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Industrial Maintenance Service Quality Evaluation and Improvement Strategies
-A Case Study of A Corporation

Zhang Baihe

Doctor of Management

Supervisors:
PhD Nelson Antonio, Professor,
ISCTE University Institute of Lisbon
PhD Ruoyu Lu, Professor,
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BUSINESS
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Marketing, Operations and General Management Department

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June, 2021

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Zhang Baihe

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Abstract

Improving industrial maintenance service quality is not only essential for service providers to acquire and retain customers, but also plays a critical role in the shift from "Made in China" to "Intelligent Manufacturing in China". The study focuses on the case of Company A to explore how to boost industrial maintenance service quality. Firstly, factor analysis is used to construct an industrial maintenance service quality scale, which is adopted to evaluate the service quality through analytic hierarchy process. Secondly, taking repurchase intention and recommendation intention as the measurement dimensions of customer behavioural intentions, structural equation model is used to explore the effect of industrial maintenance service quality on customer behavioural intentions. Last but not the least, the study explores the key factors that affect the quality of industrial maintenance service, and offers suggestions on how to improve industrial maintenance service quality. The study develops the industrial maintenance service quality scale with four dimensions, namely service professionalism, service reliability, service customization, and service digitization, all of which have direct, significant and positive effects on repurchase intention and recommendation intention. It is also found that industrial maintenance service quality can be improved through successful customer relationship maintenance, brand-building management, and information technology upgrading. Such improvement will contribute to the development of industrial maintenance service providers and promote their transformation and upgrading.

Keywords: Industrial Maintenance Service; Service Quality; Customer Behavioural Intention

JEL: C93, L86

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Resumo

A melhoria da qualidade do serviço de manutenção industrial é não só importante para as empresas fornecedoras destes serviços como também desempenha um papel crítico na mudança da política “Produzido na China” para a política “Manufatura Inteligente na China”. Esta tese tem como objeto de estudo a empresa A e analisa o modo de impulsionar a qualidade de serviço de manutenção. Primeiramente, a análise fatorial é utilizada para construir uma escala de qualidade de serviço de manutenção industrial, que será adoptada para avaliar a qualidade do serviço segundo o processo analítico hierárquico. Seguidamente, tomando a intenção de recompra e intenção de recomendação como dimensões de medida das intenções comportamentais dos clientes, utilizamos o modelo de equações estruturais para estudar o efeito da qualidade do serviço de manutenção industrial nas intenções comportamentais dos clientes. Por último, mas não menos importante, este estudo explora os fatores chave que afetam a qualidade do serviço de manutenção industrial e propõe sugestões para melhoria da qualidade do serviço de manutenção industrial. Esta tese desenvolve a escala de qualidade de serviço de manutenção industrial com quatro dimensões, nomeadamente profissionalismo do serviço, confiabilidade do serviço, serviço personalizado e digitalização do serviço, todas estas dimensões têm efeitos positivos diretos e significantes nas intenções de recompra e recomendação. Esta tese concluiu também que a qualidade do serviço de manutenção industrial pode ser melhorada através da manutenção de relacionamento com o cliente, a gestão de construção da marca e atualização da tecnologia de informação. Estas melhorias irão contribuir para o desenvolvimento das empresas de serviços de manutenção industrial e promoverão a sua transformação e atualização.

Palavras-chave: Serviço de Manutenção Industrial; Qualidade de Serviço; Intenção Comportamental do Cliente

JEL: C93, L86

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摘 要

工业维护服务企业提升服务质量，不仅对获取并保持客户至关重要，也是推动我国从“中国制造”向“中国智造”发展的关键。基于如何提升工业维护服务质量这一学术问题，本文以 A 企业为依托，首先采用因子分析构建了工业维护服务质量量表并采用层次分析法进行质量评价。其次，以再购意愿和推荐意愿作为客户行为意向的衡量维度，采用结构方程模式进一步探讨了工业维护服务质量对客户行为意向的影响。最后基于影响工业维护服务质量的关键因素提出了提升服务质量的对策建议。研究表明：工业维护服务质量量表涉及服务专业性、服务可靠性、服务个性化、服务数字化四个关键维度，对再购意愿和推荐意愿都有直接、显著、正向的影响。同时发现，工业维护服务企业可以从客户关系维护、品牌建设管理、信息技术提升等方面入手提升服务质量。从而助力工业维护服务企业发展并推动工业企业转型升级。

关键词：工业维护服务；服务质量；客户行为意向

JEL: C93, L86

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After five years hard work, I finished my thesis of doctor of management. Honestly, the process was full of frustration, sometimes with a few joys. However, it has been valuable memory in my life.

First, I am particularly grateful to my supervisor Professor Nelson Jose Antonio and Professor Lury Lu, the thesis is finished under their careful guidance which covering whole process from topic selection, problems and questions clarifying, structuring to specifics statements, the whole thesis is embodied their wisdom and hard work. From where, I was baptized and hereby show my greatest respect to their broad and profound knowledge, the great minds' modesty and rigorous scholarship. Moreover, I am also thankful to Professor Virginia and Xiaowen, they pay me encouragement whenever I encounter great difficulties and feel helpless, desperate, which help me to regain my confidence. Additionally, I appreciate Dean Ma Yongkai, who always recharge us by his wisdom, humor and Maotai, make me quickly refreshed from frustrating, on this, send all my best wishes and thanks to all teachers and leaders in the management schools. Second, I would like to specially thank my family, my wife Joey Zhou, her support and understanding enable me concentrating on the study. My two lovely sons, you are my extra power to finish the thesis, I should set a good model myself since I always teach you to do things with persistence, should I?

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Chapter 1: Introduction

1.1 Research background and research significance

As the supply chain of Chinese manufacturing industry is fully in shape and professional specialization is getting more intensive, industrial enterprises are paying growing attention to their core competitiveness so to achieve development of higher quality and efficiency. Professional providers of industrial maintenance services have emerged as the facilitator to the transformation and upgrading of industrial enterprises. The management, operation and maintenance of industrial equipment and system extend from post-failure stage to the entire life cycle, which enables monitoring and predictive maintenance by predicting probable failures. This has dramatically reduced the cost and improved the efficiency of industrial enterprises. At the same time, with the vigorous development of the Industrial Internet, industrial service software has been widely applied to industrial maintenance services, effectively realizing the interaction between man and machine. Therefore, it is of great value to discuss how industrial maintenance service companies can improve service quality in the context of the industrial Internet.

1.1.1 Research background

1.1.1.1 Background of reality

In the wake of a new wave of technological revolution, the Industrial Internet is regarded by major industrial countries as a powerful tool to reshape their competitive advantages. Germany and the United States put forward "Industry 4.0 Strategy" and the "Industrial Internet Initiative" respectively so as to build a digitalized and intelligent industry. As the new global industrial landscape is taking shape, China has been actively deploying its industrial Internet at this critical moment. In 2015, the State Council of China issued the "Internet plus" action plan and "Made in China 2025" strategy with a focus on intelligent manufacturing. Through the application of emerging technologies such as the Internet of things, big data, cloud computing, and artificial intelligence in industrial manufacturing, China aims to transform its traditional mode of production organization and business operation and inject new vitality into traditional industries via industrial Internet. As the key enabler of the fourth industrial revolution, the

Industrial Internet is based on three major systems of network, platform, and security. It provides products and services covering all production factors and the entire value chain to achieve interconnection and interaction among people, machines, and products, making the manufacturing industry more network-based, digitalized and intelligent. Through the intensive combination of information technology and manufacturing technology, industrial Internet can integrate all links in the industrial system and better allocate resources to improve overall production efficiency, exerting a great impact on the industrial economy. China’s manufacturing industry, although large in size, is not strong enough: it is to a large extent positioned in the middle and lower end of the global value chain, intensive in labour but low in profitability and technology level. With the diminishing demographic dividend and rising labour cost, China’s advantage as a low-cost manufacturer is shrinking. On the other land, as Chinese consumers have growing demands for high-end consumer goods, there is an urgent need to accelerate the development of the industrial Internet and the transformation from “Made in China” to “Intelligent Manufacturing in China”.

As the international cooperation and industrial division of labour continue to evolve, the production of goods and provision of services keep differentiating and integrating in various forms in the industrial value chain. With the growing demand of manufacturing industry for services, industrial services gradually separate from the manufacturing industry and evolve into an independent industrial sector. Industrial services directly or indirectly input products or services into the intermediate production process of manufacturing enterprises, who are the recipients of services rather than consumers. Acting as the “adhesive” between industrial sectors and “booster” for economic development, industrial services provide intermediate service inputs for manufacturing sector, which leads to a mutually-reinforcing and interdependent relationship between them. As an important part of industrial services, industrial maintenance service is aimed at providing maintenance service to the equipment and systems of industrial enterprises. Industrial enterprises, as the demand side, will generate growing demand for industrial maintenance service as they experience further division of labour. The highly specialized industrial maintenance service helps industrial enterprises reduce production costs, improve overall efficiency and organizational performance, and enhance their competitiveness. It can be seen that industrial maintenance service companies are highly relevant to industry, intensive in knowledge and sophisticated in technology. Against the backdrop of surging industrial Internet, the provision of industrial services is of great significance to the transformation and upgrading of industrial enterprises. As China is experiencing the “new normal” in its development, the industrial growth has slowed down while industrial maintenance service, as a modern service industry, will have a strong development momentum and act as a contributor to the steady and stable development of Chinese economy. But on the whole, industrial maintenance services in China are still in the preliminary stage, as manifested in the following aspects: firstly, China's industrial maintenance service is much less developed than that of developed countries, and global leading companies such as IBM, SAP, SKF and Siemens are all foreign brands; secondly, high-end industrial maintenance service is not adequately developed or well-structured; thirdly, the external suppliers of industrial maintenance service need to improve their professionalism; fourthly, the competition environment for industrial maintenance service players is not completely open, which leads to entry barriers to the sector; fifthly, China's industrial maintenance service sector and the manufacturing industry are not well interconnected or integrated. The relatively low-level development of China's industrial maintenance service sector cannot efficiently support the development of industrial enterprises, resulting in a relatively weak position in the global competition and a slower pace of industrial transformation and upgrading. In order to accelerate the development of China's industrial maintenance service sector, the State Council issued *the Guiding Opinions on Accelerating the Development of Manufacturing Services for Industrial Restructuring and Upgrading* in 2014. This was the first time for the State Council to make the overall deployment of industrial service and industrial maintenance service, promoting the transition of industrial centres from being production oriented to production-service oriented, and encouraging industrial enterprises to pursue industrial transformation and upgrading through outsourcing some of their non-core businesses. At the 19th National Congress of the Communist Party of China, it was reiterated that China's development should be underpinned by efficiency and quality. A number of policies highlighting industrial upgrading and innovation as the driving force for economic development were promulgated to boost industrial maintenance service and realize its deep integration with the manufacturing industry. In 2017, the National Development and Reform Commission issued the *Development Outline for Service Industry Innovation (2017-2025)*, calling for more professional and premium industrial services, as well as a more competitive industrial system with higher quality. These national policies have provided a great impetus to the development of industrial maintenance service companies, aiming to empower China's manufacturing industry through "manufacturing plus service industry". With the endorsement for industrial Internet from the national government, there has been a surge of breakthroughs in the new-generation technologies such as information technology, Internet technology, and artificial intelligence, blurring the boundaries between industrial sectors. The role of emerging technologies in industrial maintenance service has never been more important.

In the context of the Industrial Internet, it can be expected that China's industrial maintenance service sector will embrace a new round of booming development, receiving even larger service procurement from industrial enterprises in the future. It is therefore crucial for industrial maintenance service providers to attract and retain industrial enterprise customers. Behavioural intention is an important "indicator" of customer behaviour. Ensuring that industrial companies have positive behavioural intentions will help industrial maintenance service companies keep long-term and stable customer relationships. Service quality, as the basis for industrial maintenance service companies to gain a foothold in the market, affects their relationship with the customers. Therefore, it is of great significance to explore how to measure the service quality of industrial maintenance service enterprises and the influence of industrial maintenance service quality on customer behavioural intentions, and to propose strategies to improve the quality of industrial maintenance services.

1.1.1.2 Theoretical background

Service quality is considered as a subjective quality, resulting from the comparison between the customers' perception and expectation. The concept of perceived service quality was first proposed by Grönroos (1984), which was widely recognized among scholars, who however, have not reached a consensus on the its dimensional structure. Breakthrough in the research on service quality elements was then made by Parasuraman (1998) who constructed the famous SERVQUAL model, and held that service quality consists of five dimensions: tangibles, reliability, responsiveness, assurance, and empathy. It was found in later research that SERVQUAL model cannot apply to all industries, and modification is needed in specific contexts (Cronin & Taylor, 1992). Gounaris (2005) went further to point out that the SERVQUAL model, originally proposed for consumer service market, should be adjusted to adapt to industrial maintenance service sector. Regarding the relationship between service quality and behavioural intentions, existing studies mainly focus on consumer services (Fan & Du, 2006; Bloemer et al., 1998), while research in the field of industrial maintenance service is limited (Y. H. Xu et al., 2013). Compared with consumer services, industrial maintenance service is a typical knowledge intensive business service (KIBS), requiring strong capabilities to solve complex problems. The service process is characterized by the two-way flow of resources between customers and service providers, both of whom should be equipped with professional knowledge for effective cooperation (Muller & Zenker, 2001). As industrial maintenance service is highly knowledge-intensive, professional and technically complex, the interaction between customers and industrial maintenance service enterprises is more complicated and frequent. Industrial maintenance service enterprises need to leverage on industrial Internet to push the transformation and upgrading of industrial enterprises (Zhang & He, 2014; Nordin & Kowalkowski, 2010). As industrial maintenance service quality is different from traditional consumer service quality, how industrial maintenance service quality affects customers' behavioural intentions is not clear at the moment. In the context of the Industrial Internet, the empirical study on the measurement dimensions of industrial maintenance service quality and its effect on customer behavioural intentions will expand the applicability and perspectives of service quality research.

1.1.1.3 Research problem and research questions

In the area of consumer services, there has been much research on the measurement dimensions of service quality and its effect on customer behavioural intentions, the results of which have been widely applied in different sectors. Researchers home and abroad have shown that service quality has a direct or indirect effect on customer behavioural intentions. In the field of consumer services, higher service quality contributes to the positive behavioural intentions of customers and long-term and stable cooperative relationships. Based on the results of research on consumer services, and with unique features of industrial maintenance service taken into consideration, this research aims to build an industrial maintenance service quality scale, explore the effect of industrial maintenance service quality on the customer behavioural intentions, and suggest measures to improve industrial maintenance service quality. The author studied lots of literature, conducted interviews with representatives of industrial maintenance service companies and industrial enterprise customers to work out a preliminary scale of industrial maintenance service quality. The scale was then revised based on data from questionnaires to form the final scale of industrial maintenance service quality. The purpose of this research is to explore the specific dimensions of the service quality of industrial maintenance service companies and its impact on customer behavioural intentions in the context of the booming industrial Internet and industrial services. The research questions of this thesis include:

(1) How to measure industrial maintenance service quality in the context of the industrial Internet?

(2) What is the effect of industrial maintenance service quality on customer behavioural intentions in the area of industrial services?

(3) What are the key factors that affect the quality of industrial maintenance service and

what measures should be adopted to improve the quality of industrial maintenance services?

The research aims to develop a service quality scale suitable for industrial maintenance service, draw a conceptual conclusion of whether industrial maintenance service quality has a direct and positive impact on customer behavioural intentions and offer well-targeted measures to improve industrial maintenance service quality. It is hoped that these measures can contribute to a robust and stable relationship between industrial maintenance service enterprises and industrial customers, and more professional industrial maintenance service, which in turn will effectively promote the transformation and upgrading of industrial enterprises and realize the development of “intelligent manufacturing”.

1.1.2 Research significance

1.1.2.1 Theoretical significance

There has been research on the measurement dimensions of service quality and its influence on customer behavioural intentions since earlier times, but scholars hold different views on the dimensions of service quality in different sectors and whether service quality affects customer behavioural intentions in direct or indirect ways. As industrial service sector has its unique characteristics, it is still unclear whether the existing theories on consumer service sector is applicable to industrial maintenance service companies in the context of the industrial Internet. Therefore, it is of great significance to develop a scale of industrial maintenance service quality and explore how industrial maintenance service quality affects customer behavioural intentions in the context of the industrial Internet. If certain correlations can be found between them, the findings will make theoretical contribution to the research on industrial service companies in the fields of industrial control, industrial software, and industrial maintenance, which play a major role in the industry 4.0 era.

1.1.2.2 Practical significance

At present, the overall development of industrial maintenance service in China is at the lower-middle level. Many Chinese industrial maintenance service companies are weak in brands, technology and service provision, far lagging behind the leading international players such as Siemens, General Electric and SKF. Therefore, it is highly relevant and practically significant to find ways to improve the industrial service quality of industrial maintenance service enterprises. Compared with consumer services, industrial maintenance service is more technically complex, and more dependent on long-term relationships with customers. The research on the scale of industrial maintenance service quality and its effect on customer behavioural intentions provides management guidelines for industrial maintenance service companies. The research conclusions will also shed new light on the discussion of industrial maintenance service quality. Therefore, this research has important practical significance for industrial maintenance service companies to improve service quality, establish long-term and stable relationships with their customers, and promote the transformation and upgrading of industrial enterprises.

1.2 Research framework and research content

1.2.1 Research framework

The research framework is illustrated in Figure 1.1.

