



Examining the impact of digital transformation on the resilience of food supply chain: a comprehensive analysis

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ABSTRACT

This study analyzes the relationship between digital transformation and food supply chain resilience(FSCR). It identifies 10 factors that affect structural changes in FSCR. The Analytic Hierarchy Process (AHP) is used to hierarchically classify and analyze the factors influencing FSCR and their mechanisms of action. While Interpretive Structural Modeling (ISM) is established to study the interactions among the factors of FSCR, with digital technology as an external manifestation of digital transformation.

Through the analysis of AHP method, we find that digital technology has a weight of 0.10839 and its ranking is second among 10 factors of FSCR. This result shows that digital transformation is vital to FSCR. With the results of ISM method, we find that digital transformation plays an intermediate role in the factor system of FSCR. It functions as a bridge linking the causal factors, such as government macro-control, and result factors, such as environmental protection. While the study offers some guidance for the improvement of FSCR, the study has some limitations in methods and regions. Future research should focus on integrating advanced techniques and looking for more specific solutions.

1. Introduction

Food security is crucial for a country's economic development and the continuity of human society. Ensuring food security has become a key consideration for many countries in formulating development policies. The food supply chain serves as the "lifeline" of food security, playing a critical role in maintaining stability. The food supply chain encompasses all participants, from raw

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material procurement, production, processing centers, storage facilities, markets, and processing enterprises to end consumers. Ensuring the continuity of the food supply chain is a fundamental prerequisite for protecting food security.

On a global scale, international trade has become an essential means of ensuring global food security in response to the spatial imbalance and mismatch between food production and consumption. International food trade relies on the global food supply chain, which involves continuous economic activities. When constructing a secure food supply chain, food supply chain resilience (FSCR) is often a critical consideration for scholars. Supply chain resilience generally refers to its ability to resist, recover, and adapt to changes. In the 1970s, with globalization and technological advancements, the studies of food supply chain began to develop systematically. By the late 1980s, research on food supply chain focused on economic integration within agricultural industrialization and vertical coordination, aiming to improve food production efficiency, storage technology, and farmer income through policy support. By the early 21st century, as economic globalization deepened, research on food supply chain expanded to a global scope, emphasizing international cooperation and optimizing trade flows. These developments established a solid foundation for the digital transformation of the global food supply chain. So far, digital transformation has been considered into many industries such as logistic, medication, education and so on. Logistic is an important part of food supply chain. Now it is easy to find that with the digital techniques used in industry such as logistic, the speed and safety of food transportation have significantly improved. This suggests that digital transformation can provide advantages to food supply chain, including enhancing resilience.

Therefore, it is very important to study that under digital transformation, what changes will happen to FSCR and a country's economic development. Digital transformation refers to the process of using digital technologies and mindsets to redesign business models and processes while transforming an organization's core culture. This is a critical measure across various industries in response to current development trends, aligning with national policies and global trends. The digital transformation of the global food supply chain began around the early 21st century but gained significant momentum around 2020. On a global scale, two main factors drive this transformation: Firstly, global crises, such as the COVID-19 pandemic and extreme climate events, have exposed the vulnerabilities and inefficiencies of traditional food supply chains, necessitating the use of technology to enhance adaptability and flexibility. Secondly, advancements in technology, especially the application of big data technology, cloud computing technology, blockchain technology, and artificial intelligence, have made digital transformation more feasible. Based on these considerations, this study focuses on digital technologies as the external representation of digital transformation.

So far, less research has applied Analysis Hierarchical Process (AHP) and Interpretative Structural Modeling (ISM) to the research of FSCR. In this essay, the AHP method is used to analyze the hierarchical relationship of influencing factors in FSCR, and the ISM method is used to analyze the interaction relationship between factors. Through the integration of two methods, this study wants to figure out the role that digital transformation plays in FSCR.

From study, we find that digital transformation plays an intermediate role in the factor system

of FSCR. It functions as a bridge linking the causal factors, such as government macro-control, and result factors, such as environmental protection. With the result that this study concluded, food industries can implement digital transformation more accurately. Based on this result, the government can establish food polices to help enhance food security and FSCR.

The main objectives of this research are as follows:

- ✓ How do we understand FSCR?
- ✓ What is the hierarchy of factors affecting FSCR?
- ✓ What role does digital transformation play in FSCR?

