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An Extended TOE Model for Digital Procurement Adoption of Chinese Construction Industry: A Case Study of H Group

LUO Guan

Doctor of Management

Supervisors:
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BUSINESS
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Marketing, Operations and General Management Department

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Declaration

I declare that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university and that to the best of my knowledge it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed:  Date: 2023.3.26

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作者申明

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Abstract

With the emergence of digital transformation, Chinese construction companies have an increasing need to adopt digital procurement (D-procurement), however there is lack of theoretical background to guide and support these adoption decisions. This study aims to fill the research gap through the provision of an extended Technology-Organisation-Environment (TOE) model with critical success factors (CSF) for D-procurement adoption success (DAS). In the research, a case study approach is applied and H Group is selected since it is one of the best D-procurement examples in China.

The study includes three parts. First, a systematic literature review was conducted, and 17 CSF were identified from 12 selected studies. Second, an in-depth interview with 17 selected experts elaborated their opinions on the previously identified CSF, and derived 8 CSF that were important for real cases. Furthermore, based on the relationships between the factors found through the interview, an extended TOE model was proposed, using the technology, organisation, and environment as the independent variables, business model innovation (BMI) as the mediator variable, entrepreneur leadership (EL) as the moderator variable, and DAS as the dependent variable. Third, a final questionnaire survey was conducted where 136 effective questionnaires were collected, the model was formally validated through statistical data analysis and its value was highlighted and demonstrated.

The present study significantly contributes to field of D-procurement adoption for construction companies by providing a theoretical framework for practice and an extended TOE model for research.

Keywords: digital procurement, critical success factors, extended TOE model, D-procurement adoption

JEL: O32, L86

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Resumo

Com o surgimento da transformação digital, as empresas de construção chinesas têm uma necessidade crescente na adoção de processos de procura e aquisição digital (*D-procurement*), no entanto, há falta de fundamentação teórica que sirva para orientar e apoiar esta adoção. Este estudo visa preencher esta lacuna através do fornecimento de um modelo alargado de Tecnologia-Organização-Ambiente (TOE) com fatores críticos de sucesso (FCS) para o sucesso da adoção do *D-procurement* (DAS). Na investigação, é aplicada uma abordagem de estudo de caso e o Grupo H é selecionado uma vez que é um dos melhores exemplos de *D-procurement* na China.

O estudo inclui três partes. Primeiro, foi realizada uma revisão sistemática da literatura, e foram identificados 17 FCS de 12 estudos selecionados. Em segundo lugar, uma entrevista realizada com 17 peritos selecionados elaborou as suas opiniões sobre os FCS previamente identificados, e derivados 8 FCS que eram importantes para casos reais. Além disso, com base nas relações entre os fatores encontrados através da entrevista, foi proposto um modelo TOE alargado, utilizando a tecnologia, organização, e ambiente como variáveis independentes, inovação do modelo de negócio (IMN) como variável mediadora, estilo de liderança (EL) como variável moderadora, e DAS como variável dependente. Em terceiro lugar, foi realizado um inquérito final onde foram recolhidos 136 questionários efetivos, em o modelo foi formalmente validado através da análise de dados estatísticos e o seu valor foi realçado e demonstrado.

O presente estudo contribui significativamente para o campo da adoção do *D-procurement* para as empresas de construção, fornecendo um quadro teórico para a prática e um modelo TOE alargado para a investigação.

Palavras-chave: procura e aquisição digital, fatores críticos de sucesso, modelo TOE alargado, adoção de D-procurement

JEL: O32, L86

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摘　要

随着数字化转型升级的深入开展，中国企业采用数字采购（D-procurement）的需求也与日俱增，但现有理论缺乏对相关实践的指导与支撑。本研究旨在提供一个基于关键成功要素（CSF）的 TOE（技术-组织-环境）扩展模型，为成功实施数字采购（DAS）提供理论基础，从而填补学术上的空白。本研究采用案例研究法，H 集团作为中国最优秀的数字采购案例之一被选为研究对象。

本研究包括三个主要部分。第一，通过系统性文献回顾（Systematic Literature Review），从选取的 12 个相关文献中选择了 17 个 CSF。第二，通过深度访谈，请 17 位专家对 17 个 CSF 进行了排序，同时征求了他们对 CSF 的看法，再经过遴选和重组最终得到 8 个 CSF。进而，基于访谈中发现的关键要素间的关系，以技术、组织和环境为自变量，商业模式创新（BMI）为中介变量，创业领导力（EL）为调节变量，DAS 为因变量提出了 TOE 扩展模型。第三，通过问卷调研法收集了 136 份有效问卷，并通过对数据的统计分析验证了模型。

本研究提出的基于 CSF 的 TOE 扩展模型，为企业实施数字采购等数字化项目提供了有力的理论指导，也为相关领域的学术研究提供了新的发现。

关键词：数字采购，关键成功要素，TOE 扩展模型，数字采购实施

JEL: O32, L86

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This is absolutely one of the craziest things I've ever done in my life.

My parents are old, my daughter is still very young, and my company is in a critical period of development, but I still need to put a lot of effort into studying. In the past four years, there have been countless sleepless nights, countless anxiety, and countless gray hairs. I would like to thank my wife Borjigin Wulantuoya, without your support I would not be possible, nothing would be possible. Thank you for understanding my quest, for taking care of our daughter, for cooking for us, and for comforting me when I am troubled. I'm also very sorry, because I missed a lot of time with you because of studying.

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Life is rough and long, it’s better to burn out than to fade away.

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致　谢

这绝对是我人生中干过的最疯狂的事情之一。

我的父母老了，我的女儿还小，我的公司正处于关键发展期，但我还需要花很多精力来读书。过去四年，有无数个不眠之夜，无数的焦灼，无数白了的头发。我要谢谢我的太太孛儿只斤，没有你的支持我不可能，一切都不可能。感谢你理解我的追求，感谢你为我们照顾女儿，为我们做饭，在我烦恼的时候安慰我。也非常抱歉，因为读书错失了许多陪伴你的时间。

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我的女儿罗无双，有无数个周末，无数深夜，我们彼此坐在书桌的对面一起学习。你看到了我的努力，我也看到了你的努力，我希望能为你树立榜样，希望你能在知识的海洋中找到属于自己的乐趣，并获得成就。

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还有所有那些支持我读书的人，谢谢你们的一切。

人生崎岖而漫长，与其苟延残喘，不如从容燃烧。

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Chapter 1: Introduction

1.1 Research background

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 (Laffont & Tirole, 1993). Procurement is an essential operation of every organisation regardless of its size or domain (Shaham et al., 2021), it can represent up to 80% of an organisation's costs (Nicoletti, 2018). Therefore, in such a changing and challenging world, it is crucial to find innovative ways for procurement management in organisations. An important solution might come from the fast-developing digital technologies. In this research, the digital procurement is studied under the background of digitalisation.

1.1.1 Status quo of digitalisation in China

In March 2021, China approved its 14th Five Year Plan (2021-2025), where the digital transformation is emphasised to promote the country's competitiveness in the new general-purpose technologies expected to drive economic progress during the next decade (The State Council of the People's Republic of China, 2021).

At the national level, according to McKinsey Global Institute (MGI)'s report by K. W. Wang et al. (2017), China has become a force to be reckoned with in digital technologies at home and around the world. As a major worldwide investor in digital technologies and one of the world's leading adopters of those, it is already shaping the global digital landscape and supporting and inspiring entrepreneurship far beyond its own borders. In 2020, China has become the world's second largest digital economy. After years of practice, big data, Internet of Things (IoT), industrial Internet and cloud computing have become the powerful driving forces for the development of China's digital economy (Stern & Xie, 2020).

At the government level, Yan et al. (2021) reported that since 2016, the Chinese government has listed the digital economy high on the agenda of the blueprint of innovative growth. The development of the digital economy has been an important topic in the government work report in the past three consecutive years.

As a grand strategic blueprint, it is announced in the 14th Five Year Plan that the scale of

China's digital economy will be about 40-45 trillion yuan, accounting for more than 35% of GDP. In the next five to ten years, the role of digital economy in promoting economic development will continue to expand. This is accompanied by the rapid increase of 5G technology, the rapid integration of information and communication technology (ICT), and the continuous increase in the demand for information and communication infrastructure (Stern & Xie, 2020).

At the industry level, K. W. Wang et al. (2017) pointed out as China is pushing forward the digital transformation progress, industries will experience huge shifts in revenue and profit pools across the value chain. This creative destruction is also happening globally as the world digitises, but it is likely to happen more quickly and on a relatively larger scale in China given a combination of inefficiencies in traditional sectors and massive potential for commercialisation.

At the firm level, Yan et al. (2021) conducted a pilot study on the status quo of digital transformation in China. They have found that the majority of Chinese firms reach a consensus on the strategic importance of digital transformation and agree on the importance of technology and human resources. In general, firms in the information technology (IT) sector hold the higher level of digitalisation compared with firms in the manufacturing sector, and private-owned firms hold the higher level of digitalisation than state-owned firms. Furthermore, M. L. Zhang and Chen (2019) indicated that China’s digitalisation particularly in e-commerce and fintech sectors are already high in the world, and the digital transformation has boosted productivity growth, with varying impact on employment across different economic sectors.

1.1.2 Status quo of digitalisation in construction industry in China

Over the past 20 years, China’s construction industry has been developing rapidly. In 2015, China became the global leader in built asset wealth with US$ 47.6 trillion, overtaking the USA that came in second place with a wealth of US$ 36.8 trillion (Cayet & Cavalla, 2015). Even though the growth is slightly slowing in recent years, it is still very strong. As of 2019, China’s construction industry contributed US$ 1.02 trillion, which accounted for 7.16% of the GDP (National Bureau of Statistics of China, 2020).

However, according to MGI’s global industry digitalisation index (Agarwal et al., 2016), among 22 classified economic sectors, the agriculture and hunting sector holds the lowest ranking and construction sector is the next-to-last. The result reveals that the construction labour productivity has not kept pace with overall economic productivity.

The industry has not yet embraced the new digital technologies. Research and development spending in construction runs well behind that of other industries: less than 1 percent of revenues versus 3.5 to 4.5 percent for the auto and aerospace sectors. Even though a few new software solutions have been developed for the industry there are still less focus and concertation on that.

Focusing on China, the situation is similar. According to MGI's China industry digitalisation index (K. W. Wang et al., 2017), construction industry holds the lowest position among 22 sectors. That means that either in China or globally, the digitalisation progress is not optimistic compared with those sectors that have good digitalisation practices. As a very traditional and significant industry, on the one hand, the construction sector must change and follow China's digitalisation transformation strategy, to take advantage of the opportunities. On the other hand, digitalisation in the construction sector still has many potential barriers that need to be overcome, and more innovations are expected.

1.1.3 The rise of digital procurement

According to a study by Yap et al. (2020), the evolution of procurement can be represented in three main stages. The first stage was in 1980s, called strategic procurement. The second stage was between 1990s to 2000s, called electronic procurement (E-procurement). The third stage was 2010s and beyond, called digital procurement (D-procurement).

As Ilhan and Rahim (2020) pointed out, the notion of D-procurement is emerging in recent years. The D-procurement represents a concept that involves automation of procurement process using E-procurement systems that incorporate smart analytical tools like big data and data mining solutions (Srai & Lorentz, 2019). In particular, E-procurement systems reflects an application of electronic commerce (E-commerce) technologies to support a buying organisation's purchasing activities (Garrido-Samaniego et al., 2010).

However the concept of E-procurement systems is undergoing an evolution as it is emphasising on the incorporation of "smart" information technology systems (Schmidt et al., 2015), which extends the traditional E-procurement systems to D-procurement systems (Glas & Kleemann, 2016).

It is important to clarify that, since the electronic and digital procurement have many similarities, in this thesis, we do not intentionally differentiate the concept between E-procurement and D-procurement, we believe that by now they still have the same meaning.

And because the procurement system studied in this case has really applied many advanced

digital technologies, we uniformly use the term D-procurement in the whole context, to make sense of the state of the art. The evolution of D-procurement and its definition will be further discussed in detail in the literature review chapter.

1.1.4 Digital procurement adoption in the construction industry in China

In 2016, the China's National Development and Reform Commission (NDRC) released a notice, where the central government demanded to the local governments to further carry out pilot work of national electronic bidding and tendering (National Development and Reform Commission of China, 2016).

That is a very important trigger for the further adoption of advanced procurement solutions in China. Before that, many construction companies employed supply chain management software to manage their suppliers and procurement processes normally based on common information communication technologies.

After that, some leading companies started to design new specialised procurement solutions based on business re-engineering and develop new procurement platforms with digital technologies, such as cloud computing and blockchain.

Tens of millions of dollars were invested. After three years, the resulting cost savings and efficiency gains were significative. This stimulated more and more companies to start realising the importance of digital procurement.

Consequently, cost savings are the second trigger for D-procurement projects. According to China Industry Research (2020), in China while constructing a building, the material and labour procurement make up a significant cost share that is up to 75% of the total cost. In some circumstances, it might be even higher. Over the past ten years, the average profit rate of China's construction industry is as low as 3.5%. In 2019 it was only 3.37%, which is 0.02% lower than that of the previous year, keeping decreasing for three consecutive years.

With its cost-saving capabilities, D-procurement solutions provide an approach to potentially increase the profit. It allows several companies to buy products or services together on the digital procurement platform, and this centralised purchasing process increases the buyer bargaining power thus contributing to a possible lower final price. It also allows the buyers and suppliers to rapidly exchange online information through the platform thus enhancing the transaction efficiency and error rate reduction.

Furthermore, since the real transaction is completely recorded and stored in the digital platform, with the data mining and big data analytics (BDA) technologies, the supply chain

finance (SCF) can be embedded into the business (Kache & Seuring, 2017). As Song et al. (2021) found that with the growing mass of intangible data, the overall business ecosystem also changes, leading to the emergence of new players in SCF, such as financial service providers (FSPs). By establishing financial services based on a digital platform, many FSPs integrate supply chain participants of ecommerce together, calibrate their credits through operational data mining and BDA, and provide funds for small and medium enterprises (SMEs). As a result, payment days can be shortened, and the cash-to-cash cycle can be accelerated for SMEs embedded in the ecosystem.

According to the research by Song et al. (2021), the Ant Group formed a digital platform by connecting various entities in supply chain operations, and combining various transactions and capital activities. Through BDA, the Ant Group calibrates the credit of each transactional participant and provides customised financial lending services. It served 16.56 million SMEs in 2019, which is an 80% increase from 2018; the cumulative loans were RMB 1.7 trillion yuan, which is a 72% increase from the previous year.

To sum up, D-procurement solutions can be a significant breakthrough for China's construction industry's digital transformation. It is a good starting point with a great potential.

1.1.5 Case study of H Group

In this study, the H Group is considered as the benchmarking case. According to the information published on H Group's official website (H Group, 2021a), it was founded in 1950. It is one of the leading stated-owned construction companies in China. It has over 100 branch offices and subsidiaries with over 80 billion yuan annual revenue in 2021 (H Group, 2021b). As a pioneer in digitalisation, H Group has set up a subsidiary company specifically for conducting the D-procurement project as early as in 2016. This sub-company, was the first batch of digitalisation in the Chinese construction industry, oversees the developing, implementing and operating the digital procurement platform for all the affiliated companies of H Group.

After about three years, the platform is acknowledged as one of the best D-procurement practices in Chinese construction industry. According to a report by Xu and Hu (2018), by operating the D-procurement platform, there has originated RMB 156 million yuan in savings by the end of 2017.

It was obviously a significant achievement. In 2021, China's SASAC (State-owned Assets Supervision and Administration Commission) commended 100 typical cases of digital transformation of state-owned enterprises in 2020. The H Group awarded the only digital

procurement platform case, that means the case has been considered the best D-procurement practice in China (State-owned Assets Supervision and Administration Commission of China, 2021).

This is the reason and value for the selection of the H Group for this case study. Its organisational structure and business processes are very representative in the construction industry or in Chinese leading 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 who are interested in digital transformation fields.

1.2 Research problem

In the following sections, we are going to discuss the research pain point and related research questions, followed with the research objective, research gap, and research contributions.

1.2.1 Rise of research problem

Industry digitalisation is not only an evolving trend in China, but also around the world. The rise of Industry 4.0 (Kagermann et al., 2011) has further pushed the progress of digitalisation in multiple sectors, such as agriculture, manufacturing or construction industry.

As Oesterreich and Teuteberg (2016) explained, the context of Industry 4.0 can be described as increased digitalisation and automation in addition to increased communication enabled by the creation of a digital value chain. Zhou et al. (2015) explained that Industry 4.0 primarily includes the internet of things (IoT), cloud and cognitive computing, and digital manufacturing and cyber-physical systems that collect, transfer and make sense of Big Data, in order to develop smart industries and respond to fluctuations in the markets' demands for high-quality products and services (Papadopoulos et al., 2021).

For enterprises, on the one hand, they have proactively prepared for the transformational potential of this opportunity by defining in advance the most suitable manufacturing models, operational processes and targets for the associated challenges (Almada-Lobo, 2015).

On the other hand, digitalisation in its nature of innovation, it is totally new. The enterprises want to find some guidance, for example, they want to know the critical factors for D-procurement adoption success, but there is a lack of theoretical support. This illustrates the origin of the research problem.

The situation is similar in China. Some leading construction enterprises carried out innovative experiments in D-procurement solutions and obtained significant results in last few years, but the trial-and-error cost was significantly high. That was not only about the money, but the time and human resources that were committed. Therefore, this helps explaining why only the leading companies can afford the costs involved. However, enormous investments are not a synonym of success. This further illustrates the background of the research problem.

Therefore, there is a pain point for D-procurement. That is, no matter the Chinese companies' dimension, large, medium, or small, they are all consensual on the high value offered by D-procurement, and they want to adopt and implement D-procurement solutions, however, they are facing the fact that there is still a lack of theoretical guidance to guide them to risk reduction and successful D-procurement adoption. Which are the critical factors for successfully achieving their objectives? They really do not know. This is the primary problem that will be addressed in this research. According to the literature review, that will be discussed in detail in Chapter 2, few relevant studies were found that approached this problem, and this makes this research work relevant.

In this research, a case study will be carried out to analyse the successful experiences of D-procurement adoption. It aims to define the Critical Success Factors (CSF) impacting on the D-procurement adoption in the Chinese construction industry context. Furthermore, it also aims to develop a methodology to provide guidance to companies which are willing to adopt D-procurement solutions.

1.2.2 Research questions

Based on the research problem stated above, two research questions are proposed:

Research question 1: What are the critical success factors for D-procurement adoption in Chinese construction companies?

It is important to define the CSF within the Chinese construction context because we rarely found targeted studies on this scenario in literature research. The construction industry occupies an important position in the national economy hence it is valuable to study D-procurement for the industry.

Moreover, it aims to find out the order of relevance of these CSF, which will help companies to know which one of the CSF is more significant, so they can arrange the conditions accordingly to satisfy the D-procurement projects in real practice.

Research question 2: What are the relationships between these critical success factors?

To find out the CSF is just the first step. If we can further find the relationship between these CSF, then we can help companies to have a better understanding of the CSF and make better applications in practical projects.

Going a step further, if the relationship can be combined with a well-established theoretical model, it is quite possible to create new theoretical contributions by extending that model. In this study, the Technology-Organisation-Environment (TOE) framework (Depietro et al., 1990) is used as the basic model for studying on CSF and their relationship.

1.2.3 Research objective

The main objective of this Doctor of Management project is to find out the CSF and their relationship to provide a theoretical guidance for D-procurement adoption. The overall research objective can be decoupled in the following sub-objectives:

1) To define the CSF for D-procurement adoption.
2) To find out the order of relevance of these CSF.
3) To develop an extended TOE model.

1.2.4 Research gap

The CSF theory has been widely applied in different fields for over 50 years. There have been many CSF studies on procurement management systems or electrical procurement systems. Nowadays, with the rapid development of digital technologies, many enterprises are putting the new advanced technologies into practice to update their business daily. Meanwhile, all these explorations require guidance, but there is lack of updated theoretical supports to direct them to success. This is the research gap addressed by this research work.

In this digital age, where everything is new, grows and changes fast, researchers are trying to keep up, but this requires time. Especially for innovative projects, it is valuable to conduct case studies to make updates to existing theories.

In this study, the research gap can be filled from three different perspectives:

- First, from the contextual perspective.

The contextual gap is presented as a result in contextual differences.

The successful adoption of D-procurement depends on the contextual conditions because in different environments the critical factors are also different. In China, it is important to study the CSF for D-procurement in the context of leading large enterprises so that the findings would be reliably generalised to small and medium sized enterprises. In this case study, the context

will be focused on the H Group, and all its culture, organisation structure, business processes, challenges, and problems of digital transformation are quite representative in the construction industry. Therefore, the findings will help filling the contextual gap.

- Second, from the geographical perspective.

The geographical gap is a knowledge gap that considers the untapped potential or missing research literature in the geographical area that has not yet been explored or is under-explored (Waithaka & Kimani, 2021). As Teo et al. (2009) indicated, previous research has provided some evidence that research findings in western countries and Asia could differ. Some factors associated with D-procurement may be more salient in Asia when compared to other western countries. China as the world's second economy with high development speed on digital transformation, the findings should be representative and help contributing to fill the existing geographic gap.

- Third, from the methodological perspective.

Methodological gap is recognised as a result in limitations of the methods and techniques used in the research. Currently, and according to the research conducted, the majority of CSF studies are usually based on literature and questionnaire survey methods. There is lack of real case studies. In this research, the CSF study is based on a benchmarking case, and the TOE model is tested in the real environment. Moreover, in this case study, not only qualitative research is carried out through in-depth interview method, but also quantitative research is carried out through questionnaire survey method. The use of both methodologies not only ensures the richness and scientificity of the research, but also provides a reference for similar research in the future. these represent a contribution for CSF studies, which helps filling the methodological gap.

1.2.5 Research contribution

To fill the research gap discussed above, it is important to contribute to the current state of the art of CSF studies both practically and theoretically. By applying existing theories and approaches on a real case scenario, and finding out the CSF for D-procurement adoption from the study, this research work has the following contributions:

- First, it provides a theoretical guidance for enterprises that want to adopt D-procurement solutions. This guidance helps the enterprises understand the CSF to better adopt the D-procurement solutions, reduce cost and risk, and increase the possibility of success. Furthermore, in such a digitalisation age, the guidance can also help and boost

enterprises and industries to start and achieve their digital transformation objectives.

- Second, it defines eight CSF in a real case. By testing the CSF found in the literature in a very new and typical case, the eight CSF found contribute to both theory and practice.
- Third, it provides an extended TOE model for both practical use and theoretical studies. In this study, the TOE model is put into a real scenario for testing. In the process, methods for extending TOE are discovered through in-depth interview, and the model is refined, further tested and verified through empirical research. This is a particularly important finding with important theoretical value for future CSF research.

1.3 Research design

According to Bhattacherjee (2012), most case research studies tend to be interpretive in nature, and the interpretive case research is an inductive technology where evidence collected from one or more case sites is systematically analysed and synthesised to allow concepts and patterns to emerge for the purpose of building new theories or expanding existing ones.

As discussed in the previous sections, the main objective of this research is to find out the CSF and their relationship in between. Nowadays, as the digital innovation is in progress and developing rapidly, the theory is more or less lagging behind the practice. Therefore, it is important to study the representative cases in real practice to test and extend the existing theories. This explains why we choose the case study method for this research. Furthermore, since there are not so many Chinese construction companies have successfully adopted D-procurement solutions, considering on the familiarity of the case and the ease of data collection, we finally selected one of the best practices as the study object. This explains why we choose single case study method for this research.

In addition, in order to satisfactorily answer the two research questions and accomplish the three research objectives, we considered the use of both qualitative and quantitative research in the research design. First, CSF is confirmed through qualitative research and a new research model is proposed. Second, the model is validated through quantitative research. For the purpose there are seven research steps designed.

- Step 1: CSF selection. To find out the CSF that can be used for this case study research through literature review and select the relevant CSF from similar studies. The literature survey method is applied in this step to collect and select the original CSF for the study.

- Step 2: CSF-TOE framework. To work out the integrated CSF-TOE conceptual framework which is especially relevant for D-procurement adoption in Chinese context. In this step, the TOE framework is applied as an essential theoretical approach. The selected CSF are integrated and categorised into the TOE framework.
- Step 3: CSF identification. To further identify the CSF for the case study. The in-depth interview method is applied in this step. D-procurement specialists and key roles in H Group will be selected as the interviewee. Through the interview, the CSF are further identified and their relationship will be found out, the extended TOE model will be proposed.
- Step 4: Research hypothesis. To propose research hypotheses based on the extended TOE model. According to the findings of the relationship from the in-depth interview, the hypotheses will be proposed accordingly.
- Step 5: Data collection. To collect data for testing and verifying the research hypotheses established. In this step, a questionnaire survey will be conducted. The survey will be carried out mainly within the H Tech. It is the significant part of data collection in the study.
- Step 6: Data analysis. To process and analyse the collected data. In this step, statistical tools and methods are applied. The reliability and validity of the dataset will be tested, and the research hypotheses will be verified.
- Step 7: Findings and conclusions. Based on the results of data analysis, it is the step to discuss the findings and make conclusions. Furthermore, the management recommendations are summarised, the research limitations are explained, and the suggestions for furthers studies are discussed.

1.4 Thesis organisation

Based on the research design, this thesis is composed of six chapters, below is the short description of each of the chapters.

Chapter 1: Introduction. In this chapter, the background of the study is firstly introduced, and then the research problem is proposed. After that the research questions and objectives are described, finally the research gap and research contribution are discussed.

Chapter 2: Literature review. In this chapter, the information system adoption is firstly reviewed, and then the information system adoption theories are reviewed. After that the digital procurement and the CSF approach are reviewed. Finally, the selected CSF for this study are

discussed in detail.

Chapter 3: Research design. In this chapter, the logic of research design is firstly explained, and then the research methods and procedures are introduced. After that, the generation of the integrated CSF-TOE model is mainly discussed. Finally, the design of in-depth interview and questionnaire survey are described.

Chapter 4: Case study of H Group – in-depth interview. In this chapter, the background of H Group and its development of D-procurement project are introduced first. And then the conduct of the in-depth interview is introduced, followed with the analysis of the information collected and the discussion of the findings. Based on the findings, the extended TOE model with related research hypotheses are proposed. Finally, the design of the survey and the measurement model of the questionnaire are introduced.

Chapter 5: Case study of H Group – questionnaire survey. In this chapter, the process of data collection and analysis is described. First, the three pre-tests of the questionnaire survey are introduced. And then, the dataset of formal questionnaire is analysed by structure equation modelling, the test results of questionnaire reliability and validity are described. Finally, the test results of research hypotheses and findings are discussed.

Chapter 6: Conclusion. In this chapter, the research findings and conclusions, the management recommendations and research limitations, and the further suggestions are discussed.

The logic of the research design and the structure of the chapters are illustrated in Figure 1.1 below.

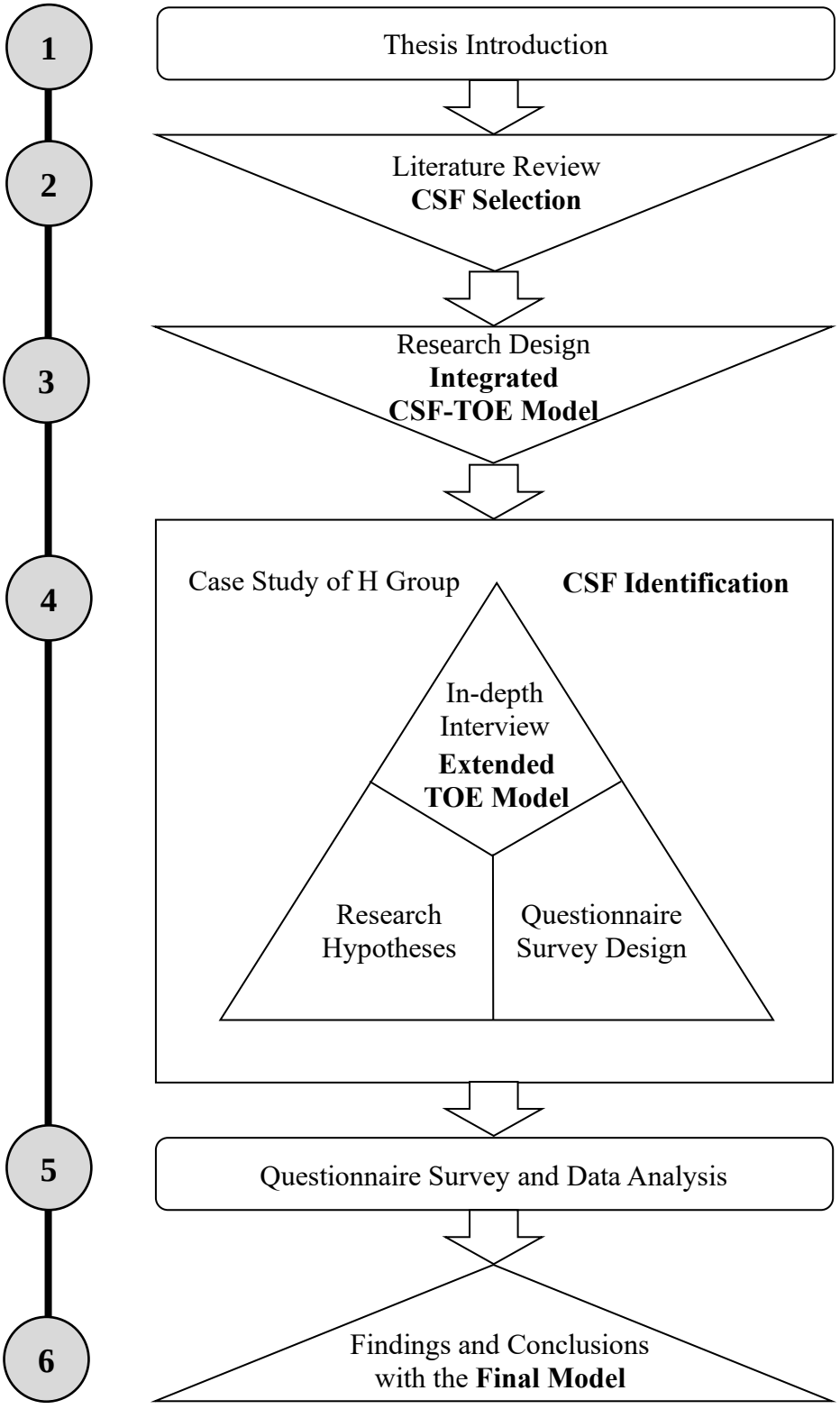

Figure 1.1 Structure of the research

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Chapter 2: Literature Review

2.1 Chapter overview

In this chapter, the Information System Adoption Theories were firstly reviewed, and then the Technology Acceptance Model (TAM), Diffusion of Innovation Theory (DOI), and Technology Organisation Environment Framework (TOE) were discussed in detail. Secondly, the evolution, definition and benefits of D-procurement were reviewed. Thirdly, the evolution, definition and existing studies of CSF approach were reviewed. And then the 17 critical success factors were extracted from the 12 selected studies by the literature survey method, finally each of the factors were discussed in detail.

2.2 Information system adoption

In the following sections, we are going to review the concepts and definitions of information system adoption and its related theories. It will help understanding the adoption of digital procurement systems in the context of this work.

2.2.1 An overview of information system adoption

An information System (IS) is a formal, sociotechnical, organisational system designed to collect, process, store, and distribute information (Piccoli & Pigni, 2019). As Boell and Cecez-Kecmanovic (2015) further indicated that IS involves a variety of information technologies such as computers, software, databases, communication systems, the Internet, mobile devices and much more, to perform specific tasks, interact with and inform various actors in different organisational or social contexts. From a sociotechnical perspective, information systems are composed by four components: task, people, structure (or roles), and technology (O'Hara et al., 1999).

A computer-based information system is an important fast growing technological innovation in this century (Zabadi, 2016). Various information systems are vital to the operation and management of every organisation (Ragowsky et al., 1996).

Because information systems can provide opportunities for businesses to increase

efficiency, effectiveness and ability to survive in competitive markets (Porter & Millar, 1985).

In another hand, enterprises decide to invest in information systems for many reasons, such as pressures to cut costs, pressures to produce more without increasing costs, and simply to improve the quality of services or products in order to stay in business (Legris et al., 2003). However, information system success is not guaranteed, numerous examples of information system adoption failures were reported (Nelson, 2007, 2021), which resulted in negative consequences for organisations or governments in terms of financial losses, time costs and many other risks (Bruque et al., 2008; Davis et al., 1989; Dwivedi et al., 2015; Kobayashi, 2018; Napitupulu & Sensuse, 2014).

Therefore, it is important to understand how to apply the new technologies successfully. Actually, scholars paid attention to the importance of information system acceptance, adoption and implementation as early as 1980s (Amrollahi et al., 2014). In the last three decades, researchers aimed to understand, predict and explain the factors that influence the adoption and implementation of technology at both individual and organisational levels (Tarhini et al., 2015).

Consequently, the technology adoption approaches have been studied from a variety of perspectives, such as information technologies, sociology, and human-computer interaction. Researchers have come up with various models incorporating factors and phases to predict technology adoption that, in turn, will lead to persistent use (Renaud & Van Biljon, 2008).

