absorption capabilities ensure that companies are actively engaged in managing specific social issues such as improving the environment, reducing emissions throughout the supply chain, and developing communities.Hunt found that supply chain innovation can enable companies to use scarce or non-renewable resources, promote green production, and deliver effective product-aware value to environmentally conscious consumers, thereby improving their environmental performance.Sinayi et al. believe that supply chain innovation capabilities help meet consumer demand for green products and play an important role in increasing profits throughout the supply chain.Zhen et al. believe that supply chain digital transformation ensures the transformation and integration of digital technology resources, and makes full use of the mechanisms of digital technology resources.Therefore, the following assumptions are made:

H3: The dynamic capabilities of an enterprise's supply chain have a positive impact on its environmental performance.

H3a: Supply chain learning and absorption capabilities have a positive impact on environmental performance.

H3b: Supply chain innovation has a positive impact on environmental performance.

H3c: Supply chain integration and optimization capabilities have a positive impact on environmental performance.

Onthe basis of H2 and H3, make H4.

H4: Supply chain dynamic capability plays a mediating role between supply chain digital transformation and enterprise environmental performance.

H4a: Supply chain learning and absorption capabilities play an intermediary role between supply chain digital transformation and enterprise environmental performance. ;

H4b:An organization's supply chain innovation capabilities act as an intermediary between supply chain digital transformation and corporate environmental performance. ;

H4c: Supply chain integration and optimization capabilities play an intermediary role between supply chain digital transformation and enterprise environmental performance.

3.4 Data Sources

This study primarily relies on questionnaire surveys conducted through platforms such as Questionnaire Star, WeChat, and email to collect data from enterprises in the Chinese automobile manufacturing industry. The survey targets top managers (such as general managers, department managers, product managers, etc.), employees, suppliers, and customersof automobile manufacturing enterprises involved in supply chain digital transformation.In January 2024, 412 questionnaires were distributed to 7 regions of China's automobile manufacturing enterprises. All potential defects have been examined, including insufficient information and overly random or extreme selection methods.The sample data collected through the questionnaire is deemed sufficient for this study's needs. Linear regression analysis will be employed to deeply analyze the characteristics, trends, and relationships among variables of the research subjects. The collected data will be processed and hypothesis testing will be conducted using SPSS 26.0 software.

4. Research Results

4.1 Sample Characteristics

In January 2024, 412 questionnaires were collected from managers, employees, suppliers, and customers of automobile manufacturing enterprises in 7 regions of China. The number of valid questionnaires collected in this study meets both measurement criteria requirements. Currently, China's manufacturing industry has matured, and the supply chain systems related to the manufacturing industry are well-established. Many enterprises have begun seeking the path of digital transformation, introducing advanced digital technologies and management concepts. This favorable research condition has enabled most enterprises to seek transformation related to digitization, providing favorable conditions for this study.

4.2 Reliability Analysis

Reliability analysis is used to study the reliability and accuracy of quantitative data, especially attitude scale questions. Firstly, analyze the α coefficient. If this value is higher than 0.8, it indicates high reliability; if it falls between 0.7 and 0.8, it suggests good reliability; if it ranges from 0.6 to 0.7, the reliability is acceptable; if it is less than 0.6, the reliability is considered poor. Secondly, if the CITC value is lower than 0.3, consider deleting the item. Thirdly, if the "α coefficient after item deletion" is significantly higher than the original α coefficient, consider deleting the item and reanalyzing.

The variable of supply chain digital transformation consists of 10 measurement items, with a Cronbach's α coefficient of 0.962, which is higher than the critical value of 0.7. The corrected item-total correlation (CITC) values of the 10 measurement items range from 0.759 to 0.866, all higher than the critical value of 0.4. Deleting any item does not improve the Cronbach's α coefficient, indicating high reliability of the measurement scale for supply chain digital transformation.

The variable of supply chain dynamic capabilities consists of 13 measurement items, divided into three dimensions. The Cronbach's α coefficients for each dimension are 0.901, 0.948, and 0.948, respectively, with an overall Cronbach's α coefficient of 0.977, exceeding 0.9, indicating high reliability of the research data. The CITC values of the 13 measurement items range from 0.762 to 0.919, all higher than the critical value of 0.4. Deleting any item does not significantly improve the Cronbach's α coefficient, indicating good correlation among the analyzed items and high reliability of the measurement scale for supply chain dynamic capabilities.

