

A DELPHI-BASED INDEX SYSTEM FOR DIGITAL TRANSFORMATION CAPABILITY OF RETAILERS

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Abstract. Digital transformation capability (DTC), as an important capability to use digital technology to innovate business and management models, enables retailers reduce costs, and enhance production. It is the main driving force for restructuring the business ecosystem of retailers. To develop the DTC of retailers, an index system is required to provide capability standards. Hence, the construction of an index system for retailers' DTC is of important research value. However, there are few studies on the DTC of retailers, and no representative capability model or index system has been formed. Therefore, based on the definition of related concepts of DTC and literature review, this paper puts forward the research proposition of "index system for retailers' DTC", aiming to build an operable and applicable index system. According to the research process of the Delphi method, the present paper constructs an index system for retailers' DTC through two rounds of expert consultations. The proposed system consists of three primary indices (e.g., technological change capability), 11 secondary indices (e.g., digital infrastructure) and 41 tertiary indices (e.g., datacenter), offering a capability development standard for the digital transformation of retailers. The research results also provide a reference for the digital transformation of retailers in the real world.

Keywords: Delphi method, retailers, digitalization, digital transformation, digital transformation capability (DTC), index system.

JEL Classification: D21, M10, M21.

Introduction

As a new engine of economic development, the digital economy is kicking off the reconstruction of traditional industrial value chains and business ecosystems. Among the traditional industries, the retail industry takes the lead in digital transformation, due to the digitization

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of marketing. According to Alibaba's *Digital Trends Report 2019* (Alibaba Cloud Research Center, 2019), the digitalization rate of retail industry is expected to reach 70–80% in the next 3 to 5 years. The digital transformation of retailers has become a development trend. Nevertheless, the practice of digital transformation in the retail industry is confronted with difficulty for retailers to successfully complete the transformation, calling for immediate research efforts from the academia (Wang et al., 2020b). The digital transformation of retailers is faced with a series of obstacles (Wolski et al., 2020), as well as the digital trap. These factors could dampen the performance and hamper the development of digital transformation among retailers. Sailer et al. (2019) demonstrated that 60–85% of enterprises fail to achieve digital transformation. To effectively avoid the digital trap and overcome the aforesaid obstacles, it is of great significance to establish the DTC (Verhoef et al., 2021), which lies at the core of the digital transformation mechanism (Wang et al., 2020b). However, the current research has not well explained what specific indices are included in the DTC of retailers, and thus is unable to provide operational and applicable standards for the development of the retailers' DTC. As a result, it affects the formation of the retailers' DTC, and ultimately hinders the digital transformation practices of retailers. Based on this research background, this paper puts forward the research proposition of "index system for retailers' DTC".

The aim of this paper is to use the Delphi method to build a index system for DTC of retailers, so as to provide more operational and applicable standards for the development of the DTC of retailers, continuously improve the DTC of retailers, and effectively promote the digital transformation practice and sustainable development of retailers.

The remainder of this paper is organized as follows. Section 1 defines the relevant concepts of DTC. Section 2 conducts a literature review. Section 3 describes the choice of research methods and the research process. Section 4 is devoted to the presentation of empirical results. The fifth part is the discussion. Finally, the management implications and limitations of this study are presented in the last section. It also provides suggestions for future research.

1. Concept definition

Digitalization was conceptualized by Wilhelm in 1703. However, digital transformation has not attracted much attention from researchers until the early 21st century (Khin & Ho, 2019). Since then, the relevant research has continued to increase, and the definitions of concepts related to DTC have also been formed (Table 1).

Although existing researches have defined concepts related to digital transformation capability, no consensus have been reached, therefore, further clarification are necessary (Aguilar et al., 2019). According to the above literature, we can find that digitization, digitalization, digital transformation, digital capability and digital transformation capability (DTC) are closely related in concept, but there are also differences.

Digitization is the process of converting information into digital format based on informatization, whose essence is the process of realizing digital form, so it is also called "digital implementation". Strictly speaking, digitization provides technical preparations for digitalization and digital transformation, which is not digitalization per se. And digitalization, a progression of digitization, refers to the process of transforming specific business processes

Table 1. Definitions of concepts related to digital transformation capability (DTC)

Concept	Definition
Digitization	The process of encoding analog information into digital format so that computers can store, process, and transmit the information (Dougherty & Dunne, 2012; Loebbecke & Picot, 2015)
Digitalization	Leveraging digital technology to change existing business processes and realization of business digitalization (Li et al., 2016), involving changes in business links such as communication channels and customer interaction methods (Ramaswamy & Ozcan, 2016)
Digital Capability (DC)	The ability to use digital technology to reform business processes (Khin & Ho, 2019)
Digital Transformation (DT)	The process of utilizing SMACIT (Social, Mobile, Analytics, Cloud, Internet of Things) (Sebastian et al., 2017) digital technology to develop technological innovation and transformations in business model, organizational management and other aspects to improve digital performance (Aguiar et al., 2019)
Digital Transformation Capability (DTC)	The capability of an organization to purposefully create, extend, or modify its resources base to become data-driven, in the sense of using data as critical evidence to help inform and influence strategy (Li et al., 2018)

by digital technology, thus different notions are represented by digitization and digitalization (Wang et al., 2021). Although the focus of digitalization is limited to specific business processes, it marks the official start of the digitalization process of enterprises. Digital capability is the ability to use digital technology to transform business processes. It is a kind of capability corresponding to digitalization. The essence of it is a digital technology skill and a dynamic capability (DC) (Teece, 2013), which may include the capability of information management, flexible development and use of IT infrastructure, etc. (Levallet & Chan, 2018).

Digital transformation refers to the process of taking full advantage of various digital technologies to carry out changes and innovations in different aspects such as specific business, business models and organizational forms, which essentially is a kind of social technological transformation (Schuh et al., 2017), as well as a manifestation of the deep integration of new generation of digital technology and the real economy (Xiao, 2020). It contains both “digitization” and “transformation” (Gebayew et al., 2018), which is a manifestation of the process of digital innovation and its subsequent impact (Bounfour, 2016). Its research perspective has shifted from digital technology to organizational change (Ilvonen et al., 2018; Hu, 2020), which is a kind of cross-system change, involving dimensions of strategy, organization, and information technology, etc. (Verhoef et al., 2021). Compared with digitalization, digital transformation involves a wider range, more content, and a deeper extent. While the digital transformation capability (DTC) is the ability to use digital technology to create, innovate or change organizational resources, business models, and management models purposefully, whose essence is the ability to execute digital strategies according to changes in the digital environment (Warner & Wager, 2019). Digital transformation capability (DTC) is a kind of dynamic management capability (DMC) (Anim-Yeboah et al., 2020) presented in digital transformation, which includes not only technical capability, but also multi-dimensional capability such as organization and management changes (Vial, 2019; Chen & Xu, 2020).

