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The impact mechanism of digital transformation on the supply chain capabilities of the fresh-cut flower industry in Yunnan province of China

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ABSTRACT

Given the rapid global economic development and continuous technical advancements, a key strategy for companies trying to improve their competitive edge and accomplish sustainable development is digital transformation. This study's goal was to investigate how the supply chain capabilities of Yunnan Province's fresh-cut flower business are affected by digital transformation. To collect data, the study employed a survey methodology based on a questionnaire. Ultimately, 402 flower businesses in Yunnan Province produced valid du-plicates. PLS-SEM was utilized in the study to evaluate the data, and the results showed that digital transformation greatly improved the enterprises' capacity for both innovation and supply chain management; innovation capabilities positively impacted supply chain capabilities and acted as a mediator in the relationship between supply chain capabilities and digital transformation. Furthermore, organizational readiness largely exhibits a positive moderating effect on the relationship between digital transformation and supply chain capabilities, whereas technology readiness not only fosters but also reinforces the relationship between digital transformation and innovation capabilities. These results offer an effective reference suggestion for fresh-cut flower companies in Yunnan Province and nationwide on how to enhance supply chain capabilities through digital transformation to improve their competitive advantages.

1. Introduction

Given how quickly information technology is developing, all industries around the world are experiencing a profound digital transformation. This transformation has not only changed the operation mode of enterprises but also had a profound impact on the entire supply chain ecosystem. Furthermore, digital technology utilization has become increasingly important for achieving sustainable growth and increasing competitiveness. The traditional supply chain of agricultural products suffers from broken information flow, slow response to demand, outstanding quality problems, a single marketing model, and high production and distribution costs, which have greatly weakened the supply chain capacity of agricultural products (Stone & Rahimifard, 2018). The "14th Five-Year Plan" for the growth of the digital economy was published by the Chinese State Council in 2022. The plan emphasizes the need to enhance the digitization of the entire industrial chain, particularly in the area of agriculture (Council, 2022). The agricultural supply chain's digital transformation eliminates information barriers between its various links by utilizing new information technology to support the chain's digital operation (Misra et al., 2020). It realizes the intelligentization of agricultural production, real-time information sharing, accurate supply and demand docking, and visualization of the supply process, which in turn improves the consumer contact rate and supply efficiency, as well as reduces the operational costs of agricultural products. While numerous studies have looked at the digital transformation of the manufacturing and service sectors, few have looked at the relationship between digital transformation and the supply chain of agricultural products. By examining the connection between Yunnan Province's fresh-cut flower supply chain and digital transformation, this article closes the current gap in the area.

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As a major producer of fresh-cut flowers, China's Yunnan Province, with its unique geographic location and climatic conditions, provides a unique advantage for the flower industry, making the region an important trading center for fresh-cut flowers in the country and even in Asia. As of 2022, in terms of planting area, production and output value, Yunnan Province's fresh-cut flowers have ranked first in China for 29 consecutive years. Fresh-cut flower production accounts for more than 70% of China's market share (Conference, 2024), and Yunnan Province has become the world's largest fresh-cut flower production area (Kong, 2024). The second-largest commercial hub in the globe and Asia at the moment is the Kunming Dounan Flower Market in Yunnan Province (Sun, 2022). However, under the global wave of digitization, floriculture enterprises in Yunnan Province are facing unprecedented challenges and opportunities. By using digital technologies, enterprises can collect and process information more efficiently to optimize decision-making processes and improve operational efficiency (Feng & Ali, 2024). A responsive and efficient supply chain system is especially important for products like fresh-cut flowers, which are highly dependent on timeliness and freshness. By implementing digital transformation, companies can not only better anticipate market demand and reduce inventory backlogs, but also ensure that every aspect of a product's journey from the field to the consumer's hand is accurately controlled, which in turn improves the overall supply chain's flexibility and reliability (Zaki, 2019). Therefore, the question of how to improve businesses' supply chain and innovation capacities using digital methods has emerged as a critical one. Investigating how digital transformation affects the supply chain capabilities of Yunnan Province's fresh-cut flower business was the aim of this study. The study also sought to investigate how innovative capabilities functioned as a mediator in this relationship. As a result, understanding how these contextual elements affect the outcomes of digital transformation is crucial. Good technical and organizational readiness is the cornerstone of the successful implementation of any change project, and it is especially critical when advancing large-scale digital transformation (Hanelt et al., 2021). Considering that differences in firms' technical readiness and organizational readiness may affect the effectiveness of digital transformation, this paper includes these two factors as moderating variables in the model. Technology readiness reflects an organization's existing IT infrastructure and level of technology adoption. On the other hand, organizational readiness covers aspects such as corporate culture, employee skills and internal collaboration. In addition, this study can offer useful reference recommendations to help fresh cut flower businesses in Yunnan Province and the surrounding area better adapt to the changes of the digital age.

2. Literature Review

2.1. Theoretical Background

2.1.1. Digital Transformation

The majority of previous research has taken a technological perspective on corporate digital transformation, defining it as the incorporation of digital technology into certain business sectors inside organizations. More recently, the term "digital transformation" has come to mean more than just using digital technology; it also refers to an organizational change process where companies use digital technologies, such as the IoT, big data, and AI, among others, to encourage improvements in their manufacturing methods and to develop new goods, services, and procedures (Yao et al., 2022). From a technological standpoint, enterprise digital transformation is the integration of digital technologies into an organization's business operations. “Digital transformation” refers to an organization's use of information technology in its production process (Zhao et al., 2022) and is described elsewhere to include embedded gadgets, social media, and mobile Internet in an organization's business improvement process (Adamczewski, 2019). Some scholars are beginning to examine the subject from the perspective of organizational change as the degree of integration between digital technology and the actual economy rises. The utilization of digital technologies is known as enterprise digital transformation., their integration with business management procedures, and the digitization of all enterprise links and components to facilitate the process of reorganizing and changing production methods and business processes (Gao, 2024). For fresh-cut flower companies in Yunnan Province, the consequences of using digital technology, are also evident in the organizational changes that lead to the digital transformation of fresh-cut flower companies. The Resource-Based View (RBV) holds that gaining a competitive edge requires an organization's resources and skills (Madhani, 2010). The RBV theory states that an organization's skills and assets can be separated into two categories: intangible resources and tangible assets. These resources and capabilities must have four characteristics: Value, Scarcity, Inimitability and Non-substitutability to become the core competence of an enterprise (Madhani, 2010). In this study, digital transformation is regarded as a scarce and hard-to-imitate resource that can bring unique competitive advantages to enterprises. By introducing advanced information technology, firms can improve their operational efficiency and service quality in several ways to stand out in a competitive market.