The variable of enterprise environmental performance consists of 3 measurement items, with a reliability coefficient of 0.930, exceeding 0.9, indicating high reliability of the research data. For the "α coefficient after item deletion," deleting any item does not result in a significant increase in the reliability coefficient, indicating that the items should not be deleted. Regarding CITC values, the CITC values of the analyzed items are all greater than 0.4, indicating good correlation among the items and good reliability level. In summary, the reliability coefficient value of the research data is higher than 0.9, which indicates that the data reliability quality is high and can be used for further analysis. The specific reliability indicators of supply chain digital transformation, supply chain dynamic capability and enterprise environmental performance are shown in Table 1.

Table 1 Reliability Analysis of Variables related to Supply Chain Digital Transformation

Measure the Item	CITC Scope	Range of α values after deletion	Cronbach's α Coefficient
Digital transformation of the supply chain	0.759-0.866	0.958-0.962	0.962
Supply chain dynamic capabilities	0.762-0.919	0.836-0.976	0.977
Enterprise environmental performance	0.810-0.870	0.897-0.917	0.930

4.3. Validity Analysis

Validity analysis is used to study the design rationality of quantitative data (especially the attitude scale): firstly analyze KMO value; if the value is above 0.8, the study data is very suitable for extraction information (from the side reaction validity is good); if the value is less than 0.6, the data is not suitable for extraction information (from the side reaction validity is generally) (if only two questions; KMO is 0.5); secondly, then analyze the correspondence relationship between items and factors; if the correspondence relationship is basically consistent with the research.

According to Table 2, the KMO for all variables was close to 1, and the significance level of the Bartlett sphere test was less than 0.01, with significant results. Therefore, the fitness of each variable factor analysis is better. From the perspective of cumulative explained variance, the cumulative explained variance of supply chain digital transformation is 75.303%, the cumulative explained variance of supply chain dynamic capacity is 85.355%, and the cumulative explained variance of enterprise environmental performance is 86.219%. From variance, the cumulative explained variance of supply chain digital transformation is 75.303%, the cumulative explained variance of supply chain dynamic capacity is 85.355%, and the cumulative explained variance of enterprise environmental performance is 86.219%. From variable supply chain on the basis of model 1-1, which passed the F test. According to the models 1-2, Control variables and the digital transformation of the supply psychological expectation, the validity is good;Third: if the validity is poor; or the corresponding relationship between the factor and the question item is seriously inconsistent with the expected, or the common degree value of an analysis item is lower than 0.4 (sometimes 0.5 as the standard); delete the question item; the fourth item has a common standard; the common degree value is lower than 0.4 (sometimes 0.5 as the standard); second, the serious deviation in the corresponding relationship between the analysis item and the factor. The validity tests of the study variables for this project are shown in Table 2.

Chain can explain 61.8% of the change in enterprise environmental performance, The F test found that the model passed the F test (F=30.462, p=0.000<0.05), That is, to explain the control variables, At least one of the digital transformation of the supply chain will affect the enterprise's environmental performance, in addition, Testing against the multiple collinearity of the model found that, All of the VIF values in the model were less than 5, It means that there is no collinearity problem; Controlling variables from model

Table 2 KMO and Bartlett

Variable	KMO price	Approximate chi square	Significance level	The number of factors precipitated	Cumulative explained variance
Digital transformation of the supply chain	0.933	1002.465	0.000	1	75.303%
Supply chain dynamic capabilities	0.929	1622.318	0.000	3	85.355%
Enterprise environmental performance	0.753	217.504	0.000	1	86.219%

1−1 do not affect enterprise environmental performance. The regression coefficient value of the digital transformation of supply chain is 0.830 (t=11.952, p=0.000 〈0.01), indicating that the digital transformation of supply chain will have a significant positive impact on enterprise environmental performance, so assuming H1 is supported.