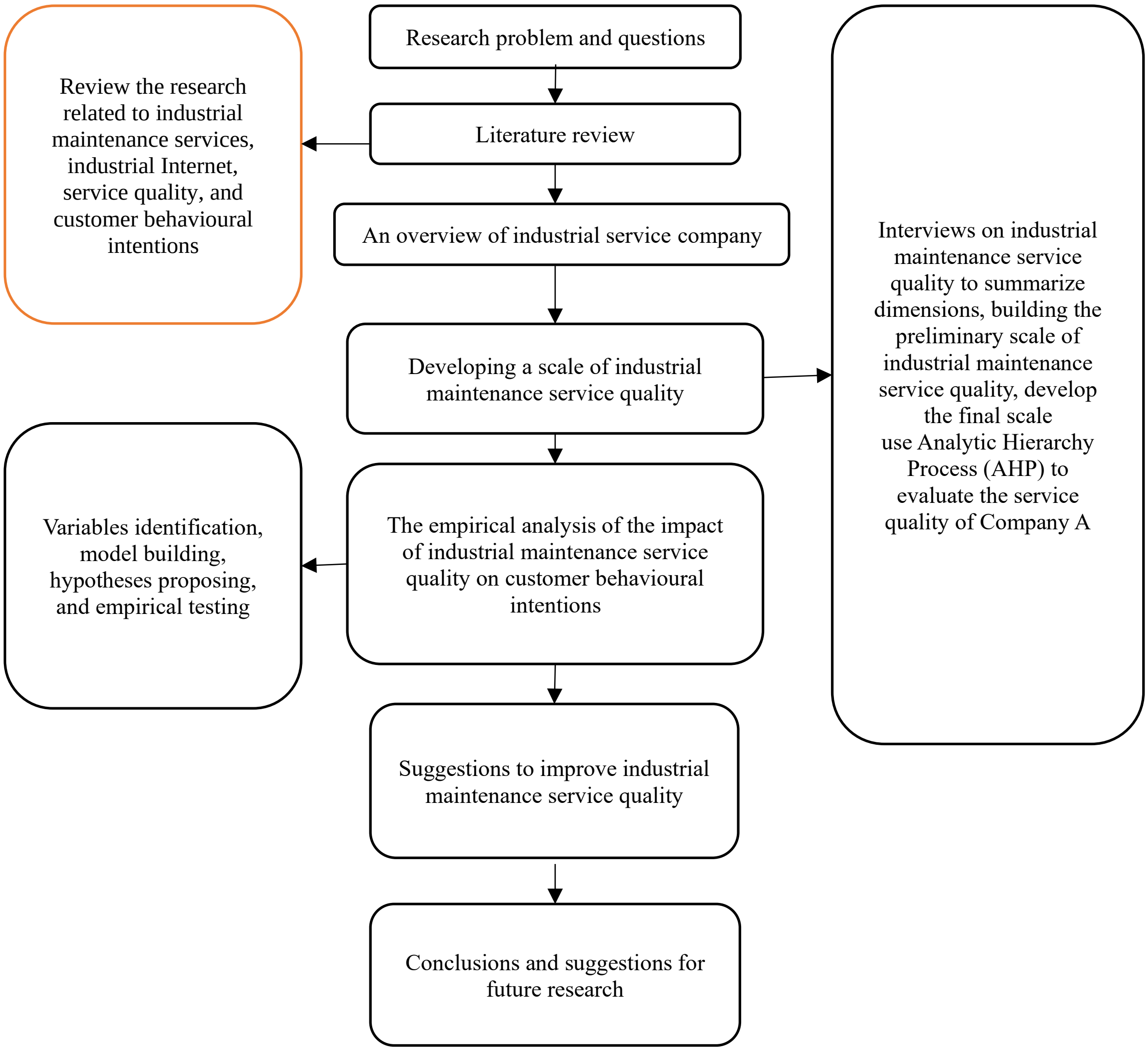

Figure 1.1 Research framework

1.2.2 Research content

From the perspective of industrial maintenance service companies, this research builds measurement dimensions of industrial maintenance service quality, explores the influence of industrial service quality on customer behavioural intentions, and offers suggestions on how to improve industrial maintenance service quality. The thesis structure is as follows:

The first chapter of the thesis is introduction. It illustrates the importance of improving the industrial maintenance services quality for the transformation and upgrading of industrial enterprises in the context of industrial Internet. It is noticed that the existing research has paid limited attention to the quality of industrial services, and there lack clear findings on how industrial maintenance service quality affects customer behavioural intentions. The author raises three research questions, points out the theoretical and practical significance of this research, and introduces the research framework, content and Research methodology.

The second chapter is literature review. This chapter first clarifies the basic concepts of industrial services, the attributes and classifications of industrial services, and the development and types of industrial maintenance service, followed by an overview of the definition and development of the Industrial Internet, and the basic characteristics of the Industrial Internet platform. The author then reviews the research related to service quality and elaborates on the building and development of the SERVQUAL model, which serves as the basis for the modelling of the industrial maintenance service quality scale. Last but not the least, the author introduces the research on behavioural intention, which is essential to modelling how industrial maintenance service quality affects behavioural intention

The third chapter is the description and analysis of the industrial maintenance service offered by Company A. The author introduces the development history of the company and its main offerings, followed by a SWOT analysis to find out its weakness. The author then elaborates on the industrial maintenance service offered by Company A with some specific examples.

The fourth chapter is the construction of industrial maintenance service evaluation model and quality evaluation. Based on literature review, company interviews and expert discussions, the author has extracted the service quality items of industrial maintenance service companies to form a preliminary scale and carried out a questionnaire survey. The data collected from the questionnaire is then processed and analysed with SPSS and AMOS, with four common factors extracted through exploratory factor analysis. The author confirms the four dimensions of industrial maintenance service quality through confirmatory factor analysis and builds the final version of the industrial service quality scale, providing the dimensions for the independent variable in the subsequent building of operational model. The industrial maintenance service quality scale is used to evaluate the industrial maintenance service quality of company A through qualitative analytic hierarchy process (AHP).

The fifth chapter studies the influence of industrial maintenance service quality on customer behavioural intention. The dimensions of industrial maintenance service quality are reflected in the Industrial Service Quality Scale, while the dimensions of customer behavioural intention are extracted from literature review. The author builds an operational model and proposes hypotheses based on theoretical analysis and deduction, which are then empirically tested through structural equation model.

The sixth chapter is about strategies to improve industrial maintenance service quality. Based on the above empirical research results, this chapter further explores the key factors that affect the quality of industrial maintenance services, and proposes strategies for improving the quality of industrial maintenance services.

The last chapter is the conclusion and prospects for future research. This chapter summarizes the research conclusions and the limitations of the thesis, and provides suggestions for future research.

1.3 Research methodology and innovation

1.3.1 Research methodology

Research methodology is crucial to the validity of research results. This thesis uses multiple Research methodology to ensure the data and conclusions are accurate and trustworthy. Specifically, the author mainly adopts the following Research methodology.

(1) Literature research

The author reviews the existing research on industrial maintenance services, industrial Internet, service quality, and behavioural intention in order to provide theoretical support for the construction of the industrial maintenance service quality scale and explore the impact of industrial maintenance service quality on customer behavioural intentions.

(2) Qualitative research

The evaluation of industrial maintenance service quality from the perspective of industrial enterprise customers has its unique characteristics, which are not fully covered by existing literature. As the existing research has not paid enough attention to the dimensions of industrial maintenance service quality, the author carried out interviews to revise the service quality scale for consumer services, with the objective to work out dimensions applicable to industrial maintenance service quality evaluation. Through interviews with employees of industrial maintenance service companies, users of industrial enterprise customers, and experts in the field of industrial maintenance services, the author adjusted and revised the general service quality scale from the literature to ensure the validity of the questionnaire.

(3) Quantitative research

The quantitative Research methodology are used in scale development, questionnaire survey, data analysis and hypothesis testing. To be more specific, the author conducts exploratory and confirmatory factor analysis with SPSS and AMOS software to construct the industrial maintenance service quality scale. The Analytic Hierarchy Process (AHP) is used to evaluate the service quality of industrial service companies. After that, structural equation model is used to test the hypotheses.

1.3.2 Research innovation

Generally speaking, this research is innovative in the following aspects:

(1) An industrial maintenance service quality scale based on SERVQUAL is developed and applied in practice to obtain the evaluation results. The research makes a preliminary exploration on the evaluation model of industrial maintenance service quality based on the SERVQUAL scale, and applies it to Company A to evaluate its industrial maintenance service quality, the results of which are enlightening. The research results show that service professionalism, service reliability, service customization, and service digitization are important dimensions to measure the quality of industrial maintenance services in the context of the industrial Internet. The results also suggest that Company A needs to improve its service professionalism and service reliability.

(2) The relationship between industrial maintenance service quality and customer behavioural intention is explored. It is found that professionalism, reliability, customization and digitization of the industrial maintenance service quality all have a direct and significant impact on customer’s repurchase and recommend intention. Prior research on customer behavioural intention is mainly limited to the field of consumer services, with neither agreement on whether service quality directly or indirectly affects customer behavioural intention, nor in-depth exploration on the relationship and interaction between industrial maintenance service quality and customer behavioural intention.

(3) Key factors affecting industrial maintenance service quality are revealed from the perspective of industrial maintenance service companies. Based on the empirical analysis of the data collected from industrial enterprise customers, the thesis has made some important findings: industrial maintenance service quality, i.e. the professionalism, reliability, customization, and digitization of industrial services, is affected by factors such as customer relationship, brand management, and information technology; long-term and stable relationship with customers, outstanding brand management and strong information technology capabilities have a direct and positive impact on the industrial maintenance service quality. The research findings shed light on the ways to improve the service quality of industrial maintenance service enterprises.

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Chapter 2: Literature Review

2.1 Industrial services

2.1.1 Definition of industrial services

2.1.1.1 Service and service industry

(1) Service

To accurately understand industrial services, it is necessary to first understand the concept of service. Mill (1848) believes that service is the utility produced by labour that is not fixed on any object, and it refers to utility directly produced by labour, rather than that indirectly given by labour in the creation of a certain object. Fuchs (1968) contends that services are provided with the participation of consumers, and disappear after being produced, which is impossible to be stored. Hill (1977) believes that service refers to the change of individuals or objects belonging to a certain economic unit. The change is implemented by another economic unit with the consent of the former economic unit, and service production and consumption occur at the same time. According to Riddle (1986), service refers to activities that bring certain changes to service recipients or their belongings through the provision of time, place, and form utility. Bitner (1992) believes that service is an activity in which a service provider changes the service recipient or their goods at the request of the service recipient. Huang (2002) argues that service is the use value realized in the form of activities, in which one economic entity increases the value of another economic entity. W. H. Zhao (2004) contends that service is an activity that satisfies the needs of others in the form of labour with remuneration paid. There has been no consensus on the concept of service, but the above concepts generally include three common meanings. First, if an individual or a business provides the utility or value directly generated by labour, and makes certain improvements on the service recipients or their objects, the individual or business is considered to be a service provider. Second, service has the characteristics of intangibility, inseparability, perishability, and variability. Intangibility means that the service is not a tangible object, inseparability refers to the simultaneous occurrence of service production and consumption, perishability refers to the fact that the service cannot be stored, and variability means that there are different manifestations in the service process. Third, service can be paid or not paid, and it is a purposeful activity for enterprises or individuals (Zheng, 2008).

(2) Service industry

Since the 20th century, there has been complete and systematic research on the service industry, or the tertiary industry, in the academia. Fisher divided the three major industries for the first time, arguing that the tertiary industry is a sector that provides final services to consumers or intermediate services to producers (Liu, 2016). In 1957, Colin Clark replaced the expression of tertiary industry with service industry, believing that service industry is an industrial sector parallel to the material production industry. In 1968, Fuchs (1968) formally used the concept of “service industry” in his work of The Service Economy (H. B. Guo, 2007). OECD defines the service industry as various economic activities that are not directly related to product manufacturing, agricultural production, and mining. Huang (2002) believes that the service industry is a collection of enterprises or economic units that produce or provide various services. Therefore, the service industry is an industrial aggregate, and the understanding of the concept of the service industry is essentially the cognition of industrial classification. Fuchs (1968) believes that the two criteria for classification of service industries are whether they are closely related to consumption, and whether they are tangible products. If production and consumption are carried out at the same time, and the products are intangible, it is considered to be the service industry.

2.1.1.2 Industrial services

There has been no consensus as for the definition of industrial services in existing studies. Boyt and Harvey (1997) believe that industrial services are different from consumer services as they are business-to-business services offered in the industrial market, usually including maintenance and repair services (such as equipment maintenance and cleaning services) and commercial consulting services such as law, accounting, advertising, and management consulting (Kotler, 1994). On this basis, Homburg and Garbe (1999) further narrowed the connotation of industrial services, arguing that business consulting services do not belong to industrial services. They classified services into consumer services and commercial services based on whether the services were provided to individuals (or groups) or organizations. In commercial services, services provided by service companies (e.g., management consulting companies) are called professional services, and services provided by manufacturing companies (e.g., machinery companies) are called industrial services. Therefore, they define industrial services as services provided by manufacturing companies to organizational customers, including engineering services, training of operating personnel, and maintenance support. Raddats and Burton (2011) believe that for traditionally product-based B2B companies, service is an important source of market differentiation, and services offered based on their products are called “industrial services”, in other words, “industrial services” are the “auxiliary products” of “basic products”. Eggert et al. (2011) contend that there are two main types of industrial services, services supporting the product (SSP) and services supporting the client (SSC). SSP supports the installation and use of the supplier’s core products, and ensure the normal operation (Mathieu, 2001), basic services include spare parts delivery, hotline, equipment repair, inspection and maintenance. SSC refers to services that support customers to act on the product, such as process optimization, research and development, business consulting and operation of the entire process on behalf of customers. SSC is more complex and more dependent on trust, and it often requires a high degree of customization and personalized delivery.

Scholars have interpreted the concept of industrial services from different perspectives. Compared with consumer services, there are mainly three differences as follows. First, industrial services are services provided by businesses to businesses (B2B services), while consumer services are services provided by businesses or consumers to consumers (B2C services); second, industrial services mainly occur in the industrial market, while consumer services mainly occur in the consumer market; third, industrial services are mainly offered based on physical objects (products or action), and consumer services can be offered based on individual consumers. Therefore, this research defines industrial services as physical objects (products or action)-based services provided by businesses to businesses in the industrial market, including SSP and SSC. Companies that specialize in providing industrial services are called industrial service providers. Manufacturing enterprises offer auxiliary industrial services in the selling of products, but they do not provide special industrial services, so general manufacturing enterprises are not industrial service providers.

2.1.2 Attribute and classification of industrial services

2.1.2.1 Attribute of industrial services

Boyt and Harvey (1997) believe that industrial services and consumer services have similar attributes. First, intangibility, it is difficult for customers to sample the service before purchase; second, inseparability, the service cannot be separated from the buyer and seller of the service, and the service is being consumed while being created; third, heterogeneity, affected by different service providers, it is difficult for services to be standardized; fourth, perishability, with fluctuations in demand, services cannot be stored or produced before demand. At the same time, service providers have a certain idle period due to differences in seasons, months, and time of service demand. Y. H. Xu et al. (2013) argue that compared with consumer services, industrial services are more professional and technology-driven, and the services are more complex. Customers pay more attention to the service qualifications, corporate image, and staffing of the service provider, and are looking for long-term service ability. Therefore, we propose that industrial services are intangible, inseparable, heterogeneous, perishable, complex, and professional.

2.1.2.2 Classification of industrial services

Different industrial services are quite different in terms of risk level, competition level, and potential for creating competitive advantage (Oliva & Kallenberg, 2003). Boyt and Harvey (1997) divided industrial services into primary services (simple and frequently purchased services), intermediate services (services that need direct participation of service providers and services with more complicated processes) and complex services (the high cost of service failure requires a high degree of attention to customers) based on six service attributes: substitution rate, importance, risk level, complexity, personal delivery, and trust. Frambach et al. (1997) divided industrial services into two categories: transaction-related services and relationship-related services. Homburg and Garbe (1999) divided industrial services into pre-purchase industrial services (such as engineering services), industrial services delivered at purchase (operating staff training services), and after-sales industrial services (such as technical maintenance services). Kumar and Kumar (2004) believe that this classification method has limitations. Based on the perspective of product sales rather than the perspective of customer needs, there may be differences between the customers' expected services and the setting of the service providers, so he classifies industrial services into planned services (such as spare parts logistics) and unplanned services (such as corrective maintenance). Based on the classification scheme of Mathieu (2001), Eggert et al. (2011) classified industrial services into two categories of services supporting the product (SSP) and services supporting the client action (SSC). As a result, industrial maintenance service is an important component of industrial service.

2.1.3 Industrial maintenance service

2.1.3.1 Development of industrial maintenance service

Industrial maintenance service is an important part of industrial services. All equipment and systems of products manufactured by industrial enterprises need industrial maintenance (Kong, 2003). Industrial maintenance service developed along with the Industrial Revolution and mainly experienced four stages (H. M. Yu, 1992). Before the 1950s, it was the post-maintenance stage. In this stage, the occurrence of equipment failures was considered unpredictable, and maintenance could only be carried out after failures occurred. From the 1950s to the 1960s, it developed to the stage of preventive maintenance, emphasizing that equipment maintenance should focus on prevention. From the 1960s to the 1970s, it developed into a production maintenance system, emphasizing preventive maintenance of key equipment and post-maintenance of ordinary equipment. Since the 1970s, it has entered the industrial maintenance stage, emphasizing the management and optimization of the life cycle of modern equipment (B. S. Xiao, 1997; Y. G. Xu, 1992). In the 1990s, the scope of industrial maintenance service became wider, the contents became more complex, and the role of improving production efficiency and competitiveness of industrial enterprises became more prominent.

In the face of the professional and complex industrial maintenance service requirements, in order to focus on their core business, industrial enterprises outsource industrial maintenance services to professional industrial maintenance service providers (Murthy & Jack, 2008; Campbell, 1995; Martin, 1997). When selecting industrial maintenance service providers, industrial enterprise customers value factors such as overall service performance, total cost reduction, and punctual delivery more than service price (Hatinen et al., 2012; Stremersch et al., 2001). Therefore, industrial maintenance service providers need to provide customers with efficient and effective services in order to create more value for them (Gulati & Smith, 2009). Among them, the Computerized Maintenance Management System, namely, industrial maintenance service software, is an important means for industrial maintenance service providers to use information technology to carry out plant maintenance and asset management, and to achieve overall optimal management of industrial enterprise maintenance service (Yan, 2008).

