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A Relevance-Based Technology–Organisation–Environment Model of Critical Success Factors for Digital Procurement Adoption in Chinese Construction Companies

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Abstract: With the emergence of digital transformation, there is an increasing need for Chinese construction companies to adopt digital procurement (D-procurement). However, there is a lack of theoretical foundation to guide and support the adoption practices. This study aims to fill the research gap through the provision of a model by grouping a set of relevance-based critical success factors (CSFs) into the Technology–Organisation–Environment (TOE) framework for D-procurement adoption success (DAS). A case study approach is applied in the research. We selected H Group as it is one of the most representative D-procurement cases in China. The study includes two parts. In the first part, a systematic literature review was conducted, and 17 CSFs were identified from 12 selected studies. By grouping the 17 CSFs into the TOE framework, we put forward a basic CSF–TOE model. In the second part, an in-depth interview was carried out in H Group, where the 17 selected experts were asked to rank the previously identified CSF. Based on their order of relevance, the 17 CSFs were re-organised in the basic CSF–TOE model, and a relevance-based CSF–TOE model was finally proposed. This study is vital for D-procurement adoption because most existing CSF studies are based on the literature and questionnaire surveys, and there is a lack of actual case studies. In addition, this study significantly contributes to the field of D-procurement adoption for construction companies by providing a theoretical framework for practice and a relevance-based CSF–TOE model for research.

Keywords: digital transformation; digital procurement; critical success factors; relevance-based CSF–TOE model; D-procurement adoption

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1. Introduction

In today's world, digitalisation has become a significant trend of social development, and the rapid wave of digitalisation is impacting all fields of human society. With the continuous and high-quality development of China's economy, the digitalisation of all walks of life is also in full swing. In 2020, China became the world's second-largest digital economy. As a grand strategic blueprint, it was announced in the 14th Five Year Plan that the scale of China's digital economy would be about 40–45 trillion yuan, accounting for more than 35% of China's GDP. In the next five to ten years, the role of the digital economy in driving economic development will continue to expand. The construction industry is one of the pillar industries of the Chinese economy, and the digital enterprise platform built with D-procurement as the core has developed rapidly in recent years.

Over the past 20 years, China's construction industry has been developing rapidly. As of 2019, China's construction industry contributed USD 1.02 trillion, accounting for 7.16%

of China's GDP [1]. However, according to MGI Industry Digitalisation Index for China [2], the construction industry ranked the lowest among the 22 sectors. That means that, in China, the digitalisation progress of the construction industry is not optimistic compared with other sectors, which have good digitalisation practices. As a traditional and significant industry, the construction sector must adopt to and follow China's digital transformation strategy to take advantage of the opportunities. However, digitalisation in the construction sector still faces many potential barriers, and more innovations are expected and needed.

Procurement is the process of finding and agreeing to terms and acquiring goods, services, or works from an external source, often via a tendering or competitive bidding process [3]. Procurement is an essential operation of every organisation regardless of its size or domain [4], and it can represent up to 80% of an organisation's costs [5]. As Ilhan and Rahim [6] pointed out, the notion of D-procurement only emerged in recent years. D-procurement refers to the automation of the procurement process using E-procurement systems with incorporated innovative analytical tools like big data and data mining solutions [7]. The procurement cycle is also one of the typical audit areas and the D-procurement systems enable the organisation to reduce audit efforts by recording digital trail for every transaction [8]. In the past ten years, with the rapid advancement of technology, advanced technologies such as cloud computing [9], big data [10], the Internet of things [11], Automatization and Robotics [12], and blockchain [13] have been integrated and applied to modern procurement platforms. Therefore, D-procurement is defined as the use of digital technologies in business procurement processes in this study.

In 2016, China's National Development and Reform Commission (NDRC) released a notice where the central government demanded the local governments further pilot national electronic bidding and tendering (National Development and Reform Commission of China, 2016). That was a significant trigger for the further adoption of advanced procurement solutions in China. Additionally, due to its cost-saving capabilities, D-procurement provides an approach to increase profit potentially. It allows multiple companies to buy products or services on the same digital procurement platform. Such a centralised purchasing process increases the buyer's bargaining power, thus contributing to a possible lower final price. It also allows buyers and suppliers to rapidly exchange online information through the platform, thus enhancing transaction efficiency and reducing error rate. D-procurement solutions can be a significant breakthrough for the digital transformation of China's construction industry. It has a good starting point with great potential. However, despite the numerous emerging technologies and available business models, there is still a lack of theoretical and practical guidance on how enterprises can successfully adopt D-procurement projects.

From a theoretical perspective, the CSF theory has been widely applied in different fields for over 50 years, and there have been many CSF studies on procurement management or electrical procurement systems. Nowadays, with the rapid development of digital technologies, many enterprises are putting the new advanced technologies into practice to upgrade their daily operations. However, we identified some gaps in the existing research. The first is the contextual gap. The successful adoption of D-procurement depends on contextual conditions because, in different environments, the critical factors are different. For research in China, it is needed to study the CSF for D-procurement in the context of leading large enterprises so that the findings can be reliably generalised to small and medium-sized enterprises. The second is the geographical gap, which refers to a knowledge gap such as untapped potential or missing research literature in an unexplored or under-explored geographical area [14]. Some factors associated with D-procurement may be more salient in Asia than in Western countries. As China is the world's second economy with a high-speed digital transformation, the findings of this study should be representative and can contribute to filling the existing geographic gap. The third is the methodological gap. A methodological gap is recognised due to the limitations of the methods and techniques used in the research. Currently, and according to the research conducted, most CSF studies

are based on the literature and on questionnaire surveys, and there is a lack of actual case studies.

From a practical perspective, with the trend of digitalisation in the industry, some leading construction enterprises have carried out innovative experiments in D-procurement solutions and obtained significant results in the last few years, but the trial-and-error cost has been significantly high, and includes the financial costs, time, and human resources committed. The high cost explains why only the leading companies can afford innovations in D-procurement. However, enormous investments are not a synonym for success, which further illustrates the background of the research problem. The pain point for D-procurement is that, regardless of the companies' scale being large, medium, or small, the Chinese construction companies are all consensual on the high value offered by D-procurement and are willing to adopt and implement D-procurement solutions. However, they encounter the problem that there is still a lack of theoretical guidance for risk control and successful adoption. What are the critical factors for successfully achieving their objectives? They do not know. That is the primary problem to be addressed in this research. Based on the research problem stated above, we put forward two research questions: What are the critical success factors for D-procurement adoption in Chinese construction companies? And what is the order of relevance of these CSFs? These two questions also reflect the objectives of this research. The first question aims to identify the CSFs, and the second question aims to find out which CSF is more significant so that companies can arrange the conditions accordingly to satisfy the D-procurement projects' requirements in actual practice. By answering the two questions, a new CSF–TOE model will be proposed.

This study contributes to the current state of the art of CSF studies both practically and theoretically. First of all, it provides practical guidance for enterprises to better understand the factors that influence D-procurement adoption and how to reduce cost and risk whiling increasing the possibility of success. Additionally, in a digitalisation age, guidance can also help boost enterprises start and achieve their digital transformation objectives. Second, it provides a relevance-based CSF–TOE model for theoretical studies. Third, by testing the basic TOE model in a real scenario, we proposed a model that serves as a very valuable reference for future researchers, especially in studying enterprise digitalisation in the Chinese economic environment.