Table 3 Linear regression of supply chain digital transformation on enterprise environmental performance

Variable		Enterprise Environmental Performance	
		Model 1-1	Model 1-2
Controlled Variable	Enterprise Scale	-0.087	-0.072
	Enterprise Years	0.145	0.099
	Enterprise Nature	0.047	-0.060
	Enterprise Area	-0.027	-0.023
Independent Variable	Supply Chain Digital Transformation		0.830**
R^2		0.038	0.618
Adjusted R^2		-0.002	0.598
F-value		0.950	3.462**

**p<0.01 and *p<0.05, Standardized Coefficients

4.3.1 The mediation effect test of the supply chain dynamic capability

(1) The role test of the digital transformation of supply chain on the dynamic capacity of supply chain

The test of the relationship between supply chain digital transformation and supply chain dynamic capability is shown in Table 5. Model 2−1 reflects the regression analysis of control variables and supply chain dynamic capability, R2.5Is 0.015, meaning that the control variable can explain 1% of the change in the dynamic capacity of the supply chain. The F test of the model found that the model did not pass the F test (F=0.375, p=0.839〉 0.05), that is, it means that the control variable does not affect the dynamic ability of the supply chain, indicating that the control variables have no significant influence on the dynamic capacity of the supply chain.

Model 2−2 adds the digital transformation of variable supply chain on model 2−1, R2For0.813 means that the control variables and the digital transformation of the supply chain can explain 81.3% of the dynamic capacity of the supply chain. Model 2−2 through F test (F=81.940, p=0.000 〈0.05), shows that the control variables, supply chain digital transformation will affect D1, supply chain dynamic ability, control variables does not affect the dynamic ability of supply chain relationship, indicating that the supply chain digital transformation has a significant positive impact on the supply chain dynamic ability, so the hypothesis H2, H4 of this study is supported.

Table 4 Linear Regression of Supply Chain Digital Transformation on Supply Chain Dynamic Capabilities

Variable		Supply chain dynamic capabilities	
		Model 2-1	Model 2-2
Controlled Variable	Enterprise Scale	-0.014	0.002
	Enterprise Years	0.019	-0.031
	Enterprise Nature	0.117	0.001
	Enterprise Area	-0.018	-0.013
Independent Variable	Supply Chain Digital Transformation		0.898**
R^2		0.015	0.813
Adjusted R^2		-0.027	0.803
F-value		0.375	81.940**

**p<0.01 and *p<0.05, Standardized Coefficients

(2) The function test of the digital transformation of supply chain on the three dimensions of the dynamic ability of supply chain

Digital transformation of supply chain and supply chain dynamic ability of three dimensions relationship test as shown in table 6, model 2−3 test the digital transformation of supply chain and the relationship between learning and absorption ability, model 2–4 test the digital transformation of supply chain and supply chain innovation ability, model 2–5 test the digital transformation of supply chain and the relationship between supply chain integration and optimization. As shown in Table 9, both models 2 – 3 to models 2 – 5 passed the F test. From these three models known, Digital transformation of supply chain can effectively explain 78% of changes in supply chain learning and absorption capacity, 74.4% of changes in supply chain innovation capacity and 78.6% of changes in supply chain integration and optimization capacity, Learning and absorption ability of supply chain digital transformation on supply chain (t=18.165, P = 0.000 〈0.01), capability of supply chain innovation (t=16.377, P = 0.000 〈0.01) and supply chain integration and optimization capability (t=18.396, P = 0.000 〈0.01) all produced significant positive effects, Thus the hypotheses H2a, H2b and H2c, H4a, H4b and H4c in this study are supported.

(3) The role test of supply chain dynamic ability on enterprise environmental performance

Supply dynamic ability and the enterprise environmental performance test as shown in table 7, model 3–1 test dynamic ability of supply chain performance and enterprise environmental performance, relationship, model 3–2 test supply chain learning and absorption ability and enterprise environmental performance, relationship, model 3–3 test supply chain innovation ability and enterprise environmental performance, relationship, model 3–4 test supply chain, integration and optimization ability and the relationship between the enterprise environmental performance, they have passed the F test. We know from model 3–1 that supply chain dynamic capacit can effectively explain 66.1% of the changes of enterprise environmental performance, and supply chain dynamic capability has a significant positive impact on enterprise environmental performance (t =13.154, p=0.000 〈0.01), so assuming H3 is supported. Model 3–2 to 3–4 respectively test the influence of three dimensions of supply chain dynamic capacity on enterprise environmental performance. The results show that supply chain learning and absorption capacity (t=11.579, p=0.000 〈0.01), supply chain innovation ability (t =11.519, p =0.000 〈0.01) and supply chain integration and optimization capacity (t =13.322, p =0.000 〈0.01) all have significant positive effects on enterprise environmental performance, so it is assumed that H3a, H3b and H3c are supported.