2.1.3.2 Classification of industrial maintenance service

The purpose of industrial maintenance service is to reduce the adverse effects of equipment failures and maximize equipment availability at the lowest cost (Paz & Leigh, 1994). Lofsten (1999) believes that industrial maintenance service mainly involves preventive maintenance and corrective maintenance. The goal of preventive maintenance is to reduce the possibility of equipment failure after maintenance and the goal of corrective maintenance is to reduce the severity of equipment failures. In response to the two different industrial maintenance service demands, there are mainly two different service delivery strategies: planned maintenance and unplanned maintenance. Planned maintenance is to perform maintenance service according to a predetermined plan, and unplanned maintenance is work performed in time to avoid serious consequences to system performance or to maintain system safety (Corder, 1976). In addition to the above two main types of industrial maintenance service, scholars (Kong, 2003; Luxhøj et al., 1997) also proposed predictive maintenance, condition-based maintenance, expert maintenance and intelligent maintenance. All of the above industrial maintenance services are inseparable from the industrial maintenance service software of professional industrial service providers to inspect and manage the entire life cycle of plant equipment. This thesis focuses on industrial maintenance services provided by industrial software in industrial services.

2.2 Industrial internet

2.2.1 Definition and development of industrial internet

2.2.1.1 Concept of industrial internet

Jeffrey Immelt, CEO of GE, proposed the concept of the Industrial Internet in 2011, arguing that the Industrial Internet is a global open network that connects people, data, and machines (Hu, 2015). In the white paper *Industrial Internet: Pushing the Boundaries of Minds and Machines* issued in 2012, the concept of Industrial Internet was clarified and defined as the intelligent interaction of data, hardware, and software (Evans & Annunziata, 2013), that is, an intelligent industrial network with self-improvement function established through sensor networks, big data analysis and software system (S. Yang, 2015). In June 2013, GE introduced the concept of Industrial Internet to China for the first time, believing that Industrial Internet is an ultimate integration of analytical sensor technology, advanced computing, and the Internet with global industrial systems. Through connection by intelligent machines and based on software and big data analysis, human-machine connection is realized, and the industrial system is reconstructed to stimulate production efficiency. Xing (2014) mentioned that Industrial Internet is a concept that combines industry and the Internet. Its essence is to connect equipment, production lines, factories, suppliers, products, and customers through an open and globalized industrial-grade Internet platform for efficient sharing of various element resources in the industrial economy as well as reduce costs and improve efficiency through automated and intelligent production methods so as to promote the extension of the industrial chain of the manufacturing industry, and achieve transformation and development. Shen (2013) and S. Yang (2015) believe that Industrial Internet is an Internet of things, machines, computers, and people. It uses advanced data analysis methods to assist in providing intelligent industrial operations and changing business output, and it is an integration of global industrial ecosystem, advanced computing and manufacturing, pervasive perception, and ubiquitous network connections. In spite of differences in the expressions of the concept, they all include the following elements. First, the means of the Industrial Internet is to realize the allocation of industrial resources through intelligentization, digitization, automation, and networking. Second, the result of the Industrial Internet is to realize the connection and integration among people, machines and data. Third, the goal of the Industrial Internet is to reduce costs and increase benefits in the industrial field, and realize the transformation and development of the manufacturing industry.

2.2.1.2 Development of industrial internet

The emergence of the Industrial Internet is a product of the integration of the development of Internet information technology and industrial technology, and its root lies in the fact that advanced technologies such as the Internet need to be more effectively used in the field of industrial production. The concept of Industrial Internet came into being in a global environment of fierce competition, and it was proposed by the American company GE in 2012 to respond to the concept of Industry 4.0 proposed by Siemens. These two concepts are both based on the understanding of the control field and the prediction of the direction of technological development, and they have been widely recognized by the industry and have been upgraded to national strategies. First of all, strong demands are the fundamental reason for GE to propose Industrial Internet. GE mentioned in the Industrial Internet white paper that as long as the Industrial Internet achieves 1% cost savings in the next 15 years, 30 billion, 66 billion, and 27 billion US dollars' worth of value will be created in aviation, power, healthcare, and railway industries respectively (Evans & Annunziata, 2012). Second, the Industrial Internet uses cyber physical systems (CPS) as its development core. GE defines the Industrial Internet as "big data plus Internet of things", while Rui (2014) directly refers to the U.S. industrial strategy as the CPS strategy. Furthermore, the Industrial Internet takes integrated development and industrial upgrading as its development direction. In the Industrial Internet, GE focuses on the upgrading and transformation of traditional industries in order to achieve the upgrading in key industrial fields. After the concept of the Industrial Internet entered China, the Chinese government has successively issued *Special Action Plan for the Deep Integration of Informatization and Industrialization (2013-2018)*, *Made in China 2025 (2015)*, and *Guiding Opinions on Deepening "Internet plus Advanced Manufacturing Industry" to Develop Industrial Internet (2017)*, requiring to increase investment in the Industrial Internet industry to achieve a close integration of the Internet and industrial entities.

2.2.2 Industrial internet platform

2.2.2.1 Reference architecture of industrial internet platform

The industrial Internet platform is a new thing that evolves and rises in the context of the development of the industrial Internet. It is an application of platform economy in the industrial field, and an innovative change of the production and organization means in the industrial field driven by digital technology (Y. Li, 2019). The industrial Internet platform, as the cornerstone of further deepening of the "Internet plus advanced manufacturing industry", is the product of deep integration of the Internet technology and the manufacturing industry, and will exert an important and revolutionary impact on future industrial development (J. W. Wang, 2018; G. Q. Li, 2016). The development of the industrial Internet platform is one of the main issues in the promotion and development of the industrial Internet, and its basic architecture has received continuous focus and attention from the industry and academia. The Industrial Internet Consortium (IIC) of the United States first proposed the Industrial Internet Reference Architecture (IIRA) consisting of data collection layer, IaaS layer (cloud infrastructure), management service platform layer (industrial PaaS), and application service layer (industrial APP). From the functional perspective, the architecture can be divided into five interrelated levels: the control domain, the operations domain, the information domain, the application domain, and the business domain (X. L. Yang, 2019). Guth et al. (2018) analysed the similarities and differences of several different industrial Internet platforms, and proposed a general reference architecture including sensors, industrial equipment, integrated middleware, applications, and actuators. F. Wang (2017) divided industrial Internet platforms into three categories: resource optimization platform, resource allocation platform, and universal platform, and put forward targeted promotion suggestions. X. W. Wang (2017) proposed an Internet of Collaborative Manufacturing (IoCM) architecture in the manufacturing industry by comparing the initial design focus and the final realized function of the Predix and MindSphere platforms. J. Li et al. (2018) proposed an industrial Internet platform composed of infrastructure layer (IaaS), platform layer (PaaS), and application layer (SaaS). This platform involves core functions of IT resource scheduling management, industrial resources connection and optimization configuration, industrial big data management and mining, management and iterative optimization, and full life cycle environment and tool services covering industrial APP. Among them, the core platform layer of the Industrial Internet is the Industrial Internet system or industrial APP integrated system, which is mainly composed of the perceptual recognition layer, the network connection layer, the platform convergence layer, and the data analysis layer.

2.2.2.2 Core functions of industrial internet platform

The application of the industrial Internet platform at the enterprise level needs adaptive development according to the main functions of the platform, so the core functions of the platform will determine the enterprise's choice and application of the industrial Internet platform. The basic functions of the industrial Internet are to realize the collaboration and utilization, and even coordination and utilization across regions and domains of enterprise resources through interconnection. The industrial Internet platform mainly has the following core functions. First, the capability of information infrastructure management and overall control of operations. In order to reduce the cost of corporate investment in IT and improve operational efficiency, the industrial Internet platform has the ability to manage and allocate the included software resources and hardware resources. The method is to first use low-cost methods such as leasing, sharing, and purchase to establish a cloud infrastructure carrier to realize the unified distribution of IT resources, and second dynamically manage IT resources and charge on-demand to obtain the technology needed by the company in an efficient and inexpensive manner. Second, the capability to optimize the allocation of digital industrial resources. The industrial Internet platform needs to have the ability to perform data processing on human, machine and other resources, as well as to carry out structural modularization, so as to realize the optimal allocation of platform resources. It is necessary to digitalize industrial resources such as machines, personnel, and materials to integrate them into the industrial Internet platform. Then these data are modularized in a standardize way, the combinations of modules are optimized, and the modification and reconstruction capability of the modules is improved. After that, through the optimization of industrial resource allocation services, the resources are connected and shared. Third, industrial data management and analysis technology. The purpose of management and analysis of industrial data is to construct an industrial knowledge system, and its data management and analysis capabilities are reflected in the scientific nature of the construction of the industrial knowledge system. The internal value system of data is found through data collection and data exploration and mining technology, and it is applied to the intelligent execution process of actual subjects through scenario-based application. The industrial knowledge system learns algorithm through machines and can constantly iterate based on data and knowledge. The industrial Internet platform is used as the carrier of the industrial knowledge system and a place for debugging applications. Fourth, the capability to provide an environment where micro-services and industrial APPs are continuously updated. The industrial Internet is not only the carrier of micro-services and industrial APPs, but also serves as a potential developer of industrial APPS to meet various role requirements of enterprises. It will not only help the continuous iterative update of the industrial Internet platform itself, but also help industrial Internet firms and business users to enhance their soft power. Fifth, the capability to continuously create ecological cycles. This capability is mainly to form an atmosphere of mutual learning and joint promotion through the universal application and sharing of data under the security mechanism. It is an attempt to break the boundaries of not only the enterprises, but also the industry and the profession to achieve precise and efficient allocation of resources.

2.3 Service quality

2.3.1 Characteristics and attributes of service quality

2.3.1.1 Concept of service quality

In the 1970s, research on service quality began in Northern Europe. Since the service itself has the characteristics of intangibility, inseparability, perishability and variability, there are certain differences between the concept of service quality and product quality. In 1978, Sassers first distinguished between intangible service quality and tangible product quality. Chinese and foreign scholars have carried out in-depth research on service quality and great results have been achieved. Lewis and Booms (1983) contend that service quality is an important manifestation of corporate image and a tool to measure whether the service level meets customer expectations. The delivery of high-quality services by companies is an important prerequisite for obtaining customer attention and recognition. Early research on service quality focuses on the impact of service quality on consumers. The higher the quality of the service, the higher the satisfaction of consumers and the greater the chance of repurchase. Grönroos (1984) promoted a breakthrough in research on service quality from the perspective of customer perception, arguing that service quality is the gap between customer perceived service and customer expected service. In Gronroos's definition of service quality, it is emphasized that customer evaluation is an important reference for defining the level of service quality. If the service experience obtained by customers meets or exceeds their expectations, then their evaluation of the service quality will be high, and the service quality of the company will also be high. In addition, he also emphasized that customer perceived service quality is also of great significance to the evaluation of corporate image, and proposed a model of customer perceived service quality. According to Kotler (1994), customers' actual perception of service is related to their expectation. The perceived service quality must be higher than the expectation for customers to be satisfied with the service quality. Therefore, the service quality is dependent on customer expectation. This view demonstrates that service quality is essentially a kind of customer perception, and a result of comparison between customer service expectations and service experience.

Based on the comparison between perceived service and expected service, many scholars further simplify the concept of service quality and believe that service quality is the subjective feelings of customers on service. Parasuraman, Zeithaml, and Berry (referred to as PZB) (Parasuraman et al., 1985) further defined the concept of service quality, arguing that service quality is the subjective feelings of customers to evaluate the service as it is delivered in the interaction between service providers and customers, and customers play a decisive role in this process. It is a kind of customer "attitude". J. B. Patterson and Marks (1992) believe that service quality affects customers' overall feelings and attitudes towards the service after the delivery of the service, and will affect their intention to purchase again. He and Su (1995) define service quality from the perspective of social groups, contending that service quality is the perception and evaluation of a representative group of a certain service, and the perception and evaluation have a certain long-term and stable satisfaction.

2.3.1.2 Dimensions of service quality

Scholars generally accept the view of perceived service quality. Afterwards, a large number of scholars have explored a more in-depth definition and classification of service quality based on this idea. However, scholars have different opinions on the components of service quality, and there is no systematic and complete definition. Grönroos (1982) first proposed a three-dimensional model of perceived service quality: corporate image, technical quality, and functional quality. Subsequently, many service quality dimensions were further developed based on this. Later, Grönroos (1984) revised it and proposed a two-dimensional model, in which service quality consists of technical quality and functional quality. Technical quality runs through the entire service process and refers to the service results obtained by customers after the service is terminated, that is, what quality is obtained by the customers, so it is also called outcome quality; functional quality describes how employees deliver services to customers, and refers to the service perception obtained by customers in the interaction process, that is, how customers obtain quality, so it is also called process quality. Rust and Oliver (1994) believe that service locality should also be considered on the basis of technical quality and functional quality, and proposed that service quality is composed of three elements: service products, service delivery and service environment. Bai and Chen (2005) further divided functional service quality into four dimensions: standardization, stability, security, and service remediation based on the dimensions of functional quality and technical quality. Process service quality was divided into service interaction interface, service process, service standard, employee service performance, service facilities and tools, service expectation management, service commitment, and service complaints, which was verified by empirical research.

In addition to the classification of functional quality and technical quality, there are some other representative ways to classify service quality. Lehtinen and Lehtinen (1991) defined service quality from the perspective of service production, namely, tangible quality, interactive quality, and overall quality. Tangible quality refers to the tangible aspects including material quality and equipment quality. Interactive quality refers to the quality of behaviour in the process of direct contact between customers and service companies. Overall quality refers to the customer's impression of the service organization based on past service experience and public service evaluation, and is a comprehensive evaluation of the service quality of the service provider. Liljander and Strandvik (1995) believe that scenario perception and relationship perception constitute customer perceived service quality. C. X. Wang et al. (1999) argue that service quality can be divided into environmental quality, emotional quality, interaction quality, skill quality, and relationship quality. Brady and Cronin (2001) divided service quality into outcome quality, interaction quality and environment quality. W. H. Zhao (2004) divided service quality into interaction quality, physical environment quality, and outcome quality, and empirically tested this classification method and explored the relationship between service quality and user satisfaction. Fan and Du (2006) believe that technical quality and interaction quality constitute service quality, and interaction quality is an important determinant of service quality. W. H. Zhao (2004) argues that information communication and communication technology are the key to service quality. Rhee and Rha (2009) divided service quality into process quality, relationship quality, outcome quality and design quality.

2.3.1.3 Characteristics of service quality

There are also studies on the characteristics of service quality, most of which explore the expected and perceived key service elements the perspective of customers. In 1980, British Airways first studied characteristics of service quality, and found that the factors affecting customer perceived service quality mainly include care and understanding, problem-solving capability, responsiveness, and service recovery capabilities. Later, Parasuraman et al. (1985) proposed the most representative PZB customer perceived service quality model, and believed that the service characteristics that affect service quality mainly include reliability, responsiveness, security, tangibles, credibility, accessibility, ability, communication, politeness, and understanding. In 1988, PZB further simplified these ten elements into five: tangibles, reliability, responsiveness, assurance, and empathy, forming the SERVQUAL scale widely used afterwards. On this basis, scholars have improved these elements and put forward some other service quality characteristics. Williams & Zigli (1987) believe that the attributes of service quality include security, availability, immediacy, integrity, attitude, and context. Ivancevich et al. (1997) argue that service quality should be measured by characteristics such as reliability, responsiveness, tangibility, security, and consideration. X. Q. Wu (1997) contends that service quality consists of economy, functionality, safety, civility, and comfort.

2.3.2 Evaluation and measurement of service quality

2.3.2.1 Service quality gap model

Parasuraman et al. (1985) believe that the perceived service quality is the result of comparison between the expected service and the perceived service, and the service quality needs to be evaluated from the perspective of customers. Due to the influence of previous experience, image of the service provider, social evaluation, and public opinion publicity, each customer has his own service needs and service expectations before receiving the service; after receiving the service, the customer will form a practical understanding and feeling of the service. By comparing the perception after receiving the service and the expectation before receiving the service, the level of service quality of the service enterprise is determined. If the perceived service is lower than the expected service, the customer will consider the service quality to be poor and thus feel dissatisfied; if the perceived service is higher than the expected service, the customer will consider the service quality to be good and therefore feel satisfied. In order to express service quality in the form of data, Parasuraman et al. (1985) proposed the formula: $Q=P-E$. P stands for perceived service, E stands for expected service, and Q stands for service quality. Thus, three relationships about service quality can be drawn. $P>E$ means perceived service exceeds expectation, and the service quality is high; $P<E$ means perceived service is lower than expectation, and the service quality is low; $P=E$ means that the perceived service is equal to expectation, and the service quality is acceptable.

Furthermore, Parasuraman et al. (1985) constructed the GAPS model to try to explain the reasons for the gap between customer perceived quality and customer expected quality. The GAPS model is based on five dimensions of tangibles, responsiveness, assurance, empathy, and reliability of service quality, and describes the following five gaps. The first is the gap between the perception of customer expectations by the internal managers of the enterprise and the actual expectations of the customers; the second is the gap between the perception of customer expectations by the internal managers of the enterprise and the actual service standards set by the enterprise; the third is the gap between the actual enterprise service and the established service standards; the fourth is the gap between the actual service and the service commitment outside the enterprise; the fifth is the gap between the service expected by the customer and the actual perception. On this basis, Parasuraman et al. (1985) revised the original service quality gap model in 1993, further divided customer expectation into adequate expectation and desired expectation, and defined the gap between the two expectations as the zone of customer tolerance. They further divided the original five gaps, and proposed the adequate service gap between the perceived service quality and the adequate expectation, and the excellent service gap between the perceived service quality and the desired expectation. In addition, Parasuraman et al. (1985) divide the influencing factors of the customer expected service quality into controllable factors such as service commitment and uncontrollable factors such as customer self-recognition experience. The service quality gap model exerts a wide range of influences, and has important guiding significance for the analysis of service process. It provides rich and excellent information for service enterprise managers, which is an important theoretical basis for promoting service quality improvement.

2.3.2.2 SERVQUAL measurement of service quality

(1) SERVQUAL scale

With the deepening exploration of service quality by scholars, how to measure service quality has gradually become the focus of attention. In order to accurately measure the service quality of enterprises with the smallest error, scholars have carried out substantial research and achieved certain achievements. Parasuraman (1998) made a breakthrough in the in-depth study of service quality elements, and constructed the SERVQUAL model based on the theory of service quality. This model is composed of two parts, the customer’s expectation of the service quality of the enterprise and the perception of the service quality. The service quality score of each dimension is derived from the gap between the perceived quality score and the expected quality score. SERVQUAL is a seven-point Likert scale composed of five dimensions and 22 items to measure service quality. Parasuraman et al. (1985) summarized the original ten factors that affect service quality into five categories, forming five dimensions, namely, tangibles, reliability, responsiveness, assurance, and empathy. Among them, tangibles refer to tangible facilities, equipment, personnel and communication equipment, reliability refers to the delivery of accurate and reliable services to customers in accordance with service commitments, responsiveness refers to the desire to help customers and provide services quickly, and assurance refers to the confidence, knowledge, etiquette, and ability expressed by employees, and empathy means putting oneself in the shoes of customers and paying special attention to customers. The scale is based on customer perception and measures the subjective attitude of customers. It first measures the expectations of customer service quality, and then quantifies the customer's perception of the actual service level. Then it compares the differences between the two to measure service quality. Scholars are full of confidence in the SERVQUAL scale as a tool to measure service quality. The scale is widely used in empirical research on the measurement and evaluation of service quality in different industries and is considered to be the most typical method to evaluate service quality.