2. Literature review

2.1. Corporate digital transformation

Digital transformation is a complex and challenging process (Hess et al., 2016). It will face more problems than other organizational changes. Therefore, digital transformation can be more difficult to achieve (Sousa-Zomer et al., 2020). In the face of these problems, many studies have been conducted uninterruptedly at home and abroad, and formed certain results. Based on the literature review, this paper mainly refer to the three-stage theory of digital transformation proposed by Verhoef et al. (2021), the four-stage theory of digital transformation research proposed by Li and Liang (2020), and the review of digital transformation research methods carried out by Gebayew et al. (2018), sorts out the research thread and main results of corporate digital transformation from four aspects: research perspective, research content, research object and research method (Figure 1).

On research perspective, the research of the internal logic (mechanism) of corporate digital transformation develops through the following stages: technological application (Lee et al., 2015), innovation integration (Hinings et al., 2018), organizational restructuring (Vial, 2019), and cross-system change (Li & Liang, 2020; Verhoef et al., 2021). The evolution of the research perspective can be divided into three phases: demand-centered digitization 1.0, supply-centered digitization 2.0, and commercial ecosystem-centered digitization 3.0 (Li et al., 2020). The three-phase evolution reflects the transformation of enterprises from technological application to digital empowerment during the digitalization practice.

The shift of research perspective into corporate digital transformation is accompanied by the changes of research contents. The focus of research contents has been moving from digitization, digitalization, to digital transformation (Verhoef et al., 2021). In the phase of digitization, researchers emphasized on information technology (IT) development, technology-driven corporate value creation (Gölzer & Fritzsche, 2017), and agility (Lucas et al., 2013). The capability required for digitalization is mainly IT skills (Dibia et al., 2014). In the phase of digitalization, researchers attached much importance to digital infrastructure, business processes, digital innovation (Lyytinen et al., 2016), and digital maturity (Solis, 2017; Ramantoko et al., 2018). The capability required for digitalization is digital capability, a dynamic capability (DC) reflecting the ability of an enterprise to handle environmental changes with digital technology. In the phase of digital transformation, researchers took digital platforms into consideration, and proposed the basic conditions for digitization: social, mobile, analytics, cloud and Internet of things, and platform and ecosystems (SMAIP). Moreover, the reform of digital business flows was extended to organizational structure, and business model changes. In addition, the focus of digital transformation was placed on changing organizational management, apart from pure technological application and revolution (Cenamor et al., 2019).

With the evolution of research perspective and contents, the research objects have also changed. In the beginning, researchers stressed the key individuals or groups from the perspective of technology applications, namely, the digital consumers, transformational leadership (Dibia et al., 2014), and digital qualities of entrepreneurs (Li et al., 2018), all of which

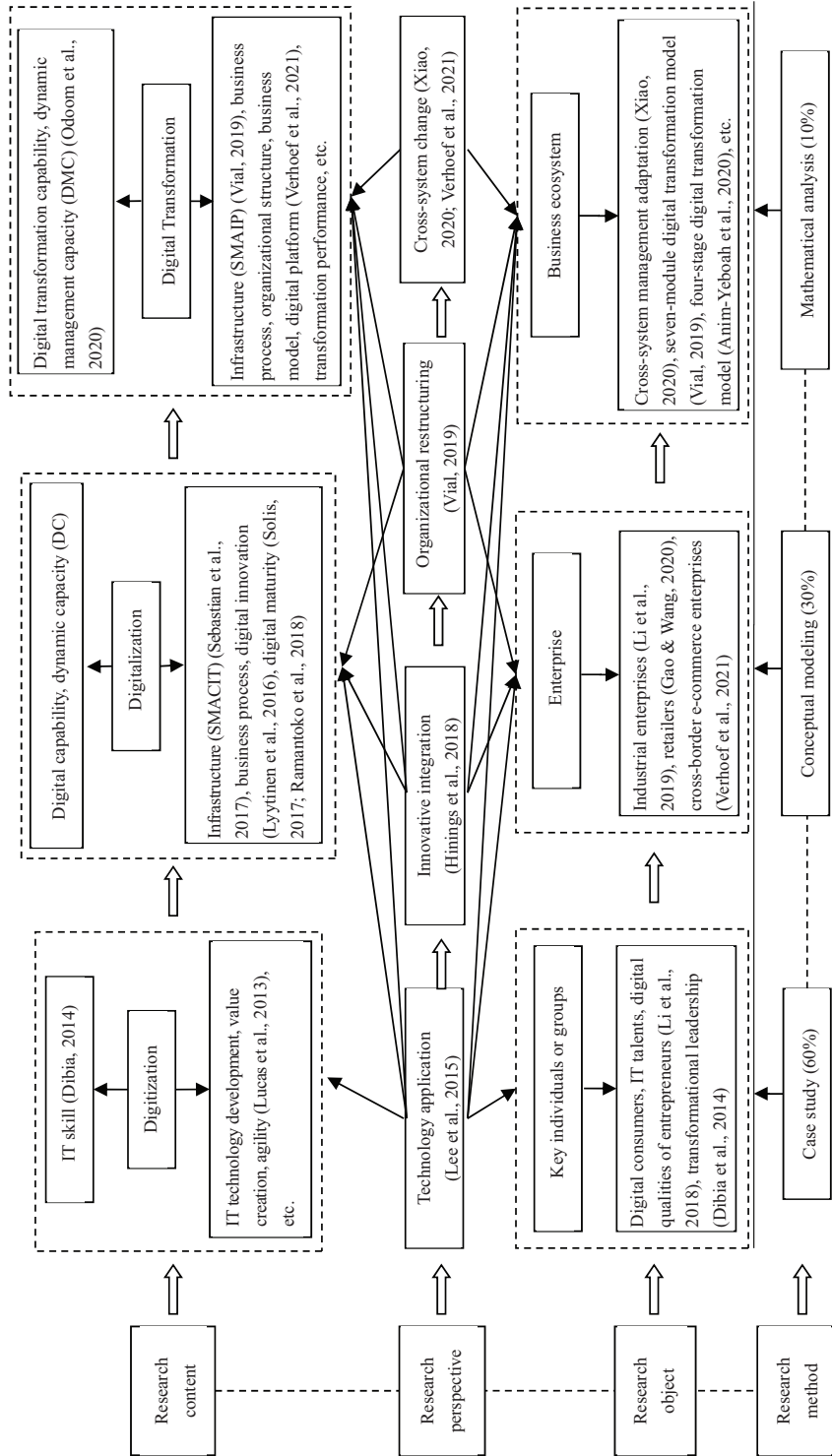


Figure 1. The research thread and results of corporate digital transformation (source: The figure mainly referred to the three-stage theory of digital transformation proposed by Verhoef et al. (2021), the four-stage theory of digital transformation research proposed by Li and Liang (2020), and the review of digital transformation research methods carried out by Gebayew et al. (2018))