Table 5 Linear regression of the three dimensions of supply chain dynamic capability

Variable		Supply chain learning and absorption capacity	Supply chain innovation capability	Supply chain integration and optimization capabilities
		Model 2-3	Model 2-4	Model 2-4
Controlled Variable	Enterprise Scale	0.001	0.018	-0.014
	Enterprise Years	-0.010	-0.054	-0.022
	Enterprise Nature	-0.002	-0.004	0.009
	Enterprise Area	0.016	-0.023	-0.020
Independent Variable	Supply Chain Digital Transformation	0.914**	0.878**	0.909**
R^2		0.782	0.744	0.786
Adjusted R^2		0.770	0.730	0.775
F-value		67.451	54.626**	69.229**

**p<0.01 and *p<0.05, Standardized Coefficients

Table 6 Linear regression of supply chain dynamic capability on enterprise environmental performance

Variable		Enterprise Environmental Performance			
		Model 3-1	Model 3-2	Model 3-3	Model 3-4
Controlled Variable	Enterprise Scale	-0.075*	-0.074*	-0.089	-0.061
	Enterprise Years	0.129	0.113	0.149	0.121
	Enterprise Nature	-0.054	-0.045	-0.041	-0.059
	Enterprise Area	-0.012	0.036	-0.006	-0.006
Independent Variable	Supply Chain Dynamic Capabilities	0.862**			
	Supply Chain Learning and Absorption Capacity		0.790**		
	Supply Chain Innovation Capability			0.801**	
	Supply Chain Integration and Optimization Capabilities				0.840**
R^2		0.661	0.604	0.601	0.667
Adjusted R^2		0.643	0.583	0.580	0.649
F-value		36.738	28.639**	28.350**	37.667

** $p<0.01$ and * $p<0.05$, Standardized Coefficients

4.3.2 Results of the hypothesis test

This study builds a theoretical model between the digital transformation of supply chain, the dynamic capability of supply chain and enterprise environmental performance, and studies the basic relationship between various variables: ① the impact of the digital transformation of supply chain on the environmental performance of manufacturing enterprises; the intermediary role of the dynamic capability of ② supply chain in the relationship between the digital transformation of supply chain and enterprise environmental performance. The results of the hypothesis tests are shown in Table Table 7.

This study is based on the supply chain management theory, resource based theory, dynamic ability theory of the digital transformation of supply chain and enterprise environment performance relationship model, the sample data reliability analysis, validity analysis and linear regression analysis, and the proposed 14 research hypothesis empirical test, the results show that 12 research hypotheses are established. This study on the empirical discusses the relationship between digital transformation of the supply chain and the enterprise environmental performance, supply chain digital transformation elaborated the impact of the enterprise environmental performance, the empirical results support hypothesis H1, H1a, the deeper the digital transformation of manufacturing enterprises, the greater the impact on the enterprise environmental performance (β=0.830, p〈0.01).

Supply chain learning and absorption ability positively influenced environmental performance (β =0.790, p〈0.01), environmental performance of supply chain innovation ability (β=0.801, p〈0.01), and supply chain integration and optimization ability positively affected environmental performance (β =0.840, p〈0.01). The empirical results support the hypothesis that H3, H3a, H3b, and H3c.

In this study, supply chain dynamic capability serves as an intermediary mechanism in the relationship between digital transformation of supply chain and enterprise environmental performance, Empirical findings support the hypothesis that H2 and H4, The digital transformation of supply chain can promote the dynamic capacity of supply chain (β=0.898, p〈 0.01), And the positive impact of the digital transformation of supply chain on the dynamic capability