The critical factors that are influencing the success or failure of an information system have been discussed frequently in the literature, meanwhile the studies on information system adoption have been conducted in various application fields (E. Y. Li, 1997). For instance:

- Knowledge management system adoption in organisations (Kaldi et al., 2008).
- Critical factors of hospital adoption of CRM systems (Hung et al., 2010).
- Critical factors for adopting cloud computing in SMEs (Abdollahzadegan et al., 2013).
- Adoption of E-procurement (Suleiman, 2015).
- Critical success factors in pharmaceutical manufacturing companies (Al-Shura et al., 2018).
- Acceptance of online learning environments (Gunasinghe et al., 2019).

2.2.2 Definition of information system adoption

In 1995, Rogers (1995) proposed the five-stage model of innovation-decision process, which includes knowledge, persuasion, decision, implementation, and confirmation.

These five stages were used as an important theoretical basis to explain the innovation

diffusion and information system adoption process.

In 1977, Gopalakrishnan and Damanpour (1997) went a step further, they conducted an important review of innovation research in economics, sociology and technology management. They pointed out that the adoption of innovation is viewed as a process of organisational change which directly affects the technical and social systems of an organisation. The adoption process consists of two main stages: initiation and implementation.

In 2012, Hameed et al. (2012) further studied on the adoption stages cycle illustrated by different researches, and they found that the cycle falls more or less into the initiation, adoption-decision and implementation stages. After that, they made some deep studies on several influential adoption theories such as the Diffusion of Innovation Theory (DOI) (Rogers, 1995), the Technology Acceptance Model (TAM) (Davis, 1985), the Theory of Planned Behaviour (TPB) (Ajzen, 1985), and the Technology Organisation Environment (TOE) framework (Depietro et al., 1990), finally, they summarised those theories and proposed a new theoretical model, which contains three phases of innovation process: pre-adoption, adoption-decision and post-adoption. This three-phase model proposed by Hameed et al. (2012) is quite important, because it provides an integrated uniform framework for information system adoption studies.

Based on the achievement by Hameed et al. (2012), in this thesis we define information system adoption as having the entire organisation embrace the information system solution, wrap it into their business processes, and become more effective and efficient as the result. Furthermore, the adoption process includes the initiation stage until the implementation and acquisition of the information system. And the assimilation of the system is assumed as the result of the user acceptance of innovation within the organisation.

2.2.3 Classic information system adoption theories

By reviewing the literature, we found that in different CSF studies, the critical factors are different. This is because these studies are carried out based on different contexts with different scope and depth. Another finding is, the selection of the CSF for a specific study is normally based on one or more models or frameworks, and these models or frameworks are generally provided in those information system adoption theories. Therefore, it is important to firstly understand these theories and get familiar with those models and frameworks, that is the objective of this section.

As Tarhini et al. (2015) pointed out, the decision of how and why people adopt or reject a particular system or technology has been a prominent topic in the field of information system

research. In the literature, there are many information system adoption theories developed to explain the determinants and mechanisms of user's adoption decisions and behaviours.

Among these adoption theories, some of them focus on user acceptance, some of them focus on adoption decision, and some of them focus on system implementation. This reveals that studies on IS adoption theories arise from different perspectives and are used for different purposes. In Table 2.1 below, a summary of those important and commonly accepted information system adoption theories found in the literature is listed.

Table 2.1 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 and that this intention is, in turn, a function of their attitude toward the behaviour and subjective norms.	Fishbein and Ajzen (1975)
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 (1977)
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 (1985), Ajzen (1991)
4	Theory Acceptance Model (TAM)	TAM is the most widely applied model of users' acceptance and usage of technology, 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 (1985), Davis (1989), Davis et al. (1989)
5	Social Cognitive Theory (SCT)	SCT is an interpersonal level theory that emphasizes the dynamic interaction between people (personal factors), their behaviour, and their environments. This interaction is demonstrated by the construct called Reciprocal Determinism.	Bandura (1986)
6	Technology Organisation Environment Framework (TOE)	TOE is a theoretical framework that explains technology adoption in organisations and describes how the process of adopting and implementing technological innovations are influenced by the technological context, organisational context, and environmental context.	Depietro et al. (1990)
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. (1991)
8	Motivational	MM helps to study information technology	Davis et al. (1992)

	Model (MM)	adoption and use. The model suggests that the behaviour of individual is based on extrinsic and intrinsic motivations.	
9	Task Technology Fit Theory (TTF)	TTF theory holds that IT is more likely to have a positive impact on individual performance and be used if the capabilities of the IT match the tasks that the user must perform.	Goodhue and Thompson (1995)
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 (1995)
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 (1995)
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 (interorganisational).	Iacovou et al. (1995)
13	Uses and Gratification Theory (UGT)	UGT indicates that uses and gratifications has always provided a cutting-edge theoretical approach in the initial stages of each new mass communications medium.	Ruggiero (2000)
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 that there are four key constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions.	Venkatesh et al. (2003)

J. C. Li (2020) pointed out that it is generally accepted that two different groups of theories are basically required to explain technology adoption: the individual level theories, and the 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 adoption of new technological solutions in organisations (Hameed & Arachchilage, 2020; J. C. Li, 2020; Oliveira & Martins, 2011).

2.2.4 Extended information system adoption theories

In some scenarios, a single classic information system adoption theory discussed above cannot fully satisfy a particular study. In this situation, the researchers would like to extend the existing theories to satisfy their research purpose. Therefore, there are many extended IS adoption theories found in the literature as well, and they are discussed in this section.

The TPB was extended by Taylor and Todd (1995) to Decomposed TPB (DTPB), which aimed to decompose the belief structures in TPB to provide a moderate increase in the explanation of behavioural intention.

The TAM received substantial empirical support during the past decades, some new factors have been added into TAM in order to improve its adaptivity, explanatory power and specificity (Taherdoost, 2018). TAM has been further extended to TAM2 (Venkatesh & Davis, 2000), and TAM3 (Venkatesh & Bala, 2008).

As one of the most comprehensive technology acceptance models, the UTAUT integrated eight typical acceptance models, including the TPB and TAM (Nordhoff et al., 2020). UTAUT has been extended to UTAUT2, which posits that in addition to the UTAUT constructs, the intention to use the technology is influenced by hedonic motivation, price value and habit (Venkatesh et al., 2012).

Hameed et al. (2012) developed a conceptual model for information system adoption process in organisations. This Perceived Characteristics of Innovations (PCI) model utilizes DOI, TRA, TAM, TPB and introduces a framework that contains characteristics of innovation, organisation, environment, chief executive officer and user acceptance.

Other than making extensions to a single theory, some scholars tried to integrate or combine two or more models together to construct a new one, these approaches are discussed below:

- Gangwar et al. (2015) used an integrated TAM-TOE model to explore the determinants of cloud computing adoption. Awa et al. (2015) integrated TAM, TPB and TOE and expanded their characteristic constructs for E-commerce adoption by SMEs.
- Thong (1999) developed and integrated model that combines TOE framework with DOI theory. The model specifies contextual variables as primary determinants of information system adoption in small business (Arpaci et al., 2012).
- Y. M. Wang et al. (2010) combined DOI with TOE to better understand the RFID adoption in manufacturing industry.
- Chiu et al. (2017) conducted a study on exploring the critical factors for enterprises to adopt broadband mobile applications by applying a TOE-DOI combined framework.
- Kayali and Alaaraj (2020) applied a combination of DOI, TAM and UTAUT to investigate the factors that affect the adoption of cloud-based E-learning.

To sum up, the classic information system adoption theories can be either expanded or integrated to adapt the various situations and natures of the practices. As Lai (2017) suggested, the development of the new theoretical research framework will depend on a number of factors but not limited to the following: the research problems and objectives, gap analysis, the target

market, the organisations' goal and the understanding of technology adoption models. Molinillo and Japutra (2017) also suggested that the theories should be used in conjunction with each other to better explain the adoption process.

2.2.5 Typically applied information system adoption theories

In previous sections, the classic IS adoption theories and their extensions were discussed briefly. In this section, three typically applied theories which are influential in CSF studies are reviewed in-depth.

2.2.5.1 Technology acceptance model

Since the seventies, researchers have focused their efforts on identifying the conditions or factors that could facilitate the integration of IS into business (Legris et al., 2003). For example, Bailey and Pearson (1983) reported on a technique for measuring and analysing computer user satisfaction, where 39 factors affecting satisfaction were identified.

From the mid-eighties, information system researchers had concentrated their efforts on developing and testing models that could help in predicting system use (Legris et al., 2003). One of them, Davis (1985) proposed the original TAM in his doctoral thesis, and in 1989, he further refined it (Davis et al., 1989). The model is shown in figure 2.1 below.

After that, the TAM model has been tested and extended by many other researchers.

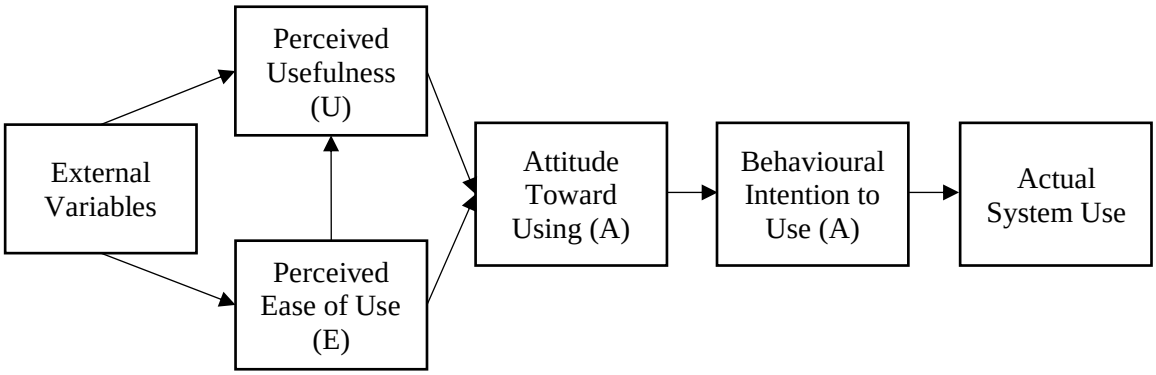

Figure 2.1 Technology Acceptance Model (TAM)

Source: Davis et al. (1989)

The key purpose of TAM is to provide a basis for tracing the impact of external variables on internal beliefs, attitudes, and intentions. It suggests that perceived ease of use (PEOU), and perceived usefulness (PU) are the two most important factors in explaining system use (Legris et al., 2003).

2.2.5.2 Diffusion of innovation theory

Diffusion of Innovation (DOI) is a theory of how, why, and at what rate new ideas and

technology spread through cultures, and operate at the individual level or firm level (Oliveira & Martins, 2011). The theory was originally proposed by Rogers (1995), he argued that diffusion is the process by which an innovation is communicated through certain channels over time among the participants in a particular social system.

As shown in Figure 2.2 below, in DOI theory, the dependent variable organisational innovativeness is related to three independent variables: individual characteristics, internal characteristics of organisational structure and external characteristics of the organisation (Jnr, 2020). According to Rogers (1995), the individual characteristics describe the leader attitude toward change. The internal characteristics of the organisational structure includes attributes:

- Centralisation is the degree to which power and control in a system are concentrated in the hands of a relatively few individuals.
- Complexity is the degree to which an organisation's members possess a relatively high level of knowledge and expertise.
- Formalisation is the degree to which an organisation emphasizes its members' following rules and procedures. Interconnectedness is the degree to which the units in a social system are linked by interpersonal networks.
- Organisational slack is the degree to which uncommitted resources are available to an organisation.
- Size is the number of employees of the organisation.

The external characteristics of the organisation refers to system openness.

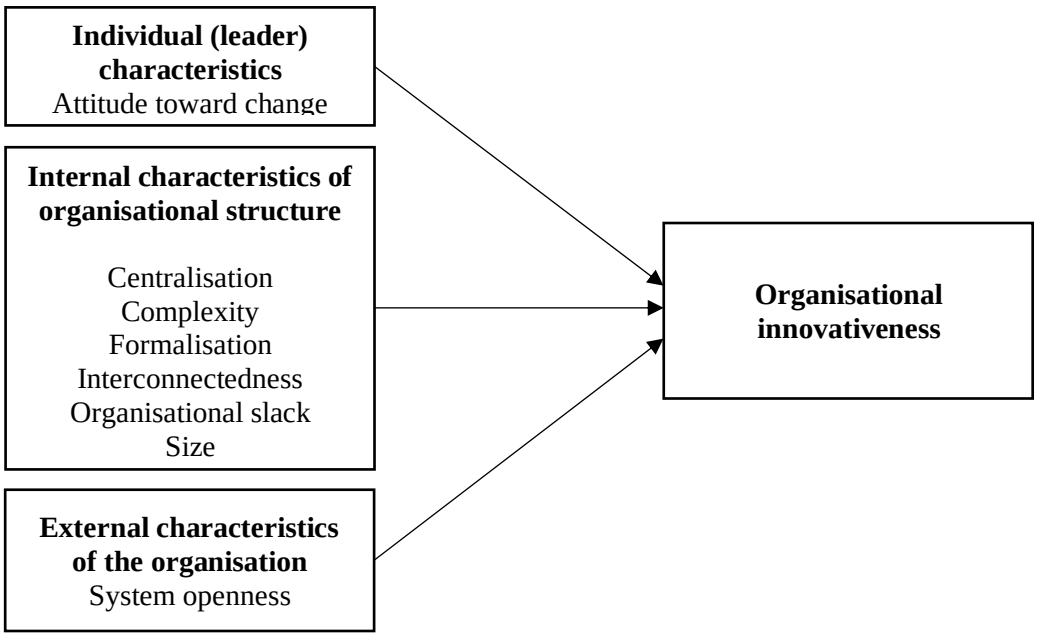

Figure 2.2 Diffusion of Innovation Theory (DOI)

Source: Rogers (1995)

2.2.5.3 Technology organisation environment framework

Technology Organisation Environment (TOE) framework is a theoretical framework that explains technology adoption in organisations proposed by Depietro et al. (1990) in the book "The Processes of Technological Innovation" edited by Tornatzky et al. (1990).

The book describes the entire process of innovation, stretching from the development of innovations by engineers and entrepreneurs to the adoption of those innovations by users within the context of a firm. And the TOE framework represents one segment of this process that is how the firm context influences the adoption of innovations (Baker, 2011).

TOE framework is an organisation level theory that explains how the three different elements of a firm's context influence adoption decisions. These three elements are the technological context, the organisational context, and the environmental context (Depietro et al., 1990).

- The technological context explains both internal and external technologies associated with the organisation and includes the characteristics and the usefulness of the innovative technologies that can be adopted.
- The organisational context is typically defined by the firm's various descriptive measures, features and resources. It contains the internal issues within the company such as management, employee, products, and services.
- The environmental context refers to the outer arena in which the organisation performs its business, its capability to access sources provided by others, and to interact with the governance and other firms (Chiu et al., 2017; Hui Zhang & Xiao, 2017).

Figure 2.3 below illustrates the TOE framework.

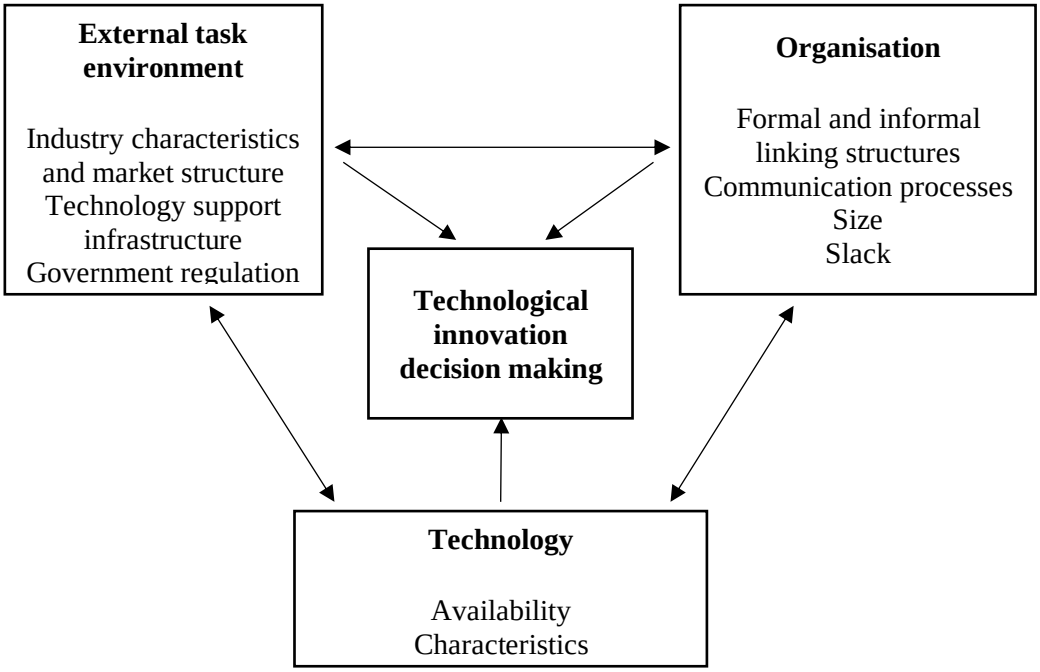

Figure 2.3 Technology-Organisation-Environment (TOE) Framework

Source: Tornatzky et al. (1990)

TOE has emerged as a widespread theoretical perspective on information technology adoption (Zhu et al., 2004). It has been examined in a number of empirical studies on various information system fields (Oliveira & Martins, 2010). By including the technological, organisational and environmental variables, TOE presents advantages over other adoption models (Gangwar et al., 2014) in studying technology adoption (Salleh & Janczewski, 2016), technology use (Borgman et al., 2013) and value creation from technology innovation (Zhu & Kraemer, 2005).

Scholars also argued the limitations of TOE framework. Basically, there are two main viewpoints. The first viewpoint is the lack of development. As Zhu and Kraemer (2005) pointed out, the TOE framework is too "generic" and offers a high degree of freedom to vary factors and measures so scholars have seen little need to change the theory itself. Furthermore according to Baker (2011), the framework aligns too "well" with other explanations of innovation adoption theories thus there is limited tension to refine the framework.

The second viewpoint is the unclear constructs. According to Dedrick and West (2003), TOE framework is just a taxonomy for categorising variables and it does not represent an integrated conceptual framework or a well-developed theory. TOE has unclear major constructs and the variables of the framework may vary with the context (Y. M. Wang et al., 2010).

The limitations of TOE mentioned by scholars are also suitable for commenting DOI and TAM, because as a basic approach that will be applied in various cases, it should be generic and should not be very detailed. Furthermore, since nowadays technology change is extremely

fast, and the adoption of information systems will depend on various conditions, therefore, it is reasonable that a theoretical model is at the generic level, and the scholars will apply it in details according to the purpose and nature of the studies.

2.3 Digital procurement

The digital procurement is the object of study in this work. Its evolution, definition, and benefits are reviewed in the following contents.

2.3.1 Definition of electronic procurement

Electronic Procurement is known as E-procurement. It is frequently defined as the use of Internet technologies in the purchasing processes (De Boer et al., 2002), or the sourcing of goods or services via electronic means, usually through the Internet (Schoenherr & Tummala, 2007).

Some representative definitions found in the literature are shown in Table 2.2 below.

Table 2.2 E-procurement definitions found in the literature

E-procurement definition	Proposer
An e-procurement technology is defined as any technology designed to facilitate the acquisition of goods by a commercial or a government organisation over the Internet.	Davila et al. (2003)
E-procurement is defined as a comprehensive process in which governments use IT systems to establish agreements for the acquisition of products or services (contracting) or to purchase products or services in exchange for payment (purchasing).	Moon (2005)
Electronic procurement refers to the use of integrated (commonly web-based) communication systems for the conduct of part or all of the purchasing process; a process that may incorporate stages from the initial need identification by users, through search, sourcing, negotiation, ordering, receipt and post-purchase review.	Croom and Brandon-Jones (2007)
E-procurement is the attempt to automate the procurement process for buyers by using electronic procurement systems, workflow system and electronic data interchange (EDI).	Gunasekaran and Ngai (2008)

2.3.2 Evolution of electronic procurement

E-procurement is a major part of supply chain management. Supply chains in procurement are traditionally supported by IT (Leenders & Fearon, 1997; Monczka et al., 1997). According to Perera et al. (2021), E-procurement can be categorised into three distinct eras:

In the first era, precursors of electronic procurement can be seen as early as the 1980s, with the evolution of Material Requirements Planning (MRP) systems to Manufacturing Resource Planning (MRP II) and then to Enterprise Resource Planning (ERP) systems in the mid 1990s

(Schoenherr & Tummala, 2007). In this period, digital storage media and emails were used to transfer procurement-related documents.

In the second era, it was web-based E-procurement in the 1990s, suppliers communicated directly with the client's E-procurement portal (Perera et al., 2021). Puschmann and Alt (2005) mentioned that E-procurement systems experienced a diffusion in the late 1990s due to the proliferation and advances of IT and the Internet. After that, Schoenherr and Tummala (2007) explained that as the tremendous potential savings achievable via E-procurement, and possibly also because of the fear associated with the Y2K (Year 2000) issue, E-procurement was widely accepted and applied by governments and companies in different countries.

Another trigger of the E-procurement emergence is the fast-changing uncertain global climate (Edmiston, 2003). Many organisations turned their attention to electronic commerce (e-Commerce) technologies to improve the efficiency of their business processes. Hawking et al. (2004) found that the most prominent form of e-commerce system concerning interactions between businesses is the electronic procurement system. It automates an organisation's procurement process, reduces transaction costs, improves interorganisational coordination within the supply chain, improves relationships with business partners and offers competitive sourcing opportunities for the buyer organisations (Chandrasekar Subramaniam, 2002). The widespread adoption of E-procurement systems by organisations in both private and public sectors lead to national performance improvement and productivity growth and it has the potential to increase the gross domestic products (GDP) significantly (Hawking et al., 2004). There are many E-procurement related studies from various perspectives found in the literature, such as CSF of E-procurement implementation (Basheka et al., 2012), evidence of the impacts of public E-procurement (Costa et al., 2013), key issues in e-procurement implementation and operation in the public sector (Croom & Brandon-Jones, 2005, 2007), CSF studies within TOE framework (Premathilaka & Fernando, 2018), and E-procurement efficiency evaluation (Vaidya & Campbell, 2016).

In the third era, the procurement system started involving cloud computing and system-to-system inter-communication in the 2000s (Perera et al., 2021). In this era, the E-procurement system consisted of a range of functions to strategically reconfigure and integrate the buyer's and the supplier's business processes into a unique digital environment (Belisari et al., 2020). And the standardised application processes enabled supplier's systems to communicate directly with client's systems.

After that, the E-procurement system had kept changing and evolving considerably for about ten years until about 2010. The evolution started from the digitalisation of procurement

activities wherein the main advantage of digitalised system is to increase the efficiency of different tasks pertaining to procurement (Rejeb et al., 2018).

In the past ten years, with the rapid development of advanced technologies, the Cloud Computing (Dinh et al., 2020), Big Data (Gholizadeh et al., 2020), Internet of things (Osmonbekov & Johnston, 2018), Automatisation and Robotics (Schnellbächer & Weise, 2020), and Blockchain (Francisco & Swanson, 2018) have been integrated and applied to modern procurement platforms. The E-procurement has been getting into its brand new stage: Digital Procurement (Kosmol et al., 2019; Perera et al., 2021).

2.3.3 Definition of digital procurement

As discussed above, the concept of D-procurement is originally evolved from its former concept: E-procurement. Actually, some scholars think they both mean the same thing thus the two concepts can be used interchangeably (Perera et al., 2021). But Rejeb et al. (2018) argued that there is a shift from E-procurement which creates a "one-to-one" communication between buyers and suppliers, to D-procurement which has "many-to-many" communication capabilities.

Srai and Lorentz (2019) distinguished between E-procurement and D-procurement by using the concepts of "basic form of digitalisation" and "advanced form of digitalisation". They explained that the basic form of digitalisation is essentially founded on the use of the Internet and other computer networks. The technologies in which E-procurement are based on this so-called basic form. In contrast to the basic form, the advanced form of digitalisation includes a range of digital technologies that have emerged more recently, such as Internet of things, cloud computing, big data, virtual reality, augmented reality, blockchain, and additive manufacturing (Srai & Lorentz, 2019). As based on this advanced form of technologies, D-procurement is state of the art.

Therefore, based on the notion of advanced form of digitalisation by Srai and Lorentz (2019), and the definition of E-procurement by De Boer et al. (2002), in this thesis we define D-procurement is the use of digital technologies in the business procurement process.

2.3.4 Benefits of D-procurement

It is important to understand the benefits of D-procurement, not only to explain why companies are eager to adopt D-procurement solutions, but also to understand the value of this study. Researchers have found that cost benefit is the main driver for companies to implement D-

procurement systems (Panda & Sahu, 2012). Operational and cost efficiency are perceived as the primary advantages of D-procurement (Fernandes & Vieira, 2015). Some representative D-procurement benefits found in the literature are discussed below.

Neef (2001) pointed out that the potential benefits of D-procurement are the following:

- Lowered transaction costs.
- Faster ordering.
- Wider vendor choices.
- Standardised and more efficient procurement processes.
- Greater control over procurement spending and better employee compliance.
- More accessible internet alternatives for buyers.
- Less paperwork and fewer repetitious administrative procedures.
- Reengineered procurement workflows.

Panayiotou et al. (2004) summed up the expected benefits of D-procurement for an organisation as follows:

- Cost reduction.
- Efficiency and productivity.
- Effectiveness.
- Transparency.

Scholars also found that digitalisation has brought some new values for procurement. As Högel et al. (2018) pointed out, digital technologies are revolutionising the procurement function, the major improvements are the cost and performance of computer power, in combination with emerging technologies, have created a whole new playing field.

Radell and Schannon (2018) further indicated that digital procurement solutions not only increase the efficiency and effectiveness of procurement but also play a more strategic role in accelerating innovation and contributing to the company's broader digital direction.

The value that digitalisation creates for procurement operations can be categorised in three distinct but interrelated ways (Högel et al., 2018):

- Insights and informed decisions: Big data and advanced analytics can help to create transparency across massive amounts of data, enhancing insights, decision making and performance.
- Automated processes: Robotic process automation (RPA) can automate and accelerate the completion of transaction tasks while enhancing accuracy and contract compliance. Artificial intelligence (AI) can augment high-value cognitive activities, improving speed and productivity.

- Collaboration: Combinations of various digital technologies make it more effective to conduct procurement work in real time with other functions, business units, organisational regions, and external partners.

From the insight of digitalisation, Högel et al. (2018) also suggested the benefits of D-procurement from a digital view, which more or less differs from the traditional views discussed above, listed as follows:

- Savings: Cost reduction is still the focus of procurement, and digital technologies can help to save cost in a variety of areas. For example, data analytics can improve management of tail spending at scale or help exploit demand pattern peculiarities.
- Quality: By using big data and machine learning technologies, companies can use algorithms to analyse data relating to past failures and identify the areas in which quality management efforts with suppliers should be intensified.
- Innovation: As more and more new technologies emerged and applied, securing the next generation of technology solutions has become a paramount focus of companies that compete based on innovation. The use of cloud computing and blockchain technologies can engage the entire ecosystem to enhance innovation outcomes.
- Speed: Robotic process automation can help cut time considerably for converting a purchase requisition to a purchase order.
- Risk: Companies expect the procurement function to avoid risks to supply chain continuity and environmental sustainability. By using algorithms, companies can anticipate a supplier's financial performance to detect any potential defaults.

To sum up, D-procurement produces significant impacts on the suppliers and providers. Namely, the information technology and digital technology are important to help organisations increase their effectiveness and efficiency by improving business communication and process, reduce cost, explore new opportunities, and increase overall competitiveness.

2.4 Critical success factors approach

The main objective of this research is to find out the CSF for D-procurement adoption. Therefore, it is important to review its evolution, definition, and existing studies in the following contents.

2.4.1 Evolution of critical success factors

According to a study by Sousa (2004), the concept of "success factors" was originally

developed by Daniel (1961) of McKinsey & Company in 1961. These success factors were focused on industry-related approaches that are appropriate for any company in a particular industry. In 1972, Anthony et al. (1972) went a step further by emphasising the need to tailor the factors to both a company's particular strategic objectives and its particular managers. Here, management planning and control systems are responsible for reporting those success factors that are perceived by the managers as relevant for a particular job and industry.

Based on the former works, Rockart (1979) and Bullen and Rockart (1981) later mainly elaborated the concept in the context of designing management information systems. They found that top management rarely applied management information systems, and then they argued that such systems must be structured according to the information needs of the managers so that the link between managers' information requirements and management information system could be established. They coined the term *Critical Success Factors* (Grunert & Ellegaard, 1993).

Critical success factors are widely applied in various scenarios, as Lampadarios (2016) indicated that each industry has its own critical success factors.

2.4.2 Definition of critical success factors

CSF was defined 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 managers goals to be attained (Rockart, 1979).

Bullen and Rockart (1981) further pointed out critical success factors are "the few key areas of activity in which favourable results are absolutely 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". As Thierauf (1982) indicated, if the results in these areas are not adequate, the organisation's efforts for the period will be less than desired.

Dadashzadeh (1989) 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 (1993), CSF originated in the field of management

information system and it was later transferred to the field of business strategy research. And the CSF is basically used in four different ways:

1) As a necessary ingredient in a management information system.
2) As a unique characteristic of a company.
3) As a heuristic tool for managers to sharpen their thinking.
4) As a description of the major skills and resources required to be successful in each market.

Scholars also concerned how to define the "success" in the context of information system adoption. As Hameed and Arachchilage (2020) suggested, the adoption process from the initiation stage until the acquisition of innovation is considered as a decision made by 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 of integration of the innovation into the organisation and its contribution to organisational conduct and outcome (Hameed et al., 2012).

Moreover, it is important to note that CSF is also called Key Success Factors (KSF) in some literatures (Freund, 1988). Masocha and Charamba (2014) defined that a KSF is anything that enables an enterprise to get business. Oakland (2003) further highlighted KSF as those elements that should be examined to ensure effective management and attainment of organisational goals. In this thesis, we believe that CSF and KSF are used interchangeably and hold the same meaning (Ab Talib et al., 2015; Sousa, 2004), this is important for the systematic literature review of the CSF because we should pay attention not only to the literature on CSF but also to the literature on KSF.

2.4.3 Existing studies on critical success factors

Scholars in different countries are trying to research on the critical factors that influence the successful adoption of D-procurement from various perspectives.

- In UK, Vaidya et al. (2006) established a significant foundation for CSF study by identifying a number of relevant variables for CSF and presenting a model for further research.
- In USA, Gunasekaran et al. (2009) found that top management involvement and support are key issues for adopting D-procurement in the Southcoast SMEs.
- In Australia, Rahim (2008) studied the factors from employees' perspective and found that perceived usefulness and perceived ease of use are the key points affecting

acceptance of D-procurement at a city council.

- In Portugal, Fernandes and Vieira (2015) introduced that Portugal was the first country with mandatory adoption of public D-procurement in Europe. And they found that technical factors dominated barriers while cost related factors dominated drivers for D-procurement adoption in SMEs.
- In Nigeria, availability of reliable, affordable and fast internet was found as a crucial component for the adoption of D-procurement in construction industry (Afolabi et al., 2019).
- In Kenya, employees and management commitment to success and reliability of information technology were found as the critical factors for D-procurement adoption in large scale manufacturing firms (Mose et al., 2013).
- In Uganda (Basheka et al., 2012), supplier involvement and systematic risk management were found as the major CSF for adopting D-procurement in public sector.
- In China, Li (2008) pointed out that relative advantage and top management support were the determinant factors in Chinese manufacturing enterprises.
- Gunasekaran and Ngai (2008) suggested that clear accountability with purchasing and organising structure change and business process re-engineering are the major factors for D-procurement adoption in Hongkong China.
- In Singapore, Teo et al. (2009) carried out an empirical study to examine various factors associated with the adoption of D-procurement, they found that firm size, top management support, perceived indirect benefits and business partner influence are the major issues.
- In Iraq, Gheni et al. (2017) carried out an online survey to find out that the highest CSF of information technology projects is commitment and motivation.
- In Sri Lanka, Premathilaka and Fernando (2018) found that the most significant factors affecting on public sector D-procurement adoption are relative advantage, compatibility and complexity.
- In Switzerland, Puschmann and Alt (2005) argued that D-procurement is merely a non-technical issue. They conducted a benchmarking study showed that companies which successfully implemented D-procurement rely on proven concepts regarding introduction, organisational change, content and catalogue management, procurement processes and system architecture in order to achieve operational efficiency.
- In Germany, Holotiuk and Beimborn (2017) developed a digital business strategy framework based on review of 21 selected industry reports, they concluded eight

generic dimensions with a total of 40 CSF for digital business.

By analysing the studies above, it is possible to conclude that CSF studies have different focuses in different countries. For example, in African countries, the availability and reliability of internet and technology are more highlighted, because the development of ICT infrastructures is still not mature enough in Africa. Whereas in European countries, the studies are more concerned with the actual reasons of the success or failure of the information system adoption. Furthermore, some CSF found in the studies are general, for example, cultural factors or organisational factors. Whereas some CSF found are more specific, such as factors about high level of computer literacy among stakeholders.

To sum up, based on the review of existing CSF studies, it is possible to conclude that CSF for D-procurement adoption are different in different scenarios, it depends on various conditions such as region, culture, technology, and organisation. Thus, it is important to understand the scenario and conditions in which the study is carried out.

2.5 Critical success factors

The literature survey method is applied to collect and select the original CSF. They will be used as the basic variables for this research. Therefore, it is important to explain how these CSF were selected, it is one of the essential procedures in this study. After that, each of the CSF is discussed in detail.