2. Literature Review

This chapter comprehensively expounds the previous research on FSCR, and analyzes the leading factors affecting FSCR based on previous research. This paper first demonstrates the development of FSCR and illuminates the concept of food supply chain. Then, based on literature and reality, this paper summarizes 10 comprehensive factors affecting FSCR.

2.1 Studies on the FSCR and Digital Transformation

Strengthening FSCR is an important measure to ensure food security, and it is also a key measure for the development of the modern food industry in the new period. After experiencing the evolution from germination to initial formation and leapfrog development, China's food supply chain has entered into a steady development stage, forming a new characteristic based on Internet technology. At present, China's food supply chain is still insufficiently resilient, facing the difficulties of infrastructure upgrading, low level of digital operation, financial service system improvement and supply chain security risk. In the new era, the development of the food supply chain should focus on basic stability, technology integration, financial support, and security barriers and seek innovative ways to strengthen FSCR.

From the perspective of academic progress, Christopher and Peck [1] first proposed a formal definition of supply chain resilience, which refers to the ability of a supply chain to return to its original state or move to a new, more desirable state. Since then, Ponomarov and Holcomb [2] argued that supply chain resilience emphasizes supply chain preparedness for emergencies, resistance to supply chain disruptions, and resilience to shocks. Based on the previous research, Yang *et al.*, [3] summarized that supply chain resilience can be measured in 3 aspects, they were Absorptive capacity, Adaptive capacity, and Restorative capacity. As a newly proposed policy concept, FSCR is rarely discussed directly in domestic literature. However, some scholars have addressed the importance of FSCR when analyzing food security. Mu *et al.*, [4] proposed that a resilient food supply chain can be vulnerable under the constant pressure and can mitigate food safety hazards so that it can make food security more stable. Sharma *et al.*, [5] advocated that a decarbonized food supply chain can help reduce greenhouse gas emissions and enhance food security. By applying some technologies, such as Industry 4.0 into food supply chain, we can build decarbonization in food supply chain. Singh *et al.*, [6] proposed that with the adoption of digital technologies, the production, efficacy, and profitability of the food supply chain can be increased while strengthening food sustainability. With the development of research, some studies have focused on food security and digital technologies. Rejeb *et al.*, [7] studied the role of information

and communications technology (ICT) in agriculture, food security, food waste, the circular economy, and the merging of Internet of Things (IoT) and blockchain in food supply chains based on existing literature. Abideen *et al.*, [8] reviewed how digital technologies had responded to food supply chain challenges that were related to quality, security, and sustainability over the past decade and concluded that IoT had gained more attention in the digital transformation of food supply chains.

Overall, although there has been some academic research on digital transformation and FSCR, research on the role of digital transformation in FSCR is still limited. Therefore, this paper discusses the specific role of digital transformation in FSCR.

2.2 Overview of Influencing Factors Affecting the Resilience of the Food Supply Chain

The food supply chain is vital to the food security of human, and how to improve its resilience has become a hot topic since the 21st century. To achieve that, we should first figure out the factors influencing FSCR. In recent years, some scholars have done some studies about the influencing factors system of FSCR.

Kumar *et al.*, [9] selected 22 enablers for the development of resilience in the food supply chain from experts. The study pointed out that innovation in food traceability, local and regional food use, market research on customer behavior pattern, providing safety stock, multi-sourcing, supplier alert management, and downstream decoupling points were selected as cause enablers. So these factors needed to be prioritized while enhancing FSCR. Arimany-Serrat *et al.*, [10] proposed that the factors which had the greatest impact on FSCR consist of 3 aspects. They were environmental sustainability (the reduction in pollutant emission), social sustainability (the safety and health of workers), and sustainability of governance (diversity in management bodies and employees). These three remaining variables can be considered as determining factors to increase FSCR. Chang and Jiang [11] made the index system to evaluate the resilience of the grain supply chain. The influencing factors were summarized as 6 aspects of the First-Class Index. They were Prevention, Prediction, Digestion, Recovery, Learning and Transformation. The Second-Class Index consisted of factors coming from the First-Class Index. The study included that at present, the grain supply chain of China should be guided by government support, economic development level, and innovative human capital to optimize resilience. Mandal *et al.*, [12] focused on COVID-19, Industry 5.0 technologies, which were the reflections of society and technology, and established a construct system. The study showed that high food safety and security is achieved by a combination of policy-related reforms and Industry 5.0-based technological reforms, especially blockchain technology. Hobbs and Hadachek [13] analyzed FSCR through different levels. They were the food system, household, firm, and sector. The study also had the consideration of defining and measuring resilience in economics. Zhong *et al.*, [14] chose influencing factors of FSCR through literature review and expert consultations. The study highlighted supply chain leadership and government support as crucial for enhancing FSCR.