Table 7 Linear Results of Hypothesis Testing

Number	Suppose the Content	Results
H1	The digital transformation of supply chain has a positive impact on enterprise environmental performance.	support
H2	Digital transformation of supply chain has a positive impact on the dynamic capacity of supply chain.	support
H2a	The digital transformation of the supply chain has a positive impact on the supply chain learning and absorption ability.	support
H2b	The digital transformation of supply chain has a positive impact on the innovation ability of supply chain.	support
H2c	The digital transformation of supply chain has a positive impact on the integration and optimization ability of supply chain.	support
H3	The dynamic ability of supply chain has a positive impact on enterprise environmental performance.	support
H3a	Supply chain learning and absorption ability has a positive impact on the environmental performance of economic enterprises.	support
H3b	Supply chain innovation ability has a positive impact on enterprise environmental performance.	support
H3c	Supply chain integration and optimization, capability has a positive impact on enterprise environmental performance.	support
H4	Supply chain dynamic capability plays an intermediary role between the digital transformation of supply chain and enterprise environmental performance.	support
H4a	Supply chain learning and absorption capacity play an intermediary role between the digital transformation of supply chain and enterprise environmental performance.	support
H4b	Supply chain innovation ability plays an intermediary role between the digital transformation of supply chain and enterprise environmental performance.	support
H4c	Supply chain integration and optimization capabilities play an intermediary role between the digital transformation of supply chain and enterprise environmental performance.	support

of supply chain is also established, Supply Chain learning and Absorption Capacity ($\beta=0.914$, $p<0.01$), Supply chain innovation capability ($\beta=0.878$, $p<0.01$), Supply chain integration and optimization capability ($\beta=0.909$, $p<0.01$). Dynamic supply chain capability plays a key role in the improvement of environmental performance of manufacturing enterprises ($\beta=0.862$, $p<0.01$). This shows that the digital transformation of supply chain can indirectly act on the environmental performance of enterprises through the dynamic capability of supply chain, that is, the deeper the digital transformation of enterprise supply chain, the better the dynamic capacity of supply chain, and the more conducive to the improvement of enterprise environmental performance. Moreover, the empirical results of this study show that the digital transformation of supply chain cannot directly act on the environmental performance of enterprises, and the dynamic capacity of supply chain plays a complete intermediary role in the relationship between the digital transformation of supply chain and enterprise environmental performance. The empirical results support H2, H2a, H2b, H2c, H4, H4a, H4b and H4c.

5. Conclusion and Implication

5.1 Conclusion

Taking the digital transformation of supply chain of Chinese automobile manufacturing enterprises, Based on the questionnaire survey data of China's automobile manufacturing industry, Based on supply chain management theory, resource base theory, supply chain dynamic capability theory To study the influence factors of the digital transformation of supply chain on the environmental performance of enterprises, Building theoretical models including variables such as digital transformation of supply chain, supply chain dynamic capability and enterprise environmental performance, And put forward 14research hypotheses; Select Chinese automobile manufacturing enterprises as the research objects and issue questionnaires, By collecting questionnaire data from the staff of automobile manufacturing enterprises, And to carry out the empirical tests, Results showed a total of nine study hypotheses with support, One study hypothesis received no support. The research shows that: (1) Digital transformation of supply chain has a significant impact on improving enterprise environmental performance.Assuming that H1 is established, the results of this study are consistent with the research of Su Taoyong et al. (2023), that is, the supply chain is digitized and integrated, which is conducive to improving enterprise environmental performance.Zhang Haowei et al. (2022) Digital transformation of the supply chain helps improve the competitive advantage of enterprises' environmental benefits.

(2) Digital transformation of the supply chain has a significant impact on the dynamic capabilities of the supply chain.Assuming that H2, H2a, H2b, and H2c are established, the results of this study are consistent with Liu Haijian et al. (2022) research that digital supply chain improves enterprise dynamic capabilities and improves enterprise environmental performance.

(3) Supply chain dynamic capabilities have a significant impact on the implementation of enterprise environmental performance.Assuming that H3, H3a, H3b, and H3c are established, this study is consistent with Cui Miao et al. (2021) that supply chain dynamic capability is conducive to improving organizational and technical flexibility.

(4) Supply chain dynamics have an intermediary effect between supply chain digital transformation and enterprise environmental performance.Assuming that H4, H4a, H4b, and H4c are established, this study is consistent with Lee Dae-yuan et al. (2009)'s research on the integration, reconstruction and updating of supply chain dynamics capabilities.

5.2 Implication

First, the Chinese government should formulate policies and regulations to encourage the environmental protection of enterprises. Through the responsive encouragement policies, recycling into reverse logistics and other supply chain links.

Secondly, the business philosophy of the managers of Chinese automobile manufacturing enterprises should be reformed. Automobile manufacturing enterprises should improve environmental protection consciousness, reduce resource consumption, through the establishment of digital supply chain management system,take due environmental responsibility.