2.5.1 Selection of critical success factors

According to Sekaran (1992), literature survey is defined as "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 is to examine the literature for a number of D-procurement studies to investigate whether a general set of CSF are existed.

In the selection of the database, we considered Science Direct, Web of Science, Ebsco, Google Scholar, and CNKI (China National Knowledge Infrastructure). Finally, based on the consideration of access rights and the convenience of searching, we chose Google Scholar because it provides an easy way to broadly search for scholarly literature. And in the same place, we can search across many disciplines and sources.

For systematically carrying out the survey, the idea of Systematic Literature Review (SLR) is applied. 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" (Okoli, 2015).For conducting the SLR, we combined the guidance by Xiao and Watson (2019) and the flow diagram by PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram (Page et al., 2021), eventually, the literature survey is composed of four phases, as shown in Figure 2.4 below:

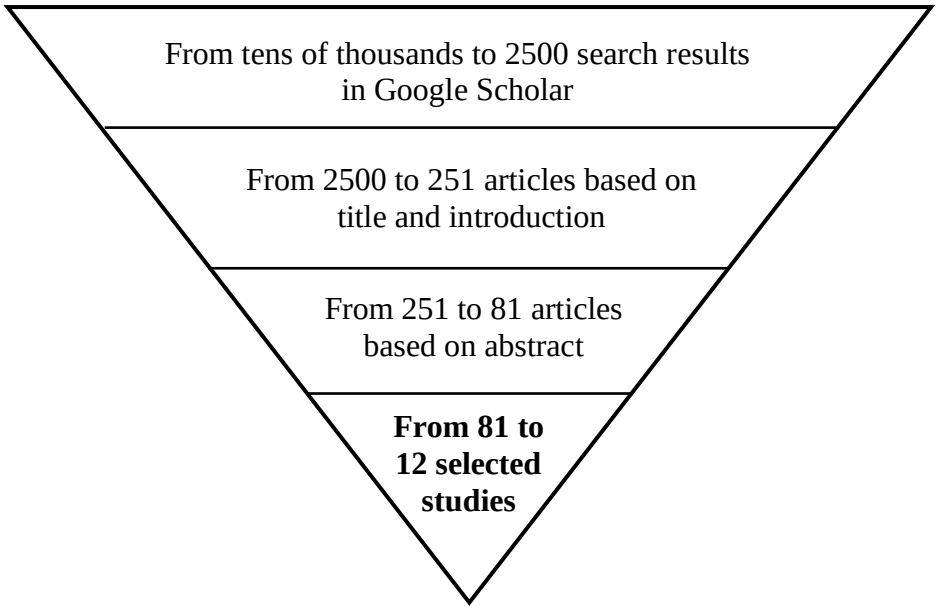

Figure 2.4 Literature survey phases

These four phases are discussed as follows:

The first phase, 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".

Each of the combinations based on the permutation of the three elements (Element 1 Element 2 Element 3) was searched as the keyword in Google Scholar.

The results were more than tens of thousands, which was too broad. Thus, we narrowed down the scope by using quotation mark and plus sign. The quotation marks were used for both Element 1 and Element 2, and plus sign was used in between them.

The Element 3 was not constrained, because we wanted to review the literature in different sectors. The search key was like:

"Element 1" + "Element 2" Element 3. For example, "critical success factors" + "digital

procurement" construction. After that, the unnecessary results were weeded out, the results were less than 2500.

The second phase, a selection of the available literature. Based on evaluating the relevance of the title and introduction of the resulted articles, 251 relevant articles were selected.

The third phase, a further selection of relevant literature. Based on evaluating the abstract of each article, 81 relevant articles were selected from the 251 ones.

The fourth phase, a selection of final literature. As listed in Table 2.3 below, based on the in-depth reading and analysing of the 81 articles, 12 studies of them were finally selected.

Table 2.3 Twelve selected CSF studies

No.	Author	Context	Research method	Identified CSF
1	Waithaka and Kimani (2021)	Determinants of adoption of D-procurement practices	Literature survey	4 CSF
2	Afolabi et al. (2019)	D-procurement adoption in construction industry	Questionnaire survey	21 CSF
3	Premathilaka and Fernando (2018)	D-procurement adoption in public sector	Questionnaire and interview	6 CSF
4	Holotiuk and Beimborn (2017)	Digital business	Literature survey of industry reports	40 CSF in 8 dimensions
5	Gheni et al. (2017)	CSF for IT projects	Online questionnaire survey	9 CSF
6	Ab Talib et al. (2015)	Supply chain management	Literature survey	9 CSF
7	Mose et al. (2013)	D-procurement adoption among large scale manufacturing firms	Questionnaire survey	5 CSF
8	Basheka et al. (2012)	D-procurement implementation in public sector	Literature survey and questionnaire survey	13 CSF
9	Teo et al. (2009)	D-procurement adoption in Singapore	Questionnaire survey	4 CSF
10	Gunasekaran and Ngai (2008)	E-procurement adoption in Hongkong China	Questionnaire survey	11 CSF
11	Vaidya et al. (2006)	D-procurement implementation in public sector	Literature survey	11 CSF
12	Puschmann and Alt (2005)	D-procurement in supply chains	Benchmarking study	13 CSF

There were four criteria used for the selection:

- The main objective of the study should focus on finding out the CSF. The way to found out the CSF should be reasonable, and the CSF found in the study should be properly explained in the findings and conclusions.
- The CSF found in the study should be related to adoption or implementation of procurement system, supply chain system, business system, electrical business, or

information system.

- The method and process to find out the CSF should be scientific, and the CSF found in the study should be generic and representative.
- The study should not be earlier than 2005.

Based on the work above, the 17 critical successful factors were finally identified, as shown in Table 2.4 below. It contains a summary of them with their respective citations. The "•" sign indicates that a certain CSF is cited from a certain literature.

Table 2.4 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	Security and authentication	User experience and satisfaction	Knowledge of D-procurement benefits	Employees' commitment and	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 (2021)	•	•						•									
Afolabi et al. (2019)	•	•		•	•	•	•	•	•	•	•		•	•			
Premathilaka and Fernando (2018)	•	•	•			•			•	•							
Holotiuk and Beimborn (2017)	•	•	•	•	•	•	•		•						•		
Gheni et al. (2017)		•			•		•				•	•					
Ab Talib et al. (2015)	•	•	•	•	•									•			
Mose et al. (2013)	•		•		•				•		•				•		
Basheka et al. (2012)		•	•	•		•	•	•				•		•			
Teo et al. (2009)	•		•							•							•
Gunasekaran and Ngai (2008)	•	•	•	•			•					•	•				
Vaidya et al. (2006)	•	•	•	•	•	•	•	•								•	
Puschmann and Alt (2005)			•	•	•	•		•					•			•	
Total number citations	9	9	9	7	7	6	6	5	4	3	3	3	3	3	2	2	1

The way to select the CSF from the 12 studies followed a few rules and steps. Firstly, the factors in each study were analysed and organised. And 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". Factors that were not commonly suggested but highly related to this case study were considered, such as "firm size and procurement volume". Factors that were related to each other or had the similar meaning were grouped together as one single factor.

2.5.2 Selected critical success factors

The CSF shown in table 2.4 are the original variables of this study as well. Each of them is discussed in detail in the following sections.

2.5.2.1 Top management support

As shown in the table, the "Top Management Support" factor has a total of nine citations in the 12 selected CSF studies considered. This is a significant factor found by many of the authors considered.

The success of any IT project to a great extent depends on the "top management support", which has been found to be the most important factor in D-procurement adoption (Panda & Sahu, 2012). Setting up goals and milestones, allocating necessary resources, pursuing changes for business process and organisational structure, formulating the policies and strategies, and mandating use of D-procurement, all of these require commitment of top leadership.

The top management team sometimes is also known as steering committee, which should involve the project manager, the consultants working with the committee, and agency staff to develop a project development strategy (Vaidya et al., 2006).

Holotiuk and Beimborn (2017) pointed out the importance of top management from cultural and strategic perspective. They suggested that a commitment to transformation in strategy and culture is needed by the leadership team. The team is responsible to set digital business strategy on the right course and lead the digital transformation by example from the top of the organisation. They emphasised that it is important to understand that the leaders drive the transformation, address technologies that bring change, and trigger the connected change of culture.

Kane et al. (2015) had the same opinion, they agreed that the value of digital innovation must be understood, recognised, and cherished by top management. And the top management should establish a new culture that supports the whole organisation to accept failure and encourage new to grow success.

Some key elements of "Top Management Support" factor are listed below:

- Project sponsor (Vaidya et al., 2006).

- Setting of goals, strategies, and baselines (Gunasekaran & Ngai, 2008; Premathilaka & Fernando, 2018; Vaidya et al., 2006; Waithaka & Kimani, 2021).
- Project alignment with business strategy (Mose et al., 2013; Premathilaka & Fernando, 2018; Vaidya et al., 2006).
- Establishment of innovation culture (Ab Talib et al., 2015; Holotiuk & Beimborn, 2017; Teo et al., 2009).
- Commitment for change and adoption of D-procurement (Gunasekaran & Ngai, 2008; Holotiuk & Beimborn, 2017; Mose et al., 2013; Vaidya et al., 2006).
- Allocation of appropriate resources (Afolabi et al., 2019).

2.5.2.2 End-user uptake and training

According to Table 2.4, the "End-user Uptake and Training" factor has nine citations in the 12 selected CSF studies. As technology alone does not ensure successful adoption, it also depends on users and buyers making use of the new processes and system. End users can realise the immediate benefits of the D-procurement system once they understand their operational functionalities (Vaidya et al., 2006).

Holotiuk and Beimborn (2017) emphasised the importance of culture and leadership for end-user uptake.

The leadership is responsible to create the culture that aims to foster a digital mindset with a digital agenda where the culture takes on an exploratory and adaptive character. The culture should be open for change, and conducive to the digital transformation. They also suggested that leaders need to entrench digital values for the culture, such as forward-thinking, openness, technology acceptance, entrepreneurial spirit, and a start-up way of working.

Another consideration is about training. Afolabi et al. (2019) pointed out that driving up the adoption of e-Procurement systems means that the users of D-Procurement systems must be computer literate and able to operate the D-Procurement environment. Users should also develop high trust for the system that it is able to deliver on the benefits attached to them. That means once an organisation accepts the adoption of a D-Procurement system, there should be adequate commitment to the employees to use the new system. However, there may be some resistance to the new technology, meaning that effective training for all the stakeholders involved in the procurement process is important to defuse their doubt and uncertainty of the system.

Basheka et al. (2012) also indicated that shifting from traditional procurement approaches to new technologies requires training staff in procurement practices and in the use of D-

procurement tools, which implies proper training activities to foster the skilled project managers, employees and information technology specialists are critical for successful adoption of system.

Some key elements of "End-user Uptake and Training" factor are listed below:

- User training and education (Waithaka & Kimani, 2021).
- Availability of skilled personnel to handle D-procurement tools and processes (Afolabi et al., 2019).
- Employee knowledge and skills (Ab Talib et al., 2015; Premathilaka & Fernando, 2018).
- Accept failure and encourage new to grow success (Holotiuk & Beimborn, 2017).
- Skilled project managers and teams (Basheka et al., 2012; Gheni et al., 2017).
- Information systems specialists with skills in the Internet (Gunasekaran & Ngai, 2008).
- User involvement, user support, user communication, user training (Vaidya et al., 2006).

2.5.2.3 Participants collaboration and adoption

According to Table 2.4, the "Participants Collaboration and Adoption" factor has nine citations in the 12 selected CSF studies.

As Gunasekaran and Ngai (2004) explained, the internet technology enables numerous web-based exchanges that connect buyers and suppliers in real-time, and this makes a significant impact on procurement and supply chain management. As technology creates the ability to forge relationships more effectively and efficiently, the collaboration between participants becomes essential.

Teo et al. (2009) also pointed out D-procurement systems are generally business to business (B2B) applications, hence business partners' influence is crucial in determining the adoption of D-procurement. Researchers suggested that organisations who have adopted D-procurement systems would attempt to influence their trading partners to adopt the new approach as well, to increase their own benefits of adoption.

Gunasekaran and Ngai (2008) indicated that a firm cannot succeed in D-procurement if it has little history of cross-functional collaboration and early supplier involvement, and the collaborative potential of the e-design component of an e-procurement strategy. They further emphasised that there is a need for a transformation in the corporate culture as well as a re-engineering of the specification development process. And if there are redundancies found in the process, then those redundancies need to be eliminated before applying an e-procurement solution (Presutti Jr, 2003).

Some key elements of "Participants Collaboration and Adoption" factor are listed below:

- Business partner influence and involvement (Ab Talib et al., 2015; Basheka et al., 2012; Holotiuk & Beimborn, 2017; Teo et al., 2009).
- Supplier readiness (Premathilaka & Fernando, 2018).
- Supplier management and inter-firm collaboration (Ab Talib et al., 2015).
- Supplier performance (Mose et al., 2013).
- Involvement of Supplier in adoption (Mose et al., 2013; Vaidya et al., 2006).
- Close collaboration with suppliers (Gunasekaran & Ngai, 2008).
- Embracement of suppliers at an early stage (Puschmann & Alt, 2005).

2.5.2.4 Business process re-engineering

As shown in Table 2.4, the "Business Process Re-engineering (BPR)" factor has a total of seven citations in the 12 selected CSF studies. This is also a significant factor found in the literature. Actually, business process re-engineering is essential for many IT projects.

BPR is often used by organisations to respond to environmental changes. It involves the fundamental and radical redesign of the old business processes for the pursuit of new directions and perspectives on the organisation (Grover et al., 1995).

BPR is a vital part of information system adoption. According to Attaran (2004), the term "reengineering" first appeared in the information technology field and has evolved into a broader change process. He argued that those aspiring to do BPR must begin to apply the capabilities of information technology.

The adoption of D-procurement requires the re-engineering of existing procurement process as well. As Panda and Sahu (2012) pointed out, implementation of traditional procedures in D-procurement system often leads to unmanageable and inefficient system flow. Thus, it is important that organisations undertake a fresh look at all procurement processes and functions. The inefficient processes must be purged or re-built, meanwhile the mandatory processes must be optimised to speed up the process, reduce needed resources, improve business productivity and efficiency, and improve competitiveness.

Some key elements of the "Business Process Re-engineering" factor are listed below:

- Diagnostic and analysis of business procurement processes (Basheka et al., 2012).
- Establishment of new business procurement process model (Ab Talib et al., 2015; Gunasekaran & Ngai, 2008; Puschmann & Alt, 2005; Vaidya et al., 2006).
- Embedding new procurement processes into information system (Afolabi et al., 2019).
- Alignment of D-procurement strategies with the procurement process (Puschmann &

Alt, 2005).

- Seamlessly integrated offline and online channels (Holotiuk & Beimborn, 2017).

2.5.2.5 ICT infrastructure and technology standards

According to Table 2.4, the "ICT Infrastructure and Technology Standards" factor has seven citations in the 12 selected CSF studies. The ICT infrastructure, such as software, hardware, firmware, networks, and the company websites, provides the fundamental elements for developing, applying and operating the information system in an organisation. As D-procurement system is an inter-organisational system, the multiple organisations should follow the uniform technology standards, which are related to system development, inter-system integration, information communication, and content management, to complete the procurement process collaboratively among participants.

As Afolabi et al. (2019) pointed out, it is important to note that for the success of D-procurement adoption, all the infrastructure to ensure seamless operation must be reliable and affordable. And as the D-procurement system would undergo integration across systems and organisations, the system should be developed based on cross-platform technologies, communication standards, and data exchange standards.

Another key concern are the standards for formatting digital catalogues (Vaidya et al., 2006). It is important to make sure that the procurement related product information can be exchanged both within the organisations and between participants.

Some key elements of "ICT Infrastructure and Technology Standards" factor are listed below:

- Availability of reliable, and affordable ICT services (Ab Talib et al., 2015; Afolabi et al., 2019; Mose et al., 2013).
- Real-time and large-scale data processing (Holotiuk & Beimborn, 2017).
- Modular IT platform (Holotiuk & Beimborn, 2017).
- Hardware and software tools (Gheni et al., 2017).
- Technical and content standards, process and procedural standards, compliance with the standards frameworks, interoperability (Vaidya et al., 2006).
- Use of standards for catalogues and data interchange (Puschmann & Alt, 2005).

2.5.2.6 System integration and compatibility

According to Table 2.4, the "System Integration and Compatibility" factor has six citations in the 12 selected CSF studies. D-procurement in its nature of a cross-organisation and cross-

platform system, the integration and compatibility across various business processes, information platforms and databases are significant.

For recent web-based systems, there are many integrations and compatibility related issues that should be taken into consideration. These issues include the system development technologies, the cloud platform used to deploy the system, the data structure and exchange method, and the stakeholders' existing systems. The designers should also consider the Service Oriented Architectures (SOA) and Application Programming Interfaces (API) (Jabr & Al-Omari, 2010).

Other than the technological issues, the system should also be integrated with the cultural environment and the business processes (Panda & Sahu, 2012). The processes in D-procurement systems should be integrated with the existing processes. For example, the D-procurement system should be linked to the organisation's financial management system in order to facilitate the process of online payment to suppliers (Vaidya et al., 2006).

Some key elements of "System Integration and Compatibility" factor are listed below:

- Interoperability of D-procurement software packages, applications and systems (Afolabi et al., 2019).
- Compatibility of D-procurement process with the existing procurement processes (Afolabi et al., 2019).
- D-procurement system appropriate with existing information technology infrastructure (Premathilaka & Fernando, 2018).
- D-procurement system appropriate with organisation's preferred way for conducting purchasing activities (Premathilaka & Fernando, 2018).
- D-procurement adoption is consistent with organisation's business strategy (Premathilaka & Fernando, 2018).
- D-procurement adoption is consistent with organisation's values (Premathilaka & Fernando, 2018).
- Network effects with open systems and partner integration (Holotiuk & Beimborn, 2017).
- Information matching, sending and receiving of real time information to other information systems, electronic commerce with suppliers (Basheka et al., 2012; Vaidya et al., 2006).
- Integration of the D-procurement system with other relevant systems (Puschmann & Alt, 2005).

2.5.2.7 Project management and change management

As shown in Table 2.4, the "Project Management and Change Management" factor has six citations in the 12 selected CSF studies. During the long progress of D-procurement adoption, it is important to manage time, cost, milestones and especially the changes, towards the right time and right way to project success.

According to Munns and Bjeirmi (1996), project management can be defined as the process of controlling the achievement of the project objectives. It seeks to manage the project by applying a collection of tools and techniques without adversely disturbing the routine operation. The function of project management includes identifying the requirement of work, establishing the extent of work, allocating the relevant resources, planning the execution of the work, monitoring the progress of the work, and adjusting deviations from the plan.

Change management is the process that helps organisation to request, prioritize, authorize, approve, schedule and implement any changes. Changes required to support business processes are directly related to the speed of adoption of D-procurement, and it is important to pay attention to the increased interests and needs of stakeholders.

Some key elements of "Project Management and Change Management" factor are listed below:

- Effective change management plan and training of all the stakeholders (Afolabi et al., 2019).
- Change management for radical and rapid change (Holotiuk & Beimborn, 2017).
- Established routines to discover and take preventive action to avoid them (Gheni et al., 2017).
- Active use and continuous updates of project plan and actions taken immediately (Gheni et al., 2017).
- Strong project management skills (Basheka et al., 2012).
- Centralised control and management of D-procurement initiatives (Gunasekaran & Ngai, 2008).
- Identification and management of key stakeholders (Vaidya et al., 2006).
- D-procurement impact assessment, potential barriers to implementation, and organisational resistance (Vaidya et al., 2006).

2.5.2.8 Security and authentication

According to Table 2.4, the "Security and Authentication" factor has five citations in the 12 selected CSF studies. Because of the importance and sensitivity of company information and

the legal nature of orders and payments, security and authentication are critical in D-procurement systems.

As Stephens and Valverde (2013) pointed out, as the number and frequency of security violations continues to rise, there is a corresponding dependence on information technology to drive business value, which in turn increases the importance and criticality of transaction data. This results in an increasing demand for processes and methodologies to ensure the confidentiality, integrity, and availability of data.

Another issue are the access controls to prevent unauthorised personnel from entering or accessing the D-procurement system. As Guidorizzi (2013) argued, many standard methods for validating a user's identity requires creating, remembering, and managing long and complex passwords. But that is not enough, it is also important to verify that the originally authenticated person is still the same person controlling the keyboard.

Therefore, the security technology must support the active authentication for web-based systems.

Waithaka and Kimani (2021) conducted a literature review on adoption of D-procurement practices, and they found that most of the organisations keep their business information secret as a protective mechanism to effectively compete and remain competitive in the business environment. However, the balance between transparency, protection against unauthorised data disclosure, ensuring the authenticity of a data source and the impact of disclosure of procurement process still remains unclear. That means the security and authentication issues should be paid closer attention in D-procurement project.

Some key elements of “Security and Authentication” factor are listed below:

- Data authorisation and authenticity of data source (Waithaka & Kimani, 2021).
- Security and authentication of D-procurement transactions (Afolabi et al., 2019).
- Infrastructure authentication and authorisation, confidentiality and integrity, security requirements (Basheka et al., 2012; Vaidya et al., 2006).
- Automation of authorisation of workflow (Puschmann & Alt, 2005).

2.5.2.9 User experience and satisfaction

According to Table 2.4, the “User Experience and Satisfaction” factor has four citations in the 12 selected CSF studies. User acceptance is often the focus of MIS implementation research in determining the success or failure of an IT product. And the importance of understanding the antecedents of attitudes toward computers, satisfaction, and usage is underscored by many MIS researchers (Al-Gahtani & King, 1999).

According to Davis (1993), user acceptance is often the pivotal factor determining the success or failure of information system adoption. The acceptance of new information system by users has critical and profound impact on the overall usage and success of the system adoption (Succi & Walter, 1999; Venkatesh et al., 2003).

As Pikkarainen et al. (2004) pointed out, a system that satisfies user's needs reinforces satisfaction with the system and is a perceptual or subjective measure of system success. Furthermore, user acceptance and system usage define the effectiveness or ineffectiveness of the system. Dillon and Morris (1996) suggested that understanding the factors that influence user acceptance of information technology is undoubtedly of interest to both scholars and researchers in a variety of fields as well as procurers of technology for large organisations.

Mose et al. (2013) explained why user acceptance will lead to the success of the system. this is because users involved will have a positive attitude in learning on how to use the system thus making it easy to incorporate most of the operations into the system.

And for senior management, they should recognise that it is important to provide the system functions to staffs as easy as possible. The functions such as automatic routing of purchase orders to proper managers for approval, accessing to online catalogues, sending purchase orders to suppliers, producing expense report capabilities, will encourage employees to accept and use the system without hesitation.

Some key elements of "User Experience and Satisfaction" factor are listed below:

- Ease of use of D-procurement tools, applications and processes (Afolabi et al., 2019).
- Learning to operate D-Procurement is easy (Premathilaka & Fernando, 2018).
- Interaction with D-Procurement system is clear (Premathilaka & Fernando, 2018).
- D-Procurement is flexible to interact with (Premathilaka & Fernando, 2018).
- Easy to become skillful at using D-Procurement (Premathilaka & Fernando, 2018).
- Outstanding customer experience and satisfaction (Holotiuk & Beimborn, 2017).
- User acceptance of D-procurement systems (Mose et al., 2013).

2.5.2.10 Knowledge of D-procurement benefits

According to Table 2.4, the "Knowledge of D-procurement Benefits" factor has three citations in the 12 selected CSF studies. The adoption of D-procurement will bring many benefits both at organisation level and individual level. However, the people in an organisation from top, middle and operational management level, must perceive and understand these benefits as much as possible, so that they can make the right decisions, commit to the adoption, and have enthusiasm to make the benefits come true. Otherwise, there will be resistance.

Gunasekaran and Ngai (2008) indicated that the knowledge of benefits also includes the understanding that optimum organisational performance is the key objective of any organisations. Therefore, any changes in the process or technology should have a positive impact on an organisation's performance. D-procurement does have some implications for process improvement, but more important is how this improvement affects organisational performance in both financial and non-financial terms.

Other than that, the organisation should reach a consensus on those generally accepted D-procurement benefits, such as reduced overall procurement costs compared with current traditional methods, shorter order processing and fulfillment cycles, reduction in administrative costs, improved strategic sourcing, and reduced inventory costs (Raghavan & Prabhu, 2004).

Furthermore, as Teo et al. (2009) pointed out, it is also important to understand both direct and indirect benefits. Direct benefits include reduction in transaction errors and transaction costs, improved data accuracy and information quality, and faster application process.

On the other hand, indirect benefits are associated with the impact of adopting D-procurement for management of procurement process and relationships, such as better customer services and improved relationship with business partners.

At last, Afolabi et al. (2019) found that the knowledge of D-procurement benefits is also related to how employees believe the innovative tool that will improve their productivity on the job. Thus, adequate training is necessary to have the employees familiar with the system and perceive the value of using D-procurement.

Some key elements of "Knowledge of D-procurement Benefits" factor are listed below:

- Knowledge of benefits of using D-procurement (Holotiuk & Beimborn, 2017; Premathilaka & Fernando, 2018).
- Perceived indirective benefits (Teo et al., 2009).

2.5.2.11 Employees' commitment and motivation

According to Table 2.4, the "Employees' Commitment and Motivation" factor has three citations in the 12 selected CSF studies. Gheni et al. (2017) conducted a research on CSF for IT projects, among nine factors, it is found that committed and motivated team ranked the first place. Therefore, they concluded that it is important for the project team to be committed and motivated in order to achieve successful adoption of D-procurement system.

Similarly, Mose et al. (2013) found that employees and management commitment to the success of D-procurement adoption among large scale manufacturing firms is the most critical success factor. They suggested that for successfully adopting the D-Procurement system, it

should allow employees to focus on their day jobs without sacrificing the visibility, and management needs to effectively control organisational spending. These can be achieved through training and communicating all the guidelines and procurers that can help easy use of the technology.

Moreover, management should set the vision and the goals that are relevant to the objectives of the organisation. Company policies and strategies formulated should enable the adoption of the new technology, management should provide all the financial support that is necessary for the development of D-procurement infrastructure for easy adoption.

Some key elements of "Employees' Commitment and Motivation" factor are listed below:

- Employees' commitment to success of adoption (Afolabi et al., 2019).
- Committed and motivated team (Gheni et al., 2017).
- Employees and management commitment to success of adoption (Mose et al., 2013).

2.5.2.12 Participants communication

According to Table 2.4, the "Participants Communication" factor has four citations in the 12 selected CSF studies. As Gheni et al. (2017) pointed out, communication is very important for realising the allocation of information system project roles and relationships. Sufficient participants communication ensures the project to take place in an opened and transparent environment, allows stakeholders to get the unanimous understanding on the objectives of the project and take their responsibility.

With communication to external partners, firms could form strong and collaboratively partnerships. Additionally, extensive external orientation supports learning and innovation. The collaboration goes beyond boundaries of the firm and extends to customers, technology providers, and suppliers, allows partners to communicate for specialised expertise and utilise partnerships for specific innovations (Holotiuk & Beimborn, 2017).

Furthermore, Gunasekaran and Ngai (2008) indicated that developing standards and systems for facilitating more effective interoperability than traditional communication systems will help the adoption of D-procurement fairly well with minimum investment and changes to the business processes.

Some key elements of "Participants Communication" factor are listed below:

- Effective communication between partners (Basheka et al., 2012; Gheni et al., 2017; Gunasekaran & Ngai, 2008; Holotiuk & Beimborn, 2017).
- Network effects with open systems and partner integration (Holotiuk & Beimborn, 2017).

2.5.2.13 Uniform codes and data standards

According to Table 2.4, the "Uniform Codes and Data Standards" has three citations in the 12 selected CSF studies. As an inter-organisation and inter-system platform, uniform codes and data standards are significant. Afolabi et al. (2019) conducted research on CSF for D-procurement adoption in construction industry, they found that the existence of a uniform standard for describing, displaying, and specifying construction materials, works, and services is essential. Consequently, the essence of data standards is to have a unified and generally accepted criteria or parameters for describing the characteristics of tangible and intangible entities amongst people.

Puschmann and Alt (2005) conducted another study on the successful use of D-procurement using the benchmarking method. They analysed several famous companies and found that the use of standards plays a critical role in D-Procurement.

In these cases, the standardised objects are catalogues, data, and processes. For example, if the data catalogue were not organised according to an ordered structure, they would be virtually unusable. And the use of standards for data interchange was much more important for Bayer and SAP because these companies used e-Markets to integrate their procurement systems with their suppliers.

Some key elements of "Uniform Codes and Data Standards" factor are listed below:

- Existence of a uniform standard for describing, displaying and specifying construction materials, works and services (Afolabi et al., 2019).
- Content management (Gunasekaran & Ngai, 2008).
- Preparation of catalogues (Puschmann & Alt, 2005).
- Standardisation of services for representation in the catalogue (Puschmann & Alt, 2005).
- Strategy for the physical hosting of the catalogues (Puschmann & Alt, 2005).
- Use of standards for catalogues and data interchange (Puschmann & Alt, 2005).

2.5.2.14 Government support

According to Table 2.4, the "Government Support" factor has three citations in the 12 selected CSF studies. Government support is quite important especially in those countries where government dominates the economy. As Al-Shura et al. (2018) pointed out that the more the government's involvement in digital supply chain initiatives, the more participation among SMEs. Similarly, government support will most certainly influence firms to apply IT in their supply chain operation (Lin, 2007).

According to the study by Ab Talib et al. (2015), the influence from external elements such as government intervention will indefinitely ease web-based supply chain adoption among firms. They argued that by highlighting governmental factor as one of the CSF, it draws the supply chain managers into paying more attention on government-related elements such as regulations, policies, or certification.

Afolabi et al. (2019) also suggested that the government need to supply the required leadership and seamless legal and policy backing for D-Procurement technologies, and there would be more commitment in supplying the reliable, affordable, and fast Internet services and other ICT infrastructure needed for an unbroken procurement process. In China, government policy is especially important and sometimes vital to the digital project, because the policy will really push everything forward in a right direction.

Some key elements of "Government Support" factor are listed below:

- Existence of supportive D-procurement policies and legislation (Ab Talib et al., 2015; Afolabi et al., 2019).
- An enabling legal framework (Basheka et al., 2012).

2.5.2.15 D-procurement operation and performance

According to Table 2.4, the "D-procurement Operation and Performance" factor has only two citations in the 12 selected CSF studies, but it might not mean it is not important, it will be tested later in the case study.

As Farzin and Nezhad (2010) pointed out, D-procurement enables companies to decentralise operational procurement processes and centralise strategic procurement processes as a result of the higher supply chain transparency and efficiency. D-procurement includes the activities such as advertising tenders, digital ordering, searching supplier markets and internet sourcing via third parties, and it allows web-based submission of tenders, and integration of procurement within the financial and inventory systems (Farzin & Nezhad, 2010). Hence, all these online activities mentioned should be supported by the technological team and business team in those companies applying the D-procurement system. That means to fulfil the expected value, it is not enough to only implement the system, but to operate the system.

Holotiuk and Beimborn (2017) further indicated that operation is infused with data to create data-driven and digitally automated processes for higher automation. This allows supply chains to react quickly and anticipate customer demand. The further automated handling of services and completely automated customer interactions can increase speed and efficiency. Blending human and digital resources creates human-centric designs for businesses with individual

solutions by interlocked human and digital channels. D-procurement operation should focus on efficiency in the interaction between people and technology, with digital technologies adding velocity to processes and services.

Furthermore, as Mose et al. (2013) found, using the D-procurement system it is possible to measure and monitor orders and their details such as processing time, time an order was sent, and current order status, these digital methods help to evaluate the performance of the procurement processes. This is important for continuously updating and refining the D-procurement system. As part of the adoption, processes are standardised and improved, and non-value-added activities are removed. After process automation, paper documents are eliminated resulting in faster order approval and document processing.

Some key elements of "D-procurement Operation and Performance" factor are listed below:

- Blending human and digital resources (Holotiuk & Beimborn, 2017).
- Not just business but operating models change (Holotiuk & Beimborn, 2017).
- Data-driven and digitally automated process (Holotiuk & Beimborn, 2017).
- Providing financial resources (Holotiuk & Beimborn, 2017).
- Monitoring the performance of D-procurement systems (Mose et al., 2013).

2.5.2.16 D-procurement adoption strategy

As shown in Table 2.4, the "D-procurement Adoption Strategy" factor has only two citations in the 12 selected CSF studies. It seems that this factor is not that important. However, without a proper strategy the whole adoption process might move towards wrong direction, thus, we consider this factor and would like to further test and verify it in the case study.

Peppard and Ward (2004) pointed out that while IT investments continue to make for both efficiency and effectiveness purposes, the enterprise should be proactively seeking out opportunities for competitive advantages through IT. The enterprises should formulate the information system adoption strategy to accommodate the requirement for alignment of IT investments with business strategy and assess the disruptive impact of technology.

As Neef (2001) pointed out, the creation of documented and executable strategies prior to the deployment of the D-procurement solution is an important success factor. The D-procurement adoption strategy includes the process of defining how the information system will be built and deployed, ensuring that the system is operational and used, and ensuring the system meets quality and business standards.

Some key elements of "D-procurement Implementation Strategy" factor are listed below:

- A consistent approach to procurement (Vaidya et al., 2006).

- Alignment of D-procurement implementation strategy with business strategy (Puschmann & Alt, 2005).

2.5.2.17 Firm size and procurement volume

According to Table 2.4, the "Firm Size and Procurement Volume" factor has only one citation in the 12 selected CSF studies. This citation is by Teo et al. (2009) in their D-procurement adoption study in Singapore. They conducted a survey to collect data from 141 companies in Singapore, and found firm size ranked in the first place of key factors which are positively and significantly associated with the adoption.