Based on the above literature and the analysis of the real situation, this paper will establish a factor system to extract 10 factors that affect supply chain resilience from the aspects of organization, society, and technology. Among them, organization, society, and technology are the first level of factors. 10 factors of the second level are as follows:

Market structure, government macro-control, enterprise integration, resource distribution, environmental protection, international situation, digital technology, infrastructure, logistics services, and risk prevention.

The organization aspect consists of three factors: the organization aspect consists of market structure, government macro-control, and enterprise integration; the social aspect consists of resource distribution, environmental protection, and international situation; the technological aspect consists of digital technology, infrastructure, logistics services, and risk prevention.

2.3 Studies on the ISM Method

In recent years, ISM methods have been one of the important tools for solving complex decision problems. In this passage, ISM has been used to figure out the structure of 10 factors that may influence the resilience of the food supply chain. The application of the ISM method in different aspects emphasizes the flexibility of the methodology and its effectiveness in decision-making processes. Some studies based on the ISM method in the literature are presented below:

Wu *et al.*, [15] classified the relationship and structure of factors that may influence urban rail transit construction accidents and established a factor system by using the integrated ISM-MICMAC method. The study was innovative since most existing research did not go beyond finding the influence relationships of risk factors through ISM or making general recommendations based on the identified interrelationships. This study demonstrated the capacities and effectiveness of the ISM method. Alshibani *et al.*, [16] figured out the drive of the barriers to the adoption of Building Information Modelling(BIM) in construction management by ISM. In the study, the ISM method was used to categorize and prioritize the barriers. This method offers a thorough comprehension of the primary barriers to BIM adoption and their interconnections, linking theoretical models with practical insights. It assists stakeholders in devising targeted strategies for the efficient utilization of BIM in the construction sector. Nazarian-Jashnabadi *et al.*, [17] established the structure of the problem of what can make sense in patient satisfaction by the ISM method. In the study, they used the ISM method to help choose the policy and identify the leverage points that impact the model most. Then, they used the Analytic network process(ANP) to identify the importance of the problem's criteria. This study investigated and identified the main criteria affecting patient satisfaction.

Through studies about ISM method which have shown above, we see the flexible application of the ISM method. The ISM method is useful to identify the structure of those factors that may affect the problem.

2.4 Studies on the AHP Method

The Analytic Hierarchy Process (AHP) is a method that breaks down decision-making problems into a hierarchical structure, starting from the overall goal, through various levels of sub-goals and evaluation criteria, down to specific alternative solutions. AHP provides a new, concise, and practical method for decision-making in the study of a complex system composed of numerous interrelated and interdependent factors.

Today, the AHP method is applied in different sectors and integrated into various decision-

making problems. Huang *et al.*, [18] calculated the weight of a performance evaluation index system for an energy supply chain of a four-tier structure based on the "double-carbon" goals. By using the AHP method, they established a model to solve the weight of energy supply chain performance evaluation indicators under the "double-carbon" goals. Šostar and Ristanović [19] used the AHP method to analyze, evaluate, and rank the influencing factors of consumer habits. The result showed that personal and psychological factors have a principal influence on consumer habits. Especially personal budget, which worked as the dominant criterion in a group of set criteria, contributed to the fact that personal factors can make some dominant effect in consumer habits. Das *et al.*, [20] analyzed factors that affected the supply chain networks with the onset of COVID-19 by Analytic Hierarchy Process (AHP) and Decision-Making Trial and Evaluation Laboratory (DEMATEL). The AHP method facilitated a hierarchical ranking of the factors according to their relative weights while DEMATEL ascertained the inter-relationships among the factors and classified them into cause and effect groups. The study identified that cost optimization was the most significant factor, and human resource management was the least important factor in reducing vulnerabilities of the supply chain network.

Those studies use AHP method as a tool to identify, rank, and analyze the relationship between different factors that have some intangible or tangible influence on the problem they focus on. So far, AHP method has usually been useful for those decision-making problems, helping people make better decisions.

3.Methodology

Digital transformation is a critical factor that makes sense in the efficiency and sustainability of the FSC. Therefore, identifying the inner relationship between digital transformation and the FSCR and implementing appropriate policies are vital to food safety and economic development.