contribute to the application of digital technologies. Later, researchers extended their attention to enterprises and commercial ecosystem. On the level of enterprises, the objects were mostly the digital operation and management changes of entire organizations. The digitalization and transformation of specific enterprises were also studied, such as industrial enterprises (Li et al., 2019), retailers (Gao & Wang, 2020), and cross-border e-commerce enterprises (Verhoef et al., 2021). On the level of commercial ecosystem, corporate digitalization and transformation were discussed from the broader perspective of commercial value system, breaking away from the hierarchical architecture of enterprises. For example, Xiao (2020) probed into the digital transformation and management adaptation of enterprises across systems. Vial (2019) and Anim-Yeboah et al. (2020) developed digital transformation models.

When it comes to research methods, most foreign studies on corporate digital transformation are case studies (60%), followed by conceptual modeling (30%), and mathematical analysis (10%) (Gebayew et al., 2018). As the relevant research goes deeper, more and more scholars are resorting to theoretical derivation, model construction, and mathematical analysis. Comparatively, fewer researchers still stick to phenomenon description and empirical summary by case studies. This means the research of corporate digital transformation is moving from superficial factual statement to in-depth verification of internal mechanism and logic, revealing the significance of theoretical refining, promotion, and application.

2.2. Corporate DTC model

International Data Corporation (IDC) demonstrated that 78% of all respondents consider capability limit as the main obstacle of corporate digital transformation, highlighting the importance of releasing corporate DTC (Gao et al., 2020). As a result, more and more experts and scholars have turned their attention to corporate DTC, and achieved fruitful research results. Corresponding to the three phases of corporate digital transformation (Figure 1), the research of corporate DTC can be divided into three phases: IT skills, digital capability, and DTC.

In the first phase (IT skills) (2011–2014), the research focus lies in the capability of enterprises to develop IT-based products or services to meet business needs (Lu & Ramamurthy, 2011). That is, corporate digitization was investigated from the angle of technological development. In the second phase (digital capability) (2015–2018), the research focus lies in the capability of enterprises to change business flows with digital technology at the core, i.e., the dynamic capability of enterprises in the face of digital changes. In the third phase (DTC) (2019–), the research focus lies in the capability of enterprises to utilize digital technology to purposefully create, innovate, or reform organization resources, business model, and management model, which are the key capabilities in the digital age (Sousa-Zomer et al., 2020). Just because of this, DTC is the focus of current research at home and abroad, and it is also the capability category that this research focuses on. After more than three years of research, some representative corporate DTC models have been formed (Table 2).

Table 2. Representative models for the corporate DTC

Researcher	Model	Description
Vial (2019)	Strategic response, digital technology application, structural change, and value creation path change	DTC was proposed from the perspective of digital transformation process, but specific indices have not yet been constructed.
Chen (2019)	Dual business models, firm leaders, right people, open organizations, technology penetration, and collaborative symbiosis culture	A six-dimensional capability system was proposed, but the definitions of capabilities were unclear and there were no specific indices.
Wolski et al. (2020)	Basic technical capability, information management capability, analytical techniques, process agility, and governance maturity	Focusing on digital capabilities rather than DTC.
Gao et al. (2020)	Exploratory capability: product market exploration capability, technology exploration capability, scientific exploration capability Development capability: product market development capability, technological development capability, and scientific development capability	The DTC model was proposed from the perspective of inter-organizational duality, but the definitions of these capabilities were very abstract and lacked index system.
Fahmi et al. (2020)	Technical capability, process or systematization capability, employee or talent capability, digital literacy, and organizational culture	The digital talent capability model was proposed instead of the DTC model, and there was no specific index system.
Gao and Wang (2020)	Digitalization (core process digitalization, omni-channel touchpoints, digital supply chain, etc.), transformation management (transformation strategy, leadership), transformation support (digital platform operation, personnel digital gene cultivation, ecosystem construction)	The digital transformation maturity model was built.
Li et al. (2020)	Smart supply chain systems, data resources and digital analysis capability, organizational changes, business process reengineering, and digital platforms	The digital capability model was proposed from the perspective of digital business system, but there was no clear concept definition and index system.
Xu (2020)	Product technology innovation, organizational management innovation, and business model innovation	Through literature review, three capabilities of digital transformation were summarized. However, the capability system was incomplete.
Chen and Xu (2020)	Technological changes(digital infrastructure, digital investment, etc.), organizational changes (organizational structure, digital talents), and management changes (digital business management, digital production management, and digital financial management)	The proposed DTC model was relatively complete and of strong internal logic, but it was suitable for manufacturing enterprises.
Liu and Chang (2020)	Collaborative innovation, omni-channel experience, seamless security, digital foundation, employee empowerment, etc.	What it proposed was a digital capability model, which did not distinguish the differences between digital capability and DTC.

End of Table 2

Researcher	Model	Description
Xia and Dang (2020)	Perception capability (technical innovation capability, product innovation capability), acquisition capability (marketing capability, relationship capability), and transformation capability (management innovation capability, business model innovation capability)	Based on the perspective of dynamic capability, a DTC model was proposed, but the research system was not complete.
Wang et al. (2020a)	Strategy and organization, digital foundation, digital technology application, business integration, enterprise comprehensive integration, industrial collaborative innovation, benefits and effectiveness	The proposed DTC model and index system were suitable for manufacturing enterprises.
Wang et al. (2020b)	Digital infrastructure capability, digital governance capability, capability to bridge gaps and traps, digital consumer value creation capability, value creation capability based on digital production elements, and value creation capability based on digital ecology	It was a case study, so the proposed DTC model did not have strong application value.
Wang et al. (2021)	Digital readiness (strategy and organization, infrastructure), digital intensity (digitalization of business process and management, comprehensive integration), digital contribution (digital performance)	The research proposed the enterprise digital maturity index system.
Verhoef et al. (2021)	Digital assets (digital infrastructure), digital agility, digital network capability, and big data analysis capability	Based on the literature, the DTC model was summarized, but there were no specific indices.