Teo et al. (2009) also explained, that previous research has generally found that larger firms tend to adopt new technologies more rapidly than their smaller counterparts. Likewise, larger firms are more likely to adopt e-commerce. The reason is that larger firms have more resources and may meet a greater need to stay at the technological forefront than those with smaller operational scale. In contrast, the small firms would want the others to test the technology first, so that allow them to conserve their resources and learn from others.

The firm size effect can also be traced back to 1990s. Banerjee and Golhar (1994) and Germain and Dröge (1995) have also reported that with higher average annual revenue, adopter firms may encounter more financial slack and hence allocate higher budgets to embark on their IT initiatives. Adopter firms also had a larger work force as well as more IT staff, and hence may have more expertise and manpower to complement their adoption of D-procurement.

Another issue highly associated with firm size is the procurement volume. Devaraj et al. (2012) carried out a research based on survey data collected from 130 purchasing and procurement managers, and they found that online purchase volume plays a significant role in the ability of firms to benefit from e-procurement.

Waithaka and Kimani (2021) explained that organisational structure and processes have a great influence on the adaptation of D-procurement systems in the organisations including their financial capacity, infrastructure and organisational power. Therefore, a buying firm with a large purchasing unit is more likely to possess the financial, skill resources and bargaining power to achieve the economies of scale required.

Some key elements of "Firm Size and Procurement Volume" factor are listed below:

- Firm size (Teo et al., 2009).
- Procurement volume (Waithaka & Kimani, 2021).

2.6 Summary

In this chapter, we firstly reviewed the information system adoption theories, and discussed the TAM, DOI, and TOE models in detail. Secondly, the evolution, definition and benefits of D-procurement were reviewed. And it is defined that in this thesis, the term D-procurement is used to mean both E-procurement and D-procurement. Thirdly, the evolution, definition and existing studies of CSF approach were reviewed. And then with the literature survey, 17 critical factors were selected from 12 selected studies, each of them was discussed in detail.

Basically, there are two findings from the literature review:

- Most of the CSF studies are quantitative research, the data collection methods normally used are systematic literature review or questionnaire survey. There is a lack of qualitative research, therefore a real case study for CSF in D-procurement adoption is highly required.
- The recent CSF studies are conducted in different scenarios, different industries, and different countries, and the findings are different as well. This suggests that it is quite important to understand the environment and conditions in which the CSF study will be carried out. For this study, as the second-largest economy country in the world, China is undergoing a digital revolution, thus, it is valuable to conduct a CSF study in digitalisation field in Chinese organisations.

Chapter 3: Research Design

3.1 Chapter overview

Research design refers to the overall strategy that is chosen to integrate the different components of the study in a coherent and logical way (Kirshenblatt-Gimblett, 2006). In this chapter, we firstly explain the logic of the research design, followed with the introduction of the research procedures. After that, the research methods and data collection techniques are discussed in detail.

3.2 Research design logic

The main logic of the research design explains how the objectives of this research are fulfilled by case study approach and literature support, as illustrated in Figure 3.1 below.

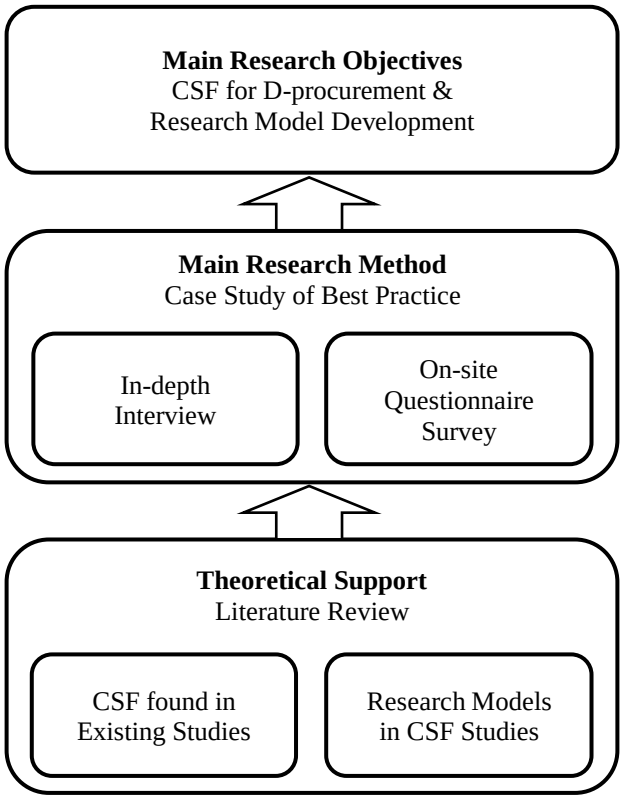

Figure 3.1 Research design logic

First, the main objectives of this research are to find out the CSF for D-procurement adoption, and the relationships between CSF by developing and examine an extended TOE

research model.

Second, for achieving these objectives, case study approach is selected as the main research method. It is because that the application of advanced digital technologies in D-procurement adoption in Chinese construction industry has been developed not very long but extremely fast in recent years. Thus it is valuable to study the successful experiences from those forerunners, the findings may contribute to both theory and practice. In this case study, our research object is one of the best D-procurement practices in China. In research methods, both qualitative and quantitative methods will be applied. The in-depth interview will be used to identify the CSF and to develop the new research model, the questionnaire survey will be applied to further test and verify the model to explain the relationships between CSF (variables) in the model.

Third, for carrying out the case study, the literature review is needed to provide theoretical support, the CSF and relevant research models in existing studies should be found out first.

3.3 Research procedures

By understanding the research design logic, in this section we discuss the five procedures to perform the research logic, as illustrated in Figure 3.2 below.

- Procedure 1: CSF and Research Models selection by literature survey.

It is the procedure to select the original CSF and relevant models for this research through reviewing the existing CSF studies. The CSF are the variables, the research model embodies the relationship between those variables.

- Procedure 2: Basic Research Model establishment.

In this procedure, the integrated research model is established by categorising and integrating the selected CSF into the selected research model. In this model, the original independent and dependent variables are defined.

- Procedure 3: In-depth Interview.

Based on the integrated research model, the in-depth interview with the specialists from H Group and its stakeholders will be applied, and then the CSF will be further identified and refined. Importantly, it is also the procedure to find out new CSF and use them to further refine the integrated research model.

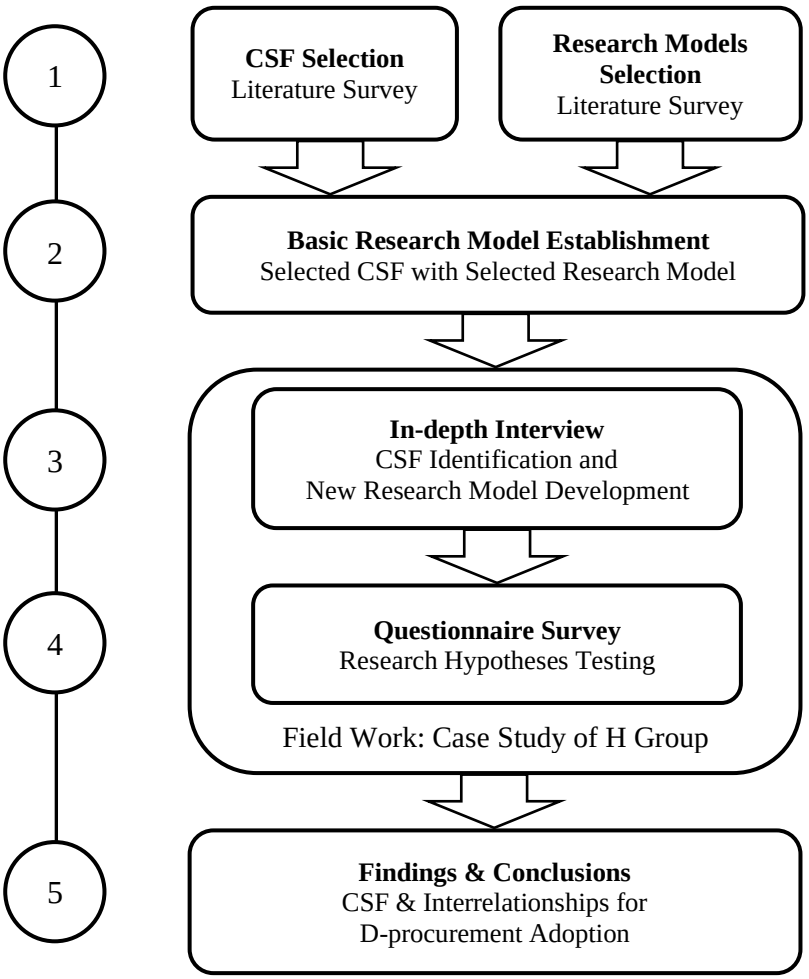

Figure 3.2 Research procedures

- Procedure 4: Questionnaire Survey.

Based on the newly refined research model through in-depth interview analysis, the research hypotheses are proposed. The questionnaire survey will be conducted to collect data to test the research hypotheses.

- Procedure 5: Findings & Conclusions.

In the last procedure, findings and the conclusions are summarised, and the research questions will be finally answered and research objectives will be achieved.

In the following sections, the methods and techniques applied in each of the procedures mentioned above will be introduced in detail.

3.4 Integrated CSF-TOE model

In the literature review chapter, three typically applied IS adoption models were discussed, they are: Technology Acceptance Model (TAM), Diffusion of Innovation theory (DOI), and Technology Organisation Environment framework (TOE).

In this case study, we choose TOE as the research model. There are two main reasons for this selection:

- First, we need to select a research model at the organisational level.

In this case study, we are going to investigate the H Group to find out the CSF for D-procurement adoption in practice. Furthermore, we are trying to analyse the relationships between those CSF. Among the various typically applied IS adoption theories, only the TOE and DOI are commonly used to examine adoption of numerous IS/IT products and services at organisational level, the other theories such as TAM, TPB and UTAUT are at the individual level (Gangwar et al., 2014; Ibem et al., 2016; J. C. Li, 2020; Oliveira & Martins, 2011).

- Second, the environment factors should be included in the model.

In the Chinese context, the business organisation and operations are significantly impacted by government regulations and supports. Thus, it is absolutely important to consider the environment factors when studying the CSF for D-procurement adoption success. The TOE includes the environment context that is not included in the DOI theory (Oliveira & Martins, 2011).

As Legris et al. (2003) indicated, rather than a long list of identified factors, it is better to group them into a model to facilitate analysis of information system adoption for practical use. The TOE model has exactly three groups: technology, organisation, and environment. Therefore, we can integrate the 17 CSF selected through literature review into TOE model according to grouping.

This is an important result produced in this study. This model organically combines the 17 CSF and the TOE model, so that companies preparing for digitalisation can refer to and apply this model to objectively evaluate their own digitalisation capabilities.

In addition, because this model is based on the real situation of the digitalisation development of Chinese construction industry, it also provides a valuable theoretical reference for the academic community.

In this integrated CSF-TOE model, the 17 CSF are the original independent variables, and the D-procurement adoption success is the original dependent variable. This model also provides a significant foundation for the following research procedures and will be tested and verified through case study.

The model is illustrated in Figure 3.3 below.

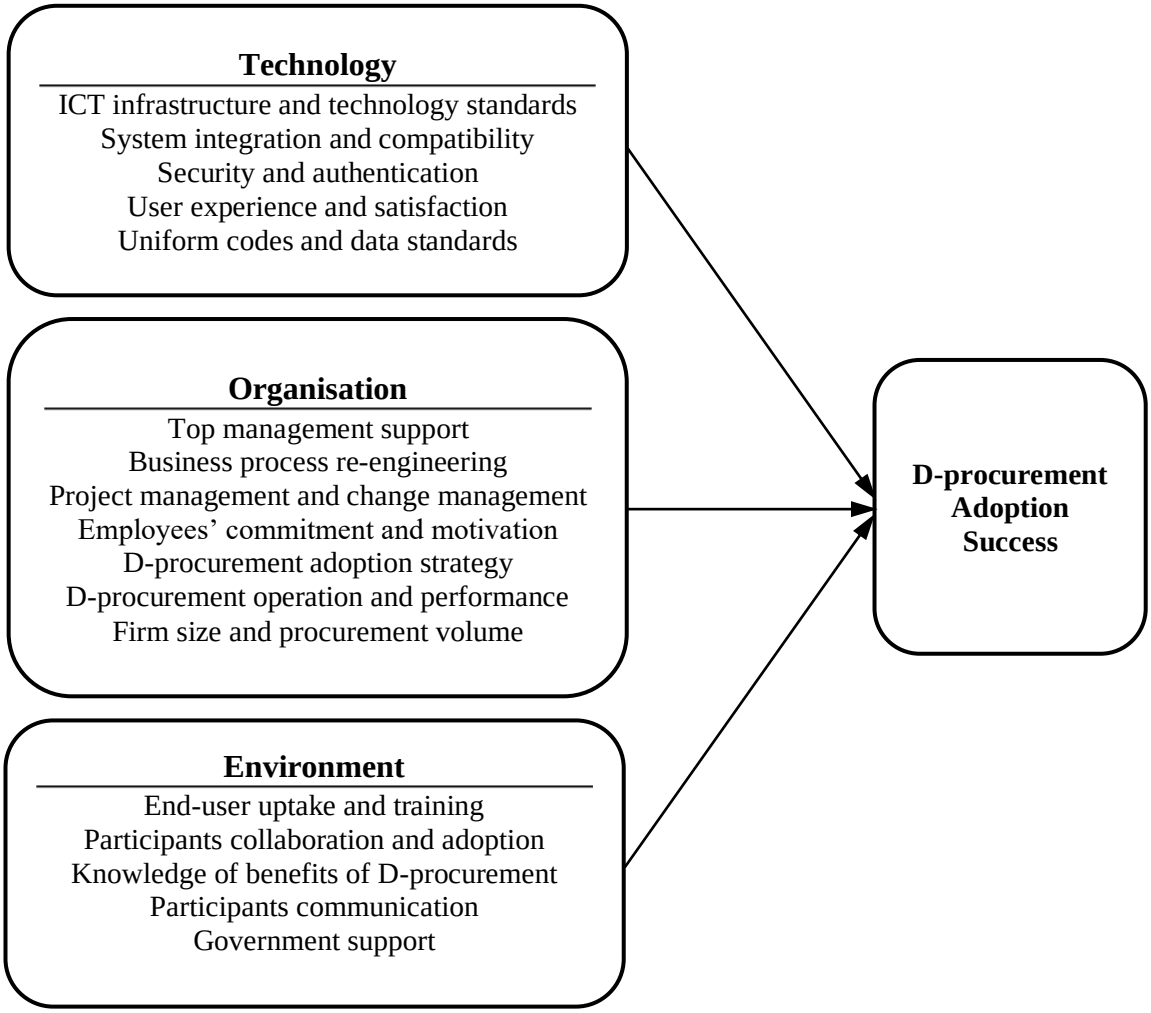

Figure 3.3 Integrated CSF-TOE model

3.5 Case study of H Group

As Yin (2018) pointed out in his famous book "*Case Study Research: Design and Methods*", the case study is relevant while your research questions seek to explain some present circumstance or to require an extensive and in-depth description of some social phenomenon. Although we have identified 17 CSF from the existing studies, and grouped them into the integrated CSF-TOE model, there are three questions that still need to be answered:

- Are the factors relevant in Chinese context?
- Are the factors relevant in the most updated business scenario?
- Are there any new factors can be found in the real case?

A case study can help to answer these questions. However, it is important to choose the relevant case. In order to do that there are three basic criteria:

- It should be really a successful D-procurement adoption case, and the case should be

commonly influential in the construction industry.

- The enterprise should be influential, and its organisation culture and structure should be representative among construction enterprises.
- It should be convenient to collect required data for this research.

Based on the criteria, we strived for the chance to study the H Group. The D-procurement project carried out by H Group was commended as the best case of digital supply chain by China's SASAC in 2021 (State-owned Assets Supervision and Administration Commission of China, 2021). In another word, this case is currently the best representative practice of the Chinese construction industry.

We also tried to find some additional cases to see whether multiple case study was possible, but due to the business information constraints and data security considerations, we could not get permissions from any more companies, thus finally we decided to apply single case study approach for this research.

The data will be collected through multiple sources of evidence (Yin, 2018), including entrepreneurship and business history, company specific documentation, media reports, project documentation, D-procurement platform database, semi-structured in-depth interview, and questionnaire survey. In the following sections, we are going to discuss the two main methods for data collection: in-depth interview and questionnaire survey.

3.6 In-depth interview

The reason to design an in-depth interview is that the integrated CSF-TOE model needs to be put into the real-world scenario and evaluated by specialists with their practical experiences in conducting D-procurement project in H Group. The goal is to evaluate which of these 17 CSF are and which are not relevant for the case of H Group. Moreover, it is an opportunity to find out new CSF and to discover any possibility to refine the integrated CSF-TOE model. Based on the considerations, there are three main objectives for the interview:

- To find out the order of relevance for the 17 CSF.
- To find out any new factors not in the 17 CSF.
- To find out relationships between CSF.

3.6.1 Semi-structured in-depth interview

To achieve the objectives, a semi-structured in-depth interview is designed (see Annex A). As Rahman (2019) indicated, semi-structured interview is suitable for finding previously unknown

qualitative trends and issues, explore new areas of the research interest and in phenomenographic studies. As one of the main data collection techniques in qualitative methods, semi-structured interview is a good way of accessing people's perception, meanings, definitions of situations, and constructions of reality. It is a technique allowing the researcher to obtain the first-hand historical and real-time qualitative data of the companies (Kallio et al., 2016).

There are planned and unplanned questions designed for this semi-structured in-depth interview. The planned questions have three parts. At the beginning, a set of open questions are designed to guide the conversation and collect the interviewee's personal opinion:

- How long have you been working in this company?
- What was your role in the DP project? Are you still involved?
- What is your opinion about the added value of the DP project?
- What do you think: what are the most CSF for D-procurement adoption success?

Besides the answers, another effect of the open questions above is to allow the interviewee to calm down as much as possible through the conversation and focus on the question-and-answer scene of the interview. After the four open questions, the most important part of the interview is the ranking of CSF. A list of the 17 CSF will be given to the respondents, and they will decide the order according to CSF relevance. At the end, there is an open question:

- Other than the 17 CSF, which else do you think should be included? Please explain the reason and order it in the CSF list according to its relevance.

Other than the predetermined questions above, there will be some unplanned open questions given in the interview according to the progress and context of the conversation.

3.6.2 Interviewee selection

It is important to select the relevant candidates for the interview. Ideally, the stakeholders of the D-procurement project should be included so that the data can be collected from different group of people with different perspectives. These stakeholders may include:

- Top management of H Group, since they are the project decision makers.
- Managers and staff that participated in the project.
- Suppliers of the D-procurement business, since they are the partners and end-users.
- Technology partners that participated in the development, operation, and maintenance of the D-procurement platform.

The interviewees should be selected on the basis of their position and involvement of the

project. As Dubois and Araujo (2007) suggested, the selection of multiple respondents allows to capture a variety of perceptions surrounding a complex phenomenon. Therefore, the interviewees will be selected from the headquarters, the subsidiaries, and the partners of H Group. As these are key participants representing the strategic and operational levels of the project, it is anticipated that the information collected would be the most reliable and assertive possible (Fernandes & Vieira, 2015). The target interviewees will be about 20 specialists.

3.6.3 CSF relevance ranking

For the CSF ranking, it aims to reveal the relative importance among the 17 CSF without actually establishing the degree of variation between them. Therefore, the ordinal scale is considered.

According to Stevens (1946), ordinal scale is the 2nd level of the four measurement scales, which are nominal, ordinal, interval, and ratio. The primary advantage of using ordinal scale is the ease of comparison between variables. Thus, it not only fulfils the purpose of CSF ordering, but also is extremely convenient to group the variables after ordering them. That is important for regrouping the CSF and refining the integrated CSF-TOE model.

Moreover, ordinal scale can be effectively used in surveys, polls, and questionnaires due to the simplicity of analysis and categorisation, and the collected responses are easily compared to draw impactful conclusions about the target audience (Liu et al., 2019). This is convenient for the in-depth interview, making the way to get opinions from the specialists as simple and quick as possible.

Based on the ordinal scale, the ordinal ranking method is considered. In ordinal ranking, all items receive distinct ordinal numbers, for example, “1-2-3-4”. Thus, in the in-depth interview, it is considered to let the specialists rank the 17 factors in order from 1 to 17.

As Lavrakas (2008) pointed out, ranking is a question-response format used when a researcher is interested in establishing some type of priority among a set of objects, whether they be policies, attributes, organisations, individuals, or some other topic or property of interest. For the CSF ranking, there are two methods might be considered: direct ranking and Likert scale.

To decide which method is better, we pretested three of the interviewees, asked them to rank CSF using both direct ranking and Likert scale. They all responded that the direct ranking is better. It is because they found that it is harder to measure the CSF by using 5-point Likert scale, and the direct ranking method is easier. They further explained that they could make

decision on the CSF order by directly putting a factor in the ranking list with intuition, which was faster than making decision on giving a point to it.

This result proves Lufityanto et al. (2016)'s study in psychological field. That is, many people use the phrase 'intuition' to describe a sensation or feeling they have when making decisions. The study showed that nonconscious emotional information can boost accuracy and confidence in a concurrent emotion-free decision task, while also speeding up response times. As Chambers (1988) revealed, the direct ranking moves quickly from early discussion and questioning to recording respondents' views directly onto a table or matrix. It is simple, quick, and informative.

Based on the considerations above, it is decided to use the direct ranking in the interview, it will result a ranked CSF list in the order from 1 to 17.

3.7 Questionnaire survey

In this study, we are committed on finding real CSF in practice and their relationships through case study to revise and refine the TOE model. So, the in-depth interview is designed to accomplish this goal. Now assuming that we have proposed a new research model based on the TOE, it is necessary to further formulate and demonstrate the research hypotheses. The questionnaire survey is designed to implement this approach.

3.7.1 TOE model extension

In the original TOE, there are only independent and dependent variables in the model, so there is only a linear relationship from the independent variable to the dependent variable. Based on the findings of the literature review, most studies on CSF are based on this original TOE model, and some scholars have integrated TOE with DOI or TAM, adding some mediator variables to the integrated model. However, few studies extend the TOE model with new findings in practice. In this study, we aimed to discover whether there are other relationships between CSF as independent variable and D-procurement success as a dependent variable. If so, we will try to introduce these relationships into the original TOE model, which would be the core value of this study.

The extended TOE model will be the basis for research hypotheses as well as design of questionnaire survey.

3.7.2 Research hypotheses and questionnaire survey

Suppose that the extended TOE model is established, the next procedure is to propose the research hypotheses. A research hypothesis is a specific statement that predicts the direction and nature of the results of a study (Connelly, 2015). Hypothesis can be simple or complex but should be understandable. Normally, a hypothesis outlines a presumed relationship between two or more variables, it represents an association between variables or a cause and effect relationship (Chigbu, 2019). And there are two fundamental types of variables in a causal relationship, one is the independent variable, another is the dependent or outcome variable.

There is also a mediator variable that explains the process through which two variables are related, and it is a way in which an independent variable impacts a dependent variable. And there is a moderator variable affects the direction and/or strength of the relationship between an independent variable and a dependent variable.

In the case of a hypothesis, the researcher has strong reasons to believe the results will take a certain direction based on the literature or a theory (Polit & Beck, 2020). Once the hypotheses are identified, a questionnaire survey can be applied to test the hypotheses. A questionnaire is a series of questions asked to individuals to obtain statistically useful information about a given topic. Questionnaires are frequently used in quantitative marketing research and social research, if the questionnaire is properly constructed and responsibly administered, it will become a vital instrument by which statements can be made about specific groups or people or entire populations (Roopa & Rani, 2012).

In this study, the questionnaire survey is not designed to be distributed via web-based questionnaires or via email. Compare with giving a web address to the respondents and ask them to fill out the questionnaire, it would be better to talk with them first, let them feel calm and relaxed, understand the background and objectives of the survey, and then give them the questionnaire, they should concentrate more on the questions and seriously give answers. Based on the consideration, an on-site questionnaire survey is designed. The survey involves three parts:

- Introduction of the research

Firstly, the research background will be introduced, it is important to let interviewee understand the value of the research.

And then, the information about previous in-depth interview will be shared to the interviewee. At last, the procedures and objectives of the survey will be explained. All these conversations intend to get interviewee involved in the scenario and pay attention.

- Open-ended questions

There are some open-ended questions will be given to make the interviewee talk about the D-procurement project, think about critical factors, and get ready to answer the following close-ended questions.

- Close-ended questions

The close-ended questions are essential, these contain a set of structured questions. The interviewee will be asked to fill out the questionnaire to answers the questions alone.

3.7.3 Likert scale

According to Joshi et al. (2015), Likert scale was devised in order to measure 'attitude' in a scientifically accepted and validated manner in 1932. The original Likert scale is a set of statements offered for a real or hypothetical situation under study, participants are asked to show their level of agreement with five response alternatives: strongly approve, approve, undecided, disapprove, and strongly disapprove (Boone & Boone, 2012).

As Nemoto and Beglar (2014) suggested, some advantages of Likert-scale questionnaires are:

- Data can be gathered relatively quickly from large numbers of respondents.
- Validity of the interpretations made from the data can be established through a variety of means.
- Data collected can be profitably compared, contrasted, and combined with qualitative data-gathering techniques, such as open-ended questions, participant observation, and interviews.

Different from the previous in-depth interview that focus on finding out the CSF order of relevance and new CSF to refine the integrated CSF-TOE model. In this questionnaire survey, the main purpose is to examine the research hypotheses derived from the extended TOE model, the collected data will be analysed by statistic methods, the Likert scale is an appropriate choice for measuring the variables. The SPSS 26.0 will be used as the statistical software for data analysis.

3.8 Summary

To sum up, there are two main features for this research design. The first feature, a double interview is designed. The 1st round interview aims to find out the CSF order as simple and quick as possible, therefore, the specialists will use direct ranking method to rank the CSF list

conveniently. The 2nd round interview aims to test and verify the hypotheses based on the extended TOE model, Likert scale will be used to measure the variables.

The second feature, both qualitative and quantitative research methods are used accordingly. The qualitative method is used in the 1st round interview to understand the specialists' knowledge and perspectives about CSF. The quantitative method is used in the 2nd round interview by a questionnaire survey, there are an interrelated set of variables under hypotheses will be assessed, and the relationship among the variables in terms of importance will be specified.

Chapter 4: Case study of H Group - In-depth Interview

4.1 Chapter overview

This chapter mainly includes four parts. The first part contains the introduction of H Group, H Tech and their D-procurement project. The second part firstly describes the process of in-depth interview in detail, then introduces the comprehensive and in-depth analysis of the interview results, and explains the process to obtain the final CSF, which completes the first major goal of this research. The third part, based on the important findings of the in-depth interview, the extended TOE model is proposed and the measurement model is discussed. Finally, the design of the questionnaire survey to verify the model is introduced.

4.2 Introduction to H Group

H Group was founded in May 1950. It was composed of three major systems: the First Bureau of the Ministry of Construction, the Southwest Administration of the Ministry of Construction, and the Sichuan Provincial Construction Department. In 1997, it was restructured into H Group Co., Ltd., which is an important state-owned backbone enterprise in China.

4.2.1 Overview of H Group

After more than 70 years of development, the group has become a large-scale construction group with important influence in the western region, the whole country and even overseas. It is accelerating its progress towards a first-class state-owned capital investment company in the construction industry in China.

Its business involves engineering contracting, engineering intelligent manufacturing, construction industry digital economy, construction industry financial services, scientific research and design, industrial real estate, urban renewal and operation and maintenance, and engineering intelligent equipment. The market covers more than 30 administrative regions across the country and more than 20 overseas countries and regions, with an annual operating income of 80 billion yuan.

H Group has a total of more than 100 wholly owned, holding and relatively holding legal

entities, including four enterprises with special qualifications for general contracting of housing construction, five enterprises with Grade A design qualifications for construction engineering, and three high-tech enterprises.

H Group's engineering achievements are all over the country, and it has participated in a series of major construction projects such as China Automobile, Dongfeng Motor, the Great Hall of the People, Daxing International Airport, Tianfu International Airport, Huawei Research Center, and Deng Xiaoping's Former Residence.

In the field of national defence and military industry, it has participated in the construction of Xichang Satellite Launch Base, Mianyang "839" Science City, Chengfei 5118 project, and more than 2/3 of the country's wind tunnels. In the field of airport construction, it also has excellent performance with outstanding advantages. It has participated in the construction of 78% of civil airports and 100% of 4F-level airports in China.

It is unique in the field of super-high structure construction, and the self-developed "lightweight modular intelligent construction platform" called “air building machine” has reached the international leading level.

H Group is now ranked 204th in the Top 500 Chinese Enterprises, 15th in the Top 80 Engineering News-Record (ENR) Chinese Contractors, and 6th in the Top 100 Sichuan Province Enterprises.

According to the newest strategic plan, H Group aims towards the goal of achieving over 100 billion value of revenue in 2023 and Fortune 500 in the world in 2025.

4.2.2 Origin of H Tech

In 2015, H Group started to invest and survey the strategies for digital transformation and upgradation, they also carried out some feasibility studies for analysing the methods of digitalisation. In 2016, H Group decided to set up a new company that especially serves for its digitalisation, this company is named H Tech.

Initially, H Tech was positioned to build and operate H Group's D-procurement platform. Later, with the continuous development of H Tech, especially the breakthrough in D-procurement project and the continuous precipitation in the field of digitalisation, H Tech has now not only become the leading force of H Group's digital transformation, but also has brought great influence to the industry’s digitalisation.

At the beginning, there were three key factors that facilitated the establishment of H Tech:

- The policy of electronic tendering.

In 2016, the government issued the circular on solidly carrying out the pilot work of national electronic tendering and bidding (National Development and Reform Commission of China, 2016), this greatly accelerated the adoption of online procurement solutions.

- The reform of taxation system.

Before May 2016, the business tax policy was performed. If a company operates the online procurement business, then the tax payment was 5% of the gross merchandise volume (GMV), faced with such huge taxes, many companies were discouraged from doing online business.

In 2016, there was an important reform of taxation, the government issued the circular on comprehensively launching the pilot program of replacing business tax with value-added tax (VAT) (State Taxation Administration of China, 2016). This policy makes the companies such as H Tech feasible to conduct the online procurement business, because it allows the deduction of VAT. That means, if H Tech do not earn profit in the online procurement business, then they do not need to pay any tax. Even if they make a profit, that only pays VAT on the profit margin.

- The development of advanced technologies.

Taking the advantage of fast development of internet from 2000 to 2015 in China, the internet technologies were matured. The improvement of information superhighway, mobile network, cloud technologies, and big data technologies made the internet applications widely accepted by users. This made it easier for people to accept a digital procurement platform.

Other than these three key factors, there was a critical trigger to initiate the D-procurement project. Just before H Tech was established, a significant procurement corruption in H Group was discovered, and then the government ordered H Group to solve the problem as quickly as possible. This incident directly contributed to the rapid start of the D-procurement project.

4.3 Introduction to D-procurement project

After the D-procurement project was started, its value gradually emerged. Along with the implementation of the project, there has been a lot of achievements. In this section, we mainly discuss the evolution of the D-procurement project and the main features of the D-procurement platform.

4.3.1 Evolution of D-procurement project

- In 2016, H Tech started to reconstruct its procurement process, based on that, they began to design and develop the D-procurement platform. H Tech became one of the pioneers to initiate an online digital platform to operate the procurement business for a corporate group.

- In 2017, the D-procurement platform was released, two subsidiary companies were selected to run and test the system, and the system was iterated according to the feedbacks. In the second half of 2017, the platform was officially lunched, more and more subsidiaries started to use the platform for its procurement business. H Tech became one of the earliest construction supply chain management companies in the country.
- In 2018, the headquarters of H Group commanded the last two subsidiaries to use the D-procurement platform. As of then, H Group accomplished the digital transformation of its procurement business. Meanwhile, it started to embed finance services into the digital procurement process.
- From 2016 to 2019, H Tech's business turnover exceeded 5 billion yuan in three years. In 2020, under the influence of the Covid-19, the operating income still maintained a growth, reaching a new high of 5.2 billion yuan. Moreover, H Tech started to promote the platform to the other construction companies, which meant the digital capability has been duplicated to the industry.
- By the end of 2021, the platform GMV reached 70 billion yuan. There are over 200 buyer companies and about 100 thousand supplier companies using the platform. There are over 470 thousand stock keeping unit (SKU) and more than 500-million-yuan finance service product provided. It has become one of the largest B2B construction supply chain platform in China.
- Many honours were awarded to the project by governments. Other than the 2020 "Typical Case of Digital Transformation of State-owned Enterprises" award, the platform was awarded the "Successful Case of Construction Industry Digitalisation" by the Ministry of Housing and Urban-Rural Development, the "Excellent Purchasing Organisation in 2020", the "China Core Enterprise E-commerce Progress Award", "Sichuan E-commerce Industry Emerging Award", "Chengdu Demonstration Platform Enterprise", and "Supply Chain Innovation and Application Excellent Case Enterprise" by governments at all levels.
- In the newest strategic plan by H Tech, the next objective of the platform is over 100 billion GMV and 15 billion annual income.

4.3.2 Features of D-procurement platform

As an innovative and successful project in the industry, the D-procurement platform has its own

distinct features. Therefore it is important to discuss these features.