From the literature review above, this essay built an influencing factors system of the FSC's resilience. They are shown in Table 1.

Table 1.
Influencing factors of FSCR

First-Level	Second-Level	Demonstration
	market structure(S1)	The stability and changes of the grain supply and marketing market, as well as the structural composition of grain production and sales entities.
Organiza- tion(C1)	government macro- control(S2)	including government financial subsidies for food and food supply policies during major disasters
	enterprise integration(S3)	Collaboration and alliances between grain enterprises and other companies, such as cooperation between grain enterprises and intelligent logistics companies, intelligent supply chain enterprises, etc.
Society (C2)	resource distribution(S4)	Including natural resources such as arable land, water resources, etc.

Technology(C3)	environmental protection(S5)	Involves the sustainable development of the food supply chain, including the governance of food waste phenomena and the effective utilization of natural resources.
	international situation(S6)	The structure of international trade, the occurrence of wars, and global disasters.
	digital technology(S7)	including grain production technology, processing technology, logistics technology for transporting grain, and storage technology for grain storage.
	Infrastructure(S8)	Equipment, factories, vehicles, etc., for processing and producing grain.
	logistics services(S9)	Including food timely, effective dispatch, transportation route optimization, etc.
	risk prevention(S10)	Including the prevention and control of natural disasters such as pests in food crops and major communicable diseases in human society.

The process steps, which are given in Fig. 1, show how the study works and gets the final result.

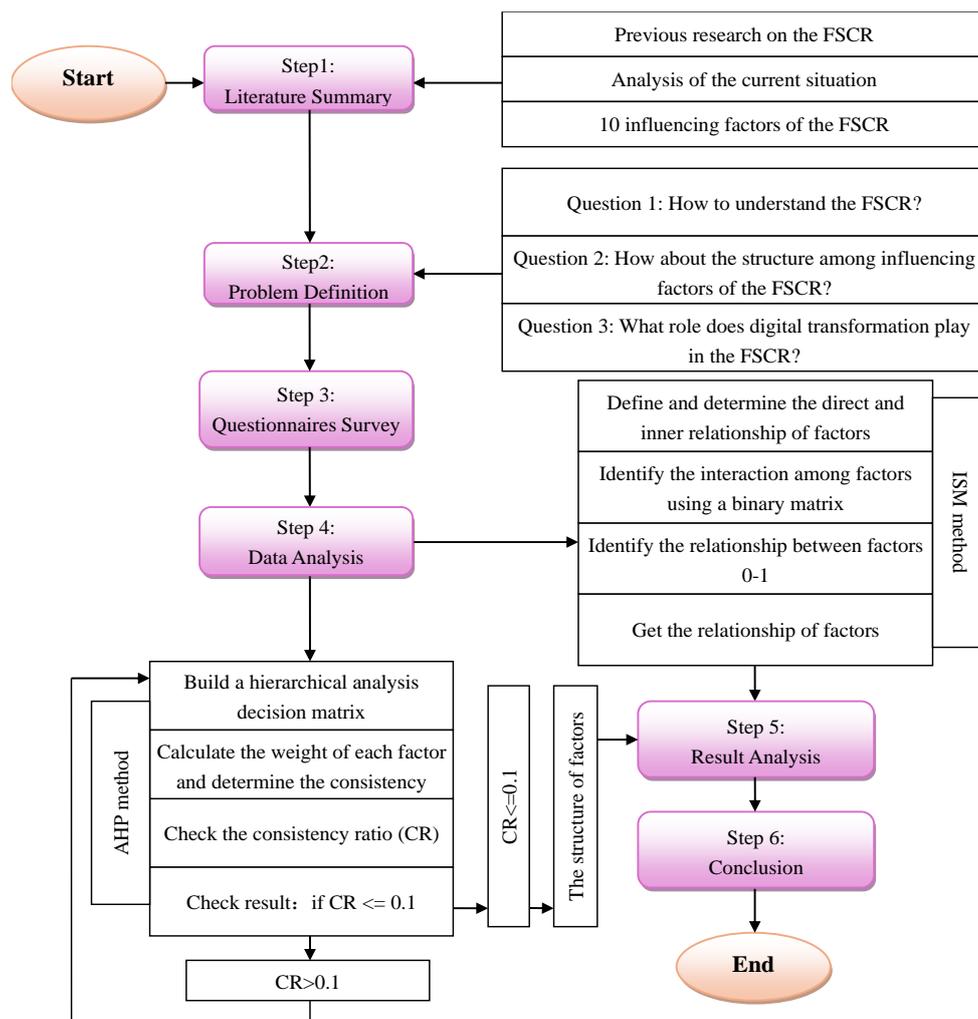


Fig. 1. The framework of the study

By analyzing the final result of the study, the interaction of influencing factors can be presented clearly. Based on that, scientists and policy makers of the FSCR can have more understanding of the FSC, helping them do deeper research and implement more appropriate policies.