(2) Modification of SERVQUAL scale

The formation of the SERVQUAL scale solves the problem of lack of quantitative research on service quality, but it also has certain shortcomings. Carman (1990) first questioned the SERVQUAL scale, arguing that the scale's scores of service expectation and service quality are all post-event data. Customers who score service expectation after receiving services may be affected by perceived service. Asubonteng et al. (1996) also found that the SERVQUAL scale is not applicable to all service industries, and the five dimensions may produce inconsistent results when used in different industries. Faced with the questioning, PZB further studied and revised the SERVQUAL scale. Based on the investigation of the three service industries of banking, insurance, and telecommunication maintenance, Parasuraman et al. (1996) changed the expected ideal standard (should) to the predictive standard (would, will), and changed the rhetorical questions into positive sentences in the 22 items. The tone was also revised at the same time, which improves the reliability and validity of the revised scale. However, the service quality in the revised SERVQUAL scale is still measured by the gap between the perceived service and the expected service, which is essentially the same as the SERVQUAL scale.

(3) SERVPERF scale

Cronin and Taylor (1992) believe that the SERVQUAL scale has conceptual and measurement problems, and thus proposed another service quality measurement method based on perceived service performance. By further revising the SERVQUAL scale, the SERVPERF scale was formed. The SERVPERF scale is based on the same items as the original SERVQUAL scale, but does not use the gap comparison method in the SERVQUAL scale. Only service performance is selected as a single variable to measure the service quality perceived by customers. The measurement does not involve weighting issues, and the evaluation of service quality is based on the actual customer perception. After comparing and studying the SERVQUAL scale, the PZB modified SERVQUAL scale and the SERVPERF scale, Cronin and Taylor (1992) found that the SERVPERF scale is simpler, which reduces the burden on respondents and makes the data processing process simpler. It is also more practical and precise in some domains.

2.3.2.3 Industrial service quality

Homburg and Garbe (1999) were the first to measure the quality of industrial service, and they believe that the quality of industrial service consists of structural quality, process quality, and outcome quality. Structural quality refers to the tools and resources available to the service providers, as well as the physical organization environment in which they work. It mainly includes the human, material and financial resources required for industrial service, and is related to the technical qualifications and availability of service personnel. Process quality refers to the activities carried out between the service providers and the customers, including not only technical elements such as information technology in the service delivery process, but also interpersonal elements such as the friendliness of industrial service personnel. Outcome quality refers to the outcome after the service is delivered, including technical outcomes such as the machine working normally again and attitude outcome such as being very satisfied with the service outcome. Similarly, Su et al., (2010) contend that in the industrial service market, customers not only pay attention to the current service quality and level, but also pay attention to the long-term and sustainable service quality and level. Therefore, Y. H. Xu et al. (2013) argue that, in addition to the service process and service outcome, the service capabilities of industrial service providers, that is, the hardware equipment of suppliers, should be included in the measurement of service quality, thereby increasing the hardware environment quality in the traditional consumer service quality dimensions. He proposed to measure industrial service quality from three dimensions of technical quality, functional quality, and hardware environment quality. However, the above measurement of industrial service quality is only an improvement based on the measurement dimension of consumer service quality, and does not consider the impact of industrial Internet. In terms of industrial Internet, some scholars have discussed the service quality of management software and information system. Bailey and Pearson (1983) put forward 39 indicators such as the degree of participation of management, the competition on resources, and the priority of resource allocation to evaluate information system through a survey of 29 IT leaders. Ives et al. (1983) integrated 39 indicators into 13 after surveying 100 production supervisors in the manufacturing industry. R. Guo (2015) compared the management software industry with other industries in terms of service composition, willingness to communicate, customer relations, service evaluation, and tangibility, and made certain adjustments and improvements to the SERVQUAL scale based on this. On the whole, scholars pay much less attention to industrial service quality than consumer service quality, and no consensus has been reached as for the measurement and evaluation of industrial service. Few scholars pay attention to the industrial maintenance service quality in the context of industrial Internet. In the industrial market, the measurement of industrial maintenance service quality based on industrial software has not been discussed.

2.4 Behavioural intention

2.4.1 Concept of behavioural intention

2.4.1.1 Definition of behaviour

In psychology, human behavior is composed of a series of actions that point to a certain goal and adopt a certain way or method based on certain knowledge (Che, 2001). Behaviour is usually generated on certain conditions. It is believed in early research that behaviour is a response triggered by external stimuli. This view denies the role of subjective consciousness and internal experience, and simplifies complex behaviour (Wei, 2011). Later, American psychologist Tolman (1938) added subjective attitudes and mental states as intermediary variables between external stimuli and behavioural responses, and he contended that the action of external stimuli on organisms can only be reflected on behavioural responses through internal mental state. Furthermore, German psychologist Lewin (1997) believes that in addition to the internal psychological state, human behaviour is also related to the environment, and behaviour will have different forms of response due to differences in time and space. In summary, external stimuli generate behavioural responses by influencing people's internal psychological state and subjective perception, and this process is also affected by the external environment.

2.4.1.2 Origin of the concept of behavioural intention

In the research on customer behaviour, scholars mostly use the concept of "customer behavioural intention" to replace "customer behavior" (Fang, 2015). The concept of behavioural intention comes from the Attitude Theory. Ajzen and Driver (1992) had identified three different dimensions of attitude which are cognitive, affective and conative. According to the Attitude Theory, cognitive and affective dimensions are the determinants of attitude, and an individual's behavioural intention is determined by attitude (Ajzen & Fishbein, 2000).

Research on attitude has always been the focus of social psychology, and scholars have defined the concept of attitude from multiple angles. From the perspective of behaviorism, Cantril and Allport (1936) pointed out that attitude is a state of mental readiness, which influences the individual's response to the situation through past experience. However, according to Krech and Crutchfield (1948), attitude is generated based not on past experience, but on current experience. Individuals construct attitudes based on their own thinking. Morale psychology proposes from the perspective of morals and values that the formation of attitude is based on personal morals and values, including three dimensions of inner feelings, emotions, and intentions, thereby forming evaluations of things and behavioural tendencies (Ma, 2014). The theory of planned behaviour believes that attitude refers to an individual's positive or negative feelings about a certain behavior. In other words, an individual's attitude is formed after he conceptualizes behavioural evaluation (Ajzen, 1991). It can be seen that attitudes are not inherent, but are gradually formed through the process of socialization in the acquired environment. Among them, desire, knowledge and personal experience are important factors that affect the formation of attitudes. It is worth noting that attitude is a process of gradual formation. Kelman (1958) proposed that attitude formation requires three stages: compliance, identification, and internalization. In addition, attitudes are not static. When the subject receives new external information, the new information will trigger a change in the subject's attitude.

Social psychologists have conducted substantial research on the relationship between attitude and behaviour, but have not reached a consistent conclusion. Wicker (1969) believes that the correlation between attitude and behaviour is low. However, studies in the fields of consumption and politics have confirmed a high degree of correlation between attitude and behaviour (M. Zhao, 2010). It can be seen that the relationship between attitude and behaviour is relatively complex and is often affected by many factors (D. Yu et al., 2008). Therefore, it is necessary to analyze the characteristics of attitudes in a more in-depth manner so as to have a deeper understanding of the relationship between attitude and behaviour. Attitude mainly has the following four characteristics (M. Zhao, 2010). First, intensity, that is, the degree of like or dislike of the target object. It can directly affect the information judgment ability and behavioral decision-making process, and a relatively tough attitude is not easy to change. Second, resistance, that is, the degree to which the attitude is not easy to change. The formation of a person's attitude often takes a long time, and once the attitude is formed, it will have a certain degree of persistence and stability. Third, persistence, that is, the degree of persistence of attitude change over time. If a person shows a constant and stable tendency to like or dislike the target object, then the correlation between attitude and behaviour will be higher. Fourth, confidence, that is, the degree of firmness of an individual in believing the correctness of his attitude. The firmer the confidence in the attitude, the harder it is to change the attitude. At the same time, personal attitudes are also very susceptible to other factors, so the relationship between attitude and behaviour is more complicated. In the process of studying the relationship between attitude and behaviour, it is often necessary to adopt more accurate methods for different situations and even different individuals in order to obtain more scientific results.

2.4.1.3 Definition of behavioural intention

Since the buying behaviour of customers is determined by various complex factors, it is generally not easy to quantify. Fishbein and Ajzen (1975) believe that behavioural intention is the individual willingness to perform a certain behaviour, that is, the subjective probability of engaging in a certain behaviour, and it is the best indicator for behavioural prediction. Doll and Ajzen (1992) contend that intention is a necessary process of behavioural performance, reflecting the intensity of intention to complete a certain behaviour. Ajzen and Driver (1992) argue that behavioural intention is the direct driving factor of real behaviour. The stronger the individual's intention to complete a certain behaviour is presented, the more accurate the behaviour can be predicted. Zeithaml et al. (1996) believe that behavioural intention can be divided into positive behavioural intention and negative behavioural intention. Positive behavioural intention refers to the positive evaluation made by customers towards the services or products and the service provider after they experience the services or products, and it includes the behavioural tendency of recommending products or services to other customers, repeatedly purchasing products or services, being loyal to the service provider, and actively communicating and interacting with the service provider. Negative behavioural intention refers to the negative evaluation of the services or products made by the customer, and it includes the behavioural tendency of reducing the volume of transactions or withdrawing from the service provider, such as complaints and turning to a competitor company. Harrison and Shaw (2004) believe that behavioural intention is the intensity of a spontaneous plan to engage in a certain behaviour. Without the influence of other environmental factors, individuals with stronger behavioural intention are more likely to engage in a certain behaviour. R. Han and Tian (2005) argue that behavioural intention refers to the intention to recommend, purchase and repurchase that customers may adopt after consumption experience. Jing (2009) believes that behavioural intention refers to the behavioural tendency that customers may adopt towards the service provider and products after experiencing the service. Based on existing research, this thesis defines behavioural intention as the intensity of willingness to take a certain behaviour after customers experience the service. In the context of industrial service, behavioural intention is the recommendation intention and transaction intention of customers after experiencing the service. It will affect their subsequent repurchase behaviour and can be used as an important indicator to predict customer behaviour.

2.4.2 Dimensions of behavioural intention

2.4.2.1 Division of the dimensions

As for the measurement of behavioural intention, scholars have proposed different measurement dimensions. Parasuraman et al. (1996) proposed a behavioural intention scale containing five dimensions including loyalty, switch, pay more, external response, internal response and thirteen items. Loyalty refers to the strength of the relationship between the customer and the service provider, as well as the possibility of the customer to conduct multiple transactions; switch refers to the possibility of the customer reducing the transaction with the service provider and turning to the competitor; pay more refers to the possibility that customers still want to trade even if the price of a product or service increases; external response refers to the possibility that customers will complain to others or turn to competitors when they encounter problems in the service process; internal response refers to the possibility that customers encounter problems during the service process and want to complain or respond to the service staff. Boulding et al. (1993) measured behavioural intention with two indicators: repurchase intention and recommendation intention. R. Han and Tian (2005) measured behavioural intention in terms of switch intention and recommendation intention. Alexandris et al. (2002) used four dimensions of word-of-mouth communications, purchase intentions, price sensitivity, and complaining behaviour to measure behavioural intention. Y. Wang et al. (2004) used purchase intention, recommendation intention, and close relationship intention to measure customer behavioural intention. Cronin et al. (2000) used the possibility of buying again, the possibility of recommending to relatives and friends, and the possibility of making the same choice if going back to the past to measure customer behavioural intention. Haemoon (2000) used the possibility of buying again, the possibility of recommending to others, and the possibility of becoming a frequent customer to measure behavioural intention. Bigne et al. (2001) used five dimensions of purchase willingness, repurchase willingness, purchase intention, spending intention, and consumption intention to measure customer behavioural intention. Dong and Jin (2003) used repurchase willingness, word-of-mouth, and premium purchases to measure customer behavioural intention. M. L. Chen (2004) used repeat purchase intention, cross purchase willingness, and price tolerance to measure customer behavioural intention.

Based on existing research, it is found that repurchase intention and recommendation intention are very important for service providers. On the one hand, retaining an existing customer will cost less than attracting new customers. Most of the company's profit growth is attributed to the contributions of existing customers, and repeat purchases can reduce the need for an enterprise to attract new customers, highlighting the importance to retain customers (I. J. Chen & Popovich, 2003). On the other hand, loyal customers can also provide free publicity for the company, and customer verbal recommendations are also very important. L. Wu et al. (2014) found that customer verbal promotion can reduce customer's perceived risk and increase repurchase intention. Customer behavioural intention is more important to industrial services, because industrial services are often recommended in the form of projects and services are delivered through contract signing, which are often continuous. Industrial services are more susceptible to customer behavioural intention. Based on this, this thesis divides customer behavioural intention into repurchase intention (behavioural loyalty) and recommendation intention (attitudinal loyalty). Repurchase intention refers to the customer's willingness to repurchase the service and maintain a relationship with the service providers, and it is measured by three items of "I am willing to choose the service of the service company again", "The service company is my first choice in the same field", and "I will do more business with the service company in the next few years". Recommendation intention refers to the psychological attachment of customers to the service providers and their verbal recommendation, and it is measured by three items of "I will speak good of the service company to other companies", "I will recommend this service company to other companies", and "I will encourage other companies to do business with this service company".

2.4.2.2 Recommendation intention

The importance of recommendation intention in the literature on service has been fully emphasized (Zeithaml et al., 1985; Day, 1980). The recommendation intention provides information about the service company, and the information often affects other customers in making consumption decisions on whether to choose this service company. Richins (1983) found that customer recommendation has a relatively great impact on other customers' purchase process. L. Xiao and Yao (2005) found that customers with better service experience are inclined to make positive word-of-mouth recommendations. Customer recommendation also plays an important role in promoting brand transformation of other customers. This is because customer recommendation is often spread through word of mouth, and this face-to-face information dissemination method is more influential than other methods. It is worth noting that although positive word-of-mouth communication helps companies acquire new customers without additional costs, negative word-of-mouth will have a strong negative impact and greatly weaken the effectiveness of other communication methods. At the same time, due to the intangibility of services and the simultaneity of production and consumption, service marketing is more difficult and complicated than tangible product marketing. Customer recommendation has become an important method to solve this problem. It can be seen that service recommendation through word-of-mouth communication of customers plays a vital role in the success of service companies. Regarding the research on customer word-of-mouth, the U-shaped model proposed by Tax and Chandrashekaran (1992) first attracted academic attention. In this model, customer satisfaction is the independent variable and customer word-of-mouth is the dependent variable. When customer satisfaction is high, the customer word-of-mouth will tend to the positive extreme. When the customer satisfaction is low, the customer word-of-mouth will tend to the negative extreme. When the customer satisfaction is average, the customer word-of-mouth will be in a state of inaction.

2.4.2.3 Repurchase intention

The repurchase intention refers to the possibility that customers will purchase services again in the future (S. H. Li, 2009). In the marketing field, customer repurchase intention is an important concept to improve customer retention, and the increase in customer retention is regarded as one of the key factors to improve corporate profits and long-term performance (Reichheld & Sasser, 1990; Heskett et al., 1994; Jones & Sasser, 1995). Generally speaking, the higher the customer satisfaction with the service, the more likely it is to purchase the service again (Smith et al., 1999). A survey conducted by TARP in 1981 in the United States found that when service companies deal with user dissatisfaction in a satisfactory manner, the possibility of customers buying again will be as high as 70%; the repurchase rate of customers who have not made any suggestions and presented dissatisfaction is 9%; the repurchase rate of customers who raised dissatisfaction but did not get a response or resolved was 19%; the repurchase rate of customers who raised dissatisfaction and get problems resolved was 54%; and the repurchase rate of customers who raised dissatisfaction and get problems resolved swiftly was as high as 82%. It can be seen that the repurchase intention of customers is vital to service companies.

2.4.3 Theories of behavioural intention

In order to predict the behavioural intention of customers more scientifically and accurately, scholars at home and abroad have constructed many behaviour prediction models, the most representative of which are Theory of Reasoned Action and Theory of Planned Behaviour.

2.4.3.1 Theory of Reasoned Action

The Theory of Reasoned Action (TRA) was proposed by Ajzen and Fishbein (1975). Its practicability has been widely verified in many fields, and it can predict and explain many behavioural phenomena in many fields. The TRA theory studies the determinants of behavioural intention. The main point of views include: the direct leading factor of actual behaviour is behavioural intentions, and behavioural intentions are jointly determined by the individual’s attitudes about the target object and the subjective norms of specific behaviours (L. Han, 2019). The TRA theory puts forward the following research hypotheses (Ajzen & Fishbein, 1975). First, before making a decision to support or oppose a certain behavior, individuals often search for relevant information systematically. Second, self-awareness controls individual behaviour and makes it reasoned. Third, the behavioural intention shown by the individual will determine whether the behaviour occurs or not. It is precisely because there are no special restrictions on behavioural attitudes and subjective norms, TRA has strong universality and can explain and verify individual behaviour in different situations. However, TRA implies an important assumption that individuals have the ability to completely control their own behavior. But in fact, customer behaviour is affected by a variety of factors and may not fit this hypothesis completely. Therefore, the theory needs to be further improved and perfected to enhance its predictive ability.