To sum up, this study proposes a relevance-based CSF–TOE model through a systematic literature review and case study on a typical case. It fills the theoretical research gap and provides a practical reference for construction companies. The structure of this article is as follows: Section 2 provides a review of relevant literature, Section 3 introduces the research design of this study, Section 4 presents the research methods and results, Section 5 includes the discussions based on the research results, Section 6 concludes the research findings, and Section 7 is about the research limitations and future research.

2. Literature Review

2.1. Information System Adoption

In 1995, Rogers [15] proposed the five-stage model of the innovation-decision process, which includes knowledge, persuasion, decision, implementation, and confirmation. These five stages served as an essential theoretical basis to explain innovation diffusion and information system adoption (ISA). In 1997, Gopalakrishnan and Damanpour [16] went a step further. They conducted an important review of innovation research in economics, sociology, and technology management, and considered adopting innovation as a process of organisational change which directly affects an organisation's technical and social systems. This process consists of two main stages: initiation and implementation.

In 2012, Hameed et al. [17] studied the adoption stages cycle illustrated by different researchers and found that the cycle roughly falls into the initiation, adoption-decision and implementation stages. Then, they conducted some profound studies on several influential adoption theories, such as the Diffusion of Innovation Theory (DOI) [15], the Technology Acceptance Model (TAM) [18], the Theory of Planned Behaviour (TPB) [19],

and the Technology–Organisation–Environment (TOE) framework [20]. They summarised those theories and proposed a new theoretical model, which contains three phases of the innovation process: pre-adoption, adoption-decision and post-adoption. This three-phase model is essential because it provides an integrated uniform framework for ISA studies.

Based on the model by Hameed et al. [17], in this study, we define ISA as having the entire organisation embrace the information system solution and incorporate it into their business processes to gain effectiveness and efficiency. The adoption process includes everything from the initiation stage to the implementation and acquisition of the information system. The assimilation of the system is assumed to be the result of the user acceptance of innovation within the organisation.

A significant research topic in ISA studies is its success and failure. In real cases, enterprises invest in information systems for many purposes, such as to cut costs, to increase production while maintaining the costs, and to improve the quality of services or products to stay competitive [21]. However, adoption success is not guaranteed. Numerous examples of ISA failures were reported [22,23], which resulted in negative consequences for organisations or governments, including financial losses, time costs, and many other risks [24–28].

Therefore, it is important to understand how to successfully adopt new technologies for business. Scholars paid attention to the importance of ISA as early as the 1980s [29]. In the last three decades, researchers have tried to understand, predict, and explain the factors that influence the adoption or implementation of technology at both individual and organisational levels [30]. The technology adoption approaches have been explored from various perspectives, such as information technologies, sociology, and human–computer interactions. As a result, researchers have developed multiple models incorporating factors and phases to predict technology adoption, which eventually leads to ongoing use [31].

2.2. Information System Adoption Theories

In CSF studies, models or frameworks from different ISA theories are generally used. As Legris et al. [21] indicated, rather than a long list of identified factors, it is better to group them into a model to facilitate analysis of ISA for practical use. Moreover, in different contexts with different scopes and depths of the study, the CSFs are also different. Table 1 summarises some important and commonly accepted ISA theories in the literature.

Table 1. Information system adoption theories found in the literature.

No.	Theory	Description	Proposer
1	Theory of Reasoned Action (TRA)	TRA suggests that a person's behaviour is determined by their intention to perform the behaviour. This intention is, in turn, a function of their attitude toward the behaviour and subjective norms.	Fishbein and Ajzen [32]
2	Theory of Interpersonal Behaviour (TIB)	TIB proposes an integrated model of interpersonal behaviour, which posits that behaviour, in any situation, is a function of intention (consistent with other behaviour models) as well as the strength of habit of the behaviour and the various facilitating conditions.	Triandis [33]
3	Theory of Planned Behaviour (TPB)	TPB is a widely applied behavioural model. It helps to understand how the behaviour of people can change. The model assumes that behaviour is planned. Hence it predicts deliberate behaviour.	Ajzen [19], Ajzen [34]

Table 1. *Cont.*

No.	Theory	Description	Proposer
4	Theory Acceptance Model (TAM)	TAM is the most widely applied model of users' acceptance and usage of technology, and it is one of the most influential extensions of TRA. TAM replaces many of TRA's attitude measures with two technology acceptance measures: ease of use and usefulness.	Davis [18], Davis [35], Davis et al. [28]
5	Social Cognitive Theory (SCT)	SCT is an interpersonal level theory that emphasises the dynamic interaction between people (personal factors), their behaviour, and their environments. This interaction is demonstrated by the construct called Reciprocal Determinism.	Bandura [36]
6	Technology–Organisation –Environment Framework (TOE)	TOE is a theoretical framework that explains technology adoption in organisations and describes how technological, organisational, and environmental contexts influence adopting and implementing technological innovations.	Depietro et al. [20]
7	Model of PC Utilization (MPCU)	MPCU suggests that behaviour is determined by what people would like to do (attitudes), what they think they should do (social norms), what they have usually done (habits), and by the expected consequences of their behaviour.	Thompson et al. [37]
8	Motivational Model (MM)	MM helps to study information technology adoption and use. The model suggests that an individual's behaviour is based on extrinsic and intrinsic motivations.	Davis et al. [38]
9	Task Technology Fit Theory (TTF)	TTF theory holds that IT is more likely to positively impact individual performance and be used if the capabilities of the IT match the tasks that the user must perform.	Goodhue and Thompson [39]
10	Computer Usage Model (CUM)	CUM proposes that self-efficacy is an antecedent of perceived ease of use and usefulness that had mainly indirect effects on usage through ease of use and perceived usefulness.	Igbaria and Iivari [40]
11	Diffusion of Innovations Theory (DOI)	DOI is one of the oldest social science theories. It originates in communication to explain how, over time, an idea or product gains momentum and diffuses (or spreads) through a specific population or social system.	Rogers [15]
12	Iacovou Model (IM)	IM is a model that includes three factors as determinants of EDI adoption and impact in small and medium-sized enterprises: perceived benefits (technological), organisational readiness (organisational), and external pressure (inter-organisational).	Iacovou et al. [41]
13	Uses and Gratification Theory (UGT)	UGT indicates that uses and gratifications have always provided a cutting-edge theoretical approach in the initial stages of each new mass communication medium.	Ruggiero [42]
14	Unified Theory of Planned Behaviour (UTAUT)	UTAUT aims to explain user intentions to use an information system and subsequent usage behaviour. The theory holds four fundamental constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions.	Venkatesh et al. [43]

Among these ISA theories, some focus on user acceptance, some concentrate on adoption decisions, and some on system implementation. it shows that studies on ISA theories arise from different perspectives and have different purposes. Li [44] pointed out that there is a general consensus that two different groups of theories are required to explain technology adoption: individual- and organisational-level theories.

At the individual level, behavioural theories, including TAM, TPB, TRA, and UTAUT, are frequently used to predict intention and actual behaviour. At the organisational level, DOI and TOE are commonly applied for predicting the adoption of new technological solutions in organisations [44–46]. Among the ISA theories, the TAM, DOI, and TOE are the three influential theories that are typically applied in CSF studies.