As for methods we used in this research, The Analytic Hierarchy Process (AHP) helps hierarchically classify and analyze the factors influencing FSCR and their mechanisms of action. Then, Interpretive Structural Modeling (ISM) is established to study the interactions among the factors of FSCR. ISM helps uncover interdependencies and hierarchical relationships between these factors.

3.1 AHP Method for Ranking Factors

AHP, which is employed to rank the decision alternatives and identify the level among factors, was developed by Saaty [21] in the 1970s. According to the methodology developed by Awad and Jung [22], the processing steps are as follows.

Step 1. Judge Factors

A 9-level numerical scale is commonly used to evaluate the intensity of importance of the criteria. The study contrasts each two factors to identify the importance among them and rank the factors. The Judge standard is given in Table 2.

Table 2.
Judge standard

Score	Demonstration
1	two factors are of equal importance when compared
3	one factor is considered slightly more important than the other
5	one factor is significantly more important than the other compared to the other
7	one factor is more important than the other
9	one factor is extremely more important than the other
2,4,6,8	The median of two adjacent judgments

Step 2. Construct the Judgement Matrix

Calculate and determine the maximum eigenvalue λ_{max} of the judgment matrix, and normalize the corresponding eigenvector to obtain the ranking weights W . Matrix A ($n \times n$) is constructed based on the number of alternatives n and accompanied with values a_{ij} where i is the base comparison criteria correlating to row i and j is the criteria that is being compared to criteria i .

$$A = \begin{bmatrix} 1 & a_{12} \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & 1 \end{bmatrix} \quad (1).$$

$$\begin{bmatrix} 1 & a_{12} \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & 1 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \end{bmatrix} = \lambda_{max} \begin{bmatrix} w_1 \\ w_2 \end{bmatrix} \quad (2).$$

$$AW = \lambda_{max}W \quad (3).$$

Step 3. Determine the Inconsistency of the Matrix

To determine the inconsistency of the matrix, the consistency ratio (CR) is defined by analyzing the consistency index (CI) and the random index (RI).

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (4).$$

$$RI = \frac{\lambda_{max,avg} - n}{n - 1} \quad (5).$$

Where λ_{max} is the largest eigenvalue, n is the number of alternatives and $\lambda_{max,avg}$ is average value of λ_{max} for a $(n \times n)$ matrix.

Step 4. Check Result and Get the Final Level Structure of Factors

To attain reliable results through a consistent matrix, the CR should be less than 0.1. However, if the CR exceeds 0.1, the assessment process must be repeated.

$$CR = \frac{CI}{RI} \leq 0.1 \quad (6).$$

After the checking process and getting reliable results, we used the final result to calculate the weights of all factors at a certain level for the highest level (overall goal) is called the overall ranking of the hierarchy. This process is carried out sequentially from the highest level to the lowest level and involves a consistency check.

3.2 ISM Method for Interactions among Factors

ISM, which is a systems analysis method used to derive complex interrelationships and hierarchies between factors, is developed by Warfield and Cybernetics [23]. The processing steps of this study follow the methodology of Nazarian-Jashnabadi *et al.*, [17]:

Step 1. Identification of the criteria based on the literature review and experts' opinions.

Step 2. Establishment of the relative relationship between the pairwise criteria based on the opinions of experts.

Step 3. Build a binary matrix to identify the interaction among factors.

$$\begin{bmatrix} 0 & X_{12} & \cdots & X_{1n} \\ X_{21} & 0 & \cdots & X_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ X_{m1} & X_{m2} & \cdots & 0 \end{bmatrix} \quad (7).$$

Where C_i signifies criterion i and X_{ij} indicates the relationship between criterion i and j criterion.

Step 4. Establishment of the initial reachability matrix according to the structural self-interaction matrix.

Step 5. Obtain the reachability matrix using the Boolean multiplication and addition of the set theory.