In summary, an important topic of digital research is the corporate digital transformation from the perspective of business ecosystem. The relevant studies mainly focus on corporate DTC, which drives corporate digital transformation. After going through the IT skills phase and digital capability phase, corporate DTC has reached a deep-water zone (i.e., model design), yielding the above-mentioned representative models. These studies aim to build the corporate DTC in multiple dimensions, which have promoted the progress of research in this field to a certain extent, but still have the following three limitations. First, these researches is basically at the stage of model design, lacking an executable index system, which affect the practical application of enterprises. Second, these researches have not taken into account the differences in DTC between different industries and enterprises. Such researches would be relatively general and lack of segmentation, affecting the pertinence and effectiveness of the model. Third, there are few studies on the DTC model of retailers, and neither is there any index system worthy of promotion and application. Based on this research background, this paper focuses on the pioneers of digital transformation practices, namely retailers, and conducts research on DTC. It is expected to improve and enrich the existing research and promote the practice of retailers’ digital transformation, through the development of DTC model and the index system.

3. Methodology

3.1. Method selection

So far, not many scholars have studied the digital transformation of retailers. There is not yet an agreement on the index system for retailers' DTC. Hence, no research result at home and abroad can be directly referred to in this research. Under such a research background, this paper aims to construct a DTC index system for retailers based on the Delphi method.

The Delphi method is a qualitative approach involving multiple iterations, which aims to convert opinions into group consensus (Hasson et al., 2000; Shariff, 2015; McPherson et al., 2018; Barrios et al., 2021). It is especially suitable for exploring the issues lacking observational/empirical knowledge or consensus (Skulmoski et al., 2007; Keeney et al., 2011; Barrios et al., 2021). The application scope of the Delphi method has gradually been extended from military to business, and the relevant research has evolved from pure prediction to the design of models and index systems. For example, Fallah and Ocampo (2021) developed a sustainability standard and an index system for eco-tourism management. To sum up, the Delphi method provides an effective, scientific tool for deriving the model and index system for retailers' DTC, an issue without any consensus yet. Based on the Delphi method, the collected data were statistically analyzed on Excel and SPSS 23.0. The judgement methods of the data analysis are summarized in Table 3.

Table 3. Contents and judgment methods of data analysis

Dimension	Analysis content	Judgment method
About the experts	Expert activity	Expert activity coefficient (EAC)
	Expert authority	Expert authority coefficient, $C_r = (C_a + C_s) / 2$
	Coordination of expert comments	Coefficient of variation (CV), Kendall's coefficient of concordance W (Kendall's W)
	Concentration (consistency) of expert comments	Mean, full score frequency
About the index system	Index deletion, addition or partial adjustment	Boundary value method, expert suggestion

- (1) Expert activity. Expert activity was measured by expert activity coefficient (EAC), i.e., the recovery rate of questionnaires: (the number of experts responding to the survey / the number of experts being invited) \times 100%. $EAC > 50\%$ is the basic condition for analysis and reporting. If $EAC > 60\%$, the expert is highly active; if $EAC > 70\%$, the expert is very highly active. Studies have shown that $EAC > 70\%$ is generally recommended for expert consultation of the Delphi method.
- (2) Expert authority. Expert authority was measured by expert authority coefficient C_r : (judgement basis coefficient C_a + expert familiarity coefficient C_s) / 2. The measurement is mainly realized through self-evaluation. The C_a value was calculated based on the values listed in Table 4; the C_s was calculated based on the values assigned to expert familiarity. If $C_r > 0.7$, then the experts are highly authoritative (Wang et al., 2021).

Table 4. Assignment of expert judgment basis (Jiang et al., 2021)

Basis for judgment	The degree of influence on the experts' judgment		
	High	Medium	Low
Experience	0.5	0.4	0.3
Theoretical analysis	0.3	0.2	0.1
Understanding of domestic and foreign counterparts	0.1	0.1	0.05
Intuitive choice	0.1	0.1	0.05

- (3) Coordination of expert comments. The coordination of expert comments was measured by the coefficient of variation (CV) of expert scores on index reasonability, and Kendall's W. The CV = the standard deviation of scores / the mean of scores. The smaller the CV, the more coordinated the expert comments. It is generally required that CV should be smaller than 0.25. The Kendall's W reflects the consistency between the comments of different experts. If W is greater than 0.3, then the expert comments tend to be consistent.
- (4) Concentration (consistency) of expert comments. The concentration (consistency) of expert comments was measured by the mean and full score frequency. The mean is the average of recognition of index reasonability among experts. The greater the mean, the stronger the expert recognition. The full score frequency refers to the degree of strong recognition of index reasonability among experts. It can be calculated by dividing the number of experts considering an index as strongly reasonable with the total number of experts participating in the evaluation. The closer the frequency is to 1, the higher the expert recognition of the index.
- (5) Boundary value method for index adjustment. To improve the scientific nature of the study, this paper screens the indices by the boundary value method, referring to the method of Wang et al. (2021). The boundary value method mainly analyzes the bounds of mean, full score frequency, and CV. Two bounds were defined for high and low optimal indices, respectively. The high optimal index bound = mean – standard deviation. Any index with a score lower than that bound was eliminated. The low optimal index bound = mean + standard deviation. Any index with a score higher than that bound was eliminated. Specifically, mean and full score frequency are high optimal indices, while the CV is a low optimal index. For the stringency of the research, an index was not deleted, unless it did not meet the bound requirements for all three dimensions, i.e., the mean, full score frequency, and CV. The indices failing to meet the requirements in some dimensions were adjusted after consulting the experts.

3.2. Research process

More than 50 years ago, RAND Corporation invented the Delphi method for investigation. Since then, this strategy has been improved continuously. Drawing on the ideas of Hasson et al. (2000), Shariff (2015), and Haven et al. (2020), the research team designed the key

process of Delphi method for this research (Figure 2), which covers research preparation, multiple rounds of consultations, results sorting, and consensus making. Expert selection and consultation are the key steps of the Delphi method (McPherson et al., 2018). Therefore, this paper mainly details these two steps.