2.1.2. Innovation capabilities

Innovative capabilities are the capacity of a business to consistently create new goods, services, or processes (Migdadi, 2022). In a competitive market, these talents are critical for firms to stay ahead of the curve (Salunke et al., 2011). Innovative capabilities are not limited to technological innovation but also include various forms such as management innovation and service innovation (Hanaysha et al., 2022). Chen and others define a company's creative capabilities as its capacity to enhance its present methods of invention and production by successfully obtaining, assimilating, mastering, and applying knowledge and skills (S.-h. Chen et al., 2012). According to Rajapathirana and Hui, a company's capacity to consistently innovate to satisfy consumer expectations, turn a profit, and create new goods is known as its innovation capabilities (Rajapathirana & Hui, 2018). According to Knight, innovation capabilities are the organizational and coordinated ability of a firm to generate new ideas in conducting its production operations and to bring the products created from these new ideas to the marketplace (Knight & Cavusgil, 2004). The analysis of Teece's study on innovation capabilities also found that an organization can deploy and support the firm's innovation strategy in several ways. Teece's research analysis also found that it is some comprehensive characteristics that emerge in the process of deploying and supporting a firm's innovation strategy (Teece, 2010). According to Lin's study analysis, a company's capacity for innovation may also be thought of as a type of resource or attribute, including knowledge, technology, process, product, and organization (Lin, 2007). Product and organizational innovation capabilities are crucial parts of an organization's innovation capabilities, according to Najafi-Tavani and others. They are complementary and essential (Najafi-Tavani et al., 2018).

2.1.3. Supply chain capabilities

Supply chain capabilities are the capacity of a company or supply chain network to perform supply chain management activities in its particular context, including every phase of the process from acquiring raw materials to delivering finished items to customers (Hong et al., 2018). An organization's competitiveness in the market is determined by the effectiveness, responsiveness, and general performance of its supply chain, all of which are directly impacted by the strength of its capabilities. Enhancing supply chain skills has become essential for businesses to preserve their competitive advantages as globalization and digitalization trends intensify, posing previously unheard-of possibilities and challenges for supply chain management. The second-order construct known as supply chain capabilities is composed of four components: (i) coordination, (ii) information sharing, (iii) activity integration capabilities, and (iv) supply chain responsiveness (Wu et al., 2006). The fundamental elements of the supply chain process were thought to be represented by these four dimensions. Efficient supply chain management is particularly critical for perishable commodities such as fresh-cut flowers (Bockett, 2001). This study looked at how supply chain capabilities were affected by digital transformation and proposed supply chain capabilities as a second-order variable. Teece's dynamic capacities theory emphasizes how companies can keep innovating and reallocating their resources to stay competitive in a dynamic setting (Teece et al., 1997). The capacity to recognize and seize market opportunities, reorganize and integrate internal and external resources, and adapt and respond to environmental changes are examples of dynamic talents. In the cut flower industry, companies need to continuously adjust to market shifts in demand and optimize supply chain management through technological and management innovation. One of the key strategies for achieving these dynamic capacities is digital transformation. By establishing efficient information systems and data analytics platforms, companies can better predict market trends, optimize production planning, and improve the overall flexibility and responsiveness of their supply chains.

2.1.4. Technology readiness

In his research on e-services, Parasuraman coined the term "technology readiness" (TR), this characterizes people's tendency to accept and make use of new technology to achieve their objectives both at work and at home (Parasuraman, 2000). Technology readiness is not the ability to use a technology, but rather the acceptance of the technology, which is a combination of beliefs and feelings associated with the technology. According to Parasuraman, the degree of mental activity that people exhibit when they embrace new technology is referred to as technological readiness (Parasuraman & Colby, 2015). The degree of an organization's IT infrastructure at the moment and its adoption of new technological applications are referred to as technology readiness (Abdulnabi, 2024). Firms with good technology readiness are more likely to implement effective digitalization strategies (Jafari-Sadeghi et al., 2021). In addition, technology readiness relates to the awareness and support of digital tools within the organization (Lin et al., 2007).

2.1.5. Organizational readiness

Organizational readiness, which can also be referred to as organizational change readiness, is an important element in organizational change research. Organizational readiness (OR) encompasses some dimensions such as corporate culture, leadership style, employee skills, etc. (Samal, Patra, & Chatterjee, 2021). According to Weiner, organizational readiness is the members' ability and willingness to adapt to change to carry out an organizational transformation (Weiner, 2020). Alabdaly asserts that organizational preparedness, as demonstrated by members' level of motivation, is a complete indicator of their ability to accept and execute a particular change initiative (Alabdaly & Almayali, 2021). A company that is highly organizationally prepared is better equipped to handle the difficulties that come with change (Lehman, Greener, & Simpson, 2002). However, organizational preparedness also influences a company's capacity to successfully incorporate new technology into its day-to-day operations (Zhang, Sun, Yang, & Wang, 2020).

2.2. Hypothesis Development

2.2.1. Digital transformation and innovation capabilities

Digital transformation is achieved by deeply integrating digital technology with all aspects of businesses, which will bring significant development opportunities for enterprises, and act firstly on the innovation activities of enterprises (Han & Zheng, 2022). It is become the core force to promote enterprise innovation (Zhang, Wang, Xie, & Hu, 2024). In the transformation process, businesses employ sophisticated and established digital technologies to create intelligent goods and services, digitally convert existing products and services, speed up corporate product and service innovation, investigate new market prospects, and build new business initiatives. Businesses utilize digital technology to maximize the configuration and adjustment of their current material, financial, and human resources to completely realize their digital transformation. Additionally, they use it to promote innovation and change across the board, from management services to manufacturing and sales to product development. With this application of an enterprise digital strategy, the innovation ability is also significantly improved, It is because the digital economy has altered how businesses innovate (Li, Rao, & Wan, 2022). Digital transformation can improve an organization's capacity for technical innovation, which can also expedite information sharing inside the company and enable traditional manufacturing firms to adopt new technologies for intelligent manufacturing (Zhao, 2022). In addition to encouraging corporate technological innovation, the digital transformation of conventional sectors also modifies the organizational structure of innovation (Yang et al., 2022). Digitalization causes businesses' innovation methods to change, and digital transformation increases their ability to innovate while reducing their production costs (Y. Chen et al., 2021). The data given above make it clear that digital transformation fosters creative abilities. Therefore, the first hypothesis of this investigation is:

H$_1$: *Digital transformation has a positive impact on Innovation capabilities.*

2.2.2. Digital transformation and supply chain capabilities

As digital technology has grown, so too has the amount of study being done on digital technology in the supply chain domain. Gupta contended that by increasing supply chain efficiency, digitization can raise the precision of business decision-making (Gupta et al., 2021). They point that the addition of digitization can build a supply network, accomplish supply chain innovation and modernization, and encourage the business to increase its competitiveness and realize its value (Gupta et al., 2021). Wan et al. (2020) from the perspective of enterprise management, argued that the digital supply chain can be managed through innovative technology to achieve information sharing within the enterprise, which is more conducive to the production of high-quality products with a higher degree of coincidence with customer demand (Wan et al., 2020). According to Winter et al. (2023), SMEs should closely monitor upstream and downstream businesses and make use of their supply chains to meet their demands for digital transformation (Winter et al., 2023). Zhang and Deborah (2024) demonstrated through empirical research that digitalization can predict and analyze risks in the supply chain. It helps businesses increase their capacity to endure risk and assist them in judiciously avoiding it, and the supply chain operating environment is inversely proportional to the effect of risk avoidance. Zhu and others said that enterprises can build a digital platform to understand the supply chain online information and processes, have real-time mastery of the supply chain dynamics, avoid information bias, and ensure the quality of information and strategic direction, to accomplish the long-term growth of businesses (Zhu et al., 2018). The introduction of digitalization can transform and upgrade the supply chain system, and promote the traditional supply chain model to a more interconnected, fast and accurate digital model. A digitalized supply chain also facilitates the removal of communication barriers, lessens the adverse effects of information asymmetry, and makes it possible to adjust to changes in the outside world more quickly. In other words, digital transformation can enhance supply chain capabilities. Thus, the following is study hypothesis number two:

H$_2$: *Digital transformation has a positive impact on supply chain capabilities.*

2.2.3. Innovation capabilities and supply chain capabilities

Innovation Capabilities and Supply Chain Capabilities are two key elements in the competition of modern enterprises. In addition to helping businesses create new goods and services, innovation capabilities can assist them to manage and streamline internal procedures. The operational effectiveness and customer satisfaction of a business are directly impacted by supply chain capabilities, which encompass all phases of the process, from acquiring raw materials to delivering the finished product. Innovation capabilities are directly linked to improved supply chain performance, according to research findings. Firms that carry out research and development activities while fostering a continuous improvement culture are more likely to develop innovative solutions for specific supply chain challenges. For instance, innovations in cold chain logistics have been critical in maintaining quality and freshness during transportation within the fresh-cut flowers industry (Kumar & Anbanandam, 2019). Such improvements in temperature control systems help reduce spoilage thereby improving overall efficiency and reliability throughout entire supply chains. Additionally, innovation capabilities contribute towards ensuring agility and flexibility within a supply chain which is important given the highly volatile demand-supply conditions prevailing within the fresh-cut flower market. In addition, innovation capabilities can improve supply chain transparency and coordination through information sharing and system integration for mutual benefit. Song and Chen's research found that firms with high innovation capabilities usually have higher supply chain performance (Song & Chen, 2019). Pasupuleti and Malisetty's research shows that through continuous innovation and optimization, significant reductions in inventory costs and shortening of order fulfilment time have been achieved (Pasupuleti et al., 2024). Accordingly, companies with strong innovation capabilities exhibit greater adaptability and resilience in the face of market volatility and supply chain disruptions, and innovation capabilities can greatly increase the operational efficiency of supply chains. Consequently, one possible research hypothesis is as follows:

H$_3$: *Innovation capabilities have a positive impact on supply chain capabilities.*

2.2.4. Mediating role of innovation capabilities

The previous section of the paper discussed and analyzed the connections between supply chain capabilities and digital transformation, supply chain capabilities and innovation capabilities, and digital transformation and innovation capabilities. Furthermore, innovation capabilities in the supply chain context refer to the application of cutting-edge procedures and technology intended to boost productivity, lower expenses, and better satisfy consumer demands (Singhry, 2015). Digital transformation helps companies to better collect and analyze data by providing advanced data analysis tools and information systems. The supply chain's bottlenecks and areas for improvement can be found using this data, which can drive innovative activities. For instance, businesses can optimize inventory management and logistics arrangements to cut waste and boost efficiency by continuously monitoring inventory and transportation data (Pasupuleti et al., 2024). Innovation activities can, in turn, further enhance supply chain capabilities and enable more efficient operations. The data and information resources made available by digital transformation can assist businesses in recognizing and controlling supply chain risks more effectively. By developing new risk assessment tools and contingency plans, firms can react quickly in the face of unforeseen events and reduce loss (Organization, 2022). These risk management innovations increase supply chain agility and resilience, thereby enhancing supply chain capabilities. Digital transformation facilitates collaboration between companies and supply chain partners such as suppliers and distributors by providing collaborative work platforms and communication tools. By sharing knowledge and resources, all parties can work together to develop new solutions and increase the supply chain's overall efficiency (Qi, Wei, & Liu, 2022). These collaborations' creative endeavors contribute to enhancing the supply chain's overall capabilities. Digital transformation stimulates innovative thinking by providing advanced information technology and data analytics tools, which drive innovative activities in various areas such as process optimization, risk management, customer satisfaction improvement, partnership strengthening, and technology integration. These creative initiatives improve the overall performance, flexibility, and efficiency of the supply chain by converting the outcomes of the digital transformation into noticeable improvements in supply chain capabilities. In other words, innovation skills act as a bridge connecting digital transformation and supply chain capabilities. Consequently, the following study hypotheses are put forth:

H_4: *Innovation Capabilities significantly mediate the relationship between Digital Transformation and Supply Chain Capabilities.*