2.3. Critical Success Factors Approach

According to a study by Sousa [47], the concept of "success factors" was initially developed by Daniel [48] of McKinsey & Company in 1961. Those success factors focused on industry-related approaches appropriate for any company in a particular industry. In 1972, Anthony et al. [49] went a step further by emphasising the need to tailor the factors to a company's particular strategic objectives and its particular managers. Here, management planning and control systems are responsible for reporting the success factors perceived by the managers as relevant to a specific job and industry.

Based on the previous works, Rockart [50] and Bullen and Rockart [51] later mainly elaborated on the concept of designing management information systems. First, they found that top management rarely applied management information systems. Then, they argued that such systems must be structured according to the information needs of the managers so as to establish the link between managers' information requirements and management information systems. They coined the term *Critical Success Factors* [52], and defined it as "the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organisation". These factors are the few key areas where things must go right for the business to flourish and for the manager's goals to be attained [50].

Bullen and Rockart [51] further pointed out that critical success factors are "the few key areas of activity in which favourable results are necessary for a particular manager to reach his goals. Because these areas of activity are critical, the manager should have the appropriate information to allow him to determine whether events are proceeding sufficiently well in each area". Conversely, as Thierauf [53] indicated, if the results in these areas are inadequate, the organisation's efforts for the period will be less than desired.

Dadashzadeh [54] pointed out that the purpose of any CSF approach is "the determination of the set of factors that the manager considers critical for his or her success. Once identified, these factors are stated as his or her objectives and the information required to monitor their performance is then identified". According to Grunert and Ellegaard [52], CSFs originated in management information systems, and they were later transferred to business strategy research. Since then, CSFs have been widely applied in various scenarios. As Lampadarios [55] indicated, each industry has its own CSFs.

Another important issue is that scholars are also concerned with the definition of "success" in the context of ISA. As Hameed and Arachchilage [45] suggested, the adoption process from the initiation stage until the acquisition of innovation is considered a decision made by an organisation, while the process of innovation assimilation is assumed as a result of the user acceptance of innovation within the organisation. In other words, the success of the adoption is evaluated by the extent to which the innovation is integrated into the organisation and contributes to organisational conduct and outcome [17].

2.4. Current D-Procurement Adoption Studies

In academic research, most of them are still based on electronic procurement (E-procurement) [56] research. This is because the mainstream procurement system in the past ten to twenty years is the E-procurement developed with the Internet. D-procurement is the

next-generation system of E-procurement, which applies to more advanced technologies such as cloud computing, blockchain, digital mining, and machine learning [57]. The development and operation of those systems mainly appeared in the past five to ten years, and are constantly being updated, so there are not many related academic studies.

However, in recent years, there have been many CSF-related studies on the digitalisation of the construction industry. For example, Liu et al. [58] carried out a CSF study on building information modelling (BIM) adoption during the construction phase in Singapore, and they identified 26 critical factors. Li et al. [59] conducted an empirical study in Hong Kong on modelling dynamics of project-based collaborative networks for BIM implementation, and found out how the networks of project-based collaborative relationships interact with each other in BIM implementation practices across projects.

There are some CSF studies on D-procurement that focus on the application of digital technology. Yang et al. [60] pointed out that technological intelligence and supply chain cooperation are two important factors for adopting digital technologies in supply chains. Hallikas et al. [61] focused on the impact of data analytics on supply chain performance; the study confirms positive and significant relationships among digital procurement capabilities, data analytics capabilities, and supply chain performance. Especially, they found that digital procurement capabilities mediate the positive relationship between external data analytics capabilities and supply chain performance. Herold et al. [62] studied the dynamic capabilities for digital procurement transformation, and they found nine micro-foundations required for that.

Some more cutting-edge research combines advanced technology and architectural expertise in depth. Alshboul et al. [63] used the machine learning-based model to predict the shear strength of slender reinforced concrete beams without stirrups.

We believe that with the continuous development and application of digital technology, there will be more and more research on D-procurement and digitalisation of the construction industry.

2.5. Selection of Critical Success Factors for This Study

The existing studies on CSFs for D-procurement adoption are based on different scenarios. The selection of CSFs depends on various conditions such as region, culture, technology, and organisation. This suggests it is important to understand the environment and conditions in which the CSF study will occur.

In this study, relevant CSFs were selected through a literature survey. According to Sekaran [64], a literature survey is "the documentation of a comprehensive review of the published and unpublished work from secondary sources of data in the areas of specific interest to the research". In this study, the main purpose of the literature survey was to investigate whether a general set of CSFs already existed in the literature on D-procurement.

In selecting the database, we considered Science Direct, Web of Science, Ebsco, Google Scholar, and CNKI (China National Knowledge Infrastructure). Finally, taking into account access rights and the convenience of searching, we chose Google Scholar due to its convenience in broad searches for scholarly literature. Additionally, we can search across many disciplines and sources in the same platform.

To systematically carry out the survey, the idea of a Systematic Literature Review (SLR) was applied. An SLR is a "systematic, explicit, comprehensive, and reproducible method for identifying, evaluating, and synthesising the existing body of completed and recorded work produced by researchers, scholars, and practitioners" [65]. To conduct the SLR, we combined the guidance by Xiao and Watson [66] and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram [67], and eventually, the literature survey was composed of four phases, as shown in Figure 1 below:

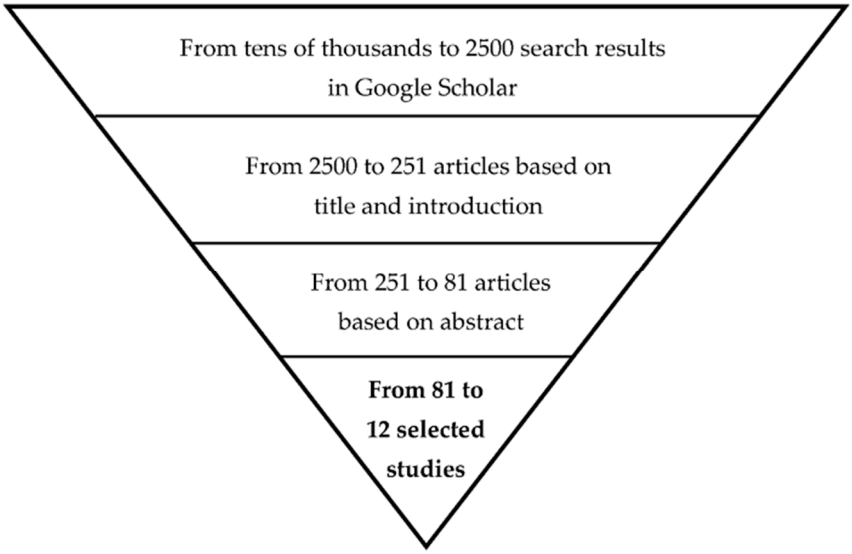

Figure 1. Literature survey phases.

The first phase included an extensive survey of the available literature. Google Scholar was used as the search engine to collect relevant works. The search key contained three elements. Element 1: "critical success factor/factors" or "key success factor/factors". Element 2: "D-procurement" or "digital procurement" or "E-procurement" or "electronic procurement". Element 3: "construction" or "construction industry" or "construction sector".

Based on the permutation of the three elements (Element 1, Element 2, Element 3), each combination was searched as the keyword in Google Scholar. We obtained tens of thousands of results, which was too broad. Thereby, we narrowed down the scope by using quotation marks and plus signs. Quotation marks were used for Element 1 and Element 2, and a plus sign was used between them. Element 3 was not constrained. For example, "critical success factors" + "digital procurement" construction. After that, irrelevant results were weeded out. The results were narrowed down to less than 2500.