According to Ronchi et al. (2010), there is wide agreement that from the technological perspective there exist three main types of procurement platforms: buyer-hosted, seller-hosted and intermediated platforms. Angeles and Nath (2007) 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. All the companies under H Group are the buyers, H Tech serves as the operator, and there are two types of suppliers: manufacturers and banks. Furthermore, H Tech also opened the platform for the other buyers outside H Group.

In contrast, it has been found that the seller-established or third-party-established platforms are difficult to be accepted in the market. It is because in construction industry, the main cost of the procurement are the raw materials such as steel and cement, the companies would buy directly from the manufactures other than the intermediate platforms. Furthermore, 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 (Mentzer et al., 2001), it is easier for them to promote supply chain platforms.

A supply chain leader is like a channel captain in the marketing channels and plays a key role in coordinating and overseeing the whole supply chain (Ellram & Cooper, 1990). As Bowersox and Closs (1996) suggested that, in many situations, a specific firm may function as a supply chain leader as a result of their size, economic power, customer patronage, comprehensive trade franchise, or the initiation of the inter-firm relationships. In this sense, H Group is definitely the leader, it dominates its supply chain ecosystem.

According to De Reuver et al. (2018) and Hein et al. (2020), there exist many digital platform definitions in the literature, mainly from four perspectives: market-based, technical, socio-technical, and organisational. In this thesis, we use the term “digital procurement platform” to describe the information system built by H Tech, and this D-procurement platform has four main features:

- It is a multi-sided platform.

Multi-sided platform (MSP) serves multi-sided markets. In particular, two-sided markets bring together two distinct groups who value each other’s participation onboard the same platform in order to generate any economic value (De Reuver et al., 2018). Based on that, MSP acts as intermediaries and provide opportunities for direct interaction and exchange between two or more parties of the platform participants (Geliskhanov, 2018).

In this study, the platform is a multiparty transaction system, the subsidiaries of H Group, H Tech, manufactures, distributors, and financial organisations participate in the transactions and create a win-win value platform.

- It primarily purchases raw materials but also MRO (Maintenance, Repair and Operations)

Whatever in construction or manufacturing industry, procurement of raw materials accounts for the largest procurement cost. The traditional decentralised procurement model not only has untransparent information and is prone to corruption, but also has the shortcomings of high procurement costs and low procurement efficiency. Therefore, it is valuable for construction companies to build a centralised procurement platform and dominate it. It helps not only to control the cost and enhance the procurement efficient but build a new platform-based business model. In contrast, the MRO is not essential, the company can choose either to digitalise the MRO procurement process on the platform, or just to purchase from the MRO B2B websites.

- It digitalises the whole procurement process.

The platform is designed to digitalise all the traditional procurement processes, including planning, tendering, contracting, ordering, delivering, inspecting, settling, paying, and recording. This serves as a preliminary condition for the supply chain finance because the credit loans are based on integrated and accurate data. It would not be possible without any part of the data. Many other online procurement systems only include the tendering and contracting processes, but the entire process has not been digitalised, therefore they are not considered as a D-procurement platform in this study.

- It applies advanced digital technologies.

The digital technologies should be applied to develop the platform. The main technologies include cloud computing technologies, mobile application development technologies, blockchain technologies, big data technologies, and artificial intelligence technologies. Among of them, the cloud computing technologies are essential, especially the software as a service (SAAS) and platform as a service (PAAS).

It is because these technologies allow multi tenants to perform procurement processes independently and to operate interactive transactions simultaneously.

4.4 In-depth interview

There are two very important parts in this field work, one is the in-depth interview, and the

other is the questionnaire survey. Through in-depth interview, the 17 selected CSF from the literature review will be verified in real practice to further screen these CSF, and the new discoveries are expected as well. In the following subsections, we will introduce how the in-depth interview was organised and conducted, how the data was collected and analysed, and what key findings were made.

4.4.1 Preliminary meeting

Before conducting the in-depth interview, it is important to identify the interviewees in advance. A preliminary meeting was held in H Group. Participants included the leader of human resource department, the leader of business centre, as well as our research team. We firstly introduced the background of the research, the objectives and procedures of the interview, and then the participants discussed how to select the specialists, below are the conclusions:

- Basically, the specialists who are capable to answer the interview questions about the CSF are in H Tech. Because only these people fully participated in the D-procurement project and experienced the entire process, they have the comprehensive understanding about the factors impacting on the succeed of project. There were 15 specialists suggested, they are the key roles participated in H Group's D-procurement project.
- The H Group's headquarters are mainly in charge of decision making of major issues of the project. The subsidiaries mainly serve as a buyer, they are using the digital platform to purchase materials. Therefore, the people from either headquarters or subsidiaries only participated in some aspects of the project, they do not have a systematic view of the CSF.
- There is another company called Y Tech, which is the main technology partner assisted H Tech to design and develop the D-procurement platform. It was suggested to invite their project director and product manager to take part in the interview, these two specialists deeply participate in the project and have thorough understanding on the CSF.

After the meeting, we also required the H group's human resource department to recommend some people from the main supplier companies who were deeply participated in the D-procurement project. They picked one person from each of the three companies, and then we discussed with these specialists. It was found that these persons only participated in some particular parts of the procurement process, such as tender or settlement, they did not have an overall understanding of the project. When we asked how about their opinions on the CSF, they

could not have an in-depth opinion.

Furthermore, we discussed another important issue which is the recording method. They did not suggest using voice recording, because people will not say what they really think based on various worries. So, we decided to record by writing, and arranged a secondary interviewer especially for recording to prevent incomplete records.

4.4.2 Interview progress

The in-depth interview was finally carried out from 2nd to 31st March 2022. The 15 specialists from H Tech were interviewed at H Tech's conference room. And the two specialists from Y Tech were interviewed at Y Tech Chairman's office.

For each interview, there were two interviewers and one interviewee participated. The primary interviewer was in charge of asking questions, talking with interviewee and recording key points. The secondary interviewer was primarily responsible to record the conversation. It was a face-to-face interview conducted on work time.

Each interview started from an introduction of each other, and then the primary interviewer began to introduce the research background, interview objectives and procedures. These conversations would normally calm down the interviewee. The interview then went in-depth with the designed questions.

There were a total of 17 specialists interviewed in 807 minutes, about 47 minutes and 28 seconds for each of them. The key information about the in-depth interview is summarised in Table 4.1 below.

Table 4.1 Basic information about in-depth interview

No.	Date	Start Time	End Time	Duration (minutes)	Interviewee	Company	Position	Join Project
1	2022.3.29	9:00 AM	10:16 AM	76	CHEN.W	H Tech	Chief Technology Officer	42 mos.
2	2022.3.29	10:18 AM	10:51 AM	33	WANG.SL	H Tech	Operation Centre, Department Manager	48 mos.
3	2022.3.29	10:50 AM	11:25 AM	35	LIU.XY	H Tech	General Administration Centre, Administration & Secretary Department Manager	24 mos.
4	2022.3.29	1:40 PM	2:25 PM	45	HE.Y	H Tech	Tax & Accounting Centre, Financial Management Department Manager	46 mos.
5	2022.3.29	3:29 PM	4:01 PM	32	CHEN.Q	H Tech	Business & Finance Centre, Settlement Department Manager	52 mos.
6	2022.3.29	4:06 PM	4:36 PM	30	PAN.X	H Tech	Technology Centre, Product Manager	42 mos.
7	2022.3.29	4:40 PM	5:35 PM	55	LUO.X	H Tech	Service and Support Centre, Director	60 mos.
8	2022.3.31	9:00 AM	9:40 AM	40	ZHANG.J	H Tech	General Administration Centre, Organisation & Human Resource Department Manager	36 mos.
9	2022.3.31	9:40 AM	10:30 AM	50	LI.LL	H Tech	Online Business Centre, Director	70 mos.
10	2022.3.31	10:38 AM	11:33 AM	55	XIE.Y	H Tech	Business & Finance Centre, Director	42 mos.
11	2022.3.31	1:25 PM	2:00 PM	35	WANG.JX	H Tech	General Administration Centre, Director	35 mos.
12	2022.3.31	2:05 PM	2:38 PM	33	LIU.B	H Tech	Technology Centre, Digitalisation Manager	69 mos.
13	2022.3.31	2:40 PM	3:18 PM	38	DONG.MR	H Tech	Marketing Centre, Manager	30 mos.
14	2022.3.31	3:45 PM	4:30 PM	45	WEI.PR	H Tech	Technology Centre, Product Manager	19 mos.
15	2022.3.31	4:35 PM	5:20 PM	45	WANG.T	H Tech	Marketing Centre, Director	42 mos.
16	2022.3.01	2:05 PM	3:30 PM	85	LI.T	Y Tech	Project Director	36 mos.
17	2022.3.02	3:30 PM	4:45 PM	75	HE.LM	Y Tech	Product Manager	21 mos.

4.4.3 Data collection

As shown in Table 4.1, the average duration of participation by interviewees in the H Tech's D-procurement project is around 42 months, which is three and half years. That means these interviewees are very experienced, most of them have grown into the core management of H Tech, and witnessed the whole process of the D-procurement project growth. In the process of interview, we found that many of them have maintained a high degree of consistency in their thinking and understanding of the project. The reason for this will be discussed in the next section.

After the interview, the recordings by two interviewers were double-checked, and then translated from Chinese to English, and finally summarised in Excel. The answers to open questions were organised and analysed based on the commonalities and differences. For the ranking of the CSF order, the collected ranking data is calculated based on the weights.

4.4.4 Data analysis and findings

After the interview, the collected data was analysed, and there are some important findings derived. Overall, the interview achieved the earlier expectations, the order of relevance of the 17 CSF was found, as well as the way to extend the integrated CSF-TOE model.

4.4.4.1 Ranking statistics of CSF order of relevance

During the interviews, respondents ranked the 17 CSF based on their understanding of the relevance. The results are summarised in Table 4.2 below.

Based on the collected data, the total ranking of each CSF is counted. For example, for the "top management support" factor, it is ranked the first for 8 times, the second for 4 times, the third for 3 times, and the fourth for 2 times.

And then, the weights are assigned to the ranking order based on the ordinal scale method. The highest rank in the order is assigned to 1.7, while the lowest is assigned to 0.1, there is an equal difference 0.1 between the weights. After that, the total weigh of "top management support" is calculated as below:

"8*1.7+4*1.6+3*1.5+2*1.4=27.3".

Table 4.2 CSF order of relevance ranked by interviewees

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

Order	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
CHEN.W	13	1	8	10	16	3	2	11	12	4	5	6	7	9	14	15	17
WANG.SL	13	3	1	5	12	2	7	8	10	9	15	14	17	11	16	4	6
LIU.XY	1	2	8	11	3	12	14	16	4	5	7	10	6	15	9	13	17
HE.Y	12	13	1	3	4	15	5	2	9	17	6	7	10	11	14	16	8
CHEN.Q	13	1	8	4	11	9	10	14	16	17	3	15	2	5	6	7	12
PAN.X	13	11	2	1	15	3	14	10	12	16	17	9	4	6	5	8	7
LUO.X	1	12	11	17	13	3	2	15	5	4	7	6	9	10	14	16	8
ZHANG.J	11	3	1	12	13	8	9	10	14	16	2	17	4	5	7	15	6
LI.LL	1	14	11	2	3	17	13	12	8	9	15	4	5	6	7	10	16
XIE.Y	1	12	8	17	2	14	10	9	4	15	5	11	3	6	7	16	13
WANG.JX	11	1	17	13	12	2	3	10	14	15	8	9	16	4	5	6	7
LIU.B	1	2	12	13	3	17	11	16	8	9	10	14	15	4	5	6	7
DONG.MR	13	1	12	3	11	16	17	5	2	8	4	6	7	14	9	10	15
WEI.PR	1	2	3	7	13	15	11	12	4	5	10	8	6	14	9	16	17
WANG.T	1	11	12	13	2	14	17	8	10	3	4	7	16	15	5	6	9
LI.T	13	12	15	1	3	2	11	7	8	14	6	10	16	17	4	5	9
HE.LM	1	13	3	15	12	11	2	4	5	6	7	10	17	14	8	9	16

The table 4.3 below shows the ranking statistics for each CSF and the final weight results. The CSF with the highest weight (top management support) is ranked the first, the one with lowest weight (employees' commitment and motivation) is ranked the last. In the table, numbers with a shaded background indicate the total number of times a CSF was ranked in a certain order.

Table 4.3 CSF ranking statistics and total weights

CSF \ Order	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total weights
Top management support	8	4	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	27.3
Business process re-engineering	0	3	1	1	2	3	3	1	1	0	1	0	1	0	0	0	0	20.3
D-procurement adoption strategy	0	2	2	2	4	3	1	0	0	1	1	0	1	0	0	0	0	20.9
Project management and change management	0	0	0	1	1	0	0	1	3	2	2	1	2	2	1	1	0	12.3
ICT infrastructure and technology standards	0	0	0	1	0	0	1	1	2	2	2	0	1	2	4	1	0	11
Security and authentication	0	0	0	0	0	0	0	0	0	1	2	3	2	3	1	3	2	7.3
System integration and compatibility	0	0	0	1	0	0	1	1	0	0	3	2	2	0	3	1	3	9.2
D-procurement operation and performance	0	0	4	0	0	1	0	2	3	1	1	1	0	0	1	1	2	14.7
End-user uptake and training	0	0	0	0	0	1	1	1	1	3	0	2	1	1	3	1	2	10
Participants collaboration and adoption	0	0	0	1	0	0	2	3	2	0	2	3	1	1	0	2	0	12.9
Knowledge of benefits of D-procurement	2	2	2	1	2	1	3	1	0	0	0	1	0	2	0	0	0	20.5
Firm size and procurement volume	1	3	3	1	3	1	0	2	2	0	0	0	0	0	0	0	1	21.4
Government support	6	2	0	3	3	0	1	0	0	0	0	0	0	0	0	1	1	22.9
Participants communication	0	1	0	0	0	2	2	1	2	1	0	2	0	3	3	0	0	13.1
Uniform codes and data standards	0	0	1	1	1	2	0	1	0	2	2	1	1	2	0	2	1	13
User experience and satisfaction	0	0	0	0	1	1	0	2	1	2	0	0	3	0	1	4	2	9.8
Employees' commitment and motivation	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 4.3, the final ranking of the 17 CSF is shown in Figure 4.1 below.

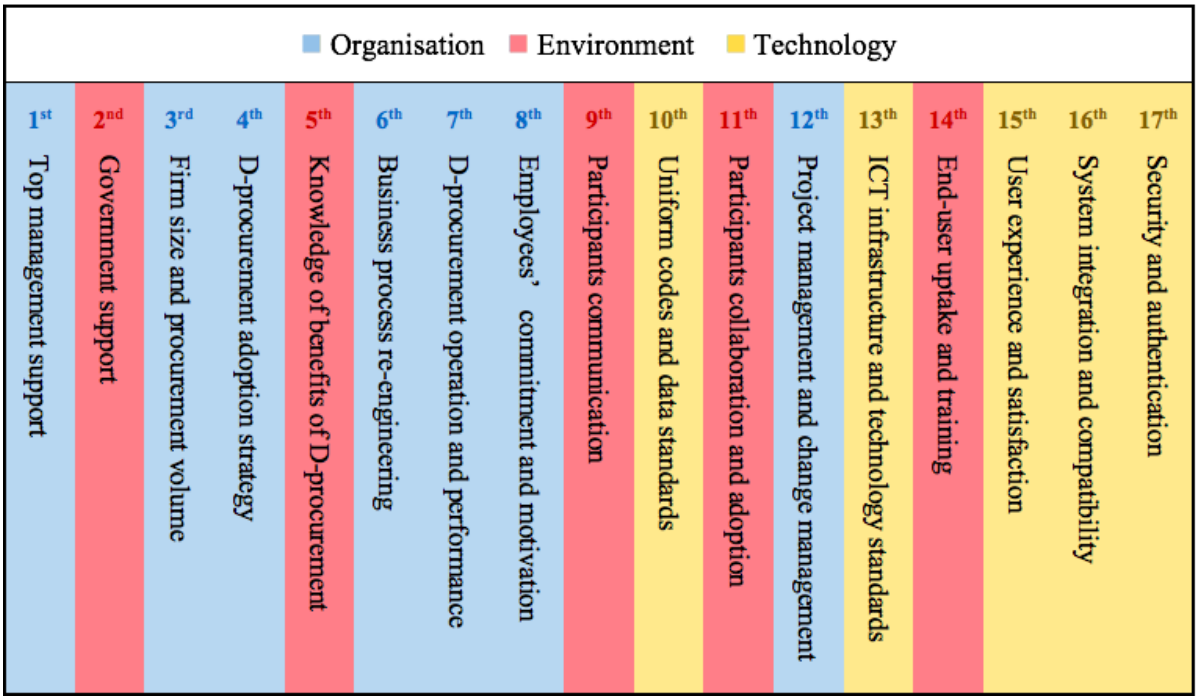

Figure 4.1 CSF order of relevance ranked by specialists

4.4.4.2 Main logic to rank the order

From Figure 4.1, it is found that the Organisation and Environment factors have the higher rank than that of Technology factors. With this finding we further reviewed the in-depth interview record, and we found most of the interviewees have the same logic to rank the CSF order of relevance.

First, they thought environment factors make it feasible to carry out the D-procurement project. Therefore, these factors become prerequisites. And among the factors, they emphasised two points, which were the government support and the consensus on the value of D-procurement.

Second, they thought that the advanced digital technologies are already there, which have been matured and widely applied in many industries nowadays. However, how to apply the technologies well in business is more important. Therefore, the success or failure of the D-procurement project depends more on the organisation factors.

Based on the findings above, we interviewed Mr. Ding, who is the founder of H Tech, he is the most important person for H Group's D-procurement project. He highly agreed with the logic that the interviewees used to rank the CSF. And he further explained that it does not mean the technology factors are not important, it is quite important.

The rapid development of digital technologies in China has driven changes in the political environment and the development of business management. It is precisely because of advanced technologies that innovations that were previously impossible are now possible. This is like the promotion of productive forces to production relations. Through the results of this survey we found that, when the productivity is sufficiently advanced, people's attention will focus on the change and innovation of production relations, that is why the environment and organisation factors are ranked higher than technology factors.

Mr. Ding further indicated that, the technology, environment and organisation factors are interacting and promoting each other, they are developed circularly in the progress of industry digital transformation and upgradation.

4.4.4.3 Business model innovation

In the in-depth interview, before asking interviewees to rank the order of CSF, they were asked an open question: what do you think, what are the most CSF for D-procurement adoption success? Most of the answered CSF were within the range of the 17 CSF, but it was noticed that two CSF were brought up very intensively, one was about innovation and the other was about leadership.

There were 12 of 17 interviewees that mentioned about the business model innovation (BMI). According to their description, there are four major features of this BMI that are summarised below:

- Multi-party trading platform

The D-procurement platform developed and operated by H Tech is a multi-party trading platform that allows buyer companies, seller companies, finance companies (banks), and operation companies (H Tech) to interact and conveniently do business with each other.

- Service providers not middleman

The D-procurement solution provided by H Tech was originally designed to save procurement cost for buyer companies by centralised online procurement. It does not intend to earn money from the spread between buying and selling prices. therefore, for the buyers or sellers, both of their transaction costs are lowered down, that attracts them to participate in the platform.

- Supply chain finance

Through the multi-party trading platform, offline business can be fully operated online, and all real-time real transaction data can be deposited on the platform thus forming a complete data chain.

Then, by analysing these data through big data technology, the financial and credit status of both buyers and sellers can be analysed. This analysis result can be used for credit evaluation of banks in the process of lending, hence reducing their evaluation costs, so that banks can provide supply chain financial products for buyers and sellers at lower prices than the market.

- A win-win platform for all parties

By using the platform, the first advantage is that the procurement efficiency is highly increased. For example, the H Tech's procurement department used to be able to complete up to 30 bidding projects per year, but now it can complete 50 projects per year. Moreover, purchasing transactions that previously took 15 days to complete offline can now be completed in hours online.

The second advantage is that the buyers and sellers can complete procurement transactions at different times and places, which saves lots of travel expenses and time costs compared to the traditional offline face-to-face transactions. The third advantage is that the purchasers have greatly reduced procurement costs through centralised procurement. For example, H Group saved 1.2 billion yuan in steel procurement alone within three years.

According to Foss and Saebi (2015), a business model (BM) is the articulation of the logic by which a business creates and delivers value to customers. It performs two important functions: value creation and value capture (Chesbrough, 2007). And it consists of two essential elements: the value proposition and the operating model (Lindgardt et al., 2009).

According to Björkdahl and Holmén (2013), A BMI is the implementation of a business model that is new to the firm. Foss and Saebi (2017) further defined that BMI is "designed, novel, and non-trivial changes to the key elements of a firm's business model and/or the architecture linking these elements."

4.4.4.4 Mediating effect of BMI

BMI is a very significant factor found through in-depth interview. It enables an important goal of this study to be achieved, which is to find relationships between CSF through case study.

In the interviews, the participants emphasised the importance of BMI. They agreed that it was the core factor that made the project successful. Because they believed that no matter whether there are technology, organisation or environment factors, these factors would not directly lead to the success, they must act on an intermedia, and this intermedia in D-procurement project was the innovative business model.

The respondents' opinion is supported by Phangestu et al. (2020)'s similar study on the effect of BMI to start-ups. They found that when a start-up has competitive advantage such as

advanced technologies, it is not advisable to use competitive advantage alone without BMI since the direct association between competitive advantage and start-up is negative. Competitive advantage can only improve start-up when BMI is there since a positive correlation was found between competitive advantage and BMI.

The above discussion implies that BMI has a positive effect on project success, and, BMI has a mediating effect between TOE and project success. This finding provides an important basis to extend the existing TOE model.

4.4.4.5 Entrepreneurial leadership

Another major finding from in-depth interview was entrepreneurial leadership (EL). During the interviews, every time the interviewee mentioned BMI, we always asked them who first proposed the idea, and the answer pointed to the same person: the founder of H Tech, who is also H Group's top management.

In 2016, he decided to found H Tech, and the initial purpose was to carry out the D-procurement project. He firstly requested and obtained the permission from H Group, and then he registered H Tech and started to built the team. After that, he prepared to design and develop the D-procurement platform in the second half of 2016.

This person is good at innovation, project management, team motivation, and directing the company towards the entrepreneurial goals. More importantly, he is good at coordination between H Group headquarters and subsidiaries, this enables the D-procurement project to be implemented smoothly in H Group. All these characters fit well with the definition of entrepreneurial leadership. According to Renko et al. (2015), entrepreneurial leadership (EL) entails influencing and directing the performance of group members towards the achievement of organisational goals that involve recognising and exploiting entrepreneurial opportunities.

4.4.4.6 Positive and moderating effect of EL

As Sayyam et al. (2022) indicated, an EL style is recognised as a crucial source of enhancing creativity in project-based organisations. In our interviews, 8 out of 17 respondents emphasised the importance of EL as a prerequisite for their D-procurement project to be successful, they proposed four major points to describe the EL:

- The leader created and continued to iterate on the BMI.
- The leader played an important coordinating role between H Group and stakeholders.
- The leader is a cross-disciplinary expert in the fields of architecture and digitalisation.
- The leader's persistence in the project.

The description above implies that EL may have a positive effect on D-procurement adoption success. Furthermore, respondents also described that the strong or weak power of the founder's EL should have a significant impact on project success. It is because the power of the effect of EL will affect the performance of BMI, thus affecting the success of the project. This implies that BL might have a moderating effect between BMI and project success. The findings of EL provide us another key point to extend the existing TOE model.

4.4.4.7 CSF final refinement

After discussing our findings on two major CSF, BMI and EL, now we discuss the final refinement of the CSF based on the findings through in-depth interview. In the interviews, after the respondent ranked the 17 CSF, the last question was: "other than the 17 CSF, which else do you think should be included? Please explain the reason and order it in the CSF list according to its relevance".

Interestingly, most respondents agreed that the 17 CSF were already complete, thorough, and detailed. This includes the previous 12 respondents who proposed EMI and 8 respondents who proposed EL, only 3 respondents proposed new CSF. The reason for this is most likely that after the respondents ranked the CSF, they were influenced, thinking that these CSF were scientific and authoritative, and their initial views were not necessarily correct, so they chose not to bring it up.

Of the three who proposed the new CSF, one suggested supplementing EL as CSF, one suggested supplementing BMI as CSF, and one suggested supplementing EL and talent team as CSF. And they also believed that either BMI or EL should at least be in the top three of all CSF.

To sum up, based on the discussion all above, we believe that BMI and EL should be added to the CSF. In addition, we also found that the 17 CSF obtained from the literature review did not integrate very well with the real-world cases.

On the one hand, these CSF need to be updated with the latest digitalisation trend, on the other hand, they need to be combined with the terms applied in real business. Therefore, we refined the 17 CSF with the newly discovered 2 CSF through grouping and merging. This is to reduce the number of CSF while making them more specific and clearer, and more in line with the reality.

The results are shown in Table 4.4 below.

Table 4.4 CSF final refinement

	Original CSF	Refined CSF	TOE
Technology	ICT infrastructure and technology standards	CSF1: Advanced digital technologies	T
	System integration and compatibility		T
	Security and authentication		T
	User experience and satisfaction		T
	Uniform codes and data standards	CSF2: Uniform data standard	T
Organisation	Top management support	CSF 3: Top management support	O
	Firm size and procurement volume	CSF 4: Firm size	O
Environment	Government support	CSF 5: Government support	E
	Employees' commitment and motivation	CSF 6: Value consensus	O
	End-user uptake and training		E
	Participants collaboration and adoption		E
	Knowledge of benefits of D-procurement		E
	Participants communication		E
Business model innovation	Business process re-engineering	CSF 7: Business model innovation	O
	D-procurement operation and performance		O
	D-procurement adoption strategy		O
Entrepreneurial leadership	Project management and change management	CSF 8: Entrepreneurial leadership	O

Based on Table 4.4, below is a detailed explanation of how the final 8 CSF are obtained.

- CSF1: Advanced digital technologies

According to the interview results, the CSF rankings of technology context are all relatively low, at 10th, 13th, 15th, 16th, and 17th respectively. This does not mean that technology is not important, but in the case of a mature technology environment, people are more concerned about factors such as environment and organisation for the adoption of new systems.

There were originally 5 factors in the technology context. The first 4 factors, which are the "ICT infrastructure and technology standards", "system integration and compatibility", "security and authentication", and "user experience and satisfaction" have been gradually replaced by 5th generation wireless networks (5G), big data analytics, mobile technologies, artificial intelligence (AI), cloud computing and blockchain (Ting et al., 2020), and all these key digital innovations in information and communications technology are collectively referred as advanced digital technologies (J.-P. O. Li et al., 2021). Therefore, based on the principle of simplification, these 4 CSF were integrated into "advanced digital technologies" as one factor (Deepu & Ravi, 2021).

- CSF2: Uniform data standard

For the last technology factor, "Uniform codes and data standards", the respondents

believed that it is significantly important. Because if there is no unified coding, standardisation cannot be achieved, and various parties cannot conduct transactions on the platform. For example, the SKU code must be unified among suppliers, buyers, and platform operators so that the transactions are possible. Otherwise, if the same product has different names, the transaction cannot be completed because one party has no idea what the other party is talking about. Furthermore, in H Tech's D-procurement project, it is more inclined to use the term "uniform data standard". Therefore, we used "uniform data standard" to replace "Uniform codes and data standards", making it more practical.

- CSF3: Top management support

The "top management support" is an organisation factor, it ranks first among the 17 CSF in interviews. This also confirms that in many studies on CSF, top management support is always ranked in a very important position (Afolabi et al., 2019; Lutfi et al., 2022; Premathilaka & Fernando, 2018; Waithaka & Kimani, 2021).

- CSF4: Firm size

The factor "firm size and procurement volume" is simplified to "firm size" since according to the H Group, we found that procurement volume normally depends on firm size as well (Waithaka & Kimani, 2021). This factor ranks third in interviews. "Firm size" was considered a prerequisite for an enterprise to build a D-procurement platform. As the interviewers said, only when an enterprise is large enough and occupies a dominant position in the supply chain can it have the financial resources to build a D-procurement platform and maximise its value.

- CSF5: Government support

In the original TOE model, environment context included 5 factors, of which the highest ranking in the interview was "government support". Therefore, this factor was first reserved. As top management support, the government support is also recognised as an essential prerequisite for information system adoption in many studies (Lutfi et al., 2022; Park & Kim, 2021; Perdana et al., 2022; Sánchez-Torres et al., 2021).

- CSF6: Value consensus

In the in-depth interview, the first question was about the value of the D-procurement. We found there was a remarkable phenomenon, which is when we asked respondents to talk about the value of D-procurement, almost everyone could blurt out the same answer: cost reduction, management improvement, and corruption prevention.

And then, we asked the reason, they said that H Tech attaches great importance to the extraction and promotion of the value of D-procurement, so in recent years, H Group have formed a unified understanding of the value of D-procurement.

There are 6 out of 17 respondents that directly suggested “value consensus” should be an independent CSF. They further emphasised that the founder and executives of H Tech believe that in order to iterate and promote the project continuously and in-depth, it is very important for all relevant parties and even the whole society to have a general understanding and consensus on the value of D-procurement.

Because only by reaching a consensus, all relevant parties can really be motivated and actively play their roles, to communicate and collaborate each other, and to create new value on D-procurement and obtain a return value.

During our interview, they told us that H Tech was preparing a launch event to launch a new round of hype around the value-driven D-procurement solution.

Based on the above understanding, we integrated the 5 factors that fall under the concept of value consensus into one. One of which is “employees’ commitment and motivation”, it is an organisation factor, and the 4 environment factors are “end-user uptake and training”, “participants collaboration and adoption”, “knowledge of benefits of D-procurement”, and “participants communication”.

- CSF7: Business model innovation

As previously discussed, EMI was an important CSF found through in-depth interview. There are three organisation factors highly correlated with it, which are “business process re-engineering”, “D-procurement operation and performance”, and “D-procurement adoption strategy”, they are combined under the concept of BMI.

- CSF8: Entrepreneurial leadership

EL was another important finding, the organisation factor “project management and change management” is strongly associated with it. But in fact, the aspects of EL contain more than that, such as strategic, motivational, creativity, vision of future, and communicative aspects (Ranjan, 2018).

The above 8 final CSF become an important basis for the extension of the TOE model, which is discussed in the following section.

4.5 Development of extended TOE model

After the in-depth interview, we have answered the first of the two research questions in this study, which was to found the CSF in H Group’s case. Meanwhile, to answer the second research question of this study, namely the relationship between these CSF, we have also found that there is an opportunity to extend the integrated CSF-TOE model.

Hence in the following contents, the discussion will focus on the development of the extended TOE model. It will start from its theoretical variables, and then the research hypotheses, the proposed model, and how to measure the model successively.

4.5.1 Theoretical variables

In the TOE-based CSF research, we found that there have been numerous studies on the relationship between various CSF contained in the TOE and successful information system adoption, whereas there are little studies to explain the relationship between TOE itself and project success. Especially after the in-depth interview, we found that the more valuable research is to find out the interaction between TOE, BMI, and EL, and their causal relationship with D-procurement adoption success. This is a particularly important difference between this study and other similar studies.

In the model to be proposed in this research, the technology, organisation, and environment are the independent variables. A few scholars have tried the same idea. Vidmar (2019) proposed a research model to explain the relationship between TOE, BM, and sustainability performance. Pucihar et al. (2019) developed a research model, where business environment, information technology, and organisation innovativeness are the independent variables, while BMI is the mediator variable, and business performance is the dependent variable.

Furthermore, as discussed earlier the BMI will be the mediator variable, and the EL will be the moderator variable.

The last variable is the D-procurement adoption success (DAS). There are correlational studies to reveal the relationships between various variables and project success. Pace (2019) tried to extend previous research by investigating the relationship between project management methodology (PMM) and project success, the result showed there is a weak correlation in between, and there were two moderating variables: industry and project manager experience.

Chow et al. (2021) found that sustainable project planning mediates the effect of sustainable project management on sustainable project success. There are also studies on the influence of project manager's experience to project success (Cooney, 2020), and the impact of communication and employee motivation on the success of the project (Salman et al., 2021).

In all these studies, project success played the role of dependent variable. In our study, the DAS has the similar meaning as project success, and it will be the dependent variable as well.

Totally, there are six variables as listed below:

- Technology - independent variable

- Organisation - independent variable
- Environment - independent variable
- BMI - mediator variable
- EL - moderator variable
- DAS - dependent variable

4.5.2 Research hypotheses

By defining the theoretical variables, we now focus on discussing the relationship between the variables, and making research hypotheses based on that.

4.5.2.1 Hypothesis of effect of technology on BMI

Zott et al. (2011) pointed out that in the digital context, BMs have become a new unit of analysis to examine the changing effects of digital technologies on the way firms produce and deliver value through BMI. Vaska et al. (2021) conducted a study on digital transformation to understand the impact of digital technologies on BMI. Reim et al. (2020) especially carried out a study to provide a deeper understanding of the relationship between AI and BMI, and how it can be used as a catalyst for BMI. In our interviews, respondents also talked about that the technology is driving innovation in business models. We therefore hypothesise:

H1: Technology has a positive effect on BMI.

4.5.2.2 Hypothesis of effect of organisation on BMI

For the establishment and implementation of innovative business models, organisational support is very important, both from the perspective of system and process, as well as from the level of execution and coordination.

Bashir and Verma (2018) proposed a theoretical model of BMI and discussed how the various internal factors, such as organisational culture and organisational structure drive BMI. Bocken and Geradts (2020) also explained how organisational factors affects dynamic capabilities needed for BMI. We therefore hypothesise:

H2: Organisation has a positive effect on BMI.