2.2.5. Moderating the role of technology readiness

Firms with high technological readiness typically have advanced information technology infrastructure and skilled technical personnel and can utilize digital tools and platforms more effectively for innovation activities. For example, these firms can identify new market opportunities and improve existing products through big data analytics and AI technologies (Caputo et al., 2019). Firms with high technological readiness can implement and integrate new digital systems more smoothly to optimize supply chain management. For instance, businesses can improve supply chain responsiveness and efficiency by managing inventories, logistics, and production planning more skillfully using real-time monitoring and data analytics (Oliveira-Dias et al., 2022). Technology readiness influences the function of innovative capabilities in improving supply chain capabilities in addition to the efficacy of digital transformation. Firms with high technological readiness are better able to apply innovations to supply chain management practices, such as by developing new logistics technologies and supply chain optimization algorithms to further improve supply chain flexibility and risk resistance (Khin & Ho, 2019). From this, hypotheses can be made:

H_5: *Technology Readiness significantly moderates the relationship between Digital Transformation and Innovation Capabilities.*

H_6: *Technology Readiness significantly moderates the relationship between Digital Transformation and Supply Chain Capabilities.*

2.2.6. Moderating the role of organizational readiness

Businesses with high organizational readiness typically have a culture that is open and creative, with management that embraces digital transformation and offers the required resources and assistance. Employees are more inclined to adopt new techniques and technology and take an active part in creative endeavors in this setting. For example, through training and development programs, employees can acquire new skills and tools that drive innovation in products and services (Lokuge et al., 2019). Organizationally prepared businesses are better equipped to handle the changes resulting from digital transformation, ensuring that new technologies and processes are implemented smoothly. For example, with clear change management plans and communication mechanisms, organizations can reduce employee resistance and increase their engagement and implementation (Konopik et al., 2022). In this case, digital transformation can more effectively optimize supply chain management and improve logistics efficiency, inventory control, and customer service. Organizational preparedness determines the function of innovation capabilities in improving supply chain capabilities in addition to the efficacy of digital transformation. In firms with high organizational readiness, innovations are more likely to be translated into practical supply chain improvements. For example, through cross-functional collaboration and knowledge sharing, firms can apply innovative thinking and technologies to supply chain management practices, develop new logistics solutions and optimization algorithms, and further improve supply chain flexibility and responsiveness (Mohamed, Stankosky, & Murray, 2004). Therefore, the research hypotheses can be listed:

H_7: *Organizational Readiness significantly moderates the relationship between Digital Transformation and Innovation Capabilities.*

H_8: *Organizational Readiness significantly moderates the relationship between Digital Transformation and Supply Chain Capabilities.*

The following conceptual framework (Fig. 1) is suggested by this study based on the previously indicated presumptions.

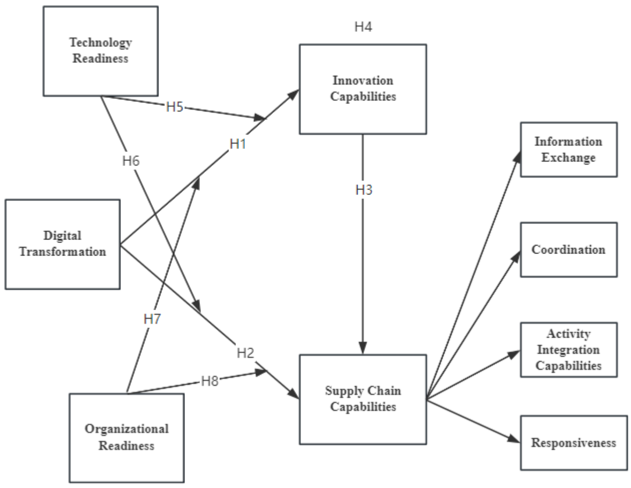

Fig. 1. Conceptual framework

3. Methodology

3.1. Measurement instrument

Data for this study were collected by questionnaires, and the sample was limited to the Yunnan Province of China. All scales were adopted from existing authoritative scales, and professionals were asked to carry out the steps of translating, back-translating, and re-testing before using them so that all the scales translated into Chinese could maintain willingness, clarity, and lack of ambiguity. Digital Transformation (DT) was referenced from Nasiri et al.'s (2020) and Zhang's (2022) research scale on digital transformation, with five measurement items. The measurement of innovation capabilities (IC) draws on the scales of Hong et al. (Hong et al., 2018) and Barreto et al. (Barreto, Freitas, & de Paula, 2024), with a total of 5 measurement items. Information exchange (IE), coordination (CO), activity integration capabilities (AIC), and supply chain responsiveness (RS) are the four first-order constructs that makeup supply chain capabilities (SCC), which is a second-order reflective construct. The PLS structural model becomes more succinct and less complicated when second-order factor modelling is constructed (Leguina, 2015). Supply chain competence draws on Wu et al.'s (2006) scale, which consists of four dimensions with 17 question items. The Technology Readiness (TR) measure was referenced from the scales of (Parasuraman & Colby, 2015) and (Blut & Wang, 2020) and consisted of 4 items. Organizational readiness (OR) draws on the 4-item scale of Kangdi Liu's (Liu, 2022) measure of a firm's organizational readiness. A seven-point Likert scale was used to score each signal, with 1 denoting “strongly disagree” and 7 denoting “strongly agree”.

Five academic supply chain management specialists and five cut flower industry professionals (with over 15 years of experience) were invited to examine the questionnaire before data collection to further improve the measuring technique. Some questions were reformulated to better fit the respondents' linguistic surroundings while maintaining willingness based on their ideas. To guarantee the data's correctness, 30 companies were handed the questionnaire for pre-testing. The questionnaire was optimized and revised through further testing and adjustment of the above scale to form a formal system of measurement indicators. As shown in Table 1.

Table 1
Constructs and items

Constructs	Indicator
Digital transformation (DT) Nasiri et al., 2020; Zhang, 2022	DT1: Our company is investing more in digital technology.
	DT2: Digital management procedures are introduced by our company.
	DT3: Our company is dedicated to gathering and keeping as much information as it can from every supply chain connection.
	DT4: Our firm is committed to building a more powerful supply chain digital management platform.
	DT5: Using sensors, the IoT, big data analysis, and other technologies, our company is dedicated to achieving real-time information monitoring and tracking in all supply chain linkages.
Innovation Capabilities (IC) Hong et al., 2018; Barreto et al., 2024	IC1: Our company can swiftly modify our technology, procedures, and goods to satisfy the demands of regional or local markets.
	IC2: As the environment evolves, our company may use new management techniques.
	IC3: To advertise our products, our company has embraced new marketing platforms.
	IC4: Our company can introduce new goods to the market.
	IC5: Our firm can quickly adapt to new technologies.