The second phase involved a selection of the available literature. By evaluating the relevance of the title and introduction of the resulting articles, 251 relevant articles were selected.

In the third phase, we further selected the relevant literature by evaluating the abstract of each article. A total of 81 articles were selected from the 251 ones.

The fourth phase was a selection of the final literature. There were four criteria used for the selection:

- The main objective of the study should be to find out the CSFs. The way to find out the CSFs should be reasonable, and the CSFs identified in the study should be properly explained in the findings and conclusions;
- The CSFs found in the study should be related to the adoption or implementation of a procurement system, supply chain system, business system, electrical business, or information system;
- The method and process to identify the CSFs should be scientific, and the CSFs found in the study should be generic and representative;
- The study should not be earlier than 2005.

Finally, based on careful reading and in-depth analysis of the 81 articles, 12 studies were selected, as listed in Table 2 below. The table reveals that in current CSF studies, the main research methods used are literature survey and a questionnaire survey. Therefore, there is a lack of case study research, which highlights the relevance of this study.

Table 2. Twelve selected CSF studies.

No.	Author	Context	Research Method	Identified CSF
1	Waithaka and Kimani [14]	Determinants of adoption of D-procurement practices	Literature survey	4 CSF
2	Afolabi et al. [68]	D-procurement adoption in the construction industry	Questionnaire survey	21 CSF
3	Premathilaka and Fernando [69]	D-procurement adoption in the public sector	Questionnaire and interview	6 CSF
4	Holotiuk and Beimborn [70]	Digital business	Literature survey of industry reports	40 CSF
5	Gheni et al. [71]	CSF for IT projects	Online questionnaire survey	9 CSF
6	Ab Talib et al. [72]	Supply chain management	Literature survey	9 CSF
7	Mose et al. [73]	D-procurement adoption among large-scale manufacturing firms	Questionnaire survey	5 CSF
8	Basheka et al. [74]	D-procurement implementation in the public sector	Literature survey and questionnaire survey	13 CSF
9	Teo et al. [75]	D-procurement adoption in Singapore	Questionnaire survey	4 CSF
10	Gunasekaran and Ngai [76]	E-procurement adoption in Hongkong China	Questionnaire survey	11 CSF
11	Vaidya et al. [77]	D-procurement implementation in the public sector	Literature survey	11 CSF
12	Puschmann and Alt [78]	D-procurement in supply chains	Benchmarking study	13 CSF

After the four literature survey phases, the final task was to select the CSFs from the 12 studies. We first analysed and organised the factors in each study. Then, factors that were too specific were eliminated, such as "rethinking of C-level roles" (Chief Development Officer, Chief Information Officer) and "observation of procurement guidelines". Then, factors not commonly suggested but highly related to our case study were considered, such as "firm size and procurement volume". Factors related to each other or with similar meanings were grouped together as one single factor.

Based on the work above, 17 CSFs were finally identified, as shown in Table 3 below. It contains a list of the CSFs with their respective citations. The "·" sign indicates that a certain CSF is cited in a certain study.

Table 3. List of selected CSF and respective citations.

References \ CSF	Top Management Support	End-User Uptake and Training	Participants' Collaboration and Adoption	Business Process Re-Engineering	ICT Infrastructure and Technology Standards	System Integration and Compatibility	Project Management and Change Management	Security and Authentication	User Experience and Satisfaction	Knowledge of D-Procurement Benefits	Employees' Commitment and Motivation	Participants' Communication	Uniform Codes and Data Standards	Government Support	D-procurement Operation and Performance	D-procurement Adoption Strategy	Firm size and Procurement volume
Waithaka and Kimani [14]	•	•						•									
Afolabi et al. [68]	•	•		•	•	•	•	•	•	•	•		•	•			
Premathilaka and Fernando [69]	•	•	•			•			•	•							
Holotiuk and Beimborn [70]	•	•	•	•	•	•	•		•						•		
Gheni et al. [71]		•			•		•				•	•					
Ab Talib et al. [72]	•	•	•	•	•									•			
Mose et al. [73]	•		•		•				•		•				•		
Basheka et al. [74]		•	•	•		•	•	•				•		•			
Teo et al. [75]	•		•							•							•
Gunasekaran and Ngai [76]	•	•	•	•			•					•	•				
Vaidya et al. [77]	•	•	•	•	•	•	•	•								•	
Puschmann and Alt [78]			•	•	•	•		•					•			•	
Total number of citations	9	9	9	7	7	6	6	5	4	3	3	3	3	3	2	2	1

2.6. Basic CSF–TOE Model

TOE was chosen as the research model in our case study for two main reasons. First, we need to select a research model at the organisational level. In this case study, we aim to investigate the H Group to determine the CSFs for D-procurement adoption in practice. Among the various typically applied ISA theories, only TOE and DOI are commonly used to examine the adoption of IS/IT products and services at the organisational level [44,46,79,80].

Second, the environmental factors should be included in the model. In the Chinese context, government regulations and support significantly impact business organisations and operations. Thus, it is absolutely important to consider the environmental factors when studying the CSFs for D-procurement adoption success. The environmental context is included in TOE, but not in the DOI theory [46].

The TOE model has three groups: technology, organisation, and environment. As shown in Figure 2 below, the 17 original CSFs were integrated into the TOE model to form a basic CSF–TOE model, which is derived from the literature review. It can as serve as a theoretical reference for the companies that are preparing for digitalisation to objectively evaluate their digitalisation capabilities and for the scholars who are interested in D-procurement adoption. In this study, the basic CSF–TOE model was further tested and verified in a typical real case.