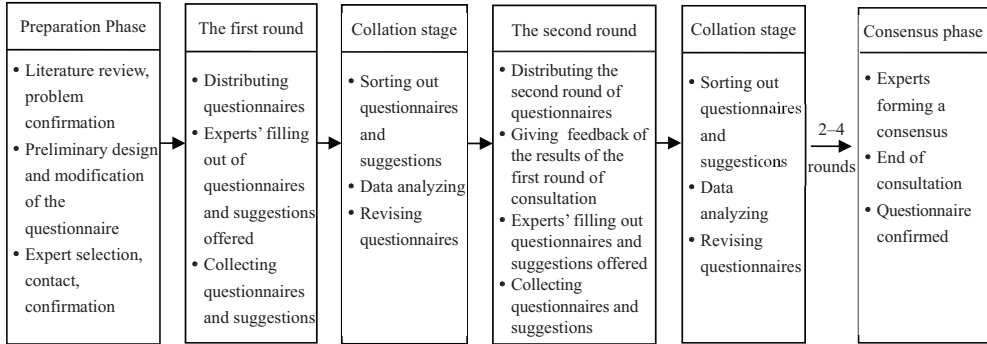


Figure 2. The key process of Delphi survey (source: Hasson et al., 2000; Shariff, 2015; Haven et al., 2020, etc.)

3.2.1. Expert selection

Currently, there is no clear suggestion on how many experts should be selected for the Delphi method. The number of experts essentially depends on the problem being surveyed (Shariff, 2015). Some scholars selected 60 experts (Alexander & Kroposki, 1999), while others only selected 15 experts (Fiander & Burns, 1998). Villiers et al. (2005) suggested determining the number of experts according to the homogeneity/heterogeneity of samples. If the samples come from the same discipline, it is recommended to choose 15–30 experts; if the samples belong to different disciplines, it is recommended to choose 5–10 experts.

Inspired by these studies, this paper adopts the purposive sampling approach, which is commonly employed for the Delphi method (McPherson et al., 2018). A total of 30 experts were selected for consultation. Half of them are practitioners from enterprises in retail, e-commerce, marketing, information, or digitalization. The other half are scholars from colleges or scientific institutions.

The practitioners meet the following criteria: working at least three years at relevant posts in retail, e-commerce, marketing, information, or digitalization; insightful about and supportive of corporate digital transformation; experienced in digital management of enterprises; willing to participate in this research. The scholars meet the following criteria: having published 2 or more theses or reports on digital transformation, with a certain academic attainment in that field; engaging in the research of digital transformation for at least 3 consecutive years; holding intermediate or higher professional titles; willing to participate in this research.

3.2.2. Expert consultation

Firstly, expert support was solicited by face-to-face or telephone interview. Next, the Likert scale, a popular tool for the Delphi method, was selected to consult the experts one by one

via email or WeChat. Our questionnaire encompasses an introduction, the basic information of experts, index reasonability evaluation (including index definition), suggestions, expert familiarity, and judgement bases.

Expert familiarity was valued by the following criteria: 1 for strongly familiar, 0.8 for slightly familiar, 0.6 for neutral, 0.4 for slightly unfamiliar, and 0.2 for strongly unfamiliar. The judgement bases and their degrees of influence are quantified in Table 4.

The reasonability of each index was evaluated by the five-point Likert scale: 5 for strongly reasonable, 4 for slightly reasonable, 3 for neutral, 2 for slightly unreasonable, and 1 for strongly unreasonable. The first and second rounds of consultation were carried out among the 30 selected experts in July and September, 2021, respectively. The survey was wrapped up after the second round, because the Kendall’s coefficient of concordance (W) surpassed 0.3 and concentrated obviously (a sign of good consistency).

4. Results

4.1. Design of model and questionnaire

According to the research process of the Delphi method, preliminary design of model and questionnaire are required in the preparation stage. Since there is no direct reference to the DTC model of retailers, this study will mainly draw on the three-order DTC model proposed by Chen and Xu (2020), which includes three dimensions: technological change, organizational change, and management change. On this basis, this study preliminarily designs a DTC model of retailers (Table 5) based on the relevant literature listed in Table 2.

Table 5. The DTC model of retailers (source: Chen & Xu, 2020; Verhoef et al., 2021, etc.)

Construct	Sources	Dimensions	Sources
Technological change capability	Dibia et al. (2014), Chen and Xu (2020), Wolski et al. (2020), Xia and Dang (2020)	Digital infrastructure	Chen and Xu (2020), Verhoef et al. (2021), Wang et al. (2021)
		Digital R & D	Sebastian et al. (2017), Chen and Xu (2020)
		Digital input	Aguiar et al. (2019), Chen and Xu (2020)
Strategic and organizational change capability	Vial (2019), Chen and Xu (2020), Wang et al. (2020a), Xu (2020), Gao and Wang (2020)	Digital strategy	Warner and Wager (2019), Gao and Wang (2020)
		The agility of organizational structure	Dibia et al. (2014), Xia and Dang (2020), Verhoef et al. (2021)
		Digital platform	Gao and Wang (2020), Verhoef et al. (2021)
		Digital talent	Liu and Chang (2020), Fahmi et al. (2020), Chen and Xu (2020)
		Digital culture	Chen (2019), Fahmi et al. (2020)

End of Table 5

Construct	Sources	Dimensions	Sources
Management change capability	Levallet and Chan (2018), Chen and Xu (2020), Wolski et al. (2020) Wang et al. (2021)	Digital management of business processes	Gao and Wang (2020), Fahmi et al. (2020), Li et al. (2020), Chen and Xu (2020), Liu and Chang (2020), Wang et al. (2020a)
		Digital consumer management	Wang et al. (2020b)
		Digital financial management	Chen and Xu (2020)

Subsequently, the researchers conducted a 3-month survey and interview with retailers, aiming to initially design an index system based on the DTC model. The researchers surveyed multiple retailers across China, including the Digital Development Division of Zhejiang China Commodity City Group Co.,Ltd., ICMall (Imported Commodities Mall), Taobao, and Tmall. In addition, interviews were held on experts of e-commerce, business data analysis, and digital marketing. The surveys and interviews consist of two aspects: open interviews on the theme of “digital transformation of retailers”; semi-structured interviews about the theme of “index system for DTC of retailers”, combined with the DTC model of retailers initially developed by the researchers. Through the above-mentioned literature research and survey, this paper has preliminarily completed the design of the DTC index system of retailers, which includes 3 primary indices, 11 secondary indices, and 43 tertiary indices, thus forming a pilot questionnaire for the follow-up Delphi qualitative study.

4.2. Basic information of experts

Depending on the criteria of expert selection, this paper chooses a total of 30 experts for consultation. The basic information of these experts is listed in Table 6.