Finally, automobile manufacturing enterprises can through the wisdom factory, digital exhibition hall, mobile travel and other digital technology, establish digital supply chain platform, improve the agility of purchasing supply system, ultimately improve the ability of digital supply chain.

References

[1] Li Wei'an, Zhang Yaowei, Zheng Minna, et al. (2019). Research on the Green Governance and Its Evaluation of Listed Companies in China [J]. Managing the World, (5): 126-133. DOI: 10.19744/j.cnki.11-1235/f.2019.0070

[2] Dai Ying, Li Xiaojia, Song Han, et al. (2023). Research on the Impact of Green Supply Chain Management in the Automotive Manufacturing Industry on Environmental Performance [J/OL]. Journal of Chongqing University of Technology (Social Sciences): 1-14. http://gfffg0bb94732401d44c2hfqq00fbbkkkp6fn6.fgfy.gxufe.cwkeji.cn/kcms/detail/50.1205.T.20231109.1616.004.html

[3] HEQP, Wang J. (2018). Statistical process monitor-

ing as a big data analytics tool for smart manufacturing [J]. Journal of Process Control, 67: 35-43. DOI: 10.1016/j.jprocont.2017.06.012

[4] Su Taoyong, Yu Yuzhu. (2023). Study on the Impact of Supply Chain Integration on Enterprise Environmental Performance [J]. Journal of Social Sciences, (6): 183-190.

[5] Pan Yongming, Zou Dinghua, Zhang Zhiwu. (2021). Research on two-level supply chain coordination mechanism based on carbon labeling system [J]. China Management Science, 29(1): 109-115. DOI: 10.16381/j.cnki.issn1003-207x.2018.0119

[6] Liu Jiaxin. (2021). The influence of green intellectual capital on environmental performance of science and technology enterprises: The regulating effect of dynamic ability [J]. Enterprise Economy, 40(6): 61-68. DOI: 10.13529/j.cnki.enterprise.economy.2021.06.007

[7] Zheng Xiuai, Ma Hongjia, Wu Juan. (2018). Review and future outlook of competency research based on a supply chain perspective [J]. Foreign Economy and Management, 40(7): 59-72. DOI: 10.16538/j.cnki.fem.2018.07.005

[8] Wen Minong,Yang Fangfang. (2022). Research on the dynamic capacity construction and evolution of the enterprise in the context of innovation ecology [J]. Research on Technical Economics and Management, (1): 55-60.

[9] Dubey R, Gunasekaran A, Childe SJ, et al. (2019). Can big data and predictive analytics improve social and environmental sustainability? [J]. Technological Forecasting and Social Change, 144: 534-545.

[10] Kamble S, Gunasekaran A, Dhone NC (2020). Industry 4.0 and lean manufacturing practices for sustainable organisational performance in Indian manufacturing companies [J]. International Journal of Production Research, 58(5): 1319-1337. DOI: 10.1080/00207543.2019.1630772

[11] Belhadi A, Zkik K, Cherrafi A, et al. (2019). Understanding big data analytics for manufacturing processes: Insights from literature review and multiple case studies [J]. Computers & Industrial Engineering, 137: 106099. DOI: 10.1016/j.cie.2019.106099

[12] Yu Lianchao, Wang Lei. (2023). Does Digital Transformation Contribute to Improving Corporate Environmental Performance? [J]. Finance and Trade Research, 34(7): 84-96. DOI: 10.19337/j.cnki.34-1093/f.2023.07.007

[13] Chen Chen, Lv Bing, Sun Xinran, et al. (2023). Research on the Impact of Information Technology Capability on Corporate Environmental Performance under the "Dual Carbon" Goal: Based on the Moderating Effect of Supply Chain Integration [J]. Management and Technology of Small and Medium-sized Enterprises,(20): 37-39.

[14] Harrison, A. (1999). Understanding the strategic importance of the supply chain. International Journal of Logistics Management, 10(2), 27-36.

[15] Ogden, J., Roos, D., & Turner, G. (2005). Supply Chain Definition and Issues. In Supply Chain Management (pp. 3-18). Springer, Boston, MA.

[16] Zhuang, Y., Yang, G., & Liu, Z. (2010). Fundamental Theory and Practice of Supply Chain Management. Beijing: Renmin University of China Press.

[17] Ma, S. (2022). Supply Chain Management: Basic Concepts and Practices. Beijing: Tsinghua University Press.