Step 6. Establish a 0-1 matrix.

Identification of the structure levels of the criteria based on the final reachability matrix, reachability set, and antecedent set. The reachability set is the sum of elements with a value of "1" for each row. Also, the antecedent set is the sum of elements with a value of "1" for each column. After, the intersection set is established by choosing similar elements from the reachability and antecedent sets. The same criteria for the reachability and antecedent sets, selecting for the top level in the ISM model. Then, the selected criteria for the top level were removed, and performing a similar process to identify the other criteria levels.

Step 7. Design a digraph determined from the final reachability matrix.

In the ISM method, the top-level criteria are placed at the top of the digraph, the second-level criteria are placed next to and so on until all criteria are continued.

4.Result

4.1 Weight Value of Factors

We designed two questionnaires, one for AHP method and the other for ISM method, to collect some effective data which may help the research. There had 104 components who answered the AHP questionnaire and 148 components who answered the ISM questionnaire. And the data we collected had passed consistency check.

By analyzing the results from questionnaires, we got the weight value of factors between each

two factors. They showed the degree that one factor influences the other. The results were shown by Table 3.

Table 3.
Weight value among factors

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
S1	1.000	1.130	1.134	1.021	0.887	1.029	0.812	0.803	0.839	0.789
S2	0.885	1.000	0.994	1.119	0.970	1.127	0.889	0.879	0.919	0.864
S3	0.882	1.006	1.000	1.263	1.096	1.274	1.004	0.993	1.038	0.977
S4	0.979	0.894	0.792	1.000	1.295	1.018	0.796	0.786	0.822	0.773
S5	1.128	1.031	0.912	0.772	1.000	1.159	0.917	0.906	0.947	0.891
S6	0.972	0.887	0.785	0.982	0.863	1.000	0.789	0.780	0.816	0.767
S7	1.232	1.125	0.996	1.257	1.091	1.267	1.000	0.989	1.034	0.973
S8	1.246	1.138	1.007	1.272	1.104	1.282	1.011	1.000	0.962	1.309
S9	1.192	1.088	0.963	1.216	1.056	1.226	0.967	1.039	1.000	1.044
S10	1.267	1.157	1.024	1.293	1.122	1.303	1.028	0.764	0.958	1.000

4.2 Ranking of influencing factors and the effect of digital transformation

Through the analysis of the AHP research results, we find that the factor with the highest weight value is infrastructure (weight value: 0.1122). It indicates that infrastructure, which includes equipment, plants, transportation tools for the production and processing of food, is the most influential factor in the resilience of the food supply chain. By analyzing the research results, we also find that resource distribution and government macro-control are dominant factors in environmental protection, risk prevention, and the policy-making related to these factors, but they are ranked lower in the AHP weight table. Therefore, we can say that government macro-control is both a dominant factor and the last in the weight ranking for FSCR. This suggests that, compared to other factors, government macro-control is the foundation for many policies aimed at building resilience in the food supply chain.

After analyzing the research results, we discovered that among the 10 factors affecting FSCR, there are causal relationships between factors. The causal factors, such as government macro-control, enterprise integration, and risk prevention, through intermediate factors like market structure, resource distribution, and digital technology, ultimately affect the result factors—such as environmental protection, international situation, infrastructure, and logistics services. Among

those factors, the weight value of digital technology is the highest, providing a solid data foundation for our research. This indicates that digital technology plays a very important role in the FSCR and is also significantly influential on other factors. It is the core element that connects and communicates the other factors of FSCR.

The rank of factors is shown in Table 4 and the weight value of 10 factors is shown in Fig. 2.

Table 4.
The Rank of factors in FSCR

Factor	Weight Value	Rank of Weight Value
S1	0.09345	8
S2	0.09554	7
S3	0.10438	5
S4	0.09035	9
S5	0.09589	6
S6	0.08544	10
S7	0.10839	2
S8	0.11220	1
S9	0.10686	4
S10	0.10750	3