2.4.3.2 Theory of Planned Behaviour

In order to adapt to situations where individual behaviours are not completely controlled by themselves and explain more complex behavioural phenomena, Ajzen (1985) added the variable Perceived Behavioural Control (PBC) on the basis of TRA, and proposed Theory of Planned Behaviour (TPB). Perceived behavioural control refers to an individual’s perception of how difficult or easy it is to complete a certain behavior, which is mainly composed of Control Belief and Perceived Facilitation. Control belief refers to the cognition about the resources, abilities and opportunities that one has to take action; perceived facilitation refers to the degree to which these resources, abilities and opportunities can affect individual behaviour. Therefore, in the theory of planned behaviour, behavioural intention is mainly affected by the dynamic combination of behavioural attitude, subjective norms and perceptual behavioural control. Many studies have confirmed that the predictive ability of TPB is significantly higher than that of TRA (Schifter & Ajzen, 1985; Madden et al., 1992). TPB is the most complete behavioural intention model developed at this stage.

Chapter 3: Industrial Maintenance Service Analysis of Company A

3.1 Company overview

3.1.1 Development history of Company A

Company A is a well-known industrial maintenance service provider in the segmented market. In 1980, APIPro was established by the Nordic industrial giant SKF in Gothenburg, Sweden, mainly to support the TPM (Total Productive Maintenance) project within the SKF Group, and it was widely used in factories within the SKF Group. In 1986, APIPro officially stepped out of the SKF Group and started to provide service business for external customers. In 2006, APIPro entered the Chinese market, relying on its parent company SKF, it carried out service business in China, and signed contracts with well-known companies such as private steel giant Rizhao Steel and international chemical giant AkzoNobel for business cooperation in industrial services related to equipment asset management. In view of the continuous expansion of business in the Greater China region, in 2012, the group decided to establish APIPro Software as a separate company to carry out business in China, and settled in the cloud computing base-Shibei High-tech Park in Jing’an District, Shanghai, which marks the formal establishment of Company A. In 2014, the CEO of APIPro China purchased 15% of the company’s shares, and the company was the first in the industry to launch an equipment asset management system based on Android industrial PDA. In 2016, the company started the process of comprehensive localization of APIPro software. In 2017, the company launched the first fully self-developed domestic equipment asset management software APIoT V1.0. In 2018, on the basis of APIoT V1.0, the company added some key functions of the intelligent manufacturing platform such as quality management and personnel management. In 2019, the company launched a low-code PAAS platform for the first time in the industry. Through this platform, it has achieved business development and delivery capabilities that are five to ten times faster than traditional software development. The localized system has opened up a rapid replacement of international counterpart systems, and it has achieved a very enthusiastic response in the market. Since then, the company has entered a stage of rapid development. In 2020, the company successively launched BPM business process engine system (becoming the second smart operation and maintenance system with independent intellectual property rights after IBM Maximo in the industry), AR (augmented reality)-based system, and CMS (condition monitoring system). Step by step, the company has developed into one of the few Chinese industrial maintenance service providers that can provide full life cycle management and full state management of equipment assets.

3.1.2 Industrial maintenance service of Company A

Company A provides industrial service based on APIoT industrial maintenance service. The main services involved include the development of equipment management software, the collection and integration of equipment data (including the connection with internal control programs and the addition of sensors), industrial big data analysis, and machinery learning product development. It is committed to providing multi-faceted, professional, data science-based equipment management platforms and intelligent manufacturing cloud services for many asset-intensive manufacturing industries such as automobile, chemical, food and medicine, and energy. In general, Company A mainly provides service solutions such as smart factory cloud platform, smart operation and maintenance management system, and manufacturing operation management system. First, in order to break data barriers and fully upgrade the digital factory, the company has built a mature componentized intelligent manufacturing cloud platform for asset-intensive enterprises, including modules of software middle platform, real-time monitoring, operational analysis, and intelligent decision-making. The software middle platform is mainly designed to promote the paperless operation and maintenance of the client enterprise, real-time automatic data aggregation and functional modularization, and high cohesion and low coupling. Real-time monitoring is mainly to control the equipment and operational progress in real time, alarm in time for production abnormalities, and achieve real-time transmission of hierarchical information. Operational analysis is to visually present and interpret data in multiple dimensions to realize independent customized analysis at all levels. Intelligent decision-making is to conduct intelligent task scheduling, rapid accounting of benefits, and tracking of product quality. Second, the three swords of “EAM (Enterprise Asset Management) plus CMS (Condition Monitoring System) plus OEE (Overall Equipment Efficiency)” are integrated through the intelligent operation and maintenance management system to create an intelligent equipment manager, and achieve “cost reduction and efficiency enhancement, safety and environmental protection”. The system can monitor the status of field equipment/facilities in real time, automatically collect data and report, intelligently monitor production efficiency, and visualize the equipment status, so that users can easily observe the overall equipment. Moreover, the system also has powerful preventive maintenance. It can flexibly realize the preparation, tracking and adjustment of equipment maintenance plan, intelligently provide feasibility report and key information early warning, and can be seamlessly integrated with mainstream enterprise software such as SAP. In addition, the system uses intuitive fault reporting and supports direct access through multiple terminals. It sends fault report information to the designated person in time, and the different colours of the repair report directly reflect the different repair work status. Third, the manufacturing operation management system helps automobile manufacturers break the information barriers of production management and production execution, and realize transparent workshop. The system can not only help to create transparent workshop, achieve transparency, controllability, flexible and convenient operation, but also has strong extensibility of functional modules and openness of integration between systems, thereby eliminating unnecessary waste of resources such as manpower, capital, and materials in the production process. On the whole, the industrial service projects provided by Company A can help enterprise customers realize better production management, stable and reliable operation of the equipment, increase of product yield, reduction of inventory, and improvement of personnel efficiency to achieve standardization, visualization and scientificization of maintenance service management in industrial enterprises, and move towards the era of Industry 4.0.

3.1.3 SWOT analysis

Service recipients of Company A involve industries such as automobile, steel, chemicals, food, medicine, and energy. Key clients include Geely, Volvo, Chery, Bosch, Aptiv, Hande Axle, BAIC Group, SAIC Group, Honda, Mitsubishi, SKF, and Fast Auto Drive in the automobile industry, Rizhao Steel, Granges Aluminium, CNOOC, Transfar Group, Huayou Cobalt, and Stepan Chemical in the steel and chemical industries, China Resources, China Resources Sanjiu Medical and Pharmaceutical, Sinograin, Charoen Pokphand Group, and AstraZeneca in the food and pharmaceutical industries, Shanghai LNG, GE, VOITH, and Shanghai Electric in the energy industry, and Huawei, Huaxing Glass and other companies in other industries. Oracle Database Company and SKF condition monitoring are its important suppliers.

In the area of industrial maintenance service system, the main competitors of Company A are IBM Maixmo, SKF CMMS (APIPro), Infor EAM, Guangzhou KingTang Data/Guangdong Zhongshe Intelligent Control Technology Co., Ltd. Among them, IBM Maixmo was established in 1976 and it is the world’s largest equipment operation and maintenance software service provider. Relying on IBM, it has strong IT technology platform capability. The company entered the Chinese market in 1995 and has hundreds of enterprise users in oil, power, gas, and rail transit, including China National Offshore Oil Corporation, Beijing Huayou Natural Gas Co., Ltd., Daya Bay Nuclear Power Plant, China Eastern Airlines, and Shenzhen Metro Group. SAP PM was established in 1972 and it is the world's largest enterprise application software company. The content of the PM modular management under the SAP ERP system is generally equipment maintenance and overhaul. It is mostly used in asset-intensive enterprises such as electricity and paper making. SKF CMMS (APIPro) was established in 1980 and it is one of the world's largest provider of professional equipment management comprehensive solutions. It originated from the Nordic enterprise asset management system (EAM) supplier. Its product APIPro system has a maintenance management background and a characteristic management system, with a deep industrial background. Infor EAM was established in 1986. Infor's EAM products aim to provide global customers with enterprise asset management solutions. The customers are mainly foreign-funded enterprises and are mainly used in manufacturing. Guangzhou KingTang Data/Guangdong Zhongshe Intelligent Control Technology was established in 1999. It started early and was backed by the China Equipment Management Association, but the products were relatively old-fashioned, and simple in function. Based on the situation of the customers, suppliers, and competitors of the above companies, we will analyse the strengths, weaknesses, opportunities and threats of the case company.

3.1.3.1 Strengths

(1) Company A has long been focusing on this business. Company A has been focusing on the development and operation and maintenance of APIoT industrial service software to provide customers with high-quality industrial maintenance services and improve the manufacturing capabilities and levels of customer enterprises. It has won many honorary titles such as Excellent Software Service Enterprise, Excellent Recommended Products of China's Intelligent Manufacturing, Excellent Supplier of China's Manufacturing Asset Management, Excellent Enterprise for Innovation, Entrepreneurship and Employment Promotion, Quality Management System Certification, and National Equipment Management Excellent Leader, receiving widespread recognition in the industrial maintenance service field.

(2) The team has the longest practicing experience in the industry and the most profound understanding of IIoT. The APIoT project team was first incubated in the SKF Group in 1980. After more than 40 years of evolution and development, the team is deeply rooted in the IIoT field and provides industrial maintenance service support for enterprises in all walks of life. In

addition, Company A is the earliest closed-loop equipment management service team in China. The team has IIoT closed-loop and top-down service derivative capabilities, end-cloud collaboration capabilities, and micro-service architecture capabilities. The team meets the rigid demands of the asset-intensive industries and masters the core of IIoT implementation.

(3) The products are advanced in technology, powerful in function, and easy to use, in line with the habits of domestic users. The system horizontally uses the IT platform technology of Maximo for reference, and vertically learns the business functions of APIPro. In addition, the product and technology iterate quickly, becoming a characteristic product in the market, which can fully meet the industrial service needs of domestic enterprises. At present, the industrial maintenance service projects of Company A have a good prospect of implementation, with a market share of approximately 25% in the automotive industry. The company has a large number of leading corporate customers in industries such as Volvo, Geely, and Huawei, and it can keep up with the pace of high-quality customers to improve industrial maintenance service quality.

3.1.3.2 Weaknesses

(1) The corporate brand is not as good as IBM, SKF and other major international service providers. Although the APIoT project of Company A was incubated early, it officially started business independently in China and established the independent company in 2012. Compared with major international service providers such as IBM and SKF, the company's brand awareness needs to be improved. Due to certain brand weaknesses, Company A has certain obstacles in the process of acquiring industrial service customers. Because industrial maintenance services involve enterprise equipment, production, operation and maintenance management, companies are more cautious when choosing service providers, so customers are more willing to choose big name service providers when information is asymmetric and inadequate.

(2) Compared with these giants, Company A is relatively weak in strength. Although Company A is rooted in the field of industrial service and provides industrial maintenance service with certain technical strength and technical advantages, compared with the giants of industrial maintenance services such as IBM, SAP, and SKF, there is still room for further improvement in the technical strength. These giant enterprises not only have super-strong technical resources, but also have relatively rich experience in industrial project service, and their overall technical strength should not be underestimated. Therefore, the technical capability of the company needs to be further improved.

(3) Company A has insufficient experience in participating in international industrial maintenance service projects. Company A mainly focuses on industrial maintenance service projects in China, and actively promotes the localization of industrial service software, which is incubated from European projects. However, the company rarely expands to foreign industrial service recipients in the European and US market, and its market experience in providing industrial maintenance services in developed countries needs to be further improved.

3.1.3.3 Opportunities

(1) The wave of Industry 4.0 and Industrial Internet on a global scale brings huge market demands for industrial maintenance service providers.

The Industry 4.0 strategy was first jointly proposed by Siemens and the German Academy of Engineering. It was included in the German "High-tech Strategy 2020", becoming one of the country's future development projects. The Industrial Internet was first proposed by General Motors of the United States and promoted by the Industrial Internet Alliance established by Cisco, IBM, Intel, AT&T, and GE. Driven by large companies, these two strategies have received the attention and recognition of the industry, and have set off a wave of industrial digitization on a global scale. On the one hand, the core goals of these two strategies are to build an intelligent industrial system to improve production efficiency. The manufacturing industry is becoming networked, digitalized, and intelligent. Information technology and digital technology are important means to improve enterprise manufacturing and increase enterprise production efficiency. On the other hand, integration and interconnection through the Internet, the Internet of Things, and big data are the basis of the two strategies to achieve data collection, processing and feedback. In general, the two major strategies emphasize the connection of machines and equipment through the network to achieve efficient operation, and this is where the core businesses and strengths of Company A lie. Therefore, in the big wave of the development of Industry 4.0 and the Industrial Internet, Company A provides a huge development opportunity for manufacturing enterprises to offer them industrial maintenance services based on industrial software.

(2) Strategic deployment of Made in China 2025 brings broad Chinese mainland industrial service market to Company A.

Faced with the practical needs of China's transformation from a manufacturing giant to a manufacturing power, on May 8, 2015, the State Council issued "Made in China 2025" to comprehensively promote the implementation of the strategic deployment of promoting China to become a manufacturing power. For this reason, the domestic industry has been greatly encouraged. According to "Made in China 2025", it is necessary to accelerate the deep integration of the new-generation information technology and manufacturing, focus on intelligent manufacturing, promote industrial transformation and upgrading, and cultivate China's special manufacturing culture, so as to realize transformation from a manufacturing giant to a manufacturing power. To achieve the goal of becoming a manufacturing power, we need to enhance the national manufacturing innovation capabilities, promote the in-depth integration of informatization and industrialization, strengthen industrial technology capabilities, strengthen quality brand building, fully promote green manufacturing, vigorously promote breakthrough development in key areas, further promote structural adjustment of manufacturing, actively develop service manufacturing and producer services, and improve the international level of manufacturing. It can be seen that under the strategic deployment of Made in China 2025, industrial maintenance service companies do have opportunities for development.

(3) The national policy of promoting independent innovation and establishing an innovative country provides a better power rebalance and a fairer competition environment for Company A in its competition with major international counterparts.

As China is promoting the implementation of the innovation-driven development strategy, the most fundamental thing is to enhance the ability of independent innovation, with science and technology as the primary productive force. In this process, the ability and level of industrial software localization will be gradually improved, and relevant technologies will be promoted to adapt to the localization of products. As the importance of localization is increasingly prominent, the company's main business is 100% self-developed industrial service software, which is undoubtedly a major opportunity for its corporate development.

3.1.3.4 Threats

(1) The threat of powerful new entrants.

On the one hand, large-scale Internet companies in China such as BAT have all begun to step in the industrial service field. For example, 1688 Industrial Products is committed to changing the procurement and production mode of the industrial chain. Tencent and Shenzhen Bao'an District build an industrial Internet characteristic industry demonstration base, and Baidu opens Open cloud IoT platforms to the industrial sector. These large domestic Internet companies have a large amount of capital, technology, and personnel advantages, so their cross-border entry into the industrial service field will be a potential threat to the development of Company A. On the other hand, a number of start-ups focusing on industrial services have emerged, some of which have received investment from well-known venture capital companies. As potential emerging entrants, new start-up companies may have technological advantages at a certain point, and they are more flexible and can quickly respond to market changes.

(2) The international situation is highly uncertain.

The current international situation is generally peaceful, but the factors of uncertainty and instability are still very prominent. First, power politics and the Cold War mentality still threaten the peace and stability of the world; second, the wave of populism and anti-globalization has emerged in some countries, and nationalist and protectionist trends have emerged in some countries; third, some countries have regional turbulence and armed conflicts. Generally speaking, there are still factors of instability in the international situation, and the development of anti-globalization will pose a greater threat to international cooperation and the development of international markets. This will bring great uncertainty to Company A when it enters the international market in the future.

Based on the above-mentioned pairwise comparisons of strengths, weaknesses, opportunities, and threats, this research sorts out possible SO, WO, ST, and WT strategic plans for Company A as per Table 3.1. By the SWOT management tool, it should further to discuss if the actions come out from comply with the organization values, if they will have a positive or negative impact in environmental, social and economic terms (Pereira et al., 2021). The core value of company is to provide “extreme, innovative and win-win” service solutions. Though SWOT analysis, company would increase its innovation via spending more in research and development, meanwhile, to improve cost-effectiveness, those actions are good practice of organizational values. Furthermore，company A will with mainly focus on domestic market and some in developing countries, to boost industries inner and outer side of China to achieve intelligence maintenance. The above actions is not only catch up the wave of industrial internet, but also make perfect fit with the goal of sustainable development of the United Nations, such as SDO 9 (Industry innovation and Infrastructure), SDO 11 (Sustainable cities and communications) and SDO 17（Partnerships for the goals）, it do good to both global economic development and social progress.

Table 3.1 SWOT strategic choice

	S (Strengths)	W (Weaknesses)
	1. Company A has long been focusing on this business. 2. The team has the longest practicing experience in the industry and the most profound understanding of IIoT. 2. 3. The products are advanced in technology, powerful in function, and easy to use, in line with the habits of domestic users.	1. The brand is not as famous as international giants such as IBM and SKF. 2. The technological strength is relatively weak compared with the international giants. 3. Experience in international industrial maintenance service projects is insufficient.
O (Opportunities) 1. The wave of Industry 4.0 and Industrial Internet on a global scale brings huge market demands for industrial maintenance service providers. 2. Strategic deployment of Made in China 2025 brings broad Chinese mainland industrial service market with huge potential to Company A. 3. The national policy of promoting independent innovation and establishing an innovative country provides a better power rebalance and a fairer competition environment for Company A in its competition with major international counterparts.	SO strategy 1. Gradually develop the international industrial maintenance service market (S_1、S_2、O_1) 2. Further take root in the domestic industrial maintenance service market (S_2、S_3、O_2) 3. Take tentative steps in relevant industrial service areas (S_2、O_3)	WO strategy 1. Carry out dislocation competition with major competitors in the international market, improve product cost-effectiveness, and focus on markets such as Southeast Asia and Africa (W_1、W_3、O_1) 2. Increase R&D investment, enhance independent innovation capabilities, and deeply integrate the Chinese context to form local advantages (W_2、O_2、O_3)
T (Threats) 1. The threat of powerful new entrants. 2. The international situation is highly uncertain.	ST strategy 1. Pay attention to the latest market trends, and use cooperation, acquisitions and other methods to achieve a win-win situation with new entrants (S_2、S_3、T_1) 2. Control the scale of the international market and maintain advantages in the Chinese market (S_1、S_3、T_2)	WT strategy 1. Strengthen brand building and form local brand advantages in the field of industrial maintenance services (W_1、T_1) 2. Choose to enter the international market where the political situation is stable, the cultural conflict is small, the relationship with China is good, and the economy is booming (W_2、W_3、T_2)

3.2 Overview of industrial maintenance service

3.2.1 Service content

Company A provides industrial maintenance service to customers with APIoT industrial service software, which mainly involves core functional modules such as equipment data management, repair and maintenance process management, spare parts management, personnel management, status management, document management, and statistical analysis management of industrial enterprises, as well as basic services such as equipment record management, visualization, status monitoring, AR, mobile and paperless office, and knowledge base.