[18] Chen, X. (2012). Supply Chain Management: Maximizing the Net Present Value of Supply Chain Collaboration Profits. Journal of Supply Chain Management, 29(4), 567-580.

[19] Walton, S. V., Handfield, R. B., & Melnyk, S. A. (1998). The Green Supply Chain: Integrating Suppliers into Environmental Management Processes. Journal of SupplyChain Management, 34(2), 2-10. DOI: 10.1007/978-94-007-1390-1_3

[20] Liu, L., & Wang, M. (2023). Application Research of Green Technology Innovation in Supply Chain Management. Journal of Environmental Sciences, 43(1), 118-125.

[21] Lopez-Morales, J. S., Rodriguez-Ulloa, A., & Garcia-Melendez, A. J. (2023). Enhancing Supply Chain Competitiveness Through Digital Embedding: Evidence from Digital Supply Chains. International Journal of Production Economics, 245, 107989.

[22] Wernerfelt, B. (1984). A Resource-Based View of the Firm. Strategic Management Journal, 5(2), 171-180.

[23] Barney, J. B., & Arikan, A. M. (2001). The Resource-Based View: Origins and Implications. In M. A. Hitt, R. E. Freeman, & J. S. Harrison (Eds.), Handbook of Strategic Management (pp. 124-188). Oxford: Blackwell Publishing. DOI: 10.1111/b.9780631218616.2006.00006.x

[24] Barney, J. B., & Hesterly, W. S. (2012). Strategic Management and Competitive Advantage: Concepts and Cases. Upper Saddle River, NJ: Pearson Prentice Hall. DOI: 10.1109/WiCom.2008.2282

[25] Barney, J. B. (1986). Strategic factor markets: Expectations, luck, and business strategy [J]. Manag. Sci., 32(10), 1231-1241. DOI: 10.1057/9781137294678.0648

[26] Li Jinghua, Lin Li, Li Qianlan. (2019). Innovation of Manufacturing Service-oriented Business Model: Based on the Resource-based View. Science Research Management, 40(3), 74-83. DOI: 10.19571/j.cnki.1000-2995.2019.03.008

[27] Teece, Rumelt, & Dosi. (1994). Teece, D. J. Pisano, G. Shuen, A. 1997 Dynamic capabilities and strategic management, SMJ, 18(7), 509-533. DOI: 10.1016/0167-2681(94)90094-9

[28] Teece, D. J. (2014). A Dynamic Capabilities-based Entrepreneurial Theory of the Multinational Enterprise. Journal of International Business Studies, 45(1), 8-37. DOI: 10.1057/jibs.2013.54

[29] TWilhelm, M. M., Holcomb, T. R., & Sullivan, D. M. (2015). The Influence of Dynamic Capabilities on Environmental Performance: A Dynamic Capabilities Viewpoint. Journal of Business Ethics, 127(2), 309-324. DOI: 10.1080/00045600701734356

[30] Liu Hua, Zhang Xiwen (2023). Study on the Impact of Supply Chain Dynamic Capability on Environmental Performance of Oil and Fat Enterprises [J]. Chinese fats, 48(12): 147-152. DOI: 10.19902/j.cnki.zgyz.1003-7969.230189

[31] Han Lu (2022). Mechanism and Decision Model of Supply Chain Digital Transformation in Manufacturing Enterprises [D], Beijing Jiaotong University. DOI: 10.26944/d.cnki.gbfju.2021.000204

[32] Zhang Haowei (2023). The Impact of Supply Chain Digital Transformation on Firm Competitive Advantage: A Study [D], Jilin University. DOI: 10.27162/d.cnki.gjlin.2022.007071

채 옥 결 (YUJIE CAI)

• 2021년 8월~현재: 세한대학교 대학원 경영학과 박사
• 2024년 3월~현재: 광서재경학원 교사
• 관심분야: 재무회계 및 재무관리
• E-mail: 1169147124@qq.com

심 재 연 (Jaeyeon Sim)

• 1985년 2월: 조선대학교 회계학과 (경영학학사)
• 1990년 2월: 조선대학교 대학원 회계학과 (경영학석사)
• 1995년 2월: 조선대학교 대학원 경영학과 (경영학박사)
• 1995년~현재: 세한대학교 경영학과 교수
• 관심분야: 회계정보시스템, 정부회계, 인적자원관리
• E-mail: simjy@sehan.ac.kr