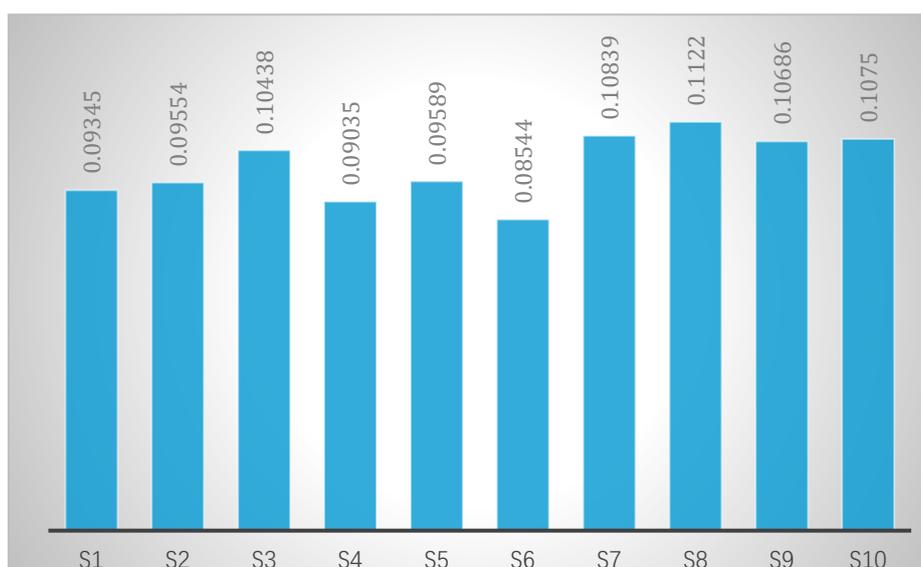


Fig. 2.The weight value of factors in FSCR

From the results, we found that digital technology, which is the main perspective of digital

transformation, plays as an intermediate factor in the influencing factors system of FSCR. It implied that among the 10 influencing factors, digital technology, as the main representative of digital transformation, has a huge impact in the formation of grain supply chain resilience, affecting all other factors except itself.

This study demonstrates the significant driving role of digital transformation in the sustainable development and economic growth of the food supply chain. Digital technology, as a product of the modern scientific revolution that keeps pace with time, plays a huge role in various industries. The level structure of factors can be shown in Table 5.

Table 5.

Level structure of factors

Level	Factor
Causal Factors	government macro-control(S2)
	enterprise integration(S3), risk prevention(S10)
Intermediate Factors	market structure(S1)
	resource distribution(S4), digital technology(S7)
Result Factors	environmental protection(S5), international situation(S6)
	infrastructure(S8), logistics services(S9)

4.3 The Interaction among Influencing Factors

According to the results of ISM method, the 10 influencing factors are categorized into three levels: government macro-control, corporate integration, and risk prevention are classified as causal elements, indicating that they play a leading role in the formation of FSCR; outcome elements include environmental protection, international situation, infrastructure, and logistics services, representing these elements as the main manifestations of the results of FSCR formation; intermediate elements comprise market structure, resource distribution, and digital technology, showing that these elements have an important role in communicating with other elements and promoting the formation of resilience in the process of resilience formation.

Based on the obtained AHP and ISM research results, the following directed structural diagram of factors can be drawn in Fig. 3.