4.5.2.3 Hypothesis of effect of environment on BMI

Innovation requires an appropriate environment, such as the political and economic environment, the cultural and social environment, and the technological and business environment. Among them, the promotion and continuous support by government policies provide a very important environmental guarantee for innovation.

Waty et al. (2022) examined the effect of ecosystem business toward business agility mediated by BMI. Tian et al. (2019) found that environment factors such as market pressure and government policy influence BMI in Chinese high-end equipment manufacturing companies. We therefore hypothesise:

H3: Environment has a positive effect on BMI.

4.5.2.4 Hypothesis of effect of BMI on DAS

In our in-depth interviews, a major finding is that many respondents believe that in H Group's D-procurement practice, the success of the project is actually the success of the business model to a large extent, while other elements such as TOE, all played a role through BMI.

Some studies focused on the relationship between BMI and business success or project success. For example, in the field of digital transformation, H. Guo et al. (2022) believed that BMI is critical to firm survival and success. Based on a survey of digital start-ups, they examined the contribution of BMI toward business success. Bouwman et al. (2019) tried to analyse how SMEs can handle the impact of digitalisation by spending more time and effort on innovating their BMs, and they found the overall digital performance was contributed by BM experimentation practices and company innovativeness. We therefore hypothesise:

H4: BMI has a positive effect on DAS.

4.5.2.5 Hypothesis of mediating effect of BMI between TOE and DAS

It was found a mediating role for BMI through the in-depth interview. Many studies also focused on the relationship especially the mediating effect between BMI and firm performance. Latifi et al. (2021) applied structural equation modelling to examine how a firm's performance is affected by innovating its business model.

Dewi et al. (2017) found that the effect of entrepreneurial orientation (EO) on performance can be mediated by collaboration but must be through a business model, because the collaboration cannot directly affect performance. Pang et al. (2019) carried out a research to examine how BMI mediates the relationship between integrative capability, business strategy, and firm performance. The results show that BMI positively mediates the relationship between integrative capability and firm performance, and a differentiation strategy positively moderates the link between BMI and firm performance. Moreover, Ferreras-Méndez et al. (2021) found that BMI is an effective way to funnel the firm's EO into its innovation processes and to increase the success of new product development.

We therefore hypothesise:

H5: BMI has a positive mediating effect on the relationship between technology and DAS.

H6: BMI has a positive mediating effect on the relationship between organisation and DAS.

H7: BMI has a positive mediating effect on the relationship between environment and DAS.

4.5.2.6 Hypothesis of effect of EL on DAS

The importance of EL to DAS was a key finding from the interview, As Ahmed et al. (2014) found that presence of leader's entrepreneurial orientation increases individuals' entrepreneurial orientation, which ultimately increases projects success. Latif et al. (2021) also found that there exists a significant impact of entrepreneurial orientation leadership on knowledge management processes and project success. We therefore hypothesise:

H8: EL has a positive effect on DAS.

4.5.2.7 Hypothesis of moderating effect of EL between BMI and DAS

According to the in-depth interview, respondents described the moderating effect of EL between BMI and DAS. They believe that the strong or weak power of the founder's EL will affect the performance of BMI thus eventually impact on project success.

There are many studies on the moderating effect of EL, and the impact of EL on organisation performance or project success. Latif et al. (2020) conducted a study investigates the impact of EL on knowledge management (KM) processes and further examines the mediating role of KM processes on the linkage between EL and project success. The study revealed that KM processes significantly impact project success while EL impact PS indirectly through KM processes. Danişman et al. (2015) found that EL has a medium-level effect on organisational performance, and the leadership style was a moderator of the positive effect of leadership on organisational performance.

Shafqat (2021) revealed that EL is positively associated with project success, and innovative work behaviour partially mediated the positive relationship between EL and project success. Phangestu et al. (2020) found that there is no direct association between EL and start-up but indirectly through BMI. It implies that EL needs to be considered because it enhances BMI, and BMI contributes to the start-up success.

We therefore hypothesise:

H9: EL has a moderating effect on the relationship between the BMI and DAS.

The research hypotheses are summarised in Table 4.5 below.

Table 4.5 Research hypotheses

No.	Hypothesis	Supporters
H1	Technology has a positive effect on BMI.	Vidmar (2019)
H2	Organisation has a positive effect on BMI.	Vidmar (2019)
H3	Environment has a positive effect on BMI.	Vidmar (2019)
H4	BMI has a positive effect on DAS.	H. Guo et al. (2022)
H5	BMI has a mediating effect on the relationship between the technology and DAS.	Pang et al. (2019)
H6	BMI has a mediating effect on the relationship between the organisation and DAS.	Pang et al. (2019)
H7	BMI has a mediating effect on the relationship between the environment and DAS.	Pang et al. (2019)
H8	EL has a positive effect on DAS.	Latif et al. (2021)
H9	EL has a moderating effect on the relationship between the BMI and DAS.	Shafqat (2021)

4.5.3 Proposed extended TOE model

Based upon discussion, we therefore propose the extended TOE model, which is illustrated in Figure 4.2 below. In this model, TOE contribute to BMI, that after combined with EL, contributes to the DAS.

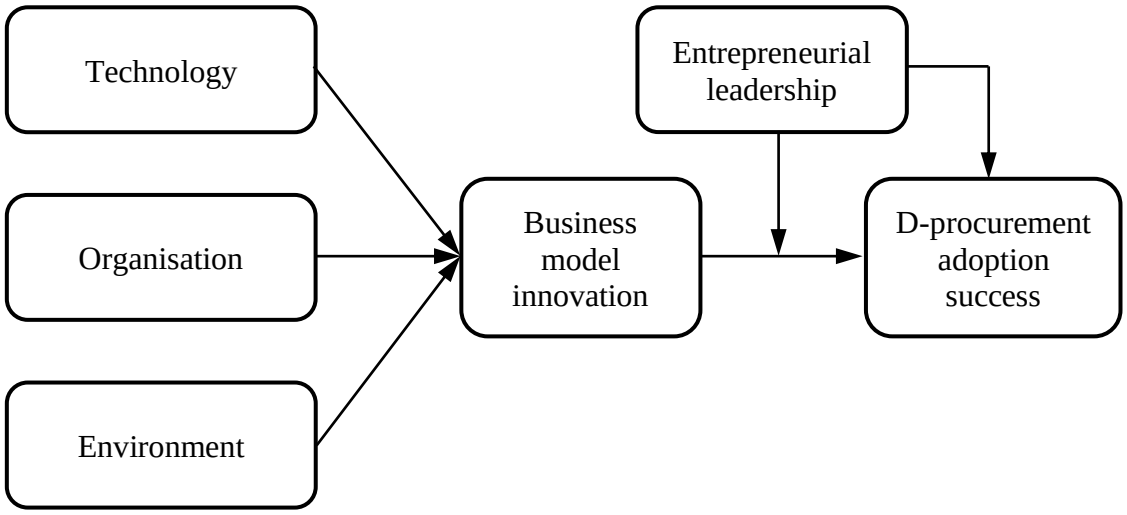

Figure 4.2 Extended TOE model

4.6 Questionnaire survey

The questionnaire survey will be used to test the extended TOE model. In the following context, we will discuss how to design the survey and set the questions.

4.6.1 Design of the survey

The main objective of the questionnaire survey is to test the research hypotheses based on the

proposed extended TOE model.

To achieve the objective, respondents will be brought together in several small groups, then the questionnaires will be conducted group by group. At the beginning, we will explain to them the background of the research and the purpose and method of the survey and answer any questions they may have. In this way, we hope that the respondents can adjust to the survey atmosphere and calm down so as to be the best prepared for the answer to the questionnaire.

The questionnaire will be prepared in advance and put online, and the respondents will fill out the questionnaire on their own mobile phone. The advantage of online questionnaire is that the results can be collected accurately and efficiently, and the results are easily input into statistic software for analysis.

4.6.2 Measurement model

Considering the measurement model, there were 15 items selected for measuring TOE, namely TEC1 to TEC5 for technology, ORG1 to ORG5 for organisation, and ENV1 to ENV5 for environment. These measurements were mainly referenced the 17 CSF, because the 17 CSF itself are from the TOE, so they also can be used to interpret the TOE from different dimensions. Table 4.6 below illustrates the 17 CSF and their corresponding measurement items.

Among the 15 measurements for TOE, except for two new environment measurements considering on the real case, the remaining 13 are all from the 17 CSF.

Moreover, it is important that the measurements were further adjusted according to the real case. For example, to measure the technology variable, we used a measurement item that is strongly correlated with the real project, which is the advanced digital technologies. Measurements for BMI, EL and DAS were mainly referenced the well-established scales in similar studies but were also fine-tuned based on the real case.

Table 4.6 Seventeen CSF with their corresponding measurement items

No.	TOE	17 CSF	Measurement Items
1		ICT infrastructure and technology standards	TEC1
2		System integration and compatibility	TEC4
3	Technology	Security and authentication	TEC2
4		User experience and satisfaction	TEC5
5		Uniform codes and data standards	TEC3
6		Top management support	ORG1 & ORG2
7		Business process re-engineering	ORG3
8		Project management and change management	ORG3 & ORG4
9	Organisation	Employees' commitment and motivation	ENV3
10		D-procurement operation and performance	ORG1
11		D-procurement adoption strategy	ORG4
12		Firm size and procurement volume	ORG5
13	Environment	End-user uptake and training	ENV3

14	Participants collaboration and adoption	ENV3
15	Knowledge of benefits of D-procurement	ENV2& ENV3
16	Participants communication	ENV3
17	Government support	ENV1

In the selection of these measurement items, an important feature is that the items we found from similar studies were adjusted based on the characteristics of Chinese construction industry and the characteristics of the real case. This attempt will bring value to similar research in the future, but also bring difficulties, because it is a relatively new scale, so more pre-test survey is needed to measure its reliability and validity, so that to adjust the scale accordingly.

There are totally 34 items used to measure the 6 variables. Other than the 15 items for TOE, there are 7 items for BMI (BMI1 to BMI7), 7 items for EL (EL1 to EL7), and 5 items for DAS (DAS1 to DAS5). A 5-point Likert scale will be used to measure responses as follows: 1-strongly disagree; 2-disagree; 3-neither disagree nor agree; 4-agree; 5-strongly agree.

The measurement items for each variable are explained below:

- Technology variable

Technology variable will be measured from five different perspectives, namely, the "support of the network infrastructure" (TEC1) for the development and operation of the platform, the "application of the advanced digital technologies" (TEC2) for the platform, the "uniform data standard" (TEC3) for the platform standardisation, the "platform compatibility" (TEC4) with the other information systems, and the "usability" (TEC5) perceived by users.

- Organisation variable

In the measurement of organisation, we also considered from different aspects. First of all, there are two related to the top management, one is their "awareness of the benefit of the D-procurement" (ORG1), this is important because the project cannot be performed well without the awareness.

Another is the "top management's investment to the project" (ORG2), it is also important because this determines how many resources the project can have. And then, "business re-engineering" (ORG3), "organisational structure support" (ORG4), and "firm size" (ORG5) are used to measure the organisation variable from three other aspects respectively.

- Environment variable

To measure the environment variable, the "government support" (ENV1) is an important item, it ranked second among all 17 CSF. The "company's competitive advantage" (ENV2) is to measure from market dimension, the "value consensus" (ENV3) item was derived from the in-depth interview, the "user acceptance" (ENV4) item tries to measure from promotion dimension, and "industry digital transformation" (ENV5) item is to measure from the angle of

digital development environment.

- BMI variable

The measurements for BMI are mainly based on the studies by Clauss (2017) and H. Guo et al. (2022). BMI is a core variable in the model, and seven items were selected from different aspects. These items are the "competitive advantage" (BMI1), "innovative processes" (BMI2), "market adoption" (BMI3), "innovative service" (BMI4), "co-sharing and win-win value" (BMI5), "revenue model" (BMI6), and "advanced technologies" (BMI7).

A notable feature is that these items have been adjusted according to H Group's real case. While retaining the original core concepts, the terminology in the real case is used as much as possible. For example, using "supply chain finance service" instead of "product and service". This is to make the questions more practical and allow respondents to better understand and answer.

- EL variable

The studies by Renko et al. (2015) and Bagheri and Harrison (2020) contributed to the selection of EL measurement items. There are seven items to measure EL, which are the "radical improvement ideas for the products and services" (EL1), the "creative solutions" (EL2), "passion for work" (EL3), "perseverance to achieve goals" (EL4), "vision of future" (EL5), "motivational skills" (EL6), and "fault tolerance" (EL7). Similarly, these seven items are also deeply combined with the actual situation of the real case.

- DAS variable

There are many studies on the evaluation of IS project success, basically it depends on the project complexity and the business levels (Joseph & Marnewick, 2021; Pereira et al., 2022). According to J. X. Guo (2019), project success comprises project management success and the achievement of business goals. It will be a successful IS project if the project outcomes reach the business goals resulting in organisational effectiveness.

In this survey, five items are used to measure the DAS, they are from "project management effectiveness" (DAS1), "procurement management improvement" (DAS2), "procurement corruption prevention" (DAS3), "procurement cost reduction" (DAS4), and "procurement risk prevention" (DAS5) aspects respectively.

The measurement items of the variables are summarised in Table 4.7 below.

Table 4.7 Measurement items of the variables

Variable	Code	Measurement Items	Source
Technology	TEC1	The network environment of digital procurement platform is fast and reliable.	Ab Talib et al. (2015); Holotiuk and Beimborn (2017); Afolabi et al. (2019); Badi et al. (2021)
	TEC2	The use of advanced digital technologies such as cloud computing, big data, blockchain, and artificial intelligence for D-procurement is technologically supportive.	Holotiuk and Beimborn (2017); Clauss (2017); H. Guo et al. (2022)
	TEC3	The uniform data standard for D-procurement is significant.	Puschmann and Alt (2005); Gunasekaran and Ngai (2008)
	TEC4	The D-procurement platform is compatible with the other systems.	Puschmann and Alt (2005); Badi et al. (2021)
	TEC5	Using D-procurement platform is easy and convenient.	Afolabi et al. (2019); Badi et al. (2021)
Organisation	ORG1	H Group's top management is aware of the value of D-procurement.	Premathilaka and Fernando (2018); Afolabi et al. (2019); Badi et al. (2021)
	ORG2	H Group's top management is willing to invest resources needed to conduct D-procurement project.	Afolabi et al. (2019); Badi et al. (2021)
	ORG3	H Group is capable to optimise procedures and processes to achieve the D-procurement innovation.	Clauss (2017); H. Guo et al. (2022)
	ORG4	H Tech is committed to upgrade strategy, culture, and organisational structure to adopt D-procurement innovation.	Clauss (2017); Holotiuk and Beimborn (2017)
	ORG5	H Group's procurement scale is supportive to carry out D-procurement and make profits from that.	Teo et al. (2009); Waithaka and Kimani (2021)
Environment	ENV1	Government policy and legislation support the adoption of D-procurement innovation.	Premathilaka and Fernando (2018); Badi et al. (2021)
	ENV2	The adoption of D-procurement would offer H Group a stronger competitive advantage.	Badi et al. (2021)
	ENV3	The value consensus of D-procurement by all partners will promote the adoption of D-procurement project.	Badi et al. (2021)
	ENV4	The Internet has cultivated good user habits thus making it easier for users to accept D-procurement platform.	Holotiuk and Beimborn (2017)
	ENV5	The rapid development of the industry digital transformation has played an important role in promoting D-procurement innovation.	Safiullin and Akhmetshin (2019); Vaska et al. (2021)
BMI	BMI1	Compared with most similar companies, the digital procurement model built by H Tech has obvious innovations.	H. Guo et al. (2022)

Variable	Code	Measurement Items	Source
	BM2	H Tech utilises innovative procedures and processes during the D-procurement business.	H. Guo et al. (2022)
	BMI3	H Tech has been committed to continuously building new capabilities in response to changing market demands.	Clauss (2017); H. Guo et al. (2022)
	BMI4	The supply chain finance service provided to buyers and sellers is valuable and innovative.	Clauss (2017); Badi et al. (2021); H. Guo et al. (2022)
	BMI5	The D-procurement platform advocate a co-sharing and win-win value with all partners.	Clauss (2017); H. Guo et al. (2022)
	BM6	Compared with similar digital supply chain platforms, H Tech's D-procurement's profit model has its own characteristics.	H. Guo et al. (2022)
	BMI7	The advanced digital technologies applied by D-procurement platform are innovative.	Clauss (2017); H. Guo et al. (2022)
EL	EL1	The leader often comes up with radical improvement ideas for the products and services.	Renko et al. (2015); Bagheri and Harrison (2020)
	EL2	The leader has creative solutions to problems.	Renko et al. (2015); Bagheri and Harrison (2020)
	EL3	The leader demonstrates passion for his work.	Renko et al. (2015); Bagheri and Harrison (2020)
	EL4	The leader perseveres to push forward the project to achieve the goals.	Renko et al. (2015); Bagheri and Harrison (2020)
	EL5	The leader has a vision of future of the business.	Renko et al. (2015); Bagheri and Harrison (2020)
	EL6	The leader is good at motivating team to achieve goals.	Renko et al. (2015); Bagheri and Harrison (2020)
	EL7	The leader encourages trying new things and is willing to tolerate mistakes to achieve goals.	Renko et al. (2015); Holotiuk and Beimborn (2017); Bagheri and Harrison (2020)
DAS	DAS1	The D-procurement project management is effective in terms of time, cost, and quality.	Radujković and Sjekavica (2017); J. X. Guo (2019); Pereira et al. (2022)
	DAS2	Adoption of D-procurement project achieves procurement management improvement.	Frefer et al. (2018); Pereira et al. (2022)
	DAS3	Adoption of D-procurement project achieves procurement corruption prevention.	Pereira et al. (2022)
	DAS4	Adoption of D-procurement project achieves procurement cost reduction.	Pereira et al. (2022)
	DAS5	Adoption of D-procurement project achieves procurement risk prevention.	Pereira et al. (2022)

4.7 Summary

In summary, the most important content of this chapter includes several important findings obtained through the in-depth interview conducted with the experts participated in H Group's D-procurement project.

First, the 17 CSF previously obtained from the literature review were ranked by 17 experts according to their importance, and the resulting 8 CSF not only helped us accomplish the first main goal of this study, which was to discover and summarise the CSF from real case study, also helped us further understand the real value of CSF in practice.

Then, two new CSF were obtained through the in-depth interview, namely BMI and EL, and more importantly, the mediating effect of BMI on the relationship between TOE and D-procurement adoption success and the moderating effect of EL on the relationship between BMI and D-procurement adoption success were found.

Finally, based on the above major findings, the extended TOE model was proposed, it was derived from practice and highly recognised by H Group's experts. They believed that this is a significantly valuable discovery.

In particular, it should be pointed out that while a large number of existing studies use the elements contained in TOE as variables to study the relationship between these variables and IS project success, this study attempts to use technology, organisation, and environment itself as the variables to study the relationship between them and BMI and project success with the moderating effect of EL between BMI and project success. This is exactly innovative and valuable both from a theoretical and practical point of view.

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Chapter 5: Case Study of H Group – Questionnaire Survey

5.1 Chapter overview

In this chapter, the main content is about the empirical study conducted to verify the proposed extended TOE model. We firstly introduce the three rounds of pre-tests of the questionnaire survey. And then, the data analysis of the formal questionnaire results is discussed, this is the core part of the chapter. Finally, the overall results of the empirical analysis are concluded and discussed.

5.2 First-round pre-test

We conducted a total of three rounds of pre-test before launching the formal questionnaire survey. The first-round pre-test was completed on 17th July, 2022 at H Tech meeting room, 15 internal experts from H Tech were invited to discuss and fill out the questionnaire. These experts come from the top and middle management of the company, thereby they are not only familiar with the D-procurement project, but also with H Tech. Moreover, we invited two experts from Y Tech as well, they are important partner of H Tech, they helped us evaluate this questionnaire as external experts.

These 17 experts were asked to evaluate the overall questionnaire design and the legibility of each measurement item. Overall, the experts agreed with the 34 questions designed, they further made suggestions on the semantic expression and the use of terminologies in the questions. Importantly, they also suggested to change the way to organise the survey.

5.2.1 Refinement of language translation

In this research, one of the challenges we face is that the basis of this research such as literature review and research tools used are all in English, whereas the research case is in the Chinese context. Therefore, in the process of research, especially in the in-depth interview and questionnaire survey, we need to pay great attention to the translation of language to avoid inaccurate research results due to misunderstanding and ambiguity.

After the pre-test, experts gave us quite a few opinions related to translation. Since our

measurement items are all from existing studies using English, translating these items directly into Chinese will be very blunt and difficult to understand. Therefore, according to the opinions of experts, we corrected the translation many times according to the language habits of Chinese and the specific scene of H Group. It was strived to make it accurate and easy to understand.

In addition, for certain terms we strived to be rigorous and faithful to the original meaning in translation. For example, to translate the 5-point Likert scale, there are many translations of “neither agree nor disagree” into Chinese something like “normal” or “not sure”, which is inaccurate and has deviated from the original meaning. In our translation, the original meaning in English is completely preserved.

5.2.2 Refinement based on company and social context

Through the pre-test, we also found that there were some expressions of questions were not very accurate and clear, and it was easy to cause ambiguity. This is because our measurement items came from different literatures, so they needed to be further integrated with the research case. Therefore, we revised those questions to make them consistent with the scenario. For example, in H Group, the D-procurement platform is actually called "digital construction supply chain platform". Objectively speaking, this name is not very accurate, but we still decided to use this term in the questionnaire because it is easier for respondents to understand and accept.

In addition to terminology, another class of problems discovered was related to social context. In the pre-test, we found that a question about "government support" scored abnormally low, so we analysed the reason in depth. In the research of Western scholars, "government support" is a very important CSF, it originally refers to the government's support for D-procurement project in terms of funds, policies and regulations. But why was the importance of "government support" not highly evaluated in pre-test? Was there a cognitive bias in this? We then reviewed the records of the in-depth interviews and found that the same problem existed.

In the in-depth interview, the respondents easily understood "government support" as "government participation". Because in China, there are indeed many D-procurement projects that are directly influenced by the government to some extent, and some government departments are even directly involved in the enterprise’s D-procurement project. Therefore, the problem arises.

On the one hand, the respondents will think that the government's policies and regulations have played an important role in the success of D-procurement, on the other hand, they will think that the government's participation has little effect on the success of the D-procurement

project, because it is believed that the government is here to add the icing on the cake, and the success of the project first depends on the efforts of the enterprise itself.

Hence in the in-depth interview, we quickly addressed this problem by explaining to respondents what "government support" means in this research. But in the questionnaire survey we are not facing respondents directly, so we had to eliminate this kind of cognitive difference. We therefore avoided the word "government" in the question and instead used the more explicit and understandable phrase “relevant policies and regulations”.

5.2.3 Re-organisation of the survey

Since this study is a single case study, the main research object is H Tech, whose scale is about 140 people. This means that the number of respondents is about 140, which is a typical small sample questionnaire. Therefore, the quality of the questionnaire is particularly important in order to obtain true and reliable research results. A high-quality questionnaire requires every participant to attach great importance and participate seriously. Therefore, when we initially designed the questionnaire, we considered conducting an on-site questionnaire survey to ensure having effective communication and getting enough attention.

But during the pre-test, the experts suggested that it is better to conduct the questionnaire through administrative means within H Tech. Because H Tech's employees are usually very busy, if researchers come to organise the survey, they will psychologically think that this is not their job. It may be answered hastily, and the questionnaire quality cannot be guaranteed.

Therefore, experts suggested that the questionnaire should be organised through H Tech's administrative department, which is the general management centre (GMC). Since an important function of this GMC is human resource management, therefore all functional departments will pay attention to and actively cooperate with the work of GMC.

The experts further suggested that GMC can divide all respondents into groups by functional departments and conduct the questionnaire one group at a time. During the questionnaire process, the GMC can send a special person to replace the researcher to introduce the research background and objectives to the respondents, answer relevant questions, and distribute the online questionnaire.

Another benefit of this is that GMC can accurately count which departments have completed the questionnaire and which have not. This ensures both quality and quantity. After discussion, we finally agreed on this plan.

5.3 Second-round pre-test

The second-round pre-test was conducted online from 20th July 2022 to 21st July 2022, a total of 30 respondents who are all from H Tech were participated. The main purpose of this round of pre-test is to further revise the content of the questionnaire according to the feedback, and to improve the questionnaire through preliminary reliability and validity analysis. The main revisions are explained below:

- Questionnaire introduction

The introduction part at the beginning of the questionnaire was adjusted. First, after two rounds of pre-test, we had a deeper understanding of what information should be put at the beginning, so we had greatly simplified the introduction. Second, we found that for employees of state-owned enterprise, they are worried that filling out such a questionnaire will have an impact on them, so we especially emphasised that this questionnaire is limited to scientific research, and the answer data will be strictly confidential and will not affect their actual work. This statement was set in bold red font. Finally, we previously explained that the "leader" in "entrepreneurial leadership" is their "chairman". As a result, it was found that many respondents were sensitive to the word "chairman", which seemed to be evaluating their boss. So, we modified the interpretation of "leader" to "entrepreneur", which removed the sensitivity to a certain extent.

- Question descriptions

To further disambiguate and make the expression more accurate, half of the question descriptions have been refined in detail.

- Validity analysis

A pre-analysis of the reliability and validity of the 30 questionnaires was conducted by SPSS 26.0 software. Although the sample size was small, it also helped us find some problems. There were two questions did not pass the validity analysis, then their expressions were revised by removing the parts that may have correlation to other questions while retaining the original meaning.

Moreover, it was found that the overall validity of the measurement items for EL was not good, we then further analysed the items, and found that two of them were likely to be confused with each other although the measurement dimensions are different, so we combined these two items. After that, the overall validity of the questionnaire was good, and the total number of questions also went from 34 to 33.

- Questionnaire simplification

Finally, because we have obtained the relevant information of all the respondents through the human resource department of H Tech, and since this descriptive information is not important for the model validation, hence the descriptive statistics questions in the first part of the questionnaire were all deleted.

5.4 Third-round pre-test

The scale for this questionnaire survey faces a challenge. Although each measurement item in the questionnaire is cited from the literature, there is no scale in the existing literature that fully meets the needs of this survey. Therefore, according to the characteristics of the study case and the needs of the research, both the structure of the scale and the description of the measurement items have been adjusted to some extent. The value of this is to provide a reliable scale for future research, but the challenge is that because the scale is relatively new, if the scale is not tested and refined properly, it will affect the result of empirical analysis.

Based on the considerations, the main objective of the third-round pre-test was to test the scale's reliability and validity to ensure the scientificity and accuracy of the study. It was conducted from 28th July 2022 to 29th July 2022, there were 50 participants involved. Afterwards, we analysed the questionnaire data by using the SPSS 26.0 software.

5.4.1 Reliability analysis

Reliability analysis was mainly used to evaluate the internal consistency of the initial questionnaire. Internal consistency describes the extent to which all the items in a scale measure the same construct, thereby it is connected to the inter-relatedness of the measurement items within the scale (Tavakol & Dennick, 2011). In this study, we mainly used Cronbach Alpha coefficient and corrected item-total correlation (CITC) to evaluate the internal consistency among measurement items. Alpha coefficient was developed by Cronbach (1951) to provide a measure of the internal consistency of a scale. It is expressed as a number between 0 and 1.

According to Nikkhah et al. (2018), the Cronbach α values between 0 and 0.49 as unacceptable, 0.5 - 0.7 as mediate, 0.7 - 0.8 as good, 0.8 - 0.9 as great, and > 0.9 as excellent.

Meanwhile, a CITC test is performed to check if any item in the set of tests is inconsistent with the averaged behaviour of the others, and thus can be discarded (Churchill Jr, 1979). When CITC is lower than 0.5, the item has some problem, when it is lower than 0.3, the item should be deleted. By removing problematic items, when CITC is above 0.5, the questionnaire has good consistency, the reliability analysis results are within an acceptable level, and the

measurement scale meets the reliability analysis requirements (Guillasper et al., 2020; Pakpahan, 2020; Tapsir et al., 2018).

5.4.2 Validity analysis

Factor analysis is generally used for questionnaire validity testing. The Kaiser-Meyer-Olkin (KMO) and Bartlett tests were conducted to understand whether the scale was suitable for factor analysis. If the KMO value is higher, it means that the correlation between the measurement items is higher, meanwhile if the corresponding Bartlett's test of sphericity is also significant, it means that the variable is suitable for factor analysis.

The KMO statistics range from 0 to 1, with values closer to 1 denoting greater adequacy of the factor analysis: KMO $\geq$ 0.6 low adequacy, KMO $\geq$ 0.7 medium adequacy, KMO $\geq$ 0.8 high adequacy, KMO $\geq$ 0.9 very high adequacy (Kükürtcü et al., 2021; Nievas Soriano et al., 2020). When KMO $\geq$ 0.7 and the result of Bartlett's test of sphericity is expected to be statistically significant ($p < 0.001$), then it indicates that the item is suitable for exploratory factor analysis (EFA) (Shrestha, 2021).

The EFA is a kind of multivariate statistical methods that attempts to identify the smallest number of hypothetical constructs that can parsimoniously explain the covariation observed among a set of measured variables (Watkins, 2018). In the EFA procedure, the factor loading is calculated for every item, which indicates the usefulness in measuring the variable, as well as determine the dimensionality of items. The minimum acceptable value for factor loading is 0.6 (Hoque et al., 2018). The EFA procedure also determines the Total Variance Explained (TVE) for the construct. The TVE indicates how much the measuring items and their components can estimate the construct, the minimum value for TVE is 0.6 (Baistaman et al., 2020). That means that the items and their components should be able to measure at least 60% of the construct (Shkeer & Awang, 2019).

5.4.3 Reliability and validity analyses of pre-test

In the case of 50 pre-test samples, the reliability and validity analyses are discussed below.

5.4.3.1 Scale reliability test

Table 5.1 Scale reliability test (N=50)

Variable	Code	Corrected Item-Total Correlation (CITC)	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
Technology	TEC1	0.734	0.853	0.881
	TEC2	0.761	0.845	
	TEC3	0.663	0.878	
	TEC4	0.770	0.843	
	TEC5	0.733	0.851	
Organisation	ORG1	0.660	0.906	0.908
	ORG2	0.769	0.881	
	ORG3	0.835	0.867	
	ORG4	0.828	0.870	
	ORG5	0.737	0.888	
Environment	ENV1	0.813	0.913	0.929
	ENV2	0.823	0.912	
	ENV3	0.803	0.915	
	ENV4	0.765	0.927	
	ENV5	0.906	0.896	
BMI	BMI1	0.879	0.935	0.948
	BMI2	0.872	0.936	
	BMI3	0.777	0.944	
	BMI4	0.769	0.945	
	BMI5	0.742	0.947	
	BMI6	0.865	0.937	
	BMI7	0.883	0.935	
EL	EL1	0.813	0.920	0.933
	EL2	0.845	0.918	
	EL3	0.759	0.926	
	EL4	0.805	0.921	
	EL5	0.763	0.929	
	EL6	0.891	0.909	
DAS	DAS1	0.677	0.928	0.934
	DAS2	0.805	0.920	
	DAS3	0.903	0.900	
	DAS4	0.857	0.911	
	DAS5	0.876	0.906	

According to the results in Table 5.1 above, the scale reliability test is discussed below.

1) Technology variable

It shows that the lowest CITC value of the 5 measurement items is 0.663, which is above 0.5. Meanwhile, the Cronbach's α is 0.881, which is above 0.8. And the Cronbach's α if item deleted (0.853, 0.845, 0.878, 0.843, 0.851) is less than 0.881. These indicate that the internal consistency of measurement items for technology variable is good.

2) Organisation variable

The lowest CITC value of the 5 measurement items is 0.660 that is above 0.5. The Cronbach's α is 0.908, which is above 0.8. And the Cronbach's α if item deleted (0.906, 0.881, 0.867, 0.870, 0.888) is less than 0.908. These indicate that there has good internal consistency

for organisation variable's measurement items.

3) Environment variable

The lowest CITC value of the 5 measurement items is 0.765 that is above 0.5. The Cronbach's α is 0.929, which is above 0.8. And the Cronbach's α if item deleted (0.913, 0.912, 0.915, 0.927, 0.896) is less than 0.929. These indicate that the environment variable's measurement items have good internal consistency.

4) BMI variable

The lowest CITC value of the 7 measurement items is 0.742 that is above 0.5. The Cronbach's α is 0.948, which is above 0.8. And the Cronbach's α if item deleted (0.935, 0.936, 0.944, 0.945, 0.947, 0.937, 0.935) is less than 0.948. These indicate that the BMI variable's measurement items have good internal consistency.

5) EL variable

The lowest CITC value of the 6 measurement items is 0.759 that is above 0.5. The Cronbach's α is 0.933, which is above 0.8. And the Cronbach's α if item deleted (0.920, 0.918, 0.926, 0.921, 0.929, 0.909) is less than 0.933. These indicate that the EL variable's measurement items have good internal consistency.

6) DAS variable

The lowest CITC value of the 5 measurement items is 0.677 that is above 0.5. The Cronbach's α is 0.934, which is above 0.8. And the Cronbach's α if item deleted (0.928, 0.920, 0.900, 0.911, 0.906) is less than 0.934. These indicate that the DAS variable's measurement items have good internal consistency.

5.4.3.2 Scale validity test

According to the results in Table 5.2 below, the scale validity test is discussed.