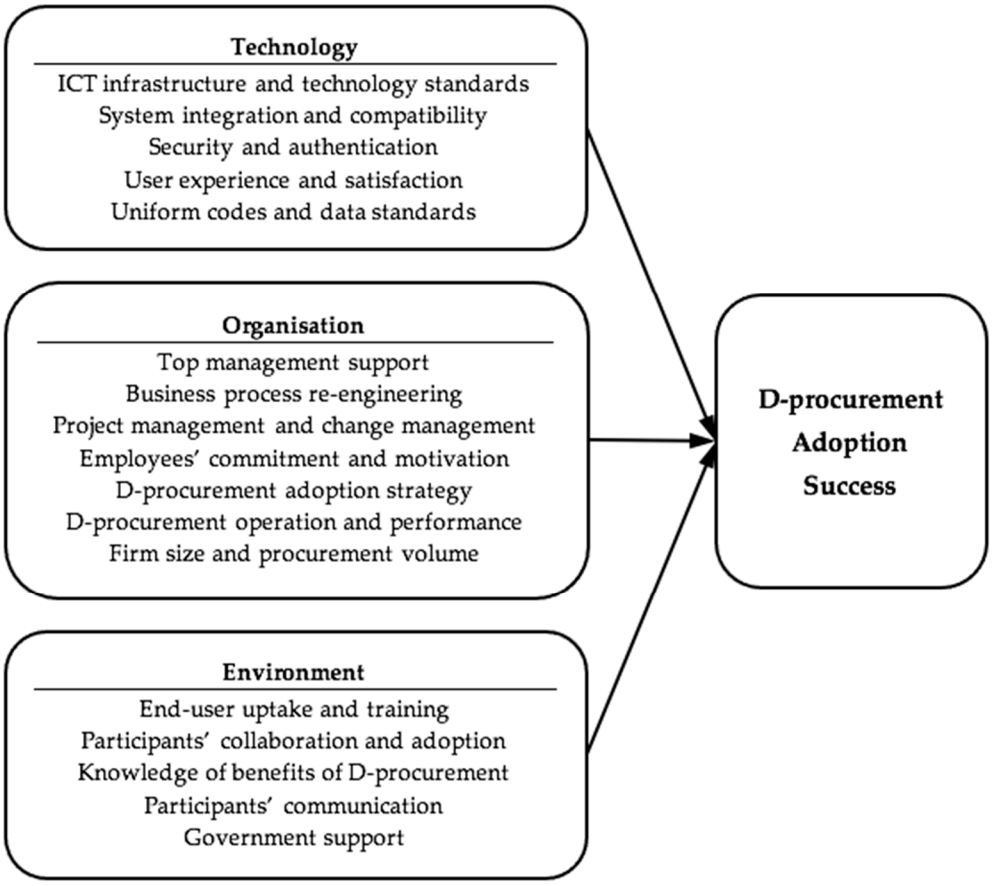

Figure 2. The proposed integrated CSF–TOE model.

3. Research Design

According to Bhattacherjee [81], most case research studies tend to be interpretive, and interpretive case research is an inductive technology where evidence collected from one or more cases is systematically analysed and synthesised to allow concepts and patterns to emerge, to build new theories or expand existing ones.

As discussed in the previous sections, the main objective of this research is to find out the CSFs and their order of relevance. As digital innovation is in progress and is developing rapidly, the theory is more-or-less lagging behind the practice. Therefore, it is important to study representative cases in real practice to test and extend the existing theories. That is why we choose the case study method for this research. Given that not many Chinese construction companies have successfully adopted D-procurement solutions, and considering the author's familiarity with the case company and the convenience of data collection, we finally selected a company with the best practices as the research object. That explains why we used a single case study method for this research.

In addition, to effectively answer the two research questions and accomplish the main research objectives, we used a qualitative research method in the research design. The three main research steps are presented in the following:

- Step 1: CSF selection. To find out the CSFs that can be used for this case study research through literature review and select the relevant CSFs from similar studies. The literature survey method was applied in this step to collect and select the original CSFs;
- Step 2: Basic CSF–TOE. To work out the basic CSF–TOE model by categorising and integrating the CSF into the TOE framework;
- Step 3: CSF relevance identification. To further identify CSFs' order of relevance. First, an in-depth interview with D-procurement specialists is designed. After that,

the collected data were analysed, and the relevance-based CSF–TOE model was finally proposed.

4. Methods and Results

As Yin [82] pointed out in his famous book *Case Study Research: Design and Methods*, the case study is relevant when your research questions seek to explain some present circumstance or require an extensive and in-depth description of some social phenomenon. However, based on the basic CSF–TOE model derived from literature, we still need to put it into a real case to find out whether it is relevant in the business scenario of Chinese construction companies and if there are any other relevant factors.

A case study can help to answer these questions. First, however, it is important to choose a relevant case. It should be a successful D-procurement adoption case in the Chinese construction industry. In addition, the enterprise should be influential, and its organisational culture and structure should be able to represent the industry. Furthermore, the required data for our study should be accessible.

Based on the criteria, we strived for the chance to study the H Group. The D-procurement project by the H Group was commended as the best case of a digital supply chain by China's State-owned Assets Supervision and Administration Commission (SASAC) in 2021 [83]. In other words, this case is currently representative of the best practices of the Chinese construction industry. We also tried to find additional cases to see whether multiple case studies were possible. Still, due to business information constraints and data security considerations, we could not obtain permission from any more companies. Thus, finally, we decided to apply a single case study approach in this study.

4.1. Introduction to the Case

In this study, the H Group is considered the benchmarking case. According to the information published on H Group's official website [84], it was founded in May 1950. After more than 70 years of development, the group has become a large-scale construction group with great influence in western China, in the whole country, and even overseas. It has over 100 branch offices and subsidiaries and yielded over CNY 80 billion in annual revenue in 2021 [85]. Its business covers more than 30 administrative regions in China and 20 overseas countries and regions.

In 2015, the H Group started to invest in and explore strategies for digital transformation and upgradation. In 2016, the H Group established a new company that especially serves its digitalisation. This company was named H Tech, and is one of the first digitalisation companies in the Chinese construction industry. It is mainly positioned in the overall responsibility for developing, implementing, and operating the D-procurement platform for all the affiliated companies of the H Group. After about three years, the platform was recognised as one of the best D-procurement practices in the Chinese construction industry. According to a report by Xu and Hu [86], by operating the D-procurement platform, it had achieved CNY 156 million in savings by the end of 2017.

It was a significant achievement. In 2021, China's SASAC commended 100 typical cases of digital transformation of state-owned enterprises in 2020, and the H Group was among of them. In addition, the H Group was the only awarded digital procurement platform case, which means the case was considered the best D-procurement practice in China [83].

That is the reason and value for selecting the H Group for this case study. Its organisational structure and business processes represent the construction industry or leading Chinese enterprises of different sectors, and its D-procurement case is typical and has universal significance in China. Hence, the findings of this case study could be reliably generalised to other enterprises, economic sectors, and even other countries. Furthermore, the findings of this study would also be helpful for scholars interested in digital transformation.

As an innovative and successful project in the industry, the D-procurement platform has its distinct features. According to Ronchi et al. [87], there is a general consensus

that from the technological perspective, there exist three main types of procurement platforms: buyer-hosted, seller-hosted, and intermediated platforms. Furthermore, Angeles and Nath [88] categorised it from the management perspective: buyer-managed, seller-managed, and electronic marketplace-managed platforms. All these types can be found in the practice of D-procurement in China.

The D-procurement platform designed and developed by H Tech is a typical buyer-established platform. The buyers have more initiative than sellers and are, therefore, more likely to dominate supply chain interactions. Thus, the buyer companies are the supply chain leaders [89] and, hence, it is easier for them to promote the supply chain platform. This platform has four main features.

First, it is a multi-sided platform, which acts as an intermediary and provides opportunities for direct interaction and exchange between two or more parties of the platform participants [90]. Second, it primarily purchases raw materials and Maintenance, Repair and Operations (MRO). Third, it digitalises the procurement process, including planning, tendering, contracting, ordering, delivering, inspecting, settling, paying, and recording. Fourth, it applies advanced digital technologies such as cloud computing, mobile application development, blockchain, big data, and artificial intelligence technologies.

4.2. In-Depth Interview

The reason for carrying out an in-depth interview is that the integrated CSF–TOE model needs to be put into a real-world scenario and evaluated by specialists with practical experiences in conducting D-procurement projects in the H Group. Another important reason is that interviews enable more direct interactions with the participants than questionnaires. As a consequence, the participants pay more attention to the interviews, thereby increasing the authenticity of the data obtained.

To achieve the objectives, a structured and in-depth interview is designed. In the beginning, a set of open questions were asked for warm-up:

- How long have you been working in this company?
- What was your role in the D-procurement project?

After that, a list of the 17 CSFs was given to the respondents. We firstly explained the meaning of each CSF to prevent deviations in understanding. After that, they started ranking the CSFs by writing a sequence number in front of each CSF. That process lasted about ten minutes, the respondents kept thinking and revising the ranking numbers until they felt satisfied.