Table 6. Basic information of experts

Personal Profile	Grouping	Frequency	Composition ratio (%)	Personal Profile	Grouping	Frequency	Composition ratio (%)
Education Background	Undergraduate	10	33.3	Technical skill level	Primary	5	16.7
	Master	14	46.7		Intermediate	11	36.7
	Ph. D.	6	20.0		Advanced	14	46.7
Field of research or work	Retail industry	10	33.3	Working time in research or position	3–6 years	16	53.3
	E-commerce or marketing	11	36.7		6–10 years	7	23.3
	Informatization or digitalization	9	30.0		More than 10 years	7	23.3

End of Table 6

Personal Profile	Grouping	Frequency	Composition ratio (%)	Personal Profile	Grouping	Frequency	Composition ratio (%)
Post	General staff	3	10.0	Category of experts	Practitioner	15	50
	Grassroots manager	2	6.7		Scholar	15	50
	Middle manager	8	26.7	Professional title (only for scholars)	Intermediate	4	13.3
	Senior manager	2	6.7		Vice-senior	6	20.0
	Scholars	15	50.0		Senior	5	16.7

4.3. EAC and C_r

As mentioned before, this paper adopts the purposive sampling approach, which is commonly employed for the Delphi method. Before consultation, the research team communicated with all the 30 experts. The questionnaires were issued and recovered through one-on-one surveys. Hence, the recovery rate (EAC) was 100% in the first and second rounds of expert consultation. The statistical analysis on the first round shows that the C_a was 0.868, the C_s was 0.873, and the C_r was 0.871 > 0.7, which testifies high authority. Therefore, the experts being consulted in the first round was also surveyed in the second round; the questionnaire for the second round did not cover any basic information of the experts.

4.4. Coordination and concentration (consistency) of expert comments

Following the flow of the Delphi method, two rounds of consultation were conducted. The relevant statistics are summarized in Table 7.

Table 7. Data analysis table of coordination and concentration (consistency) of expert comments

Items	First round					
	Mean range	Full score frequency range	CV range	Kendall's W	X2	p
Primary indices	4.400~4.967	0.400~0.967	0.037~0.113	0.438	26.273	0.000(***)
Secondary indices	4.367~4.967	0.367~0.967	0.037~0.126	0.296	88.689	0.000(***)
Tertiary indices	3.533~4.967	0.233~0.967	0.037~0.285	0.220	277.232	0.000(***)
Items	Second round					
	Mean range	Full score frequency range	CV range	Kendall's W	X2	p
Primary indices	---	---	---	---	---	---
Secondary indices	4.467~4.967	0.467~0.967	0.037~0.114	0.308	92.533	0.000(***)
Tertiary indices	4.338~4.967	0.466~0.967	0.036~0.113	0.309	370.948	0.000(***)

4.4.1. First round

The coordination of expert comments was measured by CV and Kendall's W. As shown in Table 7, the CVs of primary and secondary indices were both smaller than 0.25, but the CV of a tertiary index (C1.4 data visualization rate) was greater than 0.25 (0.285). That is, the experts believed that data visualization is not a typical indicator of digital transformation, and lacks operable judgement criteria. Therefore, this tertiary index was removed. As for Kendall's W, the primary indices had a Kendall's W of 0.438 (>0.3), a sign of high coordination; the secondary and tertiary indices had a Kendall's W smaller than 0.3, a sign of low coordination. In terms of concentration (consistency), the primary indices achieved high mean and full score frequency, i.e., the expert evaluations are highly consistent; the secondary and tertiary indices had lower mean and full score frequency than primary indices, i.e., the expert recognition was low for these two types of indices. To sum up, primary indices need no secondary round of consultation, for their high coordination and recognition; secondary and tertiary indices need the secondary round, due to their low coordination and recognition.

4.4.2. Second round

The index system was adjusted according to the results of the first round of consultation, and then subjected to the second round. Compared with the data of the first round, the CVs of secondary and tertiary indices in the second round were relatively low; the means and full score frequencies of these two types of indices were relatively high; the Kendall's Ws of them were relatively high (>0.3). Therefore, the experts had consistent comments and highly recognized the index system in the second round, eliminating the need for a third round of consultation.

4.5. Index adjustment by boundary value method

Through boundary value method and expert discussion, the statistics of the results of the two rounds were collected, and used to adjust the relevant indices (Table 8).

Table 8. Index adjustment by boundary value method

	Items			
	Dimension	Primary indices	Secondary indices	Tertiary indices
First round	Bounds for the mean; unqualified indices	4.262; no unqualified index	4.424; no unqualified index	4.232; A1.6 corporate cloud service (3.900), A1.7 app or WeChat official account (3.900), A2.2 number of digital products/services being developed (4.033), and C1.4 data visualization rate (3.533) were unqualified.
	Bounds for full score frequency; unqualified indices	0.262; no unqualified index	0.437; B2 The agility of organizational structure is unqualified (0.367)	0.409; A1.6 corporate cloud service (0.300), A1.7 app or WeChat official account (0.333), A2.1 proportion of new product output (0.400), and C1.4 data visualization rate (0.233) were unqualified.

End of Table 8

	Bounds for CV; unqualified indices	0.132; no unqualified index	0.123; no unqualified index	0.180; A1.6 corporate cloud service (0.237), A1.7 app or WeChat official account (0.246), A2.1 proportion of new product output (0.183), A2.2 number of digital products/services being developed (0.248), and C1.4 data visualization rate (0.285) were unqualified.
	Adjustment results	No adjustment; all indices are reserved	As per expert comments, B2 The agility of organizational structure should be replaced with B2 The agility of digital organizational structure, rather than be directly deleted	<i>Indices to be deleted:</i> A1.6 corporate cloud service, A1.7 app or WeChat official account, and C1.4 data visualization rate were unqualified in all three dimensions, and were thus removed. None of them entered the second round of consultation. <i>Indices to be adjusted:</i> A2.1 proportion of new product output met the bounds for the mean, but did not meet the bounds for full score frequency or CV. The experts recommended to retain this index after revising it into A2.1 proportion of new product sales, because most retailers are trading enterprises. A2.2 number of digital products/services being developed met the bounds for full score frequency, but did not meet the bounds for the mean and CV. The experts recommended to retain this index after revising it into A2.2 product/service replacing rate, a common index of retailers, because the digital products/services cannot be measured accurately.
Second round	The index system was adjusted according to the results of the first round of consultation, and then subjected to the second round. The results of the second round indicate that all three levels of indices meet the bounds for the mean, full score frequency, and CV, and that no expert raised any objection against any index. Hence, all the indices are scientific, and reasonable, and thus reserved.			