1) Technology variable

The KMO is 0.825 that is above 0.8, and the significance level of the Bartlett's test is below 0.001, these indicate that the 5 measurement items of technology variable are adequate for factor analysis. Further EFA can clearly observe that the factor loading for each of the 5 factors is greater than 0.6, and the TVE is 70.407% that is above 60%.

In general, the factor analysis results of technology variable's measurement items have achieved the expected effect, and the construct validity has reached an ideal level.

Table 5.2 Scale validity test (N=50)

Variable	Code	Mean	S.D.	Factor Loading	Cumulative % of Variance	KMO	Bartlett's Test of Sphericity
Technology	TEC1	4.51	0.698	0.705	70.407%	0.825	215.602***
	TEC2	4.63	0.584	0.731			
	TEC3	4.83	0.375	0.609			
	TEC4	4.53	0.697	0.743			
	TEC5	4.56	0.636	0.682			
Organisation	ORG1	4.73	0.551	0.601	73.240%	0.793	283.747***
	ORG2	4.71	0.512	0.742			
	ORG3	4.73	0.475	0.818			
	ORG4	4.76	0.461	0.819			
	ORG5	4.77	0.454	0.688			
Environment	ENV1	4.71	0.512	0.782	79.164%	0.883	320.502***
	ENV2	4.77	0.424	0.798			
	ENV3	4.78	0.446	0.771			
	ENV4	4.67	0.574	0.717			
	ENV5	4.72	0.453	0.890			
BMI	BMI1	4.67	0.550	0.834	76.498%	0.899	527.534***
	BMI2	4.67	0.596	0.825			
	BMI3	4.71	0.537	0.694			
	BMI4	4.71	0.486	0.689			
	BMI5	4.72	0.453	0.651			
	BMI6	4.67	0.526	0.819			
	BMI7	4.62	0.540	0.843			
EL	EL1	4.67	0.550	0.766	76.313%	0.705	507.031***
	EL2	4.78	0.416	0.806			
	EL3	4.78	0.446	0.705			
	EL4	4.78	0.446	0.760			
	EL5	4.69	0.588	0.696			
	EL6	4.72	0.507	0.846			
DAS	DAS1	4.65	0.530	0.601	79.331%	0.850	364.538***
	DAS2	4.69	0.492	0.767			
	DAS3	4.68	0.522	0.898			
	DAS4	4.74	0.468	0.841			
	DAS5	4.73	0.501	0.859			

2) Organisation variable

The KMO is 0.793 that is above 0.7 and close to 0.8, and the significance level of the Bartlett's test is below 0.001, these indicate that the 5 measurement items of organisation variable are adequate for factor analysis. Further EFA can clearly observe that the factor loading for each of the 5 factors is greater than 0.6, and the TVE is 73.240% that is above 60%. Therefore, the factor analysis results of organisation variable's measurement items have achieved the expected effect, and the construct validity has reached an ideal level.

3) Environment variable

The KMO is 0.883 that is above 0.8, and the significance level of the Bartlett's test is below 0.001, these indicate that the 5 measurement items of environment variable are adequate for factor analysis. Further EFA can clearly observe that the factor loading for each of the 5 factors

is greater than 0.6, and the TVE is 79.164% that is above 60%. Therefore, the factor analysis results of environment variable's measurement items have achieved the expected effect, and the construct validity has reached an ideal level.

4) BMI variable

The KMO is 0.899 that is above 0.8, and the significance level of the Bartlett's test is below 0.001, these indicate that the 7 measurement items of BMI variable are adequate for factor analysis. Further EFA can clearly observe that the factor loading for each of the 7 factors is greater than 0.6, and the TVE is 76.498% that is above 60%. Therefore, the factor analysis results of BMI variable's measurement items have achieved the expected effect, and the construct validity has reached an ideal level.

5) EL variable

The KMO is 0.705 that is above 0.7, and the significance level of the Bartlett's test is below 0.001, these indicate that the 6 measurement items of EL variable are adequate for factor analysis. Further EFA can clearly observe that the factor loading for each of the 6 factors is greater than 0.6, and the TVE is 76.313% that is above 60%. Therefore, the factor analysis results of EL variable's measurement items have achieved the expected effect, and the construct validity has reached an ideal level.

6) DAS variable

The KMO is 0.850 that is above 0.8, and the significance level of the Bartlett's test is below 0.001, these indicate that the 5 measurement items of DAS variable are adequate for factor analysis. Further EFA can clearly observe that the factor loading for each of the 5 factors is greater than 0.6, and the TVE is 79.331% that is above 60%. Therefore, the factor analysis results of DAS variable's measurement items have achieved the expected effect, and the construct validity has reached an ideal level.

5.5 Formal questionnaire

After three rounds of pre-tests, we repeatedly deliberated the rationality of the questionnaire design and the legibility of the content. Moreover, we revised and refined the measurement items based on the reliability and validity analysis of the scale.

Eventually, we formed the final version of the "Questionnaire on H Group's Digital Procurement Supply Chain Platform" (see Annex B).

The formal questionnaire was conducted at H Tech from 30th July 2022 to 2nd August 2022. The general management centre of H Tech dispatched a manager who is in charge of human

resource department to organise the questionnaire. Respondents were divided into groups according to departments, and the person in charge conducted the questionnaires in turn according to the groups, and the completion rate of the questionnaires was counted in real time.

In this survey, 142 questionnaires were expected to be returned, 136 were actually returned, the questionnaire recovery rate was 95.77%. Due to the full cooperation of H Tech and the great attention of employees at all levels, the effective questionnaire rate reached 100%.

5.5.1 Questionnaire reliability and validity analysis

After collecting data through questionnaire survey, we firstly conducted the reliability and validity analyses. Specifically, SPSS 26.0 software was used for the reliability tests for the core variables: technology, organisation, environment, EMI, EL, and MAS. The CITC and Cronbach's α coefficient were used to examine the reliability.

Meanwhile, confirmatory factor analysis (CFA) was performed using AMOS 26.0 software, the key indices used to examine the validity includes: standardised factor loading, degrees of freedom for the chi-square, normed fit index (NFI), Tucker Lewis index (TLI), comparative fit index (CFI), root mean square error of approximation (RMSEA), average variance extracted (AVE), and composite reliability (CR).

It should be noted that there are many fit indices in CFA, but in actual research, it is difficult to meet all indices. Therefore, if the research finds that the most commonly used indices are within the standard range, or most of the indices are basically close to or obviously within the standard range, while some other indices are not within the standard range, the model fit is also good. Hence it is not necessary to fully consider that all the fit indices meet the standard, and it is almost impossible for all the indices to meet the standard (Kenny, 2015).

5.5.1.1 Reliability analysis

Reliability analysis is mainly used to determine the consistency and stability of the questionnaire results, and whether the variables can be reliably and effectively measured by the items. In reliability analysis, when Cronbach's α is greater than 0.8 and CITC is greater than 0.5, it is decided that the scale has good reliability.

Table 5.3 below shows the reliability test results of the variables.

Table 5.3 Reliability test results

Variable	Code	Corrected Item-Total Correlation (CITC)	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
Technology	TEC1	0.790	0.843	0.884
	TEC2	0.800	0.842	
	TEC3	0.575	0.882	
	TEC4	0.784	0.845	
	TEC5	0.703	0.863	
Organisation	ORG1	0.716	0.914	0.918
	ORG2	0.798	0.898	
	ORG3	0.855	0.886	
	ORG4	0.818	0.894	
	ORG5	0.768	0.905	
Environment	ENV1	0.786	0.913	0.925
	ENV2	0.816	0.907	
	ENV3	0.751	0.918	
	ENV4	0.783	0.914	
	ENV5	0.919	0.885	
BMI	BMI1	0.872	0.948	0.956
	BMI2	0.897	0.946	
	BMI3	0.830	0.951	
	BMI4	0.845	0.950	
	BMI5	0.838	0.951	
	BMI6	0.825	0.952	
	BMI7	0.839	0.950	
EL	EL1	0.828	0.930	0.941
	EL2	0.893	0.924	
	EL3	0.859	0.927	
	EL4	0.882	0.925	
	EL5	0.698	0.941	
	EL6	0.865	0.925	
DAS	DAS1	0.800	0.951	0.954
	DAS2	0.869	0.943	
	DAS3	0.870	0.943	
	DAS4	0.901	0.939	
	DAS5	0.925	0.934	

1) Technology variable

There are finally 5 items used to measure the technology variable. According to the reliability test results, the Cronbach's α values of each item are all greater than 0.8, the CITC are all greater than 0.5, and the Cronbach's α of the overall measurement dimension is 0.884, these indicate that the measurement scale for technology variable meets the reliability requirements.

2) Organisation variable

There are finally 5 items used to measure the organisation variable. According to the reliability test results, the Cronbach's α values of each item are all greater than 0.8, the CITC are all greater than 0.5, and the Cronbach's α of the overall measurement dimension is 0.918.

These indicate that the measurement scale for organisation variable meets the reliability

requirements.

3) Environment variable

There are finally 5 measurement items for the environment variable. According to the reliability test results, the Cronbach's α values of each item are all greater than 0.8, the CITC are all greater than 0.5, and the Cronbach's α of the overall measurement dimension is 0.925, these indicate that the measurement scale for environment variable meets the reliability requirements.

4) BMI variable

There are finally 7 measurement items for the BMI variable. According to the reliability test results, the Cronbach's α values of each item are all greater than 0.8, the CITC are all greater than 0.5, and the Cronbach's α of the overall measurement dimension is 0.956, these indicate that the measurement scale for BMI variable meets the reliability requirements.

5) EL variable

There are finally 6 measurement items for the EL variable. According to the reliability test results, the Cronbach's α values of each item are all greater than 0.8, the CITC are all greater than 0.5, and the Cronbach's α of the overall measurement dimension is 0.941, these indicate that the measurement scale for EL variable meets the reliability requirements.

6) DAS variable

There are finally 5 measurement items for the DAS variable. According to the reliability test results, the Cronbach's α values of each item are all greater than 0.8, the CITC are all greater than 0.5, and the Cronbach's α of the overall measurement dimension is 0.954, these indicate that the measurement scale for DAS variable meets the reliability requirements.

5.5.1.2 Validity analysis

Validity refers to the accuracy of a measure, validity analysis is to test whether the results really represent what they are supposed to measure. In this study, the validity test mainly involves several key indices as listed below.

- NFI > 0.9: it reflects the difference between a hypothetical model and an independent model. An independent model is a simple model in which there are no correlations among the variables. The greater the difference between the hypothetical model and the independent model, the better the fitting effect of the hypothetical model. Generally, the NFI is greater than 0.9, assuming that the model fitting effect is good (Puranitee et al., 2019).
- TLI > 0.9: it is an additional suitability index that compares the tested model with the

null model and denotes a value > 0.9 is acceptable (Chang et al., 2020; Moelyo & Hanafi, 2022).

- CFI > 0.9: when the CFI value is greater than 0.9, the model is considered an adequate fit (Puranitee et al., 2019; Wiradendi Wolor et al., 2020).
- Standardised factor loading: factor loadings show the relationship between factors and measurement items, usually using standardised factor loading values to express. The analysis result depends on the standardised factor loading and the P (probability) value, when it is highly significant and the standardised factor loading is > 0.7, it means that there is a strong correlation. (Haugan et al., 2019).
- AVE > 0.5: an AVE value of at least 0.5 indicates a good convergent validity measure. That means the latent variable can explain the average of more than half the variance of the indicators (Khamaludin et al., 2022).
- CR > 0.7: it is a measure of internal consistency in scale items, a value greater than 0.7 is acceptable. AVE and CR are commonly used indices for judging convergent validity (Purwanti, 2021).
- $\chi^2/df < 5$: the model fit is considered suitable when χ^2/df is less than 5 (Puranitee et al., 2019), but it is easily affected by the sample size. The larger the sample, the smaller the value is, so the chi-square degree of freedom ratio is likely to be larger when the sample is small (Jackson, 2003).
- RMSEA < 0.08: sample size also had a practically significant effect on RMSEA, smaller values are associated with larger sample sizes (Jackson, 2003).

The validity test results for each of the variables are shown in Table 5.4 below.

1) Technology variable

It can be seen in the table that the NFI=0.972, TLI=0.969, and CFI=0.984, which are all above 0.9, these indicate that the model fit results meet the acceptable level. Moreover, it can be seen that the value of standardised factor loading is greater than 0.7 in 4 of the 5 measurement items, however that of TEC3 is 0.615. Normally, the standardised factor loading > 0.7 is preferred, but > 0.6 is still acceptable (Ab Ghani et al., 2021), meanwhile, it shows that significance at the 0.001 level (P < 0.001), these indicate there is a good correspondence between the factors and the measurement items. Furthermore, the AVE is 0.620 (> 0.5), and the CR is 0.889 (> 0.7), all these suggest that the measurement items of technology variable show good convergent validity.

Table 5.4 Validity test results

Variable	Code	Standardised Factor Loading	Standard Error	Critical Ratio	AVE	Composite Reliability
Technology	TEC1	.855***			0.620	0.889
	TEC2	.867***	.065	12.445		
	TEC3	.615***	.057	7.694		
	TEC4	.831***	.083	11.720		
	TEC5	.741***	.078	9.884		
Fit Indices	c^2 / df=2.173, RMSEA=0.093, NFI=0.972, TLI=0.969, CFI=0.984					
Organisation	ORG1	0.737***			0.694	0.918
	ORG2	0.844***	0.117	9.956		
	ORG3	0.910***	0.126	10.772		
	ORG4	0.888***	0.115	10.501		
	ORG5	0.773***	0.105	9.053		
Fit Indices	c^2 / df=7.660, RMSEA=0.222, NFI=0.926, TLI=0.935, CFI=0.918					
Environment	ENV1	0.847***			0.723	0.928
	ENV2	0.808***	0.063	11.830		
	ENV3	0.764***	0.067	10.807		
	ENV4	0.843***	0.080	12.703		
	ENV5	0.975***	0.062	16.329		
Fit Indices	c^2 / df=8.744, RMSEA=0.280, NFI=0.903, TLI=0.910, CFI=0.901					
BMI	BMI1	0.902***			0.759	0.957
	BMI2	0.925***	0.060	17.762		
	BMI3	0.858***	0.063	14.729		
	BMI4	0.858***	0.061	14.711		
	BMI5	0.852***	0.059	14.479		
	BMI6	0.843***	0.060	14.133		
	BMI7	0.858***	0.063	14.730		
Fit Indices	c^2 / df=6.091, RMSEA=0.194, NFI=0.917, TLI=0.929, CFI=0.908					
EL	EL1	0.863***			0.757	0.949
	EL2	0.937***	0.058	16.253		
	EL3	0.911***	0.062	15.270		
	EL4	0.927***	0.060	15.856		
	EL5	0.703***	0.102	9.722		
	EL6	0.860***	0.072	13.581		
Fit Indices	c^2 / df=8.951, RMSEA=0.243, NFI=0.909, TLI=0.919, CFI=0.918					
DAS	DAS1	0.807***			0.807	0.954
	DAS2	0.867***	0.084	12.259		
	DAS3	0.895***	0.086	12.883		
	DAS4	0.948***	0.076	14.132		
	DAS5	0.965***	0.080	14.532		
Fit Indices	c^2 / df=4.638, RMSEA=0.164, NFI=0.970, TLI=0.976, CFI=0.976					

2) Organisation variable

According to the results of the scale validity test results, the NFI=0.926, TLI=0.935, and CFI=0.918, they are all greater than 0.9, indicating that the model fit results meet the acceptable level. Moreover, all the 5 measurement items show significance at the 0.001 level ($P < 0.001$), and the standardised factor loading values are all greater than 0.7, which indicate there is a good correspondence between the factors and the measurement items.

Meanwhile, the AVE is 0.694 (> 0.5) and the CR is 0.918 (> 0.7), which suggest that the

measurement items of organisation variable show good convergent validity.

3) Environment variable

According to the results, the NFI=0.903, TLI=0.910, and CFI=0.901, which are all above 0.9, these indicate that the model fit results meet the acceptable level. The 5 measurement items show significance at the 0.001 level ($P < 0.001$), and the standardised factor loading values are all greater than 0.7, these indicate the factors and the measurement items are well corresponded. Furthermore, the AVE is 0.723 (> 0.5), and the CR is 0.928 (> 0.7), these suggest that the measurement items of environment variable has good convergent validity.

4) BMI variable

In the table it can be seen that the NFI=0.917, TLI=0.929, and CFI=0.908, which are all greater than 0.9, indicating that the model fit results meet the acceptable level. Furthermore, all the 7 measurement items show significance at the 0.001 level ($P < 0.001$), and the standardised factor loading values are all greater than 0.7, which indicate there is a good correspondence between the factors and the measurement items. Furthermore, the AVE is 0.759 (> 0.5), and the CR is 0.957 (> 0.7), all these suggest that the measurement items of BMI variable show good convergent validity.

5) EL variable

According to test results, the NFI=0.909, TLI=0.919, and CFI=0.918, they are all greater than 0.9, indicating that the model fit results meet the acceptable level. Moreover, all the 6 measurement items show significance at the 0.001 level ($P < 0.001$), and the standardised factor loading values are all greater than 0.7, which indicate there is a good correspondence between the factors and the measurement items. Meanwhile, the AVE is 0.757 (> 0.5) and the CR is 0.949 (> 0.7), suggesting that the measurement items of EL variable meet good convergent validity.

6) DAS variable

For the DAS variable, the model fit indices NFI=0.970, TLI=0.976, and CFI=0.976, which are all greater than 0.9, indicating that the model fit results meet the acceptable level. Moreover, all the 5 measurement items show significance at the 0.001 level ($P < 0.001$), and the standardised factor loading values are all greater than 0.7, which indicate the factors and the measurement items are well corresponded. Furthermore, the AVE is 0.807 (> 0.5) and the CR is 0.954 (> 0.7), these imply that the measurement items of DAS variable has good convergent validity.

5.5.2 Structure equation modelling analysis

This study uses the method of structural equation modelling (SEM) to test the research hypotheses. As Peugh and Feldon (2020) suggested, SEM is an powerful data analytical tool for testing multivariate causal relationships among many analytical variables. It can simultaneously test multiple mediating and moderating relationships, estimate latent variables on the basis of related measures. Fan et al. (2016) pointed out that SEMs differ from other modelling as they test the direct and indirect effects on pre-assumed causal relationships, and basically SEM is a combination of two statistical methods: CFA to validate the measurement model and path analysis to fit the structural model.

5.5.2.1 Partial least squares structural equation modelling

There are different types of SEM analysis, specially, in this study the partial least squares structural equation modelling (PLS-SEM) is selected to test the results. There are three main reasons for using this method:

- Compare with regression analysis, the SEM is easier to test the direct, indirect and mediating effects between variables (Fornell & Bookstein, 1982).
- This case study focuses on the exploration of new theories by combining well-established theory with practice. Compare with general SEM emphasises theoretical verification, the PLS-SEM is more suitable for theoretical exploration (Hair et al., 2019).
- Because this research is a single case study, the characteristics of the research and the reality of the research object determine that the data sample will not be too large, so another reason for choosing PLS-SEM is that it is able to produce reliable research results in small samples (Hair et al., 2019; Russo & Stol, 2021).

5.5.2.2 Structural equation model fit

Structural equation model fit is determined by the degree of similarity between the collective relationships specified in a given model and the covariance matrix (Peugh & Feldon, 2020). As shown in Figure 5.1 below, we firstly built the theoretical model in SmartPLS3.0 software, and then used the PLS algorithm and Bootstrapping method to verify the significance.

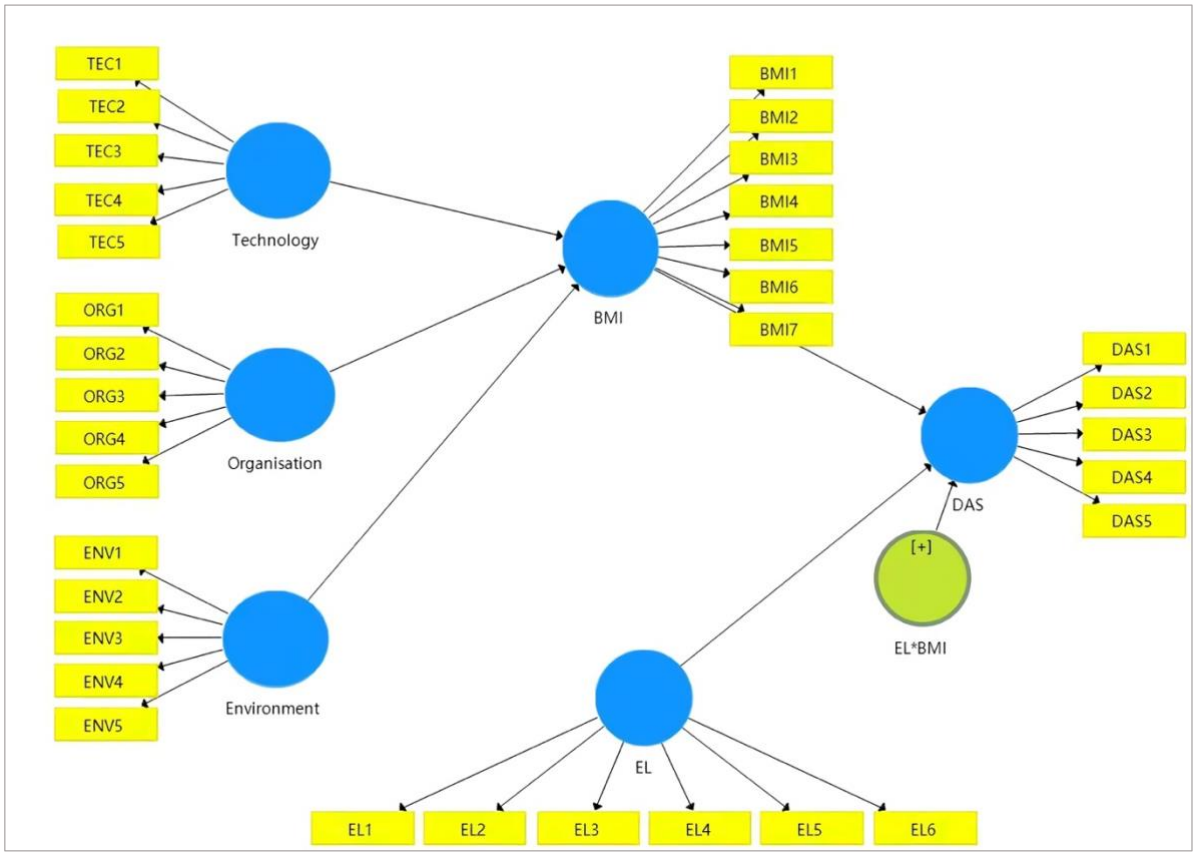

Figure 5.1 The extended TOE model Structural equation model fit

Through the PLS calculation, and the checking calculation by Bootstrapping method with the subsample set to 5000, we get the fit results shown in Table 5.5 below. According to the model fitting indices, adjusted R^2=0.768, SRMR=0.076, d_G=3.826, and NFI=0.887, the overall model fit result meets the acceptable level.

5.5.2.3 Path analysis

Table 5.5 below shows the overall fit results for the extended TOE model, based on the significance test results, the path analysis is discussed.

1) The direct path analysis

According to the path coefficient and the effectiveness of the direct effect, organisation has a significant positive effect on BMI (β=0.320, P<0.01), environment has a significant positive effect on BMI (β=0.579, P<0.001), BMI has a significant positive effect on DAS (β=0.600, P<0.001), EL has a significant positive effect on DAS (β=0.334, P<0.01).

Technology does not have a significant positive effect on BMI (β=0.076, P=0.269).

Table 5.5 The extended TOE model overall fit results

Path	β Value	t Value	P-Value	f^2
Direct path				
Technology → BMI	0.076	1.106	0.269	0.014
Organisation → BMI	0.320**	2.803	0.005	0.172
Environment → BMI	0.579***	6.391	0.000	0.651
BMI → DAS	0.600***	5.074	0.000	0.523
EL → DAS	0.334**	2.705	0.007	0.136
Indirect path				
Technology → BMI → DAS	0.046	1.163	0.245	
Organisation → BMI → DAS	0.192*	2.456	0.014	
Environment → BMI → DAS	0.347***	3.663	0.000	
Moderate effect				
EL*BMI	0.015	0.275	0.784	0.001
Adjusted R^2=0.768 SRMR=0.076. d_G=3.826. NFI=0.887				

Note.: *, ** and *** represent significance level at p < 0.05, p < 0.01, p < 0.001 respectively (N=136)

2) The indirect path analysis

Based on the path coefficient and the effectiveness of the indirect effect, it is found that the path "Organisation → BMI → DAS" has a significant path effect, the path coefficient is 0.192, significance P < 0.05.

The path "Environment → BMI → DAS" has a significant path effect, the path coefficient is 0.347, significance P < 0.001.

The path "Technology → BMI → DAS" does not have a significant path effect, the path coefficient is 0.046, significance P=0.245.

3) The moderate effect

According to the test results, as β=0.015, P=0.784, it is not found that the path "EL*BMI" has a significant moderate effect.

5.6 Results discussion

Through the questionnaire survey, we conducted an empirical study to verify the hypotheses proposed in Chapter 4. In this section, the discussion is based on the summary of the results shown in Table 5.6 below.

Overall, out of a total of nine hypotheses, the results showed that six of the hypotheses were supported and three others were not. These results played an important role in the conclusion of this study.

Table 5.6 The research hypotheses test results

No.	Hypothesis	Result
H1	Technology has a positive effect on BMI.	Not Supported
H2	Organisation has a positive effect on BMI.	Supported
H3	Environment has a positive effect on BMI.	Supported
H4	BMI has a positive effect on DAS.	Supported
H5	BMI has a mediating effect on the relationship between the technology and DAS.	Not Supported
H6	BMI has a mediating effect on the relationship between the organisation and DAS.	Supported
H7	BMI has a mediating effect on the relationship between the environment and DAS.	Supported
H8	EL has a positive effect on DAS.	Supported
H9	The EL has a moderating effect on the relationship between the BMI and DAS.	Not Supported

5.6.1 Relationship between TOE and BMI

To explore the relationship between TOE and BMI is a focus of this empirical study. It is because the relationship between TOE and BMI is a very important feature in our extended TOE model. In the literature review, it was found a lot of research on the relationship between TOE and IS adoption, but there is very little research on TOE and BMI especially putting their relationship into the specific scenario of digital project success.

Among the three hypotheses based on TOE and BMI, two were supported by data analysis. It was found that organisation and environment have positive effect on BMI. However, empirical analysis results do not support the hypothesis that technology has a positive effect on BMI.

In fact, this finding is consistent with what we found earlier through in-depth interview. In the interview, respondents ranked 17 CSF, and it turned out that the CSF related to technology ranked the lowest overall, and even the last three were subordinate to technology. We have explained the reason in detail in Chapter 4, simply speaking, the technology factors are still very important, but because it has been very mature in China, people therefore pay more attention to the organisation and environment factors for the success or failure of digital projects.

This finding also gives us an important revelation, that is, TOE are not separate from each other, but interact with each other. And in different stages of digitalisation development, their roles and people's attention to them are different. For example, Afolabi et al. (2019) studied the CSF for D-procurement adoption in the Nigerian construction industry, and they found the most CSF is the availability of reliable, affordable, and fast Internet services. This is because in African, the development of technology is still at an early stage, so the technology related CSF are more important for these countries.

5.6.2 Relationship between BMI and DAS

Through the empirical analysis, the hypothesis "BMI has a positive effect on DAS" is supported. BMI is a key finding in this case study. The essence of the D-procurement project is actually an innovation, and the core of this innovation is the innovation of business models. Hence the success of DAS is based on the success of BMI performance. This finding is of great value to our understanding of the current surging digitalisation projects and to the future research.

5.6.3 Mediating effect of BMI

In the study of the mediating effect, we hypothesised that TOE impacts indirectly on DAS by impacting on BMI. The empirical results show that BMI as a mediator variable that is significant for organisation and environment, but not for technology. This result is also consistent with the previous in-depth interview result and the test result of the direct effect between technology and BMI. Looking at this issue from another angle, this may be a manifestation of technological maturity in the process of digitalisation.

5.6.4 Relationship between EL and DAS

The hypothesis on the relationship that EL has a positive effect on DAS is proved. According to the literature survey, normally in the CSF studies more attention was paid on the relationship between some common factors such as business reengineering or top management support and project success, there were very few references to the relationship between EL and IS project success especially in the D-procurement scenario. This also reflects the value of focusing on EL in this study.

Actually, previous research has identified leadership as one of the most important organisational factors that influence entrepreneurial activity (Felix et al., 2018), and found that there is positive relationship between EL and innovation performance (Indawati et al., 2018).

In this study, there were two main reasons for why EL was discovered as a very important CSF. The first reason is that this research focuses more on innovation and the factors that affect the success or failure of innovation, so EL is easier to perceive. The second reason is that because H Tech is a very typical start-up company, the role of EL in the success or failure of this company and its business model is more obvious and easier to highlight. EL is playing an increasingly important role in digitalisation projects, which will be discussed in more depth in the next chapter.

5.6.5 Moderating effect of EL

The moderating effect of EL on the relationship between BMI and DAS is not supported by the empirical analysis. When we reviewed the records of the in-depth interview again, it was exactually that 8 of the 17 respondents raised the importance of EL to DAS, and they believed that the magnitude of the effect of EL would affect the realisation of BMI and thus affect DAS.

However, the results of the questionnaire survey did not support this moderating effect. We found that the respondents of the in-depth interview were all from top-level and middle-level management, all of them knew H Tech's leader very well. However in the questionnaire survey, except these senior and middle managers, most of the remaining respondents are employees who do not have a direct daily working relationship with the leader, they do not know very much about his work and effort at all.

Therefore, we infer that the reason for the inconsistent results between interview and questionnaire on the moderating effect of EL is because respondents had different levels of knowledge about the event. In the interview, the respondents were those who have a close working relationship with the leader, so they have a deeper understanding of the moderating effect. But in the questionnaire, most of the respondents are the general employees, they can perceive the simple positive effect of the leader on their D-procurement project, but they cannot perceive the more complex effect of EL on the relationship between BMI and DAS. This explains why the hypothesis that EL has a positive effect on DAS is supported, but the moderating effect of EL is not supported. Because of this, in the model finally given in Chapter 6, the mediating effect of EL is still retained. In a larger sample size or multiple-case study, the effect can be tested again, and the hypothesis might be supported.

5.6.6 Empirical study limitations

To sum up, the proposed extended TOE model was well verified through empirical study. The overall reliability and validity test results of the model met the acceptable level, and of the nine hypotheses proposed, six were supported and three were not. The six supported hypotheses well explained the relationship between the variables in the model, and the plausibility of the model is confirmed. The three hypotheses that were not supported also provide significant findings for further studies.

Although we have made many efforts to ensure the scientific nature of this empirical study, but because it is a single case study, there are still some limitations that cannot be overcome:

- The sample size is acceptable but not ideally large. It is affected by the real size of the

enterprise. If more samples could be collected, the test results might have been more realistic.

- The bias cannot be fully avoided. Because the research is conducted within the enterprise, for the sake of political correctness, the respondents' answers will be more inclined to the good side and avoid the bad side, resulting in biased results.

However, as far as social science research is concerned, there will be no perfect research. Under the circumstance of maximum rationality within a limited range, we believe that the overall findings have achieved the goal of verifying the hypothetical model. In the future research, we suggest that more extensive research, such as multi-case studies and cross-industry research can be undertaken.

5.7 Summary

In summary, this study completed the definition of CSF and the proposal of extended TOE model through qualitative research and completed the verification of the model through quantitative research. So far, we have accomplished the two research questions raised as well as the three research objectives set in the first chapter. And all of these will be concluded in detail in the next chapter.

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Chapter 6: Conclusion

6.1 Chapter overview

The main content of this chapter is the conclusion of the work. It mainly includes five parts. The first summarises and discusses the research findings against the research questions and research objectives. Then, based on the findings of this study, management recommendations are put forward for enterprises to help them achieve digital transformation. After that, the two main innovation points of this study are discussed. Next, the limitations of this study are presented and explained. Finally, suggestions are made for future research directions in the field of D-procurement and digital transformation.

6.2 Findings and discussion

In this study, we aim to address a major research problem, which is the lack of theoretical support for the practice of D-procurement. For this purpose, there were two research questions initially proposed:

1) What are the CSF for D-procurement adoption in Chinese construction companies?
2) What are the relationships between these CSF?

These two questions were related to the three research objectives to be fulfilled:

1) To define the CSF for D-procurement adoption success.
2) To find out the order of relevance of these CSF.
3) To develop an extended TOE model.

Through the findings in this study, we have accomplished the three research objectives, which in turn have answered the two research questions. In the following sub-sections, we summarise and discuss these findings.

6.2.1 Eight CSF found in real case

There is a total of eight CSF finally defined by literature survey and in-depth interview. This also means that we have accomplished the first objective of this study. These CSF are discussed successively below.

1) Advanced digital technologies

Basically, this CSF is an innovation in itself. It is an upgraded version of the technology related CSF found in much of the literature. Normally the traditional technology factors are more related to the web technologies such as ICT infrastructure, system integration and data security. In this study we pay more attention on the digital technologies such as big data and blockchain applied in the D-procurement project. Therefore, the factor "advanced digital technologies" is more adequate and relevant for the real world.

From another perspective, the advanced digital technologies factor also reflects the era and technological background of our entire research. Just like the procurement has moved from E-procurement to D-procurement, businesses are also entering the digital era, and the application of digital technologies and its influence on digital projects have more and more become a key point of concern for companies and researchers.