In addition, it is important to select the relevant candidates for the interview. Ideally, different stakeholders of the D-procurement project should be included so that the data can be collected from a different group of people, such as the headquarters, the subsidiaries, and the partners of the H Group. To identify the relevant candidates, a preliminary meeting was held in the H Group, where the head of the human resource department, the head of the business centre, and our research team were present.

After serious discussion, we found that most stakeholders only participated in part of the project, so they were not ideal candidates. In addition, most of the specialists who could answer the interview questions about the CSFs were in H Tech. Those people were fully involved in the project and in the entire process, and had a comprehensive understanding of the factors impacting the project's success. There were 15 specialists suggested; they were the core middle and top managers and were the key roles in the project. In addition, from another company called Y Tech, which is the main technology partner that assisted H Tech in designing and developing the D-procurement platform, the project director and product manager were invited to participate in the interview. Finally, 17 candidates were identified as interviewees (Table 4).

Table 4. The 17 selected respondents.

No.	Interviewee	Company	Position	Joined
1	CH.W	H Tech	Chief Technology Officer	42 mos.
2	W.SL	H Tech	Operation Centre, Department Manager	48 mos.
3	L.XY	H Tech	General Administration Centre, Administration and Secretary Department Manager	24 mos.
4	H.Y	H Tech	Tax and Accounting Centre, Financial Management Department Manager	46 mos.
5	CH.Q	H Tech	Business and Finance Centre, Settlement Department Manager	52 mos.
6	P.X	H Tech	Technology Centre, Product Manager	42 mos.
7	L.X	H Tech	Service and Support Centre, Director	60 mos.
8	ZH.J	H Tech	General Administration Centre, Organisation and Human Resource Department Manager	36 mos.
9	L.LL	H Tech	Online Business Centre, Director	70 mos.
10	X.Y	H Tech	Business and Finance Centre, Director	42 mos.
11	W.JX	H Tech	General Administration Centre, Director	35 mos.
12	L.B	H Tech	Technology Centre, Digitalisation Manager	69 mos.
13	D.MR	H Tech	Marketing Centre, Manager	30 mos.
14	W.PR	H Tech	Technology Centre, Product Manager	19 mos.
15	W.T	H Tech	Marketing Centre, Director	42 mos.
16	L.T	Y Tech	Project Director	36 mos.
17	H.LM	Y Tech	Product Manager	21 mos.

The in-depth interview was conducted in H Group's conference room in March 2022.

4.3. Data Analysis

Respondents ranked the 17 CSF during the interviews based on their understanding and experience. The results are summarised in Table 5 below.

Since it aimed to reveal the relative importance among the 17 CSF without actually establishing the degree of variation between them, the ordinal scale was considered. According to Stevens [91], the ordinal scale is the second level of the four measurement scales: nominal, ordinal, interval, and ratio. The primary advantage of using an ordinal scale is the ease of comparison between variables. Moreover, due to the simplicity of analysis and categorisation, an ordinal scale can be effectively used in surveys, polls, and questionnaires. The collected responses are easily compared to draw impactful conclusions about the target audience [92]. This feature was convenient for this in-depth interview, making it simple and quick to obtain opinions from the specialists.

Based on Table 3, the total ranking of each CSF was counted. For example, the "top management support" factor was ranked first eight times, second four times, third three times, and fourth two times.

Then, weights were assigned to the ranking order based on the ordinal scale method. The highest rank in the order was assigned to 1.7, while the lowest was assigned to 0.1. There was an equal difference of 0.1 between the weights. For example, the total weight of "top management support" was calculated as: "$8 \times 1.7 + 4 \times 1.6 + 3 \times 1.5 + 2 \times 1.4 = 27.3$".

Table 6 below shows the ranking statistics for each CSF and the final weight results. The CSF with the highest weight (top management support) ranked first, and the lowest (employees' commitment and motivation) ranked last. The table's numbers with a shaded background in the table indicate the total number of times a CSF was ranked in a certain order.

Table 5. CSF order of relevance ranked by interviewees.

Order →	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
CH.W	13	1	8	10	16	3	2	11	12	4	5	6	7	9	14	15	17
W.SL	13	3	1	5	12	2	7	8	10	9	15	14	17	11	16	4	6
L.XY	1	2	8	11	3	12	14	16	4	5	7	10	6	15	9	13	17
H.Y	12	13	1	3	4	15	5	2	9	17	6	7	10	11	14	16	8
CH.Q	13	1	8	4	11	9	10	14	16	17	3	15	2	5	6	7	12
P.X	13	11	2	1	15	3	14	10	12	16	17	9	4	6	5	8	7
L.X	1	12	11	17	13	3	2	15	5	4	7	6	9	10	14	16	8
ZH.J	11	3	1	12	13	8	9	10	14	16	2	17	4	5	7	15	6
L.LL	1	14	11	2	3	17	13	12	8	9	15	4	5	6	7	10	16
X.Y	1	12	8	17	2	14	10	9	4	15	5	11	3	6	7	16	13
W.JX	11	1	17	13	12	2	3	10	14	15	8	9	16	4	5	6	7
L.B	1	2	12	13	3	17	11	16	8	9	10	14	15	4	5	6	7
D.MR	13	1	12	3	11	16	17	5	2	8	4	6	7	14	9	10	15
W.PR	1	2	3	7	13	15	11	12	4	5	10	8	6	14	9	16	17
W.T	1	11	12	13	2	14	17	8	10	3	4	7	16	15	5	6	9
L.T	13	12	15	1	3	2	11	7	8	14	6	10	16	17	4	5	9
H.LM	1	13	3	15	12	11	2	4	5	6	7	10	17	14	8	9	16

1—Top management support; 2—Business process re-engineering; 3—D-procurement adoption strategy; 4—Project management and change management; 5—ICT infrastructure and technology standards; 6—Security and authentication; 7—System integration and compatibility; 8—D-procurement operation and performance; 9—End-user uptake and training; 10—Participant's collaboration and adoption; 11—Knowledge of benefits of D-procurement; 12—Firm size and procurement volume; 13—Government support; 14—Participants' communication; 15—Uniform codes and data standards; 16—User experience and satisfaction; 17—Employees' commitment and motivation.

Table 6. CSF ranking statistics and total weights.

Order / CSF	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**Total Weights**
CSF 1	8	4	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	27.3
CSF 2	0	3	1	1	2	3	3	1	1	0	1	0	1	0	0	0	0	20.3
CSF 3	0	2	2	2	4	3	1	0	0	1	1	0	1	0	0	0	0	20.9
CSF 4	0	0	0	1	1	0	0	1	3	2	2	1	2	2	1	1	0	12.3
CSF 5	0	0	0	1	0	0	1	1	2	2	2	0	1	2	4	1	0	11
CSF 6	0	0	0	0	0	0	0	0	0	1	2	3	2	3	1	3	2	7.3
CSF 7	0	0	0	1	0	0	1	1	0	0	3	2	2	0	3	1	3	9.2
CSF 8	0	0	4	0	0	1	0	2	3	1	1	1	0	0	1	1	2	14.7
CSF 9	0	0	0	0	0	1	1	1	1	3	0	2	1	1	3	1	2	10
CSF 10	0	0	0	1	0	0	2	3	2	0	2	3	1	1	0	2	0	12.9
CSF 11	2	2	2	1	2	1	3	1	0	0	0	1	0	2	0	0	0	20.5
CSF 12	1	3	3	1	3	1	0	2	2	0	0	0	0	0	0	0	1	21.4
CSF 13	6	2	0	3	3	0	1	0	0	0	0	0	0	0	0	1	1	22.9
CSF 14	0	1	0	0	0	2	2	1	2	1	0	2	0	3	3	0	0	13.1
CSF 15	0	0	1	1	1	2	0	1	0	2	2	1	1	2	0	2	1	13
CSF 16	0	0	0	0	1	1	0	2	1	2	0	0	3	0	1	4	2	9.8
CSF 17	0	0	1	2	0	2	2	0	0	2	1	1	2	1	0	0	3	13.5

Based on the results shown in Table 6, the final ranking of the 17 CSFs is shown in Figure 3 below.