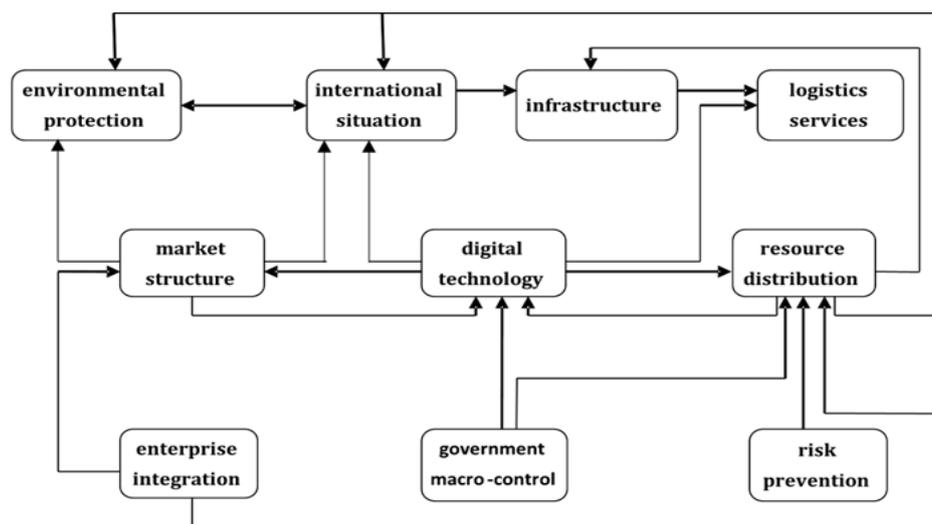


Fig. 3. Structural diagram of factors

5. Discussion

5.1 Theoretical Implications

This study brings new insights to the theoretical aspects of the food supply chain field. By employing the Analytic Hierarchy Process (AHP) and Interpretive Structural Modeling (ISM) methods, it systematically analyzes ten factors affecting the resilience of food supply chains, constructing a clear factor system and clarifying the hierarchical relationships and interaction mechanisms among these factors. This achievement fills a gap in the research on the relationship between digital transformation and FSCR, further refining the theory of food supply chains. The study finds that digital technology occupies an intermediary position within the factor system, connecting causal factors with outcome factors. This enriches our understanding of the role of digital technology within supply chains and provides a theoretical foundation and analytical framework for subsequent scholars to delve into how digital transformation affects the resilience of food supply chains. It contributes to the ongoing development and innovation of related theories.

5.2 Practical Implications

From the perspective of practical application, this research achievement has significant practical value. It is clear that infrastructure is the most important factor affecting FSCR, which points out the key directions for investment and construction for relevant departments and enterprises. For example, governments and enterprises can increase investments in infrastructure related to food production, processing, storage, and transportation, enhance modernization levels, and strengthen the food supply chain's ability to cope with risks. At the same time, recognizing the fundamental role of government macro-control and the key impact of digital technology helps to formulate more targeted policies and development strategies. When dealing with sudden public health events or natural disasters, the government can use macro-control tools to rationally allocate resources and ensure the stability of food supply; enterprises can use digital technology to optimize supply chain processes, improve operational efficiency and transparency, reduce the risk of supply chain disruption, and effectively ensure food security.

5.3 Managerial Implications

Through the analysis of research results, managers can understand the weight and interrelationships of various factors, allowing for a more scientific allocation of resources and prioritizing the management and optimization of key factors. For example, in regions where resources are limited, priority should be given to investing in infrastructure construction to ensure the stable operation of the supply chain. At the same time, managers can strengthen digital management based on the bridging role of digital technology, promoting collaborative cooperation between enterprises. By establishing digital platforms, information sharing can be achieved, facilitating close collaboration between enterprises and partners such as suppliers and logistics companies, enhancing the synergistic effect and responsiveness of the entire supply chain. In addition, based on the research findings, managers can also develop more comprehensive risk prevention and response strategies, strengthen monitoring and analysis of factors such as market structure and international situations, prepare in advance, and improve the management level and risk resistance capabilities of the food supply chain.

6. Conclusions, Limitations and Directions for the Future

This section includes summarizing the results of study, discussing the limitation of study and directions for the future studies.

6.1 Conclusions

This study demonstrates the effectiveness of the interaction of AHP and ISM methods to analyze the influence of digital transformation on FSCR.

- ✓ Identification of influencing factors: This study used literature review method to identify the factors that may affect FSCR. Factors are selected from 3 aspects, they are organization, society and technology. Besides, the 3 aspects are separated into 10 factors.
- ✓ Performance of digital transformation: Digital technology shows as an intermediate role in factor system of FSCR. It acts like a bridge linking the causal factors, such as government macro-control, and result factors such as environmental protection. We got that digital transformation (ranking:2) is a leading force in building the resilience of the food supply chain. By applying digital technology into logistic services, infrastructure of FSC, FSC can be enhanced.

6.2 Limitations

While the findings of this study provide important insights, they have some limitations:

- ✓ Method limitation: The method used in this study is quite limited and singular, relying on quantitative data and methods for research analysis. It does not provide solutions for scenarios with ambiguous conditions, and its applicability to more ambiguous situations is low. The results of the analysis may contain a certain degree of error.
- ✓ Research limitation: This study focused on the overall FSCR. However, it didn't considerate difference among different regions. Therefore, it had some limitation on exact implementation on improving food supply chain.

6.3 Future Directions

This study further explores and investigates the relationship between digital transformation and the resilience of the food supply chain based on previous research, finding that digital transformation plays a significant role in the resilience of the food supply chain, with a clear impact on the formation of resilience. It provides a reference for future research in this field.

Digital transformation is a trend across various industries today, and with the development of science and technology, digital transformation is becoming more mature. The food supply chain is an important guarantee for national security, and in the future, research on digital transformation and the resilience of the food supply chain will become more in-depth and extensive.

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