2) Uniform data standard

The reason why uniform data standards can stand out among the many technology CSF in this research is that in modern information systems, the compatibility and integration between systems are particularly emphasised, and the ability to unify standards has become one of the essential capabilities of the industrial Internet platform. Our study also further validates the importance of this ability.

As K. Li et al. (2022) pointed out, construction industry Internet platform is a new combination of information communication technology and modern construction technology and is an important carrier to facilitate digital and smart construction. It contains six main features: data digitalisation, big data analysis, resource integration, knowledge digitalisation, digital delivery, and network cooperation. H Group's D-procurement platform is a typical industrial Internet platform. To realise multi-party interaction and multi-party transactions through the platform, it is necessary to unify the platform's data standards, development standards and communication standards, which are all prerequisites. Uniform data standard as one of the two CSF strongly related to technology is a research result that keeps pace with current times.

3) Top management support

There are four organisational factors, top management support is the first. In numerous studies on CSF, top management support has always been important, and this is also consistent with our finding. When thinking deeply about this issue, the root cause is that top management has the ability to allocate resources required by the project, such as funds, human resources, such as policy inclination and management coordination.

Top management is so important because it is a symbol of power, and the success or failure of a project absolutely needs the support of those in power.

This research result crosses almost all national and geographical restrictions, and it would be universally applicable to any enterprise environment. For example, in China, whether it is a state-owned or private enterprise, there is always a top decision-maker and a core decision-making layer. A project as D-procurement that will bring a significant and far-reaching impact to the enterprise must obtain support from this level, otherwise no matter how good a project and how much effort you put into it, it will still be aborted or destroyed.

4) Firm size

The second organisation factor is firm size. The original 17 CSF were obtained from 12 related studies through literature survey, and only one of the 12 sources in the literature referred to firm size. However, based on the understanding of H Group's D-procurement project, it was finally decided to keep this factor, and the research results eventually supported this decision. According to the result of the in-depth interview, firm size ranked third among the 17 CSF, only lower than top management and government support.

Firm size is so important in the opinion of H Tech's high-level and middle-level managers, and the underlying reason is that this factor reflects H Group's leading position in its supply chain ecosystem. It is precisely because H Group is a large construction group with a large enough procurement scale, it becomes a strong buyer and has absolute control over manufacturers, service providers and banks in the procurement business. This dominant position makes it a supply chain leader. Therefore, when we are talking about firm size, we are actually talking about the leader of the supply chain.

In addition, H Group's D-procurement platform is also a typical buyer-hosted platform. In China, all the three types of D-procurement platforms that are buyer-hosted, seller-hosted, and intermediated are existing in the construction industry. But according to our observations, almost all successful D-procurement cases belong to buyer-hosted platform type. This is because the owners or general contractors in the construction industry are the real buyers. On the one hand, they can control the entire procurement supply chain. On the other hand, those large companies have the ability to invest resources to build a platform and integrate the resources of all parties to operate the platform. Therefore, it is easier for them to succeed. The leadership role of supply chain ecosystem (Batista et al., 2019) is an interesting topic, future research can focus on it.

5) Business model innovation

The third organisation factor is BMI, it is not only critical to the success of D-procurement,

but is critical for TOE to make effect on DAS. In many TOE based CSF studies especially in the D-procurement scenario, BMI appears less frequently, whereas there are actually a lot of studies on BMI in the innovation field. For example, Foltean and Glovaţchi (2021) pointed out that BMI is a key success factor for the development of IoT solutions, and innovation is the essential of BMI.

In the case of H Group, the realisation of BMI is to reduce costs and increase efficiency for all participants by optimising the resource organisation and distribution structure in the supply chain ecosystem to achieve a win-win situation for all parties. Hence this process of innovation is actually a process of value creation, the D-procurement platform is the carrier to realise this win-win model.

From a larger perspective, the relationship between TOE and BMI is that, the BMI is constructed through advanced digital technologies, the organisation is the practitioner to implement the BMI, and the environment is the external support to realise the BMI.

The discovery of BMI also makes us realise more deeply that the essence of this research on D-procurement is actually to study the digital innovation of China's construction industry through this specific business scenario. As digital innovation has become the internal driving force for the transformation and upgradation of the entire Chinese industry, such an in-depth research has important theoretical and practical value.

6) Entrepreneurial leadership

EL is the fourth organisation factor. This theoretical term, EL, is embodied in a person in reality, and this person is usually the founder or leader of the business. Unlike many CSF that emphasise on organisational capabilities, EL emphasises the role of individual in innovation success, which is rare in TOE-based innovation studies.

Based on the definition of EL, this person needs to have entrepreneurial passion, vision of future, innovative problem-solving ability, perseverance, and motivational ability (Cai et al., 2019; Kuratko, 2007). But only these capabilities are far from reality. As we know that to be successful in digitalisation, it is necessary to deeply integrate traditional industry with digital technologies and then create value. This characteristic of digitalisation naturally determines that the talent it needs is cross-border talent. Especially the leader, who must have a deep understanding of traditional industry and good professional skills, as well as a good understanding of digitalisation. Otherwise, there is no way for the leader to create and iterate the innovative business model, then BMI is out of the question.

However, in reality, such type people are too rare. Often, experts in traditional industries do not understand digitalisation, and experts in the field of digitalisation do not understand

traditional industries. In information technology field there is a famous case, which is Nokia's death.

According to a profound investigation by Vuori and Huy (2016), the biggest reason for its failure was the limitations of the leader, so that he made a wrong judgment on the trend of technological development, resulting in Nokia's loss of the smartphone battle.

For large companies with strong resources and capital, many conditions can be quickly met, such as advanced technologies can be introduced, organisation methods can be learned, and environment factors can be created. However, according to our observation, the most difficult job is to find such an excellent leader.

Someone may think that the problem can be solved by introducing professional managers, but since D-procurement is an innovative project, it requires the leader to integrate resources from all parties and coordinate various relationships, the managers from outside do not know the company well, it is quite easy for them to get unaccustomed to the situation, resulting higher cost and risk.

In this study, we believe that EL is the key among eight factors. Furthermore, it is not only the key for D-procurement adoption project, but the key for the industrial digitalisation.

7) Government support

There are two environment factors, the first is the government support, which is a most basic factor in CSF studies. In China, the State Council formulates a plan every five years since 1953, and after that, relevant policies are also formulated around this Five-Year Plan. Therefore, whether it is a state-owned or private enterprise, it will formulate its own development direction and path according to the Five-Year Plan and supporting policies.

Just like now, China is implementing the 14th Five-Year Plan, which sets out specific goals and requirements for the industrial digital transformation and upgradation, so it is particularly important for companies to seize this opportunity and make good use of relevant policies.

The government support factor ranks second in the 17 CSF, second only to top management support, it is interesting that both are about support. This implies how important the support from the top level is to achieve a project.

As for why top management support ranks ahead of government support, it indicates that the government's support is macroscopic, and the key to success should still rely on the belief and determination of the company itself.

8) Value consensus

Value consensus is the second environment factor, which is a CSF that we learned from the interview. In addition to government support, only value consensus was finally retained for

environment factors, it was because in our observation on H Tech, we found that this is a prominent factor but has been ignored or not been abstracted in many related studies.

There are some similar constructs, for example, in many TOE-based CSF studies the knowledge of benefits of D-procurement is normally emphasised. However, this construct is not enough to cover the importance of the common perception of value by all stakeholders during the development of the D-procurement project. In contrast, value consensus is more accurate and comprehensive in expression, it specifies whether it is government, participants, managers, employees, and end-users, it is necessary to reach a broad consensus based on the value of D-procurement. This also explains why value consensus is not an organisation factor, but an environment factor.

In addition, among the two environment factors, government support reflects the role of the environment from the government and policy level, while value consensus reflects the importance of the environment from the partner and stakeholder level. Therefore, these two factors are well represented.

To sum up, these eight CSF are all defined by verifying the existing CSF in the real case. We also communicated with the management of H Tech with these eight CSF and got their full affirmation and recognition. They believe that these research findings are indeed very practical, also very in line with the reality of the development of D-procurement in Chinese construction industry and have high practical significance and theoretical value.

6.2.2 Order of CSF relevance and technology maturity

Obtaining the order of CSF relevance is the second of the three objectives in this study. Based on the ranking results, the 17 CSF were further retained, merged, and eliminated, and then the eight CSF is finally defined. Other than that, it was found that CSF is possibly correlated with technology maturity in the digitalisation process.

According to the interview results, the five technology CSF were all ranked in the bottom 8 of 17, and the bottom 3 were all technology CSF. That means the technology is of lowest importance in TOE. After the questionnaire, the results were also consistent with it, because the hypothesis on the positive effect of technology on BMI was not supported, and the hypothesis on the mediating effect of BMI between technology and DAS was also not supported.

This shows that technology is unimportant not only in the mind of interviewed senior and middle managers, but also in the lower-level employees participated in the questionnaire.

Is this the situation? We noticed that an earlier study had very different results. Ab Talib et

al. (2015) selected 26 empirical papers related to CSF in supply chain management (SCM) through literature survey, 25 CSF were extracted and ranked by Pareto analysis, 9 CSF were regarded as the "vital few" and the remaining 16 CSF were regarded as the "useful many". And among the 9 "vital CSF" that were immensely important, "use of information technology" ranked the first, after that, "top management support" and "partnership/integration" came in second and third respectively. This just presents the opposite result to our study.

Therefore, we assume that CSF is related to the development stage or maturity of the technology. From 1995 to 2014, it happened to be a period of rapid development of the Internet. And from around 2010 to the present, the mobile Internet has developed vigorously. According to the report released by China Internet Network Information Centre, up to June 2021, the number of mobile Internet users in China had reached 1.007 billion, and the proportion of Chinese netizens accessing the Internet via their mobile phones had amounted to 99.6% (China Internet Network Information Center, 2021). In China, every inhabited place is covered with networks, the mobile Internet is rapidly upgrading from 4G to 5G, and various Internet applications have also brought many fundamental changes to people's lives. For example, with the popularity of mobile payment, it has been difficult to see people using cash in daily life. And for enterprise, SAAS is ubiquitous and has become a standard configuration of enterprise software applications.

Therefore, we may understand why technology ranked first in the study in 2015, whereas technology is not valued in this study. This finding is valuable, it implies us whether it is technology, organisation, or environment, the impact of CSF on digitalisation projects is not fixed, but a dynamic and interactive progress.

6.2.3 Extended TOE model

The above findings of CSF will be a good guidance for the practice of D-procurement, but it is not enough. Only by further clarifying the relationship between these CSF will it be more helpful for companies to adopt D-procurement solutions in practice. The extended TOE model addresses this issue. In figure 6.1 below, the eight CSF and the extended TOE model are combined, this figure represents the core findings and contribution of this study.

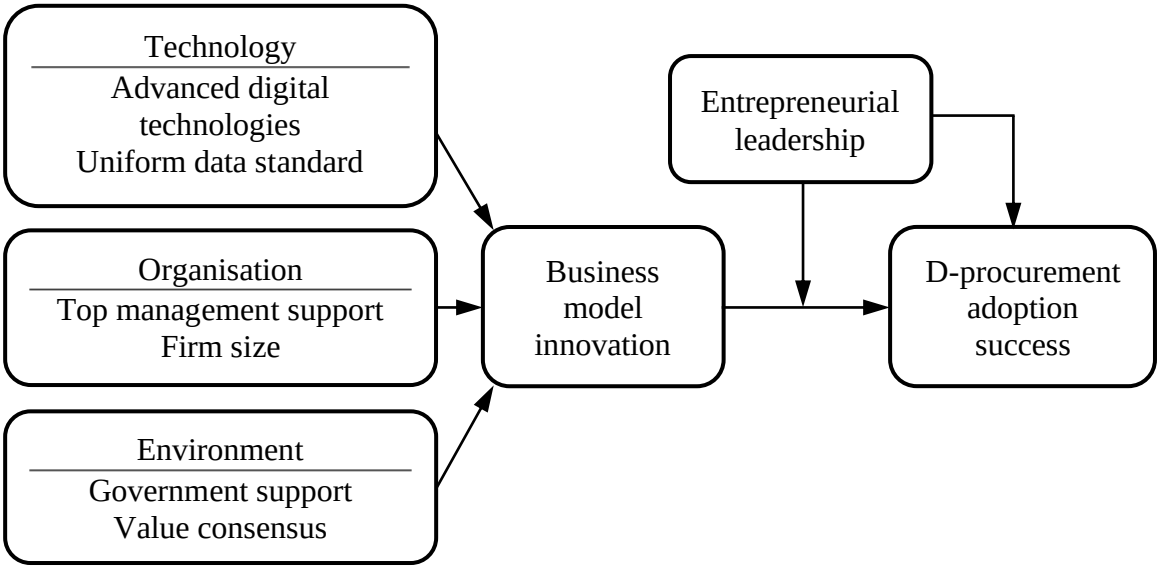

Figure 6.1 Extended TOE model with eight CSF

In this model, TOE and DAS are both traditional constructs, while BMI and EL bring new ideas to the model and both constructs are highly related to innovation. This model can be used not only for digital procurement innovation, but also for industrial digital innovation. Because digital procurement is a microcosm of industrial digitalisation.

In the model, it also clearly tells us the importance of BMI and EL while the TOE are generally met in China today. If TOE is the foundation of digitalisation, then BMI is the core of digitalisation, and EL is the soul of digitalisation.

- The mediating effect of BMI

As shown in Figure 6.1, BMI is at the heart of the extended TOE model. On the one hand, BMI is the carrier of TOE. In the case of H Group, TOE do not directly but indirectly contribute to DAS by contributing to BMI. This inspires us that BMI is the core of digitalisation projects, it is the innovation of production relations, and technology as a productive force promotes the realisation of innovation.

For enterprises, in the process of digitalisation there are generally two levels. The first level is efficiency tools. For example, in the past the accounting work of project cost was primarily calculated by manual calculation. Now most of the work is handed over to software for automatic calculation, because the big data and intelligent analysis technologies are used. The second level is digitalisation based business innovation, such as H Group's D-procurement. In the past, it was impossible for companies like H Tech to carry out their own supply chain finance business. Because in the traditional procurement business, the information is highly opaque, so that the bank could not grasp the real data of the company thus could not analyse the credit and financial status of the company.

In this case, banks prefer to provide mortgage loans, then it refuses those SMEs that has good credit but do not have so much collateral to get loans. Now H Tech has established the D-procurement platform, and all transaction data are clearly recorded on the platform. Banks can conduct risk assessments on companies through big data analysis, and because these assessment results are accurate enough to allow banks to control their own lending risk, then no longer need collateral to lend. This innovation not only improves the efficiency of lending but makes more companies to get loan. It also allows H Tech to cooperate with banks to carry out supply chain finance business, and this business has become its main source of revenue and profit.

Therefore, the mediating effect of BMI actually reveals the importance of business innovation in the process of enterprise digitalisation, which creates new sweet spots (Goldenberg et al., 2003) for enterprises.

- The moderating effect of EL

In this study, the results show that the middle and senior management of H Tech are very empathetic to the moderating effect of EL, but when the scope of the survey is expanded and most of the samples are grassroots employees, the moderating effect of EL is not significant. This may imply that EL is more suitable for qualitative research such as interview in the case of digitalisation project, because it is likely that only a small minority will really understand its meaning.

J. C. Li (2020) conducted a study to examine if a decision-maker-centred TOE analysis is consistent with the results obtained by directly applying behaviour model to predict individual decision maker's action. He found that the results were no significant difference between top management and other individuals. Therefore, we would argue that the specific research method used should depend on the characteristics of the construct and the research scenario.

In this study, EL points to the founder of H Tech. As Renko et al. (2015) pointed out, EL is more prevalent among founder-leaders than non-founder leaders. This is because founder and entrepreneurship are naturally linked. In our case, H Tech is an entrepreneurial technology company in the H Group. The success of BMI contributes to success of D-procurement adoption then contributes to success of H Tech. Therefore, DAS in study has multiple connotations, studying DAS is also studying the success of business innovation and entrepreneurship.

Finally, we would like to emphasise that, through our observation of H Tech and its similar enterprises, the top decision-makers of enterprises should deeply understand the importance of EL. They should also understand that a leader only has the abilities such as resource integration ability, coordination ability, and management ability are not enough, it is just at the general level.

An excellent leader must have entrepreneurial spirit, innovation ability, cross-border professional ability, and team motivation ability. Leaders should be always primarily considered for companies plan to carry out digitalisation.

6.3 Management recommendations

Providing a theoretical guide to companies working on D-procurement adoption is an important goal of this study. The guide is summarised into four management recommendations, which are discussed below.

1) Fully understand the eight CSF and apply them into practice.

For government support, enterprises should track and understand the policy direction in a timely manner, interpret the newly promulgated relevant laws and regulations in a timely manner, and timely grasp what the government is supporting, what tax incentives and financial support policies have been issued, and what other government resources can be used. At the same time, enterprises should maintain active communication and exchanges with relevant government departments, so that the government can understand the D-procurement goals and progress of the enterprise, and the government will know how to support the enterprise.

For value consensus, companies should communicate and publicise the value of D-procurement extensively. Within the enterprise, consensus must be reached from the grassroots to the top management. Outside the enterprise, there is a need for value consensus among all parties involved. Make it clear to all involved that D-procurement adoption is in their favour.

For top management support, the top managers should support the D-procurement project from all aspects. To protect the managers from saying one thing and doing another, it is recommended to link their key performance indicator (KPI) with the progress and success of the D-procurement project.

For firm size, it is recommended for large enterprises to build and operate their own platforms because they have the advantages of supply chain leader and investment capabilities on research and development (R&D). For small and medium-sized enterprises, due to the limitations of various resources and capabilities, they may consider entering the supply chain ecosystem of large enterprises and use their existing platforms.

For advanced digital technologies, large enterprises are advised to cooperate with external technology companies for R&D because of their complex organisational structures with long decision-making processes, and relatively conservative work attitudes.

The enterprise’s technology department is responsible for connecting with business needs,

designing the platform and controlling the overall technical architecture and standards, and the platform development is carried out by their outside technology partners.

For uniform data standard, it is recommended that the relevant departments of the enterprise cooperate with external professional consulting companies to establish a data standard system and promote its application among all partners participating in the platform.

For BMI and EL, they are discussed in following contents.

2) Transforming to digital enterprise

Enterprises need to have a solid understanding on the nature of digital innovation. Such as the D-procurement platform, it is not a simple software tool, it is a carrier of a typical business innovation. Therefore, it is not enough for enterprises to only use traditional way of thinking, resource organisation and management methods, they must gradually transform to become a digital enterprise as well. This requires the enterprise itself to continuously upgrade and iterate in all aspects of culture, awareness, professionalism, and management to cooperate with the deepening of digitalisation.

As we discussed before, the essence of digitalisation is to promote the transformation of production relations through productivity. Therefore, building a D-procurement by advanced technologies is only a skeleton. The innovation of the enterprise's production relations such as culture and management and the creation of new business value are the flesh and blood. However, according to our observation over the years, this is also a very painful and exceedingly difficult step in the process of digital innovation. Large enterprises, especially large state-owned enterprises, are behemoths, and how difficult it is to make elephants dance. But on the other hand, only companies that truly complete this transformation can win in this digitalisation competition.

3) Cultivating your own digital talents

Normally, for those companies want to conduct digital projects, the first thing they think about is to see which of their peers is doing well, and then poach the other companies' leaders or core talents. To a certain extent, this way of bringing in talents can enable digital projects to be launched and advanced quickly through the rapid acquisition of experience and capabilities. But this approach also carries huge risks.

The first is that the talents introduced from the outside are not familiar with the company, even if they are going to be familiar, this requires a process and there is a risk of failure, the company has also to pay time costs.

In addition, it is easier to understand business processes and management models, but if they cannot be quickly integrated into the corporate culture, it is a very troublesome matter. The

second point is more critical. The externally introduced talents have no interpersonal basis, it is less problem for them to do traditional business, but for projects as D-procurement, which involves transformation of almost all aspects of enterprise and touches many traditional procurement interests, they will encounter many invisible walls, there will be many difficulties.

Human society pays attention to human relations (Simon, 1990), and having good interpersonal relationships is the basis for doing a good job. If one cannot get people's support, then nothing can be done. For example, the founder of H Tech, he has worked in H Group for more than 20 years from basic staff to top level, so he has a comprehensive and profound understanding of the company and has good interpersonal relationship in H Group, no matter in group headquarters or subsidiary companies. Therefore, in the process of implementing D-procurement, he encountered much less resistance. This is also one of the key factors of his success.

We have seen many companies that spent a lot of money to hire experts with successful experience in the industry and invested a lot in the D-procurement project. However, due to the above reasons, they eventually failed or encountered many problems, so they had to change horses in the middle of the stream. As a result, the lost time cannot be made up, and how to ensure that the newcomers can move forward smoothly? There was a big company that changed thirteen leaders within eighteen months for a digital project but finally failed, which has been a real and profound lesson.

So how should companies solve this problem? First the company should realise that the talent problem is a strategic problem, and the cultivation of leaders is the top priority. Therefore, in the early stage of digitalisation, companies should cultivate talents within the organisation as soon as possible, and cultivate talents in a systematic, purposeful, and targeted manner. Second, the above analysis is not to deny the introduction of external talents. Instead, it is recommended that the cultivation of leaders should be supplemented by talent introduction but should be mainly based on internal training. That means the fundamental purpose of introducing talents is to cultivate internal talents, so that internal talents can better practice and grow faster by learning their experience.

4) Getting quick effects as possible

Companies should understand D-procurement adoption is a dynamic forward project. For example, the digital procurement is basically the combination of traditional procurement business with advanced digital technologies, and this is a dynamic cycle process.

Since the change led by technological innovation itself is a spiral continuous iterative process with a starting point but no absolute end point. At the same time, as the designer,

implementer, and promoter of BMI, the entrepreneurial leader also needs to dynamically improve its interdisciplinary knowledge and inter-professional capabilities in order to continuously bring digital projects to new heights.

In this process, the decision-making level especially the top leader of the company, must fully understand that since innovation requires investment, risk taking, and error tolerance, they must give D-procurement project enough time to development, test, and verify, after that to gradually generate benefits. The failure of many projects is precisely because the top leader is eager for quick success and require innovative projects to produce immediate benefits for political performance, thus forcing entrepreneurial leader to make some unavoidable decisions. This is a common problem in the digitalisation process of most state-owned companies in China, and this lack of vision must be avoided as much as possible.

However, this situation is extremely difficult to avoid due to institutional reasons. Then how to do it? Entrepreneurial leaders need to learn to compromise and turn bad things into good. When designing the D-procurement, a project plan is drawn up. Entrepreneurial leader should try to develop those business functions that can take effect quickly without affecting the overall platform development as early as possible. In this way, when D-procurement starts to operate, it is easier to generate benefits at an early stage. This will not only satisfy the top leader and decision-makers, but also bring confidence to innovation teams and external partners, so that all these stakeholders are willing to invest more resources to advance the D-procurement project.

The case of H Group used this method and confirmed its feasibility. Before their D-procurement platform was fully developed, some functions have been put into operation, and achieved significant cost savings through centralised procurement and profitability through supply chain finance from since the very beginning of its operation. As a result, it received strong support from all parties involved.

Therefore, company especially the project leader must understand that the design and implementation of digitalisation projects require wisdom and balance. Do not be obsessed with accomplishing a single goal but learn to balance the demands of various stakeholders through compromise, so as to gain more understanding and support. This is what game theory says: the combinations of local suboptimal solutions is often the globally optimal solutions (W. Zhang, 2017).

6.4 Research innovation

In this study, there are two innovation points that are worth to discuss. The first point is the

exploration of indirect effects in the extended TOE model. In many CSF studies in the field of innovation, the TOE model is used to either find the critical factors that influence innovation decisions, or the critical factors that influence innovation success (such as this study). And in most studies, these factors only have a simple linear relationship between them and dependent variable, which means there is only direct effects existed in TOE model.

Therefore, at the beginning of this study, the aim was similar to others, which was to study the direct effect between CSF and DAS. But after the in-depth interview, we found there possibly exists indirect effects, namely the mediating effect of BMI and the moderating effect of EL. For this reason, a further exploration was carried out to analyse the indirect effects between TOE and DAS through empirical research. This is an outstanding innovation point of this research.

The second innovation point is the choice of independent variables. In most TOE-based CSF studies, TOE are not used as variables but as classifications of CSF. What is often studied is the effects of CSF on DAS under these three classifications. But it would be of little significance if this study repeated it in a similar manner, so we took a step forward to explore the relationship between TOE itself, BMI, EL, and DAS, which made this study more innovative and theoretically valuable.

6.5 Research limitations

There were also some limitations in the study. We hope that future studies will break through these limitations to make more discoveries. Overall, two major limitations of this study are both related to the research subject, as discussed below.

1)Single case study

Because we are studying an innovation event, the natural characteristics of innovation determine that we can choose not too many research objects. For the D-procurement in this study, there are only three to five projects in China that can really meet our research requirements, and due to various reasons, such as commercial confidentiality and data security, few scholars have the opportunity to approach these projects and carry out in-depth research. Thus in fact, we have been lucky enough to study one of these scarce projects. Especially, H Group’s project that was honoured by the Chinese State Council.

For the above mentioned reasons, we did not have any more choices and could only conduct a single case study. Although this research object is already very representative and has a benchmark effect, it is still a single and unique case, and therefore a limitation.

As Suutari et al. (2013) pointed out, limitations of single case study in the generalisability of the findings should be kept in mind. For further studies, more large-scale research evidence is needed around different forms of D-procurement projects in different companies in order to fully capture the realities (Mohajan, 2018).

2)Sample size

According to MacCallum et al. (1999), necessary sample size is dependent on several aspects of any given study, including the level of communality of the variables and the level of overdetermination of the factors.

In this case study, there were enough high-quality respondents in the in-depth interview, but in the subsequent empirical study, although the sample size (N=136) has been achieved within the allowable range 100-250 (Kyriazos, 2018), and the questionnaire results have been maintained by various methods of high quality.

But if the sample size can be larger, such as more than 300 (Tabachnick et al., 2007) or more ideally more than 500 (Comrey & Lee, 2013), then the research results may be more realistic.

In this study, the moderating effect of EL in our study is likely to be verified if a large sample size survey can be conducted. In addition, since the questionnaires were conducted in the same company, the respondents work in the same culture and values for a long time, hence there will be a group consensus effect (Huanhuan Zhang et al., 2019), which will inevitably lead to a certain degree of tendency in the results of the questionnaire survey.

6.6 Further research suggestions

This research opens several new doors for future research on CSF and TOE in the field of digitalisation. We hope that more and more researchers will have the interests and opportunity to conduct in-depth research on the following aspects.

1) Multiple-case study

It is recommended to carry out multiple-case study. As the number of cases increases and the sample size increases, there should be some more discoveries. In addition, more findings can be obtained by comparative study on the differences and similarities from various cases.

2) Cross industry study

The enterprise in this case belongs to the construction industry, and researchers may also consider conducting research in other industries such as agriculture, manufacturing, and service to discover CSF for D-procurement adoption. In addition, research can also focus on finding

out the commonalities and characteristics of CSF in different industries.

3) Longitudinal study

As found in this study, CSF are likely to be different at different periods of technology maturity, management maturity, or environment maturity. Therefore, it is suggested that future researchers can study the relationship between TOE and CSF under different maturity conditions across time.

4) Moderating effect of EL

For digital projects, EL is an indispensable CSF. In this study, EL was discovered through in-depth interview, but it is likely due to the limitations of the single-case study, the empirical study results did not support the moderating effect of EL on the relationship between BMI and DAS. We hope that future research can continue to verify this moderating effect in multiple-cases or large sample size. This effect is very valuable for our understanding of enterprise digitalisation.

6.7 Summary

In conclusion, through this study we have addressed the research problem, we have answered the two originally proposed research questions, and we have accomplished the three research objectives. This research has come to an end, but this is also a new starting point. There are still many research questions that deserve further exploration to answer. Digitalisation is the direction of the times, and we will continue to conduct in-depth research in the future.

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Annex A: In-depth Interview

I. In-depth interview objective

The main objective of the in-depth interview is to refine the Critical Success Factors (CSF) identified on the literature and identify new ones that the interview might reveal. Also, it would be used to classify and rank those CSF according to their perceived importance.

II. In-depth interview method

To achieve the objective, a set of open questions are used to guide the conversation and collect the interviewee's personal opinion. And then, a list of 17 CSF will be given to let the interviewees rank the CSF. Other than the predetermined questions, during the interview there will be some questions not planned in advance will be given according to the progress of the conversation.

III. Interviewee selection

About twenty specialists from H Group and the other partner companies will be selected as the interviewees. They are the persons who participated in the decision, development, and operation of the digital procurement platform.

IV. In-depth interview questions

Thank you very much for your time to accept this interview. It is about 60 to 90 minutes. This is an anonymous interview, your personal information will never be shared to the others. We promise that all the information you provide will be kept strictly confidential and will only be used for this study. And all of the recordings will be deleted after the research work is concluded.

Part 1 Open Questions

1. How long have you been working in this company?
2. What was your role in the DP project? Are you still involved?
3. What is your opinion about the added value of the DP project?

4. What do you think: what are the most CSF for successful digital procurement adoption?

Part 2 Standard Questions

Based on your knowledge and experience, please order the 17 CSF in the table below.

No.	Critical Success Factors	Order
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	Participants 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	

Part 3 Open Questions

Other than the 17 CSF, which else do you think should be included? Please explain the reason and order it in the CSF list according to its relevance.

V. Data collection

For open questions, interviewer will record the answers. For ranking the 17 CSF order, the interviewee will fill up the form. All this information will be collected under confidentiality and only used for this study.

Annex B: Questionnaire Survey

I. Introduction

This questionnaire aims to collect data for an academic work only. The aim is to gain understanding about your opinion towards the D-procurement project carried out by H Group. The collected data by this questionnaire is limited to our scientific research only, and the data will be strictly confidential and will not affect your actual work.

Terminology:

1) Digital procurement platform: refers to the digital platform designed, developed, and operated by H Tech;
2) Digital procurement innovation: refers to the innovation of the procurement business model, including but not limited to multi-party transaction structures, bidding services, purchasing services, financial services;
3) The leader: refers to the founder of H Tech.

Thanks for participating in this survey!

II. Questionnaire

For each question below, please select the most suitable number according to your actual feeling and experience.

No.	Questions	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
	Technology					
1	The network environment of digital procurement platform is fast and reliable.	1	2	3	4	5

2	The use of advanced digital technologies such as cloud computing, big data, blockchain, and artificial intelligence for D-procurement is technologically supportive.	1	2	3	4	5
3	The uniform data standard for D-procurement is significant.	1	2	3	4	5
4	The D-procurement platform is compatible with the other systems.	1	2	3	4	5
5	Using D-procurement platform is easy and convenient.	1	2	3	4	5
	Organisation					
6	H Group's top management is aware of the value of D-procurement.	1	2	3	4	5
7	H Group's top management is willing to invest resources needed to conduct D-procurement project.	1	2	3	4	5
8	H Group is capable to optimise procedures and processes to achieve the D-procurement innovation.	1	2	3	4	5
9	H Tech is committed to upgrade strategy, culture, and organisational structure to adopt D-procurement innovation.	1	2	3	4	5
10	H Group's procurement scale is supportive to carry out D-procurement and make profits from that.	1	2	3	4	5
	Environment					
11	Government policy and legislation support the adoption of D-procurement innovation.	1	2	3	4	5
12	The adoption of D-procurement would offer H Group a stronger competitive advantage.	1	2	3	4	5
13	The value consensus of D-procurement by all partners will promote the adoption of D-procurement project.	1	2	3	4	5
14	The Internet has cultivated good user habits thus making it easier for users to accept D-procurement platform.	1	2	3	4	5
15	The rapid development of the industry digital transformation has played an important role in promoting D-procurement innovation.	1	2	3	4	5
	Business Model Innovation					
16	Compared with most similar companies, the digital procurement model built by H Tech has obvious innovations.	1	2	3	4	5
17	H Tech utilises innovative procedures and processes during the D-procurement business.	1	2	3	4	5
18	H Tech has been committed to continuously building new capabilities in response to changing market demands.	1	2	3	4	5
19	The supply chain finance service provided to buyers and sellers is valuable and innovative.	1	2	3	4	5
20	The D-procurement platform advocate a co-sharing and win-win value with all partners.	1	2	3	4	5
21	Compared with similar digital supply chain platforms, H Tech's D-procurement's profit model has its own characteristics.	1	2	3	4	5
22	The advanced digital technologies applied by D-procurement platform are innovative.	1	2	3	4	5
	Entrepreneurial Leadership					

23	The leader has creative solutions to problems.	1	2	3	4	5
24	The leader demonstrates passion for his work.	1	2	3	4	5
25	The leader perseveres to push forward the project to achieve the goals.	1	2	3	4	5
26	The leader has a vision of future of the business.	1	2	3	4	5
27	The leader is good at motivating team to achieve goals.	1	2	3	4	5
28	The leader encourages trying new things and is willing to tolerate mistakes to achieve goals.	1	2	3	4	5
	D-procurement Adoption Success					
29	The D-procurement project management is effective in terms of time, cost, and quality.	1	2	3	4	5
30	Adoption of D-procurement project achieves procurement management improvement.	1	2	3	4	5
31	Adoption of D-procurement project achieves procurement corruption prevention.	1	2	3	4	5
32	Adoption of D-procurement project achieves procurement cost reduction.	1	2	3	4	5
33	Adoption of D-procurement project achieves procurement risk prevention.	1	2	3	4	5