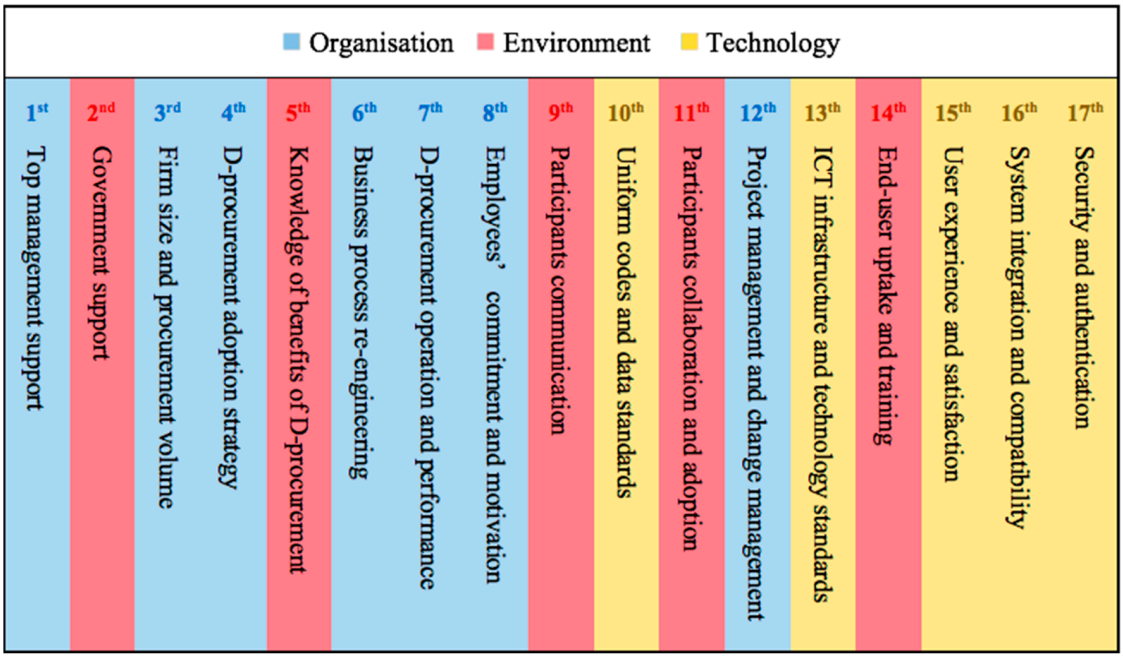

Figure 3. CSF order of relevance ranked by specialists.

5. Discussions

5.1. Implications of Research Findings

From Figure 3, it can be seen that the "Organisation" and "Environment" factors have a higher rank than the "Technology" factors. With this finding, we further reviewed the in-depth interview record and found that most interviewees had the same logic in determining CSFs' order of relevance. First, they believed that environmental factors determine the feasibility of adopting D-procurement projects. Therefore, those factors were prerequisites. Second, they considered the "government support" and "consensus on the value of D-procurement" to be significant, so they selected the factors such as "employees' commitment and motivation", "end-suer uptake and training", "participant's collaboration and adoption", "knowledge of benefits of D-procurement", and "participants' communication". Third, considering that advanced digital technologies are mature and widely applied in many industries, they found that how to apply these technologies well in business is more important. Therefore, the success or failure of the D-procurement project depends more on the organisation factors. Such thinking logic largely determines the ranking of CSFs.

In addition, we interviewed the founder of H Tech, the most important person for the project. He highly agreed with the interviewees' logic in ranking the CSFs, explaining that it does not mean the technological factors are not important. In fact, they are of great significance. He emphasised that it is the rapid development of digital technologies that has brought about changes in the political environment and business management, thus enabling innovations that were impossible before. It is like the promotion of productive forces to production relations. When productivity is sufficiently advanced, people will focus on the change and innovation of production relations, which is why the environmental and organisational factors are ranked higher than technological factors. He further stated that in the process of digital transformation and upgrading of the industry, technological, environmental, and organisational factors interact with and promote each other, and continue to develop according to business needs.

The above findings have also been confirmed in other studies. Vogelsang et al. [93] studied the CSFs for digital transformation in the manufacturing industry, and they also found that among the three dimensions of technology, organisation, and environment, the relevance of organisational factors was the highest, followed by environment, then

technology. They pointed out that it reflected a challenge, but also a chance for companies to drive their own digital transformation. In another study by Cichosz et al. [94], they discovered that, for the CSFs for digital transformation in logistic service business, the top three factors were "leadership", "organisational culture supporting customer centricity and openness to change", and "employee and partner engagement", which were organisational factors as well.

In addition, the research context is important to the findings. As Garzoni et al. [95] suggested, there were four levels of readiness for adopting digital technologies: "digital awareness", "digital requirement", "digital collaboration", and "digital transformation". And, they provided some variables for companies to access the levels. This is a good research direction. This also implies that researchers should pay attention to the specific context for CSF studies, as different results may be found in different contexts.

Furthermore, while the TOE model is used to categorise CSFs in this study, there are also some other methods used. Ubiparipović et al. [96] conducted a literature review on CSFs for digital transformation; they categorised the CSF in five dimensions: "context and contents for digital transformation", "vision and strategy", "organisational capacities and capabilities", "organisational culture", and "technology". This method has the characteristics of TOE, but emphasises organisation-related factors. Additionally, researchers also use the diffusion of innovation theory [15] to investigate the factors that influence the success of digital transformation [97]. Vogelsang et al. [93] used a combination of the information system success model of DeLone and McLean with the TOE model. Overall, the TOE model is still the most widely used in CSF studies [98].

5.2. Management Recommendations

In the process of digital transformation, a very important consideration for companies is to evaluate whether their own management and business maturity match the application of new technologies. In the case of D-procurement adoption, the 17 CSFs identified in this study can be used as a checklist to assess a company's maturity in adopting D-procurement so that companies can be very clear about their strengths and weaknesses.

In addition, this study reveals that the management capabilities of companies are important for digitalisation. If policy factors determine the general environment and technological factors provide effective tools, the company's "own cultural shaping and awareness of digitalisation", "strategic planning capabilities", "organisational management capabilities", "project implementation capabilities", "top-management push", and "employee consensus" play the decisive roles in the success of the digitalisation project. Therefore, companies must pay full attention to their own improvement in all aspects. Just as only advanced production relations can match advanced productivity, only advanced organisational management can make good use of advanced digital technologies.