(1) Equipment record management

The APIoT asset basic information module can perform basic data management related to all equipment, including location structure, maintenance objects, spare parts, cost centre structure, and budget functions. Another important function of asset basic information management is concentrated query, which can easily find the location structure of the factory, maintenance objects, spare parts, and characteristic technical parameters. The basic asset information module also includes the menu system, system management, configuration, user access control, and timer functions. It fully satisfies the needs of improving the equipment system through three dimensions.

The basic module of the factory takes the equipment resource manager as the core, and manages all the resources of the factory from the perspectives of maintenance objects, equipment location, supply type, technical data, and equipment grouping, so that relevant personnel can understand the static and dynamic information, maintenance history, spare parts list, production technical data, and financial statements of the factory equipment in a timely and accurate manner, and according to the actual production situation, make necessary adjustments to the equipment operation status tracking, maintenance plan, and spare parts inventory to ensure the safety of equipment operation.

(2) Visualization

Visualization includes graphical human-computer interaction interface, 2.5D visualization equipment status real-time prompt, and real-time push of mobile terminal equipment status. API software can display the status of all factory equipment in a graphical way. First, the equipment management of the entire factory can be clearly realized through the zoom-in and zoom-out of pictures, and the equipment and equipment-related information can be queried layer by layer. Second, the entire system can be browsed and used through graphics-based visualized operations, such as viewing various equipment data, troubleshooting reports, and spare parts delivery. Third, graphical pictures can support various common picture formats. Fourth, the repair and maintenance status (such as malfunction report, repair handling, waiting for spare parts, and technical completion) of the corresponding equipment can be displayed in different colours in the planimetric map of the factory/workshop. Fifth, the factory plan must have the function of zooming in and out, and can support mouse scrolling and zooming. Sixth, it should support the work order billboard: Seventh, the processing status of the malfunction work order is refreshed in real time, which can be directly projected on the large screen of the workshop.

(3) State monitoring

API is mainly aimed at the static state of equipment, such as normal operation, in idle, scrapped, in repair, repair finished, maintenance, and standby, as well as non-dynamic operating state, such as real-time operating states including start up, interruption, and shutdown. The real-time operating state shall be monitored and acquired through the state monitoring system, and is responsible for docking with the state monitoring system to periodically obtain the real-time state data of the equipment.

(4) AR

API software is a remote assistance system that connects user collection terminal A (work/operation site) and user operation terminal B (collection/binocular smart glasses/tablet/PC). It can realize real-time audio and video calls, indication marks, instruction content storage, and on-site first-person view, remote control, multi-system terminal and multi-party online. In addition, this function also has more prominent applications in Industry 4.0. First, it can conduct SOP guidance and practical training. Second, with the help of smart glasses and digital SOP, it can realize intelligent point inspection and operation and maintenance of operation desks, instruments and apparatus. Third, with the help of high-definition cameras of smart glasses, it can scan bar codes/QR codes to realize intelligent visual sorting and warehousing materials management. Fourth, through smart glasses, AR technology, and remote collaboration systems, it can realize intelligent visualized maintenance of cars, improve efficiency and establish a database. Fifth, based on GPS, it can develop a visualized inspection route, integrate thermal imaging and other sensor control modules, collect field equipment information, and establish a database.

(5) Mobile and paperless office

APIoT software can help customers realize mobile and paperless office. First, the APIoT software is easy to use, convenient to operate, and comfortable to use. The philosophy of APIoT software is to pursue easy-to-use, convenient, and clean software. Its function items adopt the combination of graphics and text, which highlights the core functions, enhances the user experience, and improves the user comfort. In addition, the colour can be configured, which is suitable for different customers with different needs in different industries. Second, APIoT software has integrated functions and flexible configuration. The software can not only integrate mobile terminal functions through functional componentization and standardized architecture, but also realize multi-APP, multi-functional flexible splitting and combination configuration through system management terminal function settings. At the same time, through the mobile terminal function settings, users can sort freely and set up software that suits their own habits. Third, APIoT software has the characteristics of self-adaptation, cross-platform, and high matching. APP server supports cross-platform deployment, and supports windows server, redhat, centos, and opensuse. APP mobile end supports all versions of IOS and Android. APP mobile function application supports Bluetooth printing, RFID, integrated voice, and integrated camera. Supporting PC terminal supports QR code, barcode, and RFID settings.

(6) Knowledge base

Knowledge management is the essence of the APIoT system. Its purpose is to gradually precipitate and transform the knowledge scattered in the brains of different people into a systematic and shared knowledge base. It runs through the entire APIoT work order process operation, and can provide accurate data support for APIoT KPI report statistical analysis. It can be reflected in the APIoT asset structure tree in the form of standard document. APIoT system mainly helps enterprises realize the visualization and centralization of equipment status through equipment basic data management, repair and maintenance process management, spare parts management, equipment personnel management, and statistical analysis management. It can improve enterprise equipment management level, enhance equipment reliability, and improve the comprehensive ability of equipment management personnel to reduce costs and increase efficiency.

Generally speaking, APIoT software, as a computerized equipment management system, can provide a large amount of industrial maintenance service content and bring huge benefits to industrial enterprises. According to a survey conducted by the well-known research organization Gartner Group, computerized equipment management systems can reduce downtime and increase output through modern information technology without significantly increasing maintenance costs. The benefits that computerized equipment management systems can bring to enterprises include increasing effective working time by 10% to 20%, reducing inventory costs by 10% to 25%, raising the inventory accuracy rate to above 95%, reducing equipment downtime by 10% to 20 %, increasing equipment use efficiency by 20% to 30%, and extending equipment life cycle by about 10%. In fact, the benefits of equipment management software systems are like an iceberg. The direct benefits that can be seen above are only the tip of the iceberg. Many of the benefits are actually below the surface of the water. These benefits mainly include improvement of enterprise equipment management systematization, standardization, and scientification; establishment of a knowledge base of equipment management and maintenance experience, improvement of the overall quality and ability of employees, and reduction of losses caused by personnel turnover; continuous improvement of the comprehensive competitiveness of the enterprise from the management point of view in the fierce market competition and accumulation of soft power; increase of output, improvement of quality, reduction of energy consumption, and a safer working environment. Customers are faced with huge potential benefits and will also put forward higher requirements on the quality of industrial maintenance service provided by APIoT software.

3.2.2 Typical case

APIoT software is mainly used in the equipment department, maintenance department, technology department, production department, quality management department and other related user groups of asset-intensive enterprises. We take the client Company X as an example to illustrate the industrial maintenance service provided by Company A. Through the introduction of the APIoT system, in the first year, the focus of maintenance work of Company X was to reduce the “on-site firefighting” type (emergencies) of equipment problems; in the second year, the focus was mainly to reduce major equipment failures (PM with downtime of more than four hours); in the third year, the focus was mainly to cover the maintenance behaviour, in the fourth year, the focus was mainly to implement predictive maintenance work; and in the fifth year, the focus was mainly to maintain job standardization under the group’s innovative concept. The overall equipment is divided into more than 20,000 parts, and the maintenance work can be nailed down to the component level. 129 inspection routes and more than 4,000 inspection points have been sorted out, and the subdivision of more than 2,000 fault codes and more than 1,500 preventive maintenance work order have been achieved. As a result, the work efficiency of Company X in digital summarization, modification confirmation, work order filling, parts location, statistical analysis, and work order repairing has been increased by 71%.

In the application of APIoT system in Company X, Company A mainly provides the following industrial maintenance services. First, collect data on equipment of Company X. Company A helps Company X identify EAM administrators and provides unified training for data collection. Second, sort out the equipment repair and maintenance procedures of Company X. Company A assists Company X to re-discuss the process of emergency repair, planned repair, maintenance and spot check. Third, assign the personnel authority of Company X. Company A assists Company X in determining the persons in charge of each process node. Fourth, Company X uses a mobile APP to keep track of equipment status. Company A helps Company X introduce APP terminal and arrange staff training. The above industrial maintenance service process has helped Company X a lot. First, it helps Company X to know the real situation of the equipment data. The APIoT system sorts out the equipment data, and reorganizes the equipment maintenance and inspection plan. Second, it helps Company X optimize the management process. The APIoT system unifies and optimizes the existing equipment management process, introduces GXP specifications and QA examination, and lays the foundation for the next step to become a GXP system. In addition, tag management can be achieved through equipment QR code. Third, it helps Company X clarify personnel responsibilities. The APIoT system makes the division of labour clear for enterprise personnel, and EAM system administrators have been added to each unit. Fourth, it helps Company X improve the overall work efficiency. The APIoT system has improved work efficiency through the introduction of mobile terminals and is deeply integrated with daily work to eliminate the blind spot of inspection and supervision in the past.

After the implementation of the APIoT system, through the use of APIoT maintenance strategy and asset recording system, and cost-refining equipment, factories of Company X have achieved high production capacity under the premise of low costs. Through the use of the work order management system, predictive maintenance measures are implemented, with key equipment covered. Through an effective work history management system, the maintenance efficiency is clearly evaluated, and the process has been continuously improved to ensure the sustainability of operations. In addition, all the work is timely, accurate and in place, and the indicators help the factory to tackle key problems in management operation maintenance in a planned way.

Chapter 4: Industrial Maintenance Service Quality Evaluation Model Building and Quality Evaluation

4.1 Industrial maintenance service quality evaluation model design

4.1.1 Principles of industrial maintenance service quality evaluation model design

The construction of the evaluation scale is the basis for the subsequent questionnaire analysis. Corresponding principles need to be followed in the construction of the industrial maintenance service quality evaluation model, so as to ensure that the correct conclusion can be drawn through the analysis of the model. The factors affecting the quality of industrial maintenance service are complex and diverse, in order to evaluate the industrial maintenance service quality scientifically, truthfully and objectively and to improve the service quality of industrial maintenance service providers, the following principles are followed in the establishment of the scale model.

(1) The scale should be scientific. The selection of items should be based on the relevant classic theories of service quality with the particularity of industrial services being considered. The service recipient, service content and service needs should be clarified, and the index weight should be determined based on relevant quantitative methods. Furthermore, it shall objectively discover and evaluate the industrial maintenance service status, existing deficiencies and potential causes of industrial maintenance service, and provide support for industrial maintenance service companies to improve service quality.

(2) The scale should be systematic. Due to the frequent interaction between industrial maintenance service providers and clients, it is a comprehensive and complex service process and service system. Therefore, the process of constructing the industrial maintenance service quality evaluation index system should be clear and systematic, and it should comprehensively and objectively reflect various factors that affect the quality of industrial maintenance service.

(3) The scale should be dynamic. With the continuous update and iteration of technologies such as the Internet, big data, Internet of Things, and cloud computing, industrial maintenance service is also a dynamic process of continuous development. Therefore, the evaluation index system of industrial maintenance service quality should also be dynamic to adapt to changes in the external environment.

(4) The scale should be targeted. Due to the particularity of the industrial service industry,

a targeted scale of service quality evaluation should be constructed. Related items should fully demonstrate the characteristics of industrial maintenance services, and the scale should have enlightening significance for improving the service quality of industrial maintenance service companies.

(5) The scale should be comparable. In empirical analysis, it is often necessary to conduct a horizontal and vertical comparative analysis of the research targets. In order to make the evaluation results measurable and comparable, the proposed indicators and items should be universally applicable in the industrial maintenance service industry, and the final indicators selected should be consistent among different industrial maintenance service companies.

4.1.2 Steps of industrial maintenance service quality evaluation model design

This thesis integrates exploratory and confirmatory Research methodology to design and develop the industrial maintenance service quality evaluation model. The entire development process includes the following steps.

(1) Formation of initial scale items through literature research, enterprise interview, and expert discussion

Literature research: According to the considerable existing studies on service quality, the SERVQUAL scale provides a conceptual framework for service quality evaluation, and can also be applied to the measurement of service quality. The 22 items in the five dimensions of tangibles, reliability, responsiveness, assurance, and empathy can be used as the basis for the development of the evaluation model design. However, when the SERVQUAL scale is used in different fields, it needs to be adjusted and improved according to the characteristics of the field.

Enterprise interview: In order to make the proposed service quality evaluation items more suitable for the actual situation of industrial maintenance service companies, we conducted interviews with clients of Company A before determining the quality evaluation indicators and items of industrial maintenance services. Interviewees generally mentioned the following five points. In service tangibles, automated equipment data collection tools and friendly software service interfaces are the key points of attention. In service reliability, the reduction of equipment failure rate and equipment cost is very important. In service responsiveness, being able to monitor dynamic data in the equipment in real-time and providing corresponding emergency services are important contents of service quality. In service assurance, it is important for production equipment to be able to achieve predictive maintenance and service company supervisors to have sufficient knowledge to understand the collected data. In service empathy, the service company can provide personalized analysis based on the collected data, which will affect the judgment of service quality.

Expert discussion: Based on existing literature research and enterprise interview, industrial service experts and service quality experts brainstorm and propose important measurement items in industrial services in the dimensions of tangibles, reliability, responsiveness, assurance, and empathy of service quality, thus forming the initial scale. Through expert discussion, the following opinions are mainly formed. In service tangibles, industrial service software should have good compatibility and openness, and software functions should basically cover the client's demands for equipment. In service reliability, the software system of the service provider should have advanced scientific, professional and reliable analysis tools. In service responsiveness, the software system of the service provider can record service information in a standardized and complete manner and provide detailed service plan timetables. In service assurance, the functions of the software system of the service provider are powerful and can provide good support to the on-site personnel. In service empathy, the purpose of the service provider should be client-cantered.

(2) Dimensionality reduction reconstruction of the scale through process iteration to form the final scale

Data are collect based on the initially formed scale. First, exploratory factor analysis is used to determine the dimensional structure of the factors. Based on the formed factor structure, confirmatory factor analysis is used for testing. The evaluation model is interactively verified through an iterative process to modify the initial items, and in the end the final industrial maintenance service quality evaluation model is formulated.

4.2 Establishment of industrial maintenance service quality evaluation model

4.2.1 Formation of preliminary scale

Through the above process of literature research, enterprise interview and expert discussion, based on the SERVQUAL scale of general service quality evaluation, this research adds the key factors of the industrial maintenance service field, identifying 23 influencing factors affecting the quality of industrial maintenance service as per Table 4.1. In order to measure the accuracy of the industrial maintenance service quality formed through literature research, enterprise interview, and expert discussion, data will be collected and exploratory factor analysis and confirmatory factor analysis will be used for test to form the dimensional structure of the scale, and its degree of explanation and convergence will be tested.

Table 4.1 Items of influencing factors of industrial maintenance service quality

SN	Description	Source
X1	The purpose of the service provider is customer-centric.	Expert discussion
X2	The service provider and its employees can clearly understand our needs.	PZB (X20)
X3	The service provider will provide customized services for us.	PZB (X19)
X4	The service provider can provide personalized analysis support for the company's production status monitoring data.	Enterprise interview
X5	The service software system of the service provider has a friendly interface.	Enterprise interview
X6	The service provider has automated data collection tools.	Enterprise interview
X7	The software system functions of the service provider can cover the needs of the company in equipment management.	Expert discussion
X8	The compatibility and openness of the service provider's software system can meet our company's needs.	Expert discussion
X9	The service provider can satisfy service needs of our company in time.	PZB (X11)
X10	The service provided by the service provider can effectively reduce the equipment failure rate.	Enterprise interview
X11	The software system of the service provider has advanced, scientific, professional and reliable analysis tools.	Expert discussion
X12	The service provided by the service provider can effectively reduce the level of equipment cost.	Enterprise interview
X13	The software system of the service provider can record service information in a standardized and complete manner.	Expert discussion
X14	The service provider can provide our company with a detailed service plan timetable.	Expert discussion
X15	The service provider can provide emergency services to our company in time.	Enterprise interview
X16	The system of the service provider can monitor the dynamic data of the production process in real time.	Enterprise interview
X17	The software system of the service provider can provide support services at any time.	Expert discussion
X18	The professional skills of the service provider employees are trustworthy.	PZB (X7)
X19	The service implementation methodology of the service provider convinces us.	Expert discussion
X20	The service provider can achieve predictive maintenance of our production equipment.	Enterprise interview
X21	Employees of the service provider have strong communication skills.	PZB (X14/X16)
X22	The software system of the service provider is powerful and can give us very good support on site.	Expert discussion
X23	The service provider supervisor has sufficient knowledge to understand the information provided by the machine.	Enterprise interview

4.2.2 Data collection and sample overview

(1) Questionnaire design

Questionnaire is the tool used for data collection in this thesis, and the scientific nature of the data collected will have a direct impact on the analysis results of this research. The items of the questionnaire are comprehensively determined through literature research, enterprise interview, and expert discussion, and are the guarantee of the scientific nature of the questionnaire. The questionnaire consists of three parts. The first part is the evaluation of industrial maintenance service quality and consists of 23 items. This part adopts the Likert seven-point scale, 1-7 points in turn represent strongly disagree to strongly agree. The second part is to collect the basic information of the interviewees, including the name of the company, the department, the position/title, years of working experience, age, gender, and educational background. The third part is an open-ended question, which aims to understand the reasons why business users are satisfied or dissatisfied with the quality of industrial services and suggestions for improvement.

(2) Data collection

The respondents of data collection this time are the direct users of APIoT industrial service software, and the questionnaires are issued in a combination of online and offline forms. In order to cover typical head enterprise users and reduce the geographic influence on respondents, this questionnaire interview focuses on the auto industry, involving important companies in Sichuan, Guizhou, and Hunan. The respondents in this questionnaire are mainly concentrated in Chengdu Lynk & Co., Guizhou Geely Automobile Co., Ltd., and Xiangtan Geely Automobile Co., Ltd. The interviewees' positions include technicians, management personnel and workshop workers, and they are the most direct users and service experiencers of APIoT industrial maintenance service software, having the most true and comprehensive experience of the maintenance service quality of industrial software. A total of 400 survey questionnaires are issued, with 358 questionnaires returned. Questionnaires that have many blanks and do not meet the requirements are eliminated. Finally, a total of 313 valid questionnaires are obtained. The collection rate of the questionnaires is 89.5%, and the collection rate of the valid questionnaires is 78.25%.