Table 1
Constructs and items (Continued)

Supply Chain Capabilities (SCC) Wu et al., 2006	IE1: its company communicates with its supply chain partners more frequently.
	IE2: Our business benefits more by exchanging information with our supply chain partners.
	IE3: Our company and supply chain partners can exchange information more easily.
	IE4: Accurate and timely information is shared with our supply chain partners.
	CO1: In comparison to rivals, our company coordinates with partners more effectively.
	CO2: Working with our supply chain partners helps our company do transaction follow-up tasks more effectively.
	CO3: Our business requires less time to set up transactions with partners than its competitors.
	CO4: Compared to our rivals, our company has cut coordination expenses more.
	AIC1: Standardization of data between our company and its partners.
	AIC2: Our business collaborates with partners to integrate information systems.
	AIC3: Consistency of data across our business and its partners.
	AIC4: To foresee and plan, our organization actively works with partners.
	RS1: Our supply network adapts rapidly to the shifting demands of our customers.
	RS2: Our supply network adapts well to shifting customer demands.
	RS3: Our supply network reacts swiftly to shifting tactics used by rivals.
	RS4: Because of our cooperative efforts, our supply chain is now more capable of adapting to changes in the market.
	RS5: Our supply chain can respond more quickly and effectively than our competitors to shifts in their strategic goals.
Technology Readiness (TR) Parasuraman & Colby, 2015; Blut & Wang, 2020	TR1: I feel as though technology has taken over my life and that I have no control over it.
	TR2: I am more of a thinking leader and technology pioneer.
	TR3: My mistrust of technology is a result of my uncertainties about its functionality and worries about its possibly negative effects.
	TR4: I see technology favorably and think it can improve people's lives by giving them more autonomy, flexibility, and efficiency.
Organizational Readiness (OR) Liu, 2022	OR1: Our firm believes that a particular change (such as digital technology) may improve the existing situation.
	OR2: When changes are needed, corporate management provides clear implementation plans.
	OR3: Companies encourage employees to discuss and independently learn applied technology.
	OR4: Most employees are willing to try new ideas and shift focus when necessary to adapt to new changes.

3.2. Sample and data collection

This study focuses on fresh-cut flower companies in Yunnan Province, China. As of 2021, there are 7950 flower enterprises in Yunnan Province (Cui et al., 2022). In this paper, Taro Yamane's table was used for sample selection. Taro Yamane explains an alternative to Cochran's method for calculating sample size from a population.

$$n = \frac{N}{1 + Ne^2}$$

N stands for population size, n for sample size, and e for accuracy level. Thus, with a precision(e) of 5%, by Taro Yamane's Sample Size Table. The sample size is 381 when p = 0.5 and a 95% confidence interval is used. A total of 420 questionnaires were distributed to fresh-cut flower enterprises in Yunnan Province using random sampling methods, including both online and offline methods. Among them, 412 questionnaires were retrieved, and after eliminating the questionnaires with obvious errors (e.g., incomplete data), the recovery percentage of valid questionnaires was 95.7%, and 402 valid questionnaires were kept.

3.3. Sample profile

The sample profile obtained from all valid surveys is shown in Table 2.

Table 2
Sample distribution (N=402)

Constructs	Categories	Frequency	Percentage (%)
Number of employees (company)	0-20	74	18.4
	21-50	158	39.3
	51-100	118	29.4
	>100	52	12.9
Annual sales (10,000 CNY) (company)	0-49	58	14.4
	50-499	154	38.3
	500-1999	116	28.9
	>=2000	74	18.4
Operation duration (years) (company)	0-5	80	19.9
	6-10	162	40.3
	11-15	98	24.4
	16-20	44	10.9
	> 20	18	4.5
Main Business (company)	Flower grower	84	20.9
	Distributor	147	36.6
	Wholesaler	116	28.9
	Retailer	55	13.7
Your position type	Producer	99	24.6
	Manager	115	28.6
	Technical staff	107	26.6
	Seller	81	20.1

The study contained 402 samples. The majority of the companies surveyed had between 21-50 employees (39.3%) and 51-100 employees (29.4%). Annual sales were basically in the range of 50-4.99 million yuan (38.3%) and 5-199.99 million yuan (28.9%). Operation duration was mainly in the range of 6-10 years (40.3%). The main business of the enterprises covers all the players in the fresh-cut flower supply chain enterprises in Yunnan Province: Flower grower (20.9%), Distributor (36.6%), Wholesaler (28.9%) and Retailer (13.7%). The types of jobs are also largely covered: Producer (24.6%), Manager (28.6%), Technical staff (26.6%), and Seller (20.1%).

3.4. Statistical analysis

The research model and hypotheses are tested in this study using PLS-SEM. PLS-SEM is better than other methods in some respects. First, the data does not have to have a normal distribution (Henseler et al., 2009). Second, because PLS-SEM optimizes the variance of the dependent variable and the quality of the data according to the characteristics of the measurement model, it can handle complex research models (Joseph F Hair et al., 2019). According to the features of the measurement model, it optimizes the dependent variable's variance and data quality, and the construct evaluation's nature is not overly constrictive (Joe F Hair et al., 2011). This study used a complicated research paradigm that included second-order components, moderators, and mediators. The two steps of PLS analysis are (1) evaluation of the measurement model and (2) evaluation of the structural model (Hou, 2020).

4. Results and findings

4.1. Evaluating the measurement model

The measurement model displayed in Fig. 2 is a graphical depiction of the data evaluated in this investigation using Smart PLS 4.0 software.