5.3. Applicability of Research Findings

In this study, the 12 referred CSF articles are from different countries and years, were strictly selected through a systematic literature survey, and the 17 CSFs were selected based on their frequency of occurrence in the 12 references. We believe that the 17 CSFs can serve as a good reference for research or practice of digital procurement adoption in different countries and even in different industry sectors. However, it should be noted that adjustment may be necessary according to the contextual characteristics.

Regarding the order of CSFs' relevance, it is context-dependent and correlated with the interrelationships of technology, organisation, and environment. For example, in Nigeria it was found that the "availability of reliable, affordable, and fast Internet services" was the most critical factor for D-procurement adoption in the construction industry [68]. This is because, in that country, digital technology is not yet developed, and thus technology is more important to them than organisation and environment. But, even in African countries, Chigadi and Gekara [99] found that "stakeholder participation", "government policy", "monitoring and evaluation", and "capacity building" were the critical factors for

digital procurement in public sectors in Kenya. In addition, different industries may have different CSFs. For example, Lin et al. [100] studied the CSFs for business to business (B2B) procurement systems in the travel industry in Taiwan, China, and they found "system stability", "system reliability", "sales dynamics", and "product line availability" were most critical.

The CSFs' relevance in our study provides a relevant theoretical basis, researchers or practitioners can make appropriate adjustments according to the contextual factors, so as to use it in different places and industries.

The findings of this study are highly applicable in China. First of all, the case of the H Group is very representative and, therefore, the findings in this study can serve as valuable references for construction companies. Moreover, Chinese companies have many commonalities in digitalisation, and thus the findings of this study also have important reference value for D-procurement adoption in other industries. Furthermore, the findings of this study also have high application value for other countries with similar levels of economic development and digital technology application as China.

6. Conclusions

Based on the findings in this study, a relevance-based CSF–TOE model was proposed as illustrated in Figure 4 below.

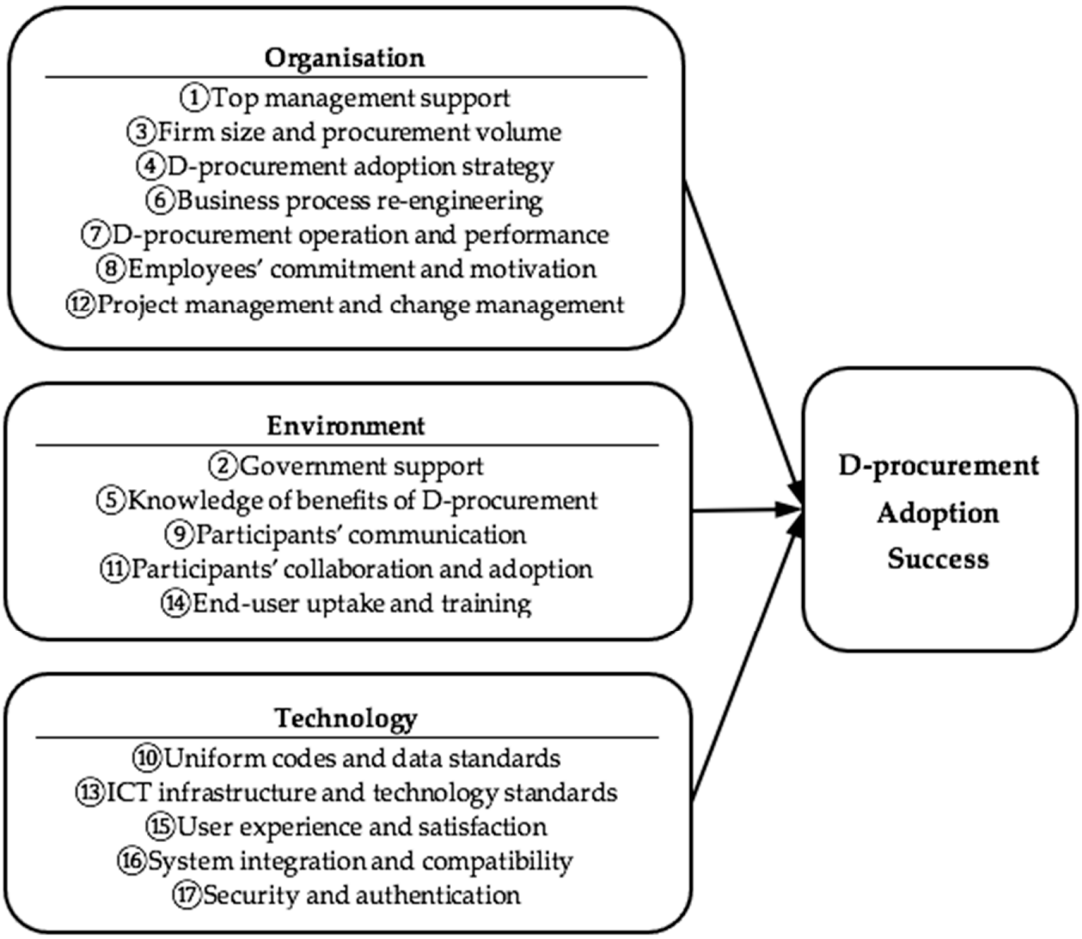

Figure 4. Proposed relevance-based CSF–TOE model.

In this model, organisational factors, as the most important elements, are placed first, followed by environmental then technological factors. It actually looks like an "OET" model. The corresponding order number was added in front of each CSF, which clearly shows the ranking of a certain CSF among the 17 CSFs, facilitating the understanding and application of this model.

This model is the core research result of this study, which answers the two research questions and addresses the research pain point initially put forward. It provides a theoretical guide for construction companies to successfully adopt digital procurement.

In addition, academic and corporate interest in sustainable supply chain management (SSCM) has risen considerably in the past 20 years [101]. In recent years, scholars have begun to pay attention to the relationship between digital transformation and sustainability. D-procurement is an important part of SSCM [102], as it contributes to economic sustainability for the construction industry by driving the supply chain into a more sustainable circular economy and digital sharing economy [103].

7. Research Limitations and Future Research

7.1. Selection of 17 CSFs

We selected 12 studies through a systematic literature survey and formulated criteria for a further selection of CSFs. However, it was impossible to exclude subjective factors in the process absolutely; otherwise, instead of 17, we may have ended up with tens or hundreds of CSFs. Overall, we felt that these subjective factors did not significantly affect the applicability and representativeness of the 17 CSFs. In addition, we believe that, to obtain a more accurate list of CSFs, a better method is to identify real CSFs in practice for comparison and verification through interviews or questionnaires. That can be a direction for future research.

7.2. Single Case Study

There are two main reasons for choosing a single case in this study. First, because D-procurement is an innovative event, there are not many successful cases worth studying. In addition, due to confidentiality and competition considerations, most companies are unwilling to participate in the research. Second, the selected company is not a random case but a national benchmark, which has proved its demonstration and benchmarking. In reality, a large number of companies are learning from the H Group.

However, the single case study has its inherent weakness. For example, most of the interviewees are from the H Group. Therefore, the interview is based on the same environment and the same project, and there may be potential bias in the interview results. To reduce bias, or to validate bias, future research may conduct multiple case studies, or even multiple case studies across industries.

7.3. Model Testing

While the proposed relevance-based CSF–TOE model is a significant contribution, its practical implications and efficacy should be further tested, ideally through additional case studies or empirical testing. Furthermore, it is suggested to carry out in-depth studies to find out the relationships between the CSFs.

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