(3) Data structure

It can be found through the descriptive statistics of the sample (see Table 4.2) that the users of APIoT industrial maintenance service software are mainly distributed in the equipment department, manufacturing department, logistics department, quality department, assembly plant and factory workshop. Among them, factory workshop has the most users, accounting for 37.1%, followed by equipment department and manufacturing department, accounting for 24% and 12.8% respectively. The logistics department, quality department, and assembly plant have relatively few users. In terms of job position, the number of factory workers is the largest, reaching 166, accounting for 53% of the total respondents. Technical personnel and management personnel account for 21.4% and 20.4% respectively. In terms of years of working experience, the number of employees who have worked for 1-3 years is the largest, with 115 people in total, accounting for 36.7%, followed by employees who have worked for more than 5 years and 3-5 years. Only 32 respondents have worked for less than one year, which is the least, accounting for 10.2%. In terms of gender, most respondents are male, with 275 people in total, accounting for 87.9%, while the number of females is relatively small, accounting for only 12.1%. In terms of the age, the users of API software are relatively young. There are 163 employees aged 18-25, 124 employees aged 25-35, and 91.7% of employees are under 35 years old. In terms of educational background, 78% of them have a college degree or below, 65 of them have a bachelor degree, accounting for 20.8%, and graduate students are scarce, with only 4 in total, accounting for 1.3%.

Table 4.2 Structural feature of effective samples

Variable	Category	Frequency	Percentage	Cumulative percentage
Department	Equipment department	75	24.0	24.0
	Manufacturing department	40	12.8	36.7
	Logistics department	22	7.0	43.8
	Quality department	25	8.0	51.8
	Assembly plant	22	7.0	58.8
	Factory workshop	116	37.1	95.8
	Others	13	4.2	100.0
	In total	313	100.0	--
Job position	Technicians	67	21.4	21.4
	Management staff	64	20.4	41.9
	Workers	166	53.0	94.9
	Others	16	5.1	100.0
	In total	313	100	--
Years of working experience	Below 1 year	32	10.2	10.2
	1-3 years	115	36.7	47.0
	3-5 years	66	21.1	68.1
	Above 5 years	100	31.9	100.0
	In total	313	100	--
Gender	Male	275	87.9	87.9
	Female	38	12.1	100.0
	In total	313	100	--
Age	18-25	163	52.1	52.1
	25-35	124	39.6	91.7
	35-45	23	7.3	99.0
	Above 45	3	1.0	100.0
	In total	313	100	--
Educational background	College degree and below	244	78.0	78.0
	Bachelor degree	65	20.8	98.7
	Postgraduate degree	4	1.3	100.0
	In total	313	100	--

4.2.3 Construction of the final scale

4.2.3.1 Scale item purification

Before performing factor analysis, the scale items need to be purified to eliminate junk items. The criterion for item purification is to test the reliability of the scale and find out the items that can improve the overall reliability of the questionnaire if deleted. Reliability refers to the degree of consistency of the results obtained when an object adopts the same method, which is used to measure the reliability and stability of the item. Among them, the Cronbach's α coefficient method is the most widely used method to measure reliability. The larger the value of α, the higher the reliability of the questionnaire and the higher the consistency of the questionnaire items. The lower the value of α, the lower the reliability of the questionnaire. This thesis uses the Cronbach's α coefficient method to measure the reliability of the questionnaire (see Table 4.3) and finds that the reliability coefficient of the scale is 0.987, which is higher than 0.8, indicating that the scale has high reliability. At the same time, the α value of each item after deletion is not higher than the α value of the undeleted items, indicating that the items as a whole do not need to be modified, and all items can be retained.

Table 4.3 Reliability analysis and purification of industrial maintenance service quality scale

Item	Cronbach's α after item deleted	Cronbach's α
X1	.987	
X2	.987	
X3	.987	
X4	.987	
X5	.987	
X6	.986	
X7	.987	
X8	.987	
X9	.987	
X10	.987	
X11	.986	
X12	.987	0.987
X13	.986	
X14	.986	
X15	.987	
X16	.987	
X17	.986	
X18	.986	
X19	.986	
X20	.986	
X21	.986	
X22	.986	
X23	.986	

4.2.3.2 Exploratory factor analysis

Factor analysis is based on the internal connection between the data of each variable to explain the variables with strong connection and similarity with the same factor, so as to extract a few concise information from a large number of items. Exploratory factor analysis is used to determine the dimensional structure of a large number of items, and dimensionality reduction can be performed on the scale through this analysis. In other words, through exploratory factor analysis, complex variable relationships can be abstracted into several core factors.

(1) KMO (Kaiser-Meyer-Olkin) test and Bartlett's test of sphericity

Before performing exploratory factor analysis, it is necessary to determine whether the variable to be analysed is suitable for factor analysis, which requires a strong correlation between the variables. In this research, KMO (Kaiser-Meyer-Olkin) test and Bartlett's test of sphericity are used to test whether the variables to be analysed are suitable for factor analysis. The statistics of the KMO test are used to compare the simple correlation and partial correlation coefficients between variables to judge the correlation between variables. The smaller the partial correlation coefficient is than the simple correlation coefficient, the closer the KMO value is to 1, indicating the correlation will be stronger. Generally speaking, if the KMO value is greater than 0.9, it is very suitable for factor analysis; if the KMO value is between 0.8 and 0.9, it means that it is fairly suitable for factor analysis; if the KMO value is greater than 0.7, it means that factor analysis is still possible; if the KMO value is around 0.6, it means that the effect of factor analysis will be relatively poor; if the KMO value is below 0.5, it means that it is not suitable for factor analysis.

The Bartlett's test of sphericity is based on the correlation matrix of variables. Its null hypothesis is that the correlation matrix is an identity matrix, that is, the original variables are not correlated. The statistics of the Bartlett's test of sphericity are obtained through the determinant of the correlation matrix. The larger the value, the less the corresponding probability value is than the specified significance level. Then the null hypothesis should be rejected and the correlation matrix is not the identity matrix, and there is a correlation between variables.

Based on the above principles, KMO (Kaiser-Meyer-Olkin) test and Bartlett's test of sphericity are performed on 23 variables, and the results are shown as per Table 4.4. It can be seen from Table 4.4 that the significance observed in the Bartlett's test of sphericity is 0. If the initial probability is 0.05, the null hypothesis should be rejected, indicating that the original variables are correlated. At the same time, the KMO value is 0.973, indicating that the partial correlation coefficient is much smaller than the simple correlation coefficient, and there is a strong correlation between variables, which is very suitable for factor analysis.

Table 4.4 KMO (Kaiser-Meyer-Olkin) test and Bartlett's test of sphericity

Kaiser-Meyer-Olkin measure of sampling adequacy		0.973
Bartlett's test of sphericity	Chi-square	10758.73
	df	253
	Significance	0

(2) Factor extraction

Principal component analysis is used to extract factors. Principal component analysis uses coordinate transformation to linearly change the original variables. It determines the number of common factors and the original variable information that the common factors (principal components) can represent by calculating eigenvalues (variance contribution), variance contribution rate, and cumulative variance contribution rate. In this thesis, the cumulative factor contribution rate of 85% is used as a criterion to determine the number of factors, as shown in Table 4.5. It can be seen from Table 4.6 that the cumulative variance contribution rate of the first four factors has reached 86.81%, exceeding the criterion of 85%, indicating that the first four factors explain 86.81% of the information. Therefore, four common factors are identified finally in this research.

Table 4.5 Eigenvalues and component variance explained

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	18.000	78.260	78.260	18.000	78.260	78.260	7.510	32.653	32.653
2	.824	3.582	81.842	.824	3.582	81.842	5.483	23.841	56.494
3	.723	3.142	84.984	.723	3.142	84.984	3.895	16.934	73.428
4	.420	1.826	86.810	.420	1.826	86.810	3.078	13.382	86.810
5	.288	1.251	88.061						
6	.276	1.200	89.261						
7	.272	1.182	90.443						
8	.239	1.038	91.481						
9	.216	.941	92.422						
10	.199	.863	93.285						
11	.186	.810	94.095						
12	.172	.749	94.844						
13	.164	.713	95.557						
14	.157	.682	96.239						
15	.135	.588	96.827						
16	.123	.535	97.363						
17	.115	.501	97.864						
18	.108	.468	98.331						
19	.096	.415	98.747						
20	.092	.399	99.146						
21	.080	.347	99.493						
22	.062	.271	99.764						
23	.054	.236	100.000						

Extraction method: principal component analysis

(3) Factor explanation

In order to clarify the specific meaning of the four extracted factors, so that the extracted factors have a reasonable explanation, it is usually necessary to rotate the initial component matrix, so as to facilitate the analysis of actual problems. Only when the absolute value of the factor loading is close to 0, or even close to 1, can the typical representative variables be highlighted. In this thesis, Varimax rotation method is adopted to rotate the initial component matrix, so that the variables with relatively high load on each principal component is kept to a minimum. The rotated component matrix is shown in Table 4.6.

Table 4.6 Rotated component matrix

	Component			
Item	1	2	3	4
X19	**.753**	.367	.338	.246
X18	**.747**	.363	.352	.282
X23	**.737**	.402	.331	.253
X20	**.736**	.381	.317	.272
X17	**.723**	.401	.301	.282
X22	**.723**	.430	.264	.321
X16	**.722**	.384	.295	.297
X15	**.715**	.375	.345	.263
X21	**.709**	.387	.375	.268
X14	**.641**	.376	.326	.419
X12	.413	**.783**	.198	.151
X10	.395	**.714**	.329	.304
X11	.448	**.709**	.275	.325
X13	.426	**.700**	.362	.279
X8	.316	**.681**	.256	.508
X9	.431	**.677**	.354	.227
X2	.435	.278	**.743**	.287
X1	.344	.475	**.735**	.153
X3	.446	.267	**.650**	.425
X4	.433	.310	**.601**	.462
X7	.452	.374	.344	**.642**
X6	.437	.439	.371	**.595**
X5	.476	.381	.395	**.581**

Note: extraction method: principal component analysis; rotation method: Varimax. Rotation converged in seven iteration

It can be seen from Table 4.5 and Table 4.6 that Component 1 includes ten items (X19, X18, X23, X20, X17, X22, X16, X15, X21, X14), the factor loading is between 0.641 and 0.753, and the total variance explained is 78.16%. Component 2 includes six items (X12, X10, X11, X13, X8, X9), the factor loading is between 0.677 and 0.783, and the total variance explained is 3.582%. Component 3 includes four items (X2, X1, X3, X4), the factor loading is between 0.601 and 0.743, and the total variance explained is 3.142%. Component four includes three items (X7, X6, X5), the factor loading is between 0.581-0.642, and the total variance explained is 1.826%. In summary, the total variance of the four factors is 86.81%. The factor loading is the correlation coefficient between the observed variable and the factors. It can be seen from Table 4.7 that the factor loadings of all factors are greater than 0.5, indicating that each observed variable has a good explanatory power for the factor.

(4) Component naming and scale formation

The components are named based on the item expressions in each component. The ten items in the first component mainly emphasize that industrial services can provide the most professional services in terms of methods, skills, knowledge, maintenance, and response, thus it is named service professionalism. The six items in the second component mainly emphasizes the ability to provide the most reliable service in both the service result and the service process, thus it is named service reliability. The four items in the third component mainly emphasize the ability to provide customized services based on customer needs, thus it is named service customization. The three items in the fourth component mainly emphasize service software friendliness and automatic data collection, thus it is named service digitization. So far, the final scale is formed as per Table 4.7.

Table 4.7 Final industrial maintenance service quality scale

Dimension	SN	Item
Service professionalism	X19	The service implementation methodology of the service provider convinces us.
	X18	The professional skills of the service provider employees are trustworthy.
	X23	The service provider supervisor has sufficient knowledge to understand the information provided by the machine.
	X20	The service provider can achieve predictive maintenance of our production equipment.
	X17	The software system of the service provider can provide support services at any time.
	X22	The software system of the service provider is powerful and can give us very good support on site.
	X16	The system of the service provider can monitor the dynamic data of the production process in real time.
	X15	The service provider can provide emergency services to our company in time.
	X21	Employees of the service provider have strong communication skills.
	X14	The service provider can provide our company with a detailed service plan timetable.
Service reliability	X12	The service provided by the service provider can effectively reduce the level of equipment cost.
	X10	The service provided by the service provider can effectively reduce the equipment failure rate.
	X11	The software system of the service provider has advanced, scientific, professional and reliable analysis tools.
	X13	The software system of the service provider can record service information in a standardized and complete manner.

Service customization	X8	The compatibility and openness of the service provider's software system can meet our company's needs.
	X9	The service provider can satisfy service needs of our company in time.
	X2	The service provider and its employees can clearly understand our needs.
	X1	The purpose of the service provider is customer-centric.
	X3	The service provider will provide customized services for us.
	X4	The service provider can provide personalized analysis support for the company's production status monitoring data.
Service digitization	X7	The software system functions of the service provider can cover the needs of the company in equipment management.
	X6	The service provider has automated data collection tools.
	X5	The service software system of the service provider has a friendly interface.

4.2.3.3 Confirmatory factor analysis

Through exploratory factor analysis, this research constructs four dimensions of 23 items. Next, Amos is used to construct a structural equation, and a confirmatory analysis of the stability between items and factors is carried out. The 23 items are used as observed variables and four components as latent variables. Table 4.8 is the verification index obtained through confirmatory factor analysis. χ^2/df is an important index to measure the degree of fit. It refers to the difference divided by the degrees of freedom. $\chi^2/df<3$ indicates that the overall fit of the model is very good, $\chi^2/df<5$ indicates that the overall fit of the model is acceptable, and $\chi^2/df>10$ means that the overall fit of the model is very poor. The value of χ^2/df of this model is 3.393, and the overall fit is acceptable. Another important indicator to measure the degree of fit is RMSEA, or the root mean square error of approximation, which refers to the overall difference divided by the degree of freedom. If RMSEA is less than 0.05, it indicates that the degree of fit of the model is good, if RMSEA is between 0.05 and 0.1, it indicates that the degree of fit of the model is acceptable, and if RMSEA is greater than 0.1, it indicates that the degree of fit of the model is poor. The RMSEA value of this model is 0.088, which indicates that the degree of fit of this model is acceptable. GFI, NFI, IFI, TLI, and CFI are other indicators to measure the degree of fit of the model. Their values are between 0 and 1. The closer the value is to 1, the better the fit of the model. In this model, the values of GFI, NFI, IFI, TLI, and CFI are 0.843, 0.931, 0.951, 0.944, 0.950, respectively, all exceeding 0.8, indicating a good degree of fit. On the whole, the fit of this model is good.

Table 4.8 Confirmatory factor analysis results (n=313)

Model	χ^2/df	GFI	NFI	IFI	TLI	CFI	RMSEA
Default model	3.393	.843	.931	.951	.944	.950	0.088
Saturated model		1	1	1		1	
Independent model	43.716	.071	0	0	0	0	0.370

4.3 Industrial maintenance service quality evaluation

Through the above exploratory factor analysis and confirmatory factor analysis, it is ensured that the service quality evaluation model of industrial maintenance service software has high reliability and validity. This part will use the analytic hierarchy process (AHP) to empirically evaluate the industrial maintenance service quality of Company A based on the evaluation index system.

4.3.1 Evaluation method

4.3.1.1 Application of AHP

The Analytic Hierarchy Process (AHP) was first proposed by the American operations researcher (Saaty, 1987). This method was widely used in the U.S. electricity distribution and oil price forecasting in the 1970s and 1980s. In 1982, the Analytic Hierarchy Process was introduced to China by Saaty’s student Gholamnezhad at the China-US Energy, Resources and Environment Conference. Chinese scholars also began to study and explore the method, and applied it in many fields such as behavioural science and outcome evaluation (Shen, 2013). The Analytic Hierarchy Process (AHP) is a method integrating qualitative and quantitative research based on a hierarchical structure model, in which the relative importance of each factor in the model is compared pairwise in order to comprehensively judge the relative importance of the whole, thereby forming the order of the importance of factors (Peng et al., 2004). Although this method requires experts to assign the weight of each indicator at first, there is a consistency check of the matrix. If the check fails, an iterative process of re-assignment by the experts is required. Thus, this method reduces subjective interference to a certain extent and corrects inconsistent views. Moreover, the calculation process of this method is relatively simple, the model construction is relatively fixed, and it has strong adaptability and popularization potential, and can be used to evaluate the quality of industrial software service.

4.3.1.2 Principles and features of AHP

AHP is a method to standardize and quantify people’s subjective judgments and thinking process, thereby reducing the influence of uncertain factors. This method can simplify the system analysis work, and can maintain the consistency of the decision-making process of the decision makers. It can achieve relatively satisfactory results for complex problems that are difficult to be fully quantified or problems that need to integrate human subjective thinking. This is a scientific way of determining weights. The basic principle of AHP is to treat the complex problem being studied as a large system, and to determine the orderly hierarchies of the factors through the systematic analysis of each factor. Then, experts make a quantitative judgment on the relative importance of each factor after objective judgment of factors at different levels. After that, a mathematical model is constructed, and the relative importance of each factor is calculated and sorted. Finally, the decision is made based on the sorting results. Therefore, AHP mainly has the following characteristics (Ye, 2010).

(1) Flexibility and practicality. AHP is an analysis method integrating qualitative and quantitative analysis. Based on people's cognition and judgment, the method measures related factors uniformly, and organically combines subjective thinking with objective judgment to achieve complementary advantages. AHP has also changed the traditional view that optimal technology can only be applied to quantitative problems, and provides an important way for the scientific and programmed research on qualitative problems.

(2) Simple and easy to understand. The decision-making process of AHP fully integrates people's understanding of the problem and reflects the choice and judgment of the decision makers. The decision-making process is clear and concise, and the method steps are simple and clear. Therefore, the use of AHP for decision-making can greatly enhance the effectiveness of decision-making.

(3) Systematicness. In daily life, when encountering simple problems, people often make decisions by causal inference. However, as the uncertainty and randomness of the problem increase, people often make decisions in consideration of probabilistic judgments in addition to causal inference. Complex issues are often regarded as a system, and decisions are made on the basis of exploring the interrelationships of the various components of the system and its environment. AHP has the characteristic of analysing complex problems and can be used to study complex systems.