4.6. The index system for retailers’ DTC

This section finalizes the index system for retailers’ DTC through literature review, Delphi method, and expert discussion above (Table 9). The index system contains three primary indices (i.e., technological change capability, strategic and organizational change capability, and management change capability), 11 secondary indices (e.g., digital infrastructure, digital research and development, and digital input), and 41 tertiary indices (e.g., backbone network/Internet interface bandwidth, and proportion of new product sales). The entire index system involves the technological applications in digital infrastructure, business management in process changes, and corporate strategies in digital culture, talents, and planning. Almost every aspect of retailers’ DTC is covered by the index system. Every index was explained by the research team to make the index system more operable and applicable.

Table 9. Index system for retailer’s DTC

Primary indices	Index explanation	Secondary indices	Index explanation	Tertiary indices	Index explanation
A Techno- logical change capability	It mainly refers to the digital infrastructure construction, digital R&D capability, and digital input level of retailers. It is the technical index for the DTC of retailers.	A1 Digital infra- structure	The level of network infrastructure, data security, and data center construction of retailers. It is the basic technical support capability	A1.1 Backbone network/ Internet interface bandwidth	total bandwidth/ average online number
				A1.2 Backbone network coverage	the coverage area of the network
				A1.3 Application rate of data security measures	physical security (backup) and 3A (authentication, authorization, auditing) application
				A1.4 Infrastructure availability	the ratio of the normal use of the infrastructure
				A1.5 Data center	whether there is a data exchange center
				A2 Digital R&D	The research and development level of retailers in the field of digitalization, which present the digital innovation capability of retailers
		A2.2 Replacement rate of goods or services	the ratio of the number of eliminated or replaced goods to the total		
		A2.3 Proportion of patents related to digitalization	the ratio of the number of digital patents to the total number of patents		
		A2.4 R&D investment intensity	the digital R&D expenses		
		A3 Digital input	The investment level of retailers in digital equipment, digital operation and maintenance, and digital security	A3.1 Proportion of digital input in total input	The ratio of total enterprise digital input to total enterprise input

Continued Table 9

Primary indices	Index explanation	Secondary indices	Index explanation	Tertiary indices	Index explanation
				A3.2 Proportion of digital input in total revenue	The ratio of total enterprise digital input to total enterprise revenue
				A3.3 Proportion of investment in digital equipment	The ratio of the enterprise's investment in digital equipment to the total digital investment
				A3.4 Proportion of digital operation and maintenance	The ratio of the enterprise's investment in digital operation and maintenance to the total digital investment
				A3.5 Proportion of data security investment	The ratio of the enterprise's investment in digital data security to the total digital investment
B Strategic and organizational change capability	It mainly refers to the level of digital strategy, the design capability of organizational structure, the level of digital talent reserve and the capability to build digital culture.	B1 Digital strategy	Digital strategy anchoring, digital planning, design and execution capabilities of retailers	B1.1 Digital strategy design	The position of digital strategy in the overall development planning of retailers
				B1.2 Digital strategy execution	Target decomposition, process execution and assessment of digital strategy of retailers
		B2 The agility of digital organizational structure	The construction of digital departments of retailers, and the capability of immediate response based on digitalization.	B2.1 Establishment of Digital Department	Is there a digital department? How long has it been established?
				B2.2 Digital Department Construction	Staffing, management system construction and daily operation of digital departments of retailers.

Continued Table 9

Primary indices	Index explanation	Secondary indices	Index explanation	Tertiary indices	Index explanation		
				B2.3 Leaderships of the digital departments	The position of the digital department leader in the entire organizational system of retailers		
				B2.4 Number of enterprise management levels	Number of layers from front-line employees to top management		
		B3 Digital platform	Construction and application of digital platform for retailers	B3.1 Establishment of Digital platform	Has the digital platform been created? How long has it been created?		
				B3.2 Digital platform operation	Number of users of digital platform and user activity, etc.		
				B3.3 Digital platform user satisfaction	Users' satisfaction with the use of digital platforms		
		B4 Digital talent	The reserve and skill level of digital talents in retailers	B4.1 Proportion of digital talents	The ratio of the number of digital talents to the total number of employees		
				B4.2 Digital skills coverage rate	The degree of digital technology application and operation proficiency of employees		
				B4.3 Ratio of digital skills talent training expenditure	The ratio of digital skills training spending to corporate employee training spending		
				B5 Digital culture	Digital management system construction of retailers, employees' recognition of digitalization and digital behavior	B5.1 Digital Management System	The proportion of digital management system in enterprise management system

Continued Table 9

Primary indices	Index explanation	Secondary indices	Index explanation	Tertiary indices	Index explanation
				B5.2 Digital recognition	The degree to which employees agree with the importance and necessity of digital transformation
				B5.3 Employee digital behavior	The extent to which employees' digital behavior is reflected in their daily work
C Management change capability	The degree of digitization in retail business processes, consumer and financial management	C1 Digital management of business processes	Mainly refers to the degree of digitalization of the sales business process of retailers	C1.1 E-commerce procurement ratio	The ratio of online purchase amount to total purchase amount
				C1.2 Proportion of digital warehousing logistics equipment	The proportion of enterprise digital logistics equipment value to total enterprise equipment value
				C1.3 On-time order delivery rate	The ratio of the number of orders delivered on time to the total number of orders
				C1.4 Proportion of online orders	The ratio of online orders to total orders
		C2 Digital consumer management	Mainly refers to the digital consumers management capability of retailers	C2.1 Proportion of online consumers	The ratio of the number of consumers buying products/ services online to the total number of consumers
				C2.2 Proportion of online marketing	The ratio of the number of online marketing to the total number of marketing
				C2.3 Digital degree of customer experience	The proportion of online links to the whole process link in the process of customer consumption
				C2.4 Extent of consumer data collection	The completeness and timeliness of consumer data collected by enterprises

End of Table 9

Primary indices	Index explanation	Secondary indices	Index explanation	Tertiary indices	Index explanation
				C2.5 Degree of consumer data analysis	Analysis and application of consumer data
		C3 Digital Financial management	The degree of digitalization of financial business management of retailers	C3.1 Proportion of online financial business	The ratio of the online financial business to all financial business
				C3.2 ERP system coverage rate	The number of businesses covered by the enterprise ERP system
				C3.3 Inter-connection rate between financial system and business system	The ratio of the number of systems directly connected between the financial system and other business systems to the total number of business systems of the enterprise

5. Discussion

As the pioneers of digital transformation, retailers have accumulated rich practical experience, however, the theoretical research on their DTC is relatively lagging behind, without any operational capability index system that could be put into operation and promoted. Therefore, it is difficult to summarize the key capabilities of digital transformation of retailers, to analyze the reasons for the success or failure of digital transformation, and to provide standards for predicting the future trends of digital transformation of retailers. In order to solve the above problems, the present research aims to establish a quantitative and standard index system for DTC of retailers with two characteristics. Following the “comprehensive digitalization” concept of the digital transformation of retailers, the index system developed from the single digital technology dimension to a broader dimension of organization and management, and designed three major constructions: technological change capability, strategic and organizational change capability and management change capability. The second feature is that a total of 41 operational and measurable specific indices were designed, with relevant explanations so as to help retailers carry out capability assessment independently, solving the quantification and evaluation problems of the existing capability models.