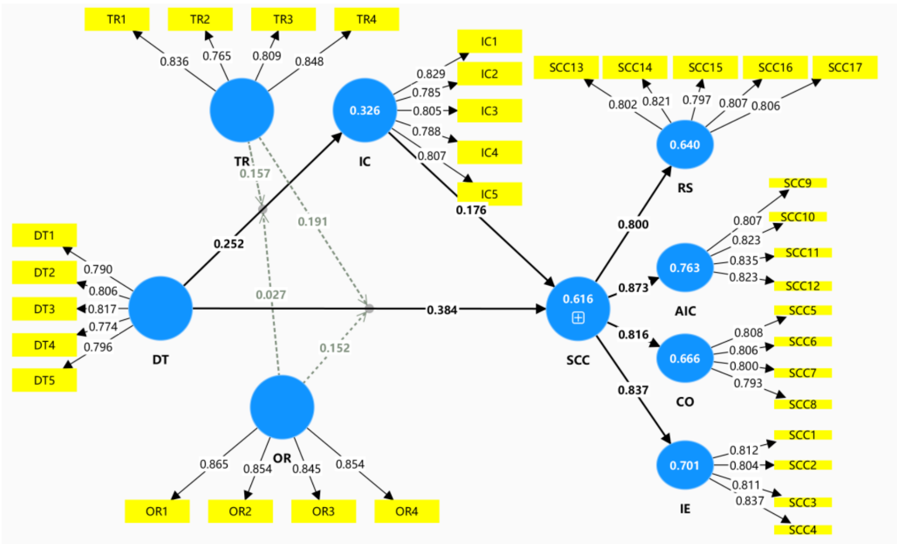

Fig. 2. Measurement Model (PLS Algorithm).

According to Fig. 2 and the report of the PLS Algorithm, this paper evaluates the measurement model through the following steps. The first step involves inspection indicator loadings. Loadings greater than 0.708 are recommended since they demonstrate that the construct explains over 50% of the indicator's volatility and offers sufficient item dependability (Joseph F Hair et al., 2019). The second step assesses the reliability of internal consistency. Composite reliability (CR), which is most frequently used, indicates "satisfactory to good" with values ranging from 0.7 to 0.9 (Drolet & Morrison, 2001). Another indicator of internal consistency dependability that makes similar assumptions is Cronbach's alpha. It needs to exceed the threshold of 0.7 (Joseph F Hair et al., 2019). Finding the average variance extracted (AVE) is the third step. This is determined by calculating the mean value after squaring the loading of each indication on a build. An acceptable AVE of 0.50 indicates that at least 50% of the variation in the construct's constituents can be explained (Joseph F Hair et al., 2019). The Cronbach's alpha and CR values in Table 3 range from 0.815 to 0.877, indicating sufficient internal consistency. The convergent validity of the sample is sufficient because all AVE > 0.5.

The evaluation of discriminant validity is the last phase. The Fornell Larcker criterion and the Heterotrait-Monotrait (HTMT) ratio were used to assess this work. Henseler's proposal for the HTMT ratio of correlations states that values below 0.85 or 0.9 are acceptable (Henseler, Ringle, & Sarstedt, 2015). In this paper, a more stringent value of 0.85 is used. All of the HTMT values are below 0.85, as Table 4 demonstrates.

Table 3
Reliability and convergent validity of the Measurement Model

Construct	Items	Loadings	Cronbach's a	CR	AVE
Digital Transformation (DT)	DT1	0.790	0.856	0.857	0.634
	DT2	0.806			
	DT3	0.817			
	DT4	0.774			
	DT5	0.796			
Innovation Capabilities (IC)	IC1	0.829	0.862	0.866	0.644
	IC2	0.785			
	IC3	0.805			
	IC4	0.788			
	IC5	0.807			
Supply Chain Capabilities (SCC) (Second-order construct)	Information Exchange	0.837	0.851	0.853	0.692
	Coordination	0.816			
	Activity Integration Capabilities	0.873			
	Responsiveness	0.800			
Information Exchange (IE)	IE1	0.812	0.833	0.833	0.666
	IE2	0.804			
	IE3	0.811			
	IE4	0.837			
Coordination (CO)	CO1	0.808	0.815	0.815	0.643
	CO2	0.806			
	CO3	0.800			
	CO4	0.793			
Activity Integration Capabilities (AIC)	AIC1	0.807	0.840	0.840	0.676
	AIC2	0.823			
	AIC3	0.835			
	AIC4	0.823			
Responsiveness (RS)	RS1	0.802	0.866	0.866	0.651
	RS2	0.821			
	RS3	0.797			
	RS4	0.807			
	RS5	0.806			
Technology Readiness (TR)	TR1	0.836	0.832	0.838	0.665
	TR2	0.765			
	TR3	0.809			
	TR4	0.848			
Organizational Readiness (OR)	OR1	0.865	0.877	0.877	0.73
	OR2	0.854			
	OR3	0.845			
	OR4	0.854			

Table 4
Discriminant Validity (HTMT Ratios).

	DT	IC	SCC	TR	OR
DT					
IC	0.482				
SCC	0.689	0.641			
TR	0.399	0.466	0.576		
OR	0.534	0.525	0.674	0.450	

* Note: Digital Transformation (DT); Innovation Capabilities (IC); Supply Chain Capabilities (SCC); Technology Readiness (TR); Organizational Readiness (OR).

To satisfy the Fornell Larcker criterion, its AVE needs to be greater than the correlation square of the other model structures (Sarstedt et al., 2020). Stated otherwise, the diagonal component of the square root of AVE in Table 5 should be greater than the non-diagonal component in the same column. The Fornell Larcker condition is met, as seen in Fig. 5.

Table 5
Fornell Larcker's discriminant validity criterion.

	DT	IC	SCC	TR	OR
DT	0.797				
IC	0.416	0.803			
SCC	0.588	0.553	0.832		
TR	0.463	0.46	0.583	0.854	
OR	0.338	0.397	0.488	0.387	0.815

* Note: Digital Transformation (DT); Innovation Capabilities (IC); Supply Chain Capabilities (SCC); Technology Readiness (TR); Organizational Readiness (OR).

It can be seen that both Tables 4 and 5 fulfil these two requirements, so the discriminant validity of the data is acceptable. In this case, Supply Chain Capabilities (SCC) are measured using the two-stage procedure (item packing method) for a second-order variable. (Sarstedt et al., 2019). Therefore, by assessing the measurement models mentioned before, it is shown that their corresponding subscales are highly acceptable.

4.2. Evaluating the Structural Model Analysis

4.2.1. Structural Model Validity Analysis

Before conducting research hypothesis testing, the structural model was assessed using the coefficient of determination (R^2), predictive relevance (Q^2) and effect size (f^2). The R^2 values of the endogenous variables were used to examine the sample predictive power, which has significant, moderate, and weak predictive accuracy shown by values of 0.75, 0.50, and 0.25, respectively (Joseph F Hair et al., 2019). According to Table 6, calculated by the PLS-SEM Algorithm, the supply chain capabilities (SCC) R^2 value is 0.616 which indicates medium prediction accuracy, however, the innovation capabilities (IC) R^2 value is 0.326 which indicates weak prediction accuracy. Nevertheless, the R^2 values for each latent variable were greater than the minimum acceptable value of 0.10 (Falk & Miller, 1992). Another method to assess the PLS path model's prediction accuracy is to find the Q^2 value (Geiser, 1974). When Q^2 values are higher than zero, the model is considered predictively relevant. (Hair Jr et al., 2021). The Q^2 of IC and SCC, as indicated in Table 6, are both greater than 0 (0.302 and 0.563, respectively), suggesting that the study model is capable of accurately predicting the correlation between variables.

Table 6
R-squared (R^2) and Predictive relevance Q-squared (Q^2).

Construct	R-square	Q-square
IC	0.326	0.302
SCC	0.616	0.563

The change in R^2 values when particular exogenous structures are removed from the model is displayed by the effect size (f^2). This indicator aids in determining whether the endogenous constructions are significantly impacted by the missing component. (El Hilali et al., 2020). F squared is classified as having a high effect size if it is larger than 0.35, a medium effect size if it is between 0.15 and 0.35, a small effect size if it is between 0.02 and 0.15, and no impact size if it is less than 0.02 (Cohen, 2013). As shown in Table 7, Innovation capabilities (IC) have a 0.054 contribution to the explanation of Supply Chain Capabilities (SCC) with a small influence effect. Digital Transformation (DT) has a 0.259 contribution to the explanation of SCC with a large influence effect, and DT has a 0.068 contribution to the explanation of IC with a small influence effect. In short, the f^2 values are all within the standard range, so the model has good explanatory ability. In summary, the model in this paper has good fitness and can be analyzed for subsequent hypothesis testing.

Table 7
Effect size f-squared (f^2).

Construct	SCC	IC	DT
SCC			
IC	0.054		
DT	0.259	0.068	

4.2.2. Research hypothesis testing analysis

This section describes the relationship between the study variables. After running 5000 subsamples using Smart PLS 4.0 for structural equation modelling applying the least squares algorithm Bootstrapping algorithm, Figure 3 displays the findings.

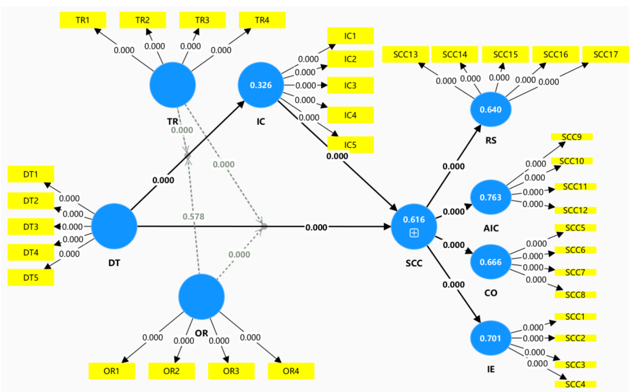

Fig. 3. Structural model (Bootstrapping)

The analysis was compiled to get these indicators to examine the direct relationship between the study's factors. The results are shown in Table 8.

Table 8
Analysing the Direct Relationship

Path	Original sample	Standard deviation	T statistics	P values	Results
H1: DT→IC	0.252	0.046	5.436	0.000	Supported
H2: DT→SCC	0.384	0.036	10.666	0.000	Supported
H3: IC→SCC	0.176	0.040	4.459	0.000	Supported

For H1, the original sample is 0.252, indicating that DT has a positive impact on IC. Taking into account the entire sample, it shows that a company is more inventive the more digitally transformed it is. The measure of dispersion is indicated by the standard deviation, which is 0.046. This suggests that, throughout the study's entire sample, innovation skills are positively impacted by changes in the firms' level of digital transformation. Furthermore, the T statistic is 5.436, above the 1.96 threshold level, and the P-value is 0.000, below the 0.05 cutoff. As a result, H1 is approved and the path is important.

Regarding the connection between Supply Chain Capabilities (SCC) and Digital Transformation (DT), consider H2. T-statistics are 10.666, the P-value is 0.000, the original sample is 0.384, and the standard deviation is 0.036, according to Table 8. It demonstrates that the two have a good friendship. It unequivocally demonstrates that supply chain capabilities increase with the level of digital transformation. As a result, digital transformation supports H2 and has a positive and significant impact on supply chain capabilities.

Supporting findings were also obtained from the analysis of H3, which examined the relationship between IC and SCC. The p-value is 0.000, the T statistics are 4.459, the standard deviation is 0.040, and the original sample size is 0.176. It implies that the stronger the innovation capabilities, the greater the impact on supply chain capabilities. As a result, H3 is supported and it is claimed that supply chain capabilities are positively and significantly impacted by innovation capabilities.

After examining the direct association between the study variables, the results of the investigation of the mediating influence of IC on the relationship between the DT and SCC are shown in Table 9.

Table 9
Mediation Results

Path	Original sample	Standard deviation	T statistics	P values	Results
H4: DT→IC→SCC	0.044	0.013	3.304	0.001	Supported

It is evident from Table 9's analysis results that H4's study hypothesis is sound. The standard deviation is 0.013 and the original sample is 0.044. These two scores offer a p-value of 0.001, that's below 0.05, and a T statistic of 3.304, which is greater than 1.96. This suggests that innovation capabilities (IC) act as a positive and important mediator in the relationship between DT and the SCC of fresh-cut flower businesses in Yunnan Province.

Following an analysis of the mediating effects, this study looks at how organizational readiness (OR) and technical readiness (TR) moderate the linkages between supply chain capabilities (SCC) digital transformation (DT) and innovation capacities (IC). The results in Table 10 are derived for this purpose.

Table 10
Moderating Effect Results

Path	Original sample	Standard deviation	T statistics	P values	Results
H5: TR × DT→ IC	0.157	0.041	3.877	0.000	Supported
H6: TR × DT → SCC	0.191	0.035	5.504	0.000	Supported
H7: OR × DT → IC	0.027	0.049	0.556	0.578	Not supported
H8: OR × DT → SCC	0.152	0.034	4.481	0.000	Supported

Firstly, the interaction term is generated by establishing the moderating relationship TR between DT, IC and SCC respectively. The original sample for H5 is 0.157, the standard deviation is 0.041, the T statistic is 3.877, and the p-value is zero, according to Table 10. By indicating that technological readiness has a favorable and noteworthy moderating influence on the relationship between Digital Transformation and Innovation Capabilities, this supports the research hypothesis of H5.

The results of the study then showed that the relationship between supply chain capabilities and digital transformation is positively and significantly moderated by technology readiness (Original sample: 0.191, Standard deviation: 0.035, T statistic: 5.504, P-value: 0). H6 The study's hypothesis is sound.

In addition, a moderating relationship Organizational Readiness (OR) was established between Digital Transformation (DT), Innovation Capabilities (IC) and Supply Chain Capabilities (SCC) to generate an interaction term. As shown in Table 10, where the original sample of H7 is 0.027 and the standard deviation is 0.049, organizational preparedness positively affects the association between digital transformation and innovation skills. However, the T statistic is 0.556, which is less than 1.96, and the P value is 0.578, which is greater than 0.05. Thus, organizational readiness has a favorable but not substantial moderating effect on the relationship between innovation capabilities and digital transformation. Consequently, H7 is not supported.

Finally, the moderating effect of organizational readiness on digital transformation and supply chain skills was examined. The T-statistic was 4.481, the P-value was 0, the standard deviation was 0.034, and the initial sample size was 0.152. As a result, H8 is encouraged and supply chain capabilities and digital transformation are positively and significantly moderated by organizational readiness.

5. Discussion

5.1. Discussion of results

This study uses an actual analysis of the fresh-cut flower industry in Yunnan Province, China, to demonstrate the substantial benefits of digital transformation on supply chain capabilities. In addition to helping businesses better collect and process information by providing advanced data analysis tools and information systems to expedite decision-making and increase operational efficiency, The results show that increasing supply chain dependability and flexibility is significantly aided by digital transformation.

The study's findings also demonstrate that supply chain capabilities are significantly enhanced by innovativeness. In particular, the capacity to innovate helps businesses create new goods and services while also streamlining internal procedures and management techniques. For perishable commodities such as cut flowers, efficient supply chain management is particularly critical. Innovation skills decrease product loss and increase the overall supply chain's efficiency and dependability by enhancing temperature control systems, cold chain logistics, and other technology. Furthermore, through information sharing, system integration, and other means, Innovative Capabilities enhance the supply chain's transparency and coordination while achieving the smooth integration of all its links.

By providing rich data resources and advanced information technology, digital transformation stimulates innovative thinking and promotes innovative activities in various aspects, such as process optimization, risk management, customer satisfaction enhancement, partnership strengthening and technology integration. Specifically, enterprises with high innovation capabilities are usually able to achieve significant reductions in inventory costs and order fulfilment times through continuous innovation and optimization, hence exhibiting increased flexibility and fortitude in the face of market instability and supply chain interruptions. The relationship between supply chain capabilities and digital transformation is significantly mediated by innovation capabilities.

Technology readiness greatly moderates favorably both the link between digital transformation and supply chain capabilities and the relationship between digital transformation and innovation capabilities. Firms with higher technology readiness typically have advanced information technology infrastructure and skilled technical talent and can more effectively utilize digital tools and platforms for innovation activities. These firms can identify new market opportunities and improve existing products through big data analytics and AI technologies, resulting in improved supply chain management and easier integration and deployment of new digital technologies.

While organizational preparedness does not significantly influence the association between supply chain capabilities and digital transformation is considerably positively moderated by the relationship between innovation capabilities and digital transformation. Firms with higher organizational readiness typically have stronger cultural adaptability and employee skills and can maintain a higher level of internal collaboration during the change process, thus better responding to the challenges posed by digital transformation. These organizations can integrate new technologies into their daily operations more effectively, improving the overall performance of their supply chains.

5.2. Practical implications

The study's conclusions have significant real-world ramifications for businesses and legislators. For enterprises, they should actively embrace digital transformation and enhance supply chain capabilities by introducing advanced digital technologies. At the same time, firms should emphasize the cultivation of innovation capabilities to improve supply chain flexibility and responsiveness through continuous innovation activities. To guarantee the successful execution of digital transformation, businesses should also improve the development of organizational and technological readiness. Legislators should enact pertinent laws and policies to assist businesses in their digital transformation, particularly in the agriculture industry, to advance the degree of digitalization throughout the entire industrial chain, and to raise the sustainability and competitiveness of the entire supply chain.

5.3. Limitations of the study

The data in this study are mainly from the fresh-cut flower industry in Yunnan Province, China, and may not be fully representative of the actual situation in other industries. Second, the dynamic process of change between supply chain capabilities and digital transformation was not captured by this study's use of cross-sectional data. For a more thorough grasp of the long-term link between these factors, future studies could think of utilizing longitudinal data. Lastly, Future studies could examine additional potential moderating factors, like corporate culture and leadership style, to enhance the pertinent theories and practices. The moderating impacts of organizational and technological readiness on the consequences of digital transformation were the main focus of this study.

6. Conclusion

This study demonstrates how supply chain capabilities are positively impacted by digital transformation and how innovation skills play a mediating role in this process through a thorough analysis of the fresh-cut flower industry in Yunnan Province, China. It has been discovered that digital transformation not only greatly enhances businesses' supply chain capabilities, but also amplifies this impact by encouraging creative endeavors. Particularly, digital transformation's cutting-edge technology and data resources encouraged businesses to improve internal procedures, strengthen their capacity for risk management, and raise customer satisfaction, all of which increased the overall flexibility and efficiency of the supply chain.

This study also looks at the moderating impacts of organizational and technological readiness in digital transformation. The results show that technical readiness considerably moderates in a positive way the relationship between digital transformation and supply chain capabilities as well as the relationship between digital transformation and innovation capabilities. This suggests that companies with more advanced infrastructure and technology can make better use of digital technologies to accomplish innovation objectives and improve supply chain performance. On the other hand, organizational readiness primarily acts as a moderator between supply chain capabilities and digital transformation, indicating that internal cooperation mechanisms, staff competencies, and company culture all play an equal part in the process of digital transformation.

In summary, digital transformation optimizes supply chain capabilities by enhancing innovation, while technological readiness and organizational readiness serve as moderating variables that further influence the effectiveness of this process. Future research may employ longitudinal data to look more closely at the long-term relationships between these variables. To offer more direction and suggestions for practice, it can also delve further into the particular difficulties and solutions encountered by various business types at various phases of the digital transformation process.

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