4.3.2 Evaluation procedure

The AHP is generally completed through the following four main steps. First, construct a hierarchical structure by systematically analysing the relationship between various factors; second, construct a judgment matrix for pairwise comparison by comparing the importance of two factors in the same hierarchy; then, calculate the relative weight through the judgment matrix, and conduct consistency check. Finally, the total ranking weights of each hierarchical system are obtained.

4.3.2.1 Construct hierarchical structure model

Before applying AHP to analyse the problem, it is necessary to construct a hierarchical structure model. In this model, complex problems are decomposed into component of elements. These elements form several hierarchies based on the attribute relationship, and the elements of the upper hierarchy dominate the elements of the lower hierarchy. The system can be divided into three levels: goal, criteria and alternatives. A good hierarchical structure is very important for problem solving.

4.3.2.2 Construct pairwise judgment matrix

After constructing the hierarchical structure model, the affiliation between the elements is determined. The next step is to determine the weight of each element through the construction of a pairwise comparison judgment matrix. If the lower level elements corresponding to the criterion-level element C are U_1, U_2, U_3,..., U_n, for the element C, the decision-maker needs to compare U_i and U_j to identify which is more important and what is the degree of importance. The decision-maker needs to assign the importance and form the corresponding judgment matrix $A=(a_{ij})_{nxn}$, in which a_{ij} represents the important scale of U_i and U_j relative to C. The judgment matrix A is a positive reciprocal matrix, which satisfies the following characteristics: (1) $a_{ij}>0$, (2) $a_{ji}=1/a_{ij}$, (3) $a_{ii}=1$. Due to the reciprocity of the matrix, only n(n-1)/2 judgments of the upper triangle or the lower triangle are required for a matrix.

4.3.2.3 Weight vector and consistency index

The judgment matrix obtained by pairwise comparison does not necessarily meet the consistency condition. The AHP uses a numerical standard to judge the consistency of the judgment matrix. Let $w=(w_1, w_2, w_3,..., w_n)^T$ be the sort weight vector of the judgment matrix A, then,

$$A=\begin{bmatrix} 1 & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & 1 & \cdots & \frac{w_2}{w_n} \\ \cdots & \cdots & \cdots & \cdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} w_1 \\ w_2 \\ \cdots \\ w_n \end{bmatrix} \begin{bmatrix} \frac{1}{w_1} & \frac{1}{w_2} & \cdots & \frac{1}{w_n} \end{bmatrix} \tag{4.1}$$

Thus, Aw=nw, indicating that w is the eigenvector of A, and the eigenvalue is n. If A is a consistent reciprocal matrix, it has the following properties: (1) $a_{ij}a_{jk}=a_{ik}$; (2) A's transposed matrix A^T is also consistent; (3) Each row of A is a positive multiple of any row, namely R(A)=1; (4) The maximum eigenvalue λ_{max} of A is n, and other eigenvalues are 0; (5) The eigenvector corresponding to the λ_{max} is $w=(w_1,w_2,w_3,\ldots,w_n)^T$, then $a_{ij}=w_i/w_j$. When the judgment matrix A is consistent, $\lambda_{max}=n$, when the eigenvector corresponding to λ_{max} is normalized, it is recorded as $w=(w_1,w_2,w_3,\ldots,w_n)^T$, w is the weight vector, which means the weight of U_1, U_2, U_3, …, U_n in C (Zhu, 2005).

If $\lambda_{max}>n$, it indicates that the judgment matrix A is not consistent. The index to measure the degree of inconsistency is CI, $CI=(\lambda_{max}-n)/(n-1)$. For a consistent judgment matrix, CI=0. However, due to the diversity of individual understanding and the complexity of objective things, it is still insufficient to conduct consistency judgment based on CI alone, so the mean random consistency index RI is introduced. Define CR as the random consistency ratio of the judgment matrix, CR=CI/RI, when CR<0.1, the consistency test passes, otherwise the judgment matrix needs to be revised.

4.3.2.4 Total-level sorting of AHP

The total-level sorting refers to the calculation of the sorting weights of the factors of the same level relative to the factors of the upper level. This process proceeds from upper level to lower level one by one. If the sorting weights of m factors in level A are a_1, a_2, a_3,...,a_m, then the sorting weights of the lower level B relative to the n factors of A_j are b_{1j}, b_{2j}, b_{3j},..., b_{nj} (when A_j has nothing to do with B_k, bkj takes 0). AHP finally obtains the weight of the alternatives level relative to the goal level, based on which decision-making can be made.

4.3.3 Quality evaluation

In this section, Analytic Hierarchy Process (AHP) will be used to measure and evaluate the service quality of API industrial service software.

4.3.3.1 Identification of dimension and index weight

(1) Build a hierarchical analysis structure model

According to the service quality evaluation scale of industrial service software that has been formed, the indicators of different attributes are grouped and classified to form a hierarchical analysis structure model, as shown in Figure 4.1.

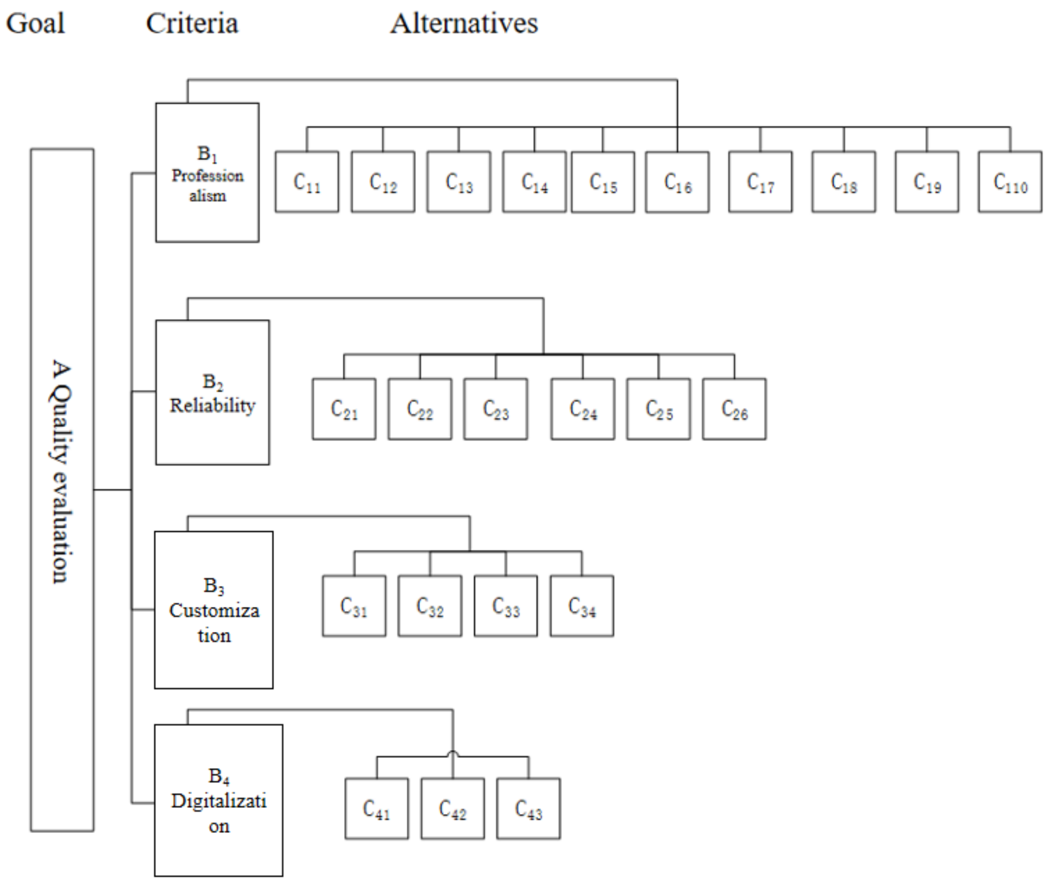

Figure 4.1 Hierarchical structure model

(2) Construct a judgment matrix and calculate

In the process of constructing the judgment matrix, six industry experts in the field of industrial services and scholar experts in the field of service quality evaluate the importance of the indicators pairwise and score them based on the scale table. Discussions are conducted during the evaluation process, and the judgment matrix is formed after consensus is achieved, and the judgment matrices of the goal level, criteria level, and alternatives level are calculated correspondingly as shown in Table 4.9, Table 4.10, Table 4.11, Table 4.12, and Table 4.13.

1) Goal level judgement matrix

Table 4.9 Judgment matrix A

A	B_1	B_2	B_3	B_4	Single-level sorting weight w_i
B_1	1	1/2	2	2	0.276
B_2	2	1	2	2	0.391
B_3	1/2	1/2	1	2	0.195
B_4	1/2	1/2	1/2	1	0.138

CI=0.040 RI=0.900 CR= 0.044<0.1

2) Index level judgment matrix

Table 4.10 Judgment matrix B_1

B_1	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{110}	Single-level sorting weight w_i
C_{11}	1	1/2	1	1/3	1/3	1/2	1/3	1/3	1/2	1	0.050
C_{12}	2	1	1	1/2	1	1	1/2	1	1	2	0.096
C_{13}	1	1	1	1/2	1	1	1/2	1/2	2	2	0.089
C_{14}	3	2	2	1	2	1	1	2	1	2	0.151
C_{15}	3	1	1	1/2	1	1	1/2	1	1	2	0.100
C_{16}	2	1	1	1	1	1	1/2	1/2	1/2	1	0.083
C_{17}	3	2	2	1	2	2	1	1	1/2	1	0.131
C_{18}	3	1	2	1/2	1	2	1	1	1	2	0.123
C_{19}	2	1	1/2	1	1	2	2	1	1	2	0.110
C_{110}	1	1/2	1/2	1/2	1/2	1	1	1/2	1/2	1	0.068

CI=0.062 RI=1.490 CR=0.042<0.1

Table 4.11 Judgment matrix B_2

B_2	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	Single-level sorting weight w_i
C_{21}	1	2	2	2	2	2	0.279
C_{22}	1/2	1	1	2	2	2	0.222
C_{23}	1/2	1	1	2	1	1	0.140
C_{24}	1/2	1/2	1/2	1	1	1	0.111
C_{25}	1/2	1/2	1	1	1	1	0.124
C_{26}	1/2	1/2	1	1	1	1	0.124

CI=0.022 RI=1.240 CR=0.018<0.1

Table 4.12 Judgment matrix B_3

B_3	C_{31}	C_{32}	C_{33}	C_{34}	Single-level sorting weight w_i
C_{31}	1	1	2	1/2	0.243
C_{32}	1	1	2	2	0.343
C_{33}	1/2	1/2	1	1	0.172
C_{34}	2	1/2	1	1	0.243

CI=0.082 RI=0.900 CR=0.091<0.1

Table 4.13 Judgment matrix B_4

B_4	C_{41}	C_{42}	C_{43}	Single-level sorting weight w_i
C_{41}	1	1/2	1/2	0.200
C_{42}	2	1	1	0.400
C_{43}	2	1	1	0.400

CI=0.000 RI=0.580 CR=0.000<0.1

(3) Calculate relative weight

According to the weights of each index at the goal level, criteria level, and alternatives level, the final index weight is comprehensively calculated, as shown in Table 4.14.

Table 4.14 Relative weights in the alternatives level

	B_1 0.276	B_2 0.391	B_3 0.195	B_4 0.138	Total-level sorting weight W_i
C_{11}	0.050				0.0138
C_{12}	0.096				0.026496
C_{13}	0.089				0.024564
C_{14}	0.151				0.041676
C_{15}	0.100				0.0276
C_{16}	0.083				0.022908

C_{17}	0.131				0.036156
C_{18}	0.123				0.033948
C_{19}	0.110				0.03036
C_{110}	0.068				0.018768
C_{21}		0.279			0.109089
C_{22}		0.222			0.086802
C_{23}		0.140			0.05474
C_{24}		0.111			0.043401
C_{25}		0.124			0.048484
C_{26}		0.124			0.048484
C_{31}			0.243		0.047385
C_{32}			0.343		0.066885
C_{33}			0.172		0.03354
C_{34}			0.243		0.047385
C_{41}				0.200	0.0276
C_{42}				0.400	0.0552
C_{43}				0.400	0.0552

(4) Determination of the weights of indexes in each dimension

After the dimension weights and index weights are determined, the customer evaluation scores of APIoT industrial maintenance service software service quality can be calculated more objectively and scientifically, thereby helping industrial maintenance service companies determine priority service content while improving service quality. The weights of indexes are presented as per Table 4.15.

Table 4.15 Weights of indexes

	Dimension (B level)	Index variable (C level)		Index dimension weight	Dimension overall weight	Index overall weight	Index weight order
Industrial maintenance service quality (A level)	B1 Service professionalism	C_{11}	(X19)	0.05	0.276	0.0138	23
		C_{12}	(X18)	0.096		0.026496	19
		C_{13}	(X23)	0.089		0.024564	20
		C_{14}	(X20)	0.151		0.041676	12
		C_{15}	(X17)	0.1		0.0276	17
		C_{16}	(X22)	0.083		0.022908	21
		C_{17}	(X16)	0.131		0.036156	13
		C_{18}	(X15)	0.123		0.033948	14
		C_{19}	(X21)	0.11		0.03036	16
		C_{110}	(X14)	0.068		0.018768	22
	B2 Service reliability	C_{21}	(X12)	0.279	0.391	0.109089	1
		C_{22}	(X10)	0.222		0.086802	2
		C_{23}	(X11)	0.14		0.05474	6
		C_{24}	(X13)	0.111		0.043401	11
		C_{25}	(X8)	0.124		0.048484	7
		C_{26}	(X9)	0.124		0.048484	8
	B3 service customization	C_{31}	(X2)	0.243	0.195	0.047385	9
		C_{32}	(X1)	0.343		0.066885	3
		C_{33}	(X3)	0.172		0.03354	15
		C_{34}	(X4)	0.243		0.047385	10
	B4 Service digitization	C_{41}	(X7)	0.2	0.138	0.0276	18
		C_{42}	(X6)	0.4		0.0552	4
		C_{43}	(X5)	0.4		0.0552	5

4.3.3.2 Analysis of industrial maintenance service quality evaluation results of Company A

Through the index level weights and evaluation index scores of the service quality model of APIoT industrial maintenance service software, the composite score and ranking as well as comparison of composite score and weight of service professionalism, service reliability, service customization, and service digitization of Company A can be obtained as per Table 4.16.

Table 4.16 Score of industrial maintenance service quality evaluation of Company A

Dimension	Index	1	2	3	4	5	6	7	Average score	Weighted average score	Dimension average score	Weighted dimension average score
Service professionalism	X19	0	0	0	22	31	80	180	6.34	0.087429	6.31	1.74
	X18	0	0	0	18	35	80	180	6.35	0.168203		
	X23	0	0	1	22	33	76	181	6.32	0.15531		
	X20	0	0	2	28	28	78	183	6.34	0.264037		
	X17	0	0	1	22	41	76	171	6.27	0.172919		
	X22	0	0	2	19	35	77	180	6.32	0.14484		
	X16	0	0	1	23	37	82	170	6.27	0.226639		
	X15	0	0	3	13	42	82	173	6.31	0.2141		
	X21	0	0	1	20	30	83	179	6.34	0.192442		
	X14	0	0	4	25	31	69	184	6.29	0.118065		
Service reliability	X12	2	0	2	18	40	70	181	6.28	0.685553	6.29	2.46
	X10	1	0	2	26	32	66	186	6.29	0.546048		
	X11	1	0	2	19	39	71	181	6.30	0.344705		
	X13	1	0	2	15	42	70	183	6.32	0.274272		
	X8	1	0	3	21	39	70	179	6.27	0.303916		
	X9	1	0	3	19	42	63	185	6.29	0.305		
service customization	X2	0	0	3	15	35	68	192	6.38	0.302174	6.38	1.25
	X1	0	0	1	12	29	62	209	6.49	0.434005		

Service digitization	X3	0	0	2	16	38	68	189	6.36	0.213349	6.33	0.87
	X4	0	0	3	20	38	67	185	6.31	0.299146		
	X7	0	0	2	21	34	71	185	6.33	0.174682		
	X6	0	0	2	19	36	66	190	6.35	0.350599		
	X5	0	0	3	20	39	63	188	6.32	0.348836		

On the whole, the industrial maintenance service quality evaluation score of Company A is 6.32, indicating that customers are relatively satisfied with the industrial service of Company A, and the API industrial maintenance service software is generally recognized by the customers. But in terms of the relative scores and weights of service professionalism, service reliability, service customization, and service digitization, there is still room for improvement.

(1) Service reliability

As for service reliability, the overall weight of the dimension is 0.391, which is the most important dimension of service quality that customers pay most attention to. However, the average score of service reliability is 6.29, ranking fourth, indicating that service reliability is an important content that needs to be further improved. Specifically, the score of X12 (The service provided by the service provider can effectively reduce the level of equipment cost.) is relatively low, but the importance of this item is 0.686, indicating that the service ability to reduce the level of equipment cost still needs to be further improved. The score of X10 (The service provided by the service provider can effectively reduce the equipment failure rate.) is not high, but its importance is also up to 0.546, indicating that the service ability to reduce the equipment failure rate also needs to be improved. The score of X8 (The compatibility and openness of the service provider’s software system can meet our company’s needs.) is the lowest, and its dimension importance is 0.304, indicating that the compatibility and openness of service software is the direction for further development. The score of X13 (The software system of the service provider can record service information in a standardized and complete manner.) is the highest, but its dimension importance is only 0.274, indicating that the software system of the service provider can record service information in a standardized and complete manner, but its importance is relatively low. The score of X11 (The software system of the service provider has advanced, scientific, professional and reliable analysis tools.) is also relatively higher, but its importance is relatively low. The score of X9 (The service provider can satisfy service needs of our company in time.) is 6.29, and the dimension importance is 0.305, indicating that the service requirements can basically be completed in time.

(2) Service professionalism

As for service professionalism, the overall weight of the dimension is 0.276, which is a relatively important dimension of service quality that customers pay relatively much attention to. However, the evaluation score of service professionalism is 6.31, ranking third, indicating that service professionalism is still a part that industrial service companies need to focus on. Specifically, the weight of X16