In terms of technological change capability, this research designed three secondary indices, A1, A2, and A3, all of which are closely related to digital technology and supplement each other: A1 is the basic technical condition, A2 is the R&D output index, and A3 is the investment support capability. A1 includes five tertiary indices, involving four aspects: basic

network (A1.1, A1.2), data security measures (A1.3), infrastructure (A1.4), and data center (A1.5). For most retailers, these five tertiary indices are easy to collect. A2 includes four tertiary indices, involving three aspects: products or services (A2.1, A2.2), patents (A2.3) and R&D (A2.4). A3 includes five tertiary indices, involving four aspects: total digital investment (A3.1, A3.2), digital equipment investment (A3.3), digital operation investment (A3.4) and data security investment (A3.5). These five tertiary indices can be obtained by calculating the proportion of digital investment to the total investment.

In terms of strategic and organizational change capability, this research has designed five secondary indices, B1, B2, B3, B4, and B5. These five indices made a leap from the technical area to the field of organizational behavior, reflecting the organizational transformation characteristics of the corporate digital transformation. Among them, B1 is about top-level design capability; both B2 and B3 are organizational support capabilities; B4 is the key to organizational change capability – digital talents, and B5 is organizational culture guarantee. Compared with technological change capability, the acquisition of strategic and organizational change capability index is more complicated, because it includes eight qualitative indices: B1.1, B1.2, B2.2, B3.1, B3.2, B3.3, B5.2, B5.3. The acquisition of these indices requires qualitative evaluation by means of questionnaires. For example, index B3.3 is designed to measure the satisfaction of digital platform users. Due to this, the evaluation and application of strategic and organizational change capability index requires retailers to establish the evaluation standards according to their own actual conditions.

In terms of management change capability, this study designed three secondary indices: C1, C2 and C3, which involve three dimensions including digital transformation of business processes, digital consumer management, and financial digitalization. Digital management of business processes (C1) is a digital transformation capability (DTC) that has been identified by researchers long before, and some researchers also bring into supply chain transformation and business model innovation. In this study, e-commerce procurement (C1.1), digital warehousing and logistics (C1.2), on-time delivery rate (C1.3) and proportion (C1.4) are taken as its tertiary indices based on current management practices of enterprises, achieving the integration of digital transformation and e-commerce. Digital consumer management is a new index based on the perspective of value co-creation, which reflects the concept of co-creation from production-driven to consumer-centric against the background of digital transformation, and is an important capability for retailers to achieve digital transformation. However, there are not sufficient relevant studies on digital consumers at present, and few experts and scholars take it as a capability index. On the basis of ample interviews and surveys, this research takes the proportion of online consumers (C2.1), the proportion of online marketing (C2.2), the degree of digitalization of customer experience (C2.3), the collection (C2.4) and analysis of consumer data (C2.5) as its tertiary indices, improving the role of consumers in the digital transformation of retailers and conforming to the current and future development trend of value co-creation. Financial digital management (C3) reflects the digital transformation capability of retailers through financial data, and its relevant indices can be obtained directly from the existing financial system or ERP system.

Conclusions

To conclude, the digital transformation of retailers is an important component of the digital transformation of traditional industries, and the DTC is the key for retailers to succeed in digital transformation. To make up for the lack of index system for retailers' DTC, this paper firstly defines the relevant concepts and reviews the literature, and then innovatively designs a DTC model for retailers. In addition, the Delphi method was adopted to start two rounds of expert consultation. According to the statistics of expert consultation, an index system was established for retailers' DTC.

The index system proposed in this study can provide valuable management implications for the theoretical research and practice of enterprise digital transformation. From the analysis of theoretical contribution, there are mainly three aspects of significance. First, this study deeply analyzed the differences and connections of related concepts such as digitization, digitalization, digital capability, digital transformation, and digital transformation capability, thus providing a research basis for scientific understanding of corporate digital transformation. Second, this research systematically sorted out the research thread and main results of corporate digital transformation from four aspects: research perspective, research content, research object and research methodology. At the same time, it also summarized the capability model of corporate digital transformation, thus forming a comprehensive and systematic literature review, which provides theoretical literature for subsequent related theoretical research. Third, this research constructed an index system of the DTC of retailers, thus achieving the extension of conceptual model to index design in theoretically, and enriching the theoretical system of corporate digital transformation.

From the perspective of practical implication, the index system for DTC of retailers proposed by this study has not only specific indices, but also corresponding index explanations or formulas (Table 9), which is highly operable and of applicable value. First of all, for retailers that have not yet started digital transformation, they can draw lessons from this index system to cultivate their capabilities and enhance the success rate of digital transformation. Secondly, for retailers that have started digital transformation, this index system can be used to evaluate the current DTC, so as to optimize the existing capability structure system. In addition, although this study focuses on the research on the index system for DTC of retailers, these research results can also provide reference for the digital transformation practices of other types of enterprises.

Of course, limited by the researcher's ability, there are several problems remain unsolved in this research. For example, some experts mentioned the necessity of index weighting in actual application, because the indices are of different importance in the index system. Without assigning a proper weight to each index, it would be difficult to evaluate the DTC of a retailer accurately. Moreover, this paper does not study whether retailers differ from other enterprises in DTC. These problems should be further explored by scholars.

Considering the limitations of this work and the future trends in the field, experts and scholars can further study retailers' DTC from the following three angles: First, strategies like analytical hierarchy process (AHP) and fuzzy comprehensive evaluation (FCE) could be utilized to analyze and evaluate the weight of each index for retailers' DTC, clarifying the importance of each index in the system. In this way, the index system will be more structured, and provide a more precise theoretical guide for the digital transformation of

retailers. Second, the index system for retailers' DTC needs to receive application research. The theoretical indices in the system should be further verified by applying the index system to corporate practice, making the index system more applicable to wider fields. Third, comparative analysis needs to be conducted across industries and organizations. For example, it is worthwhile to compare the DTC difference between retailers and manufacturers, and the difference of digital transformation capability between retailers and organizations like professional markets. These comparisons help to expand the research scope of retailers' digital transformation, and enrich the theories on corporate digital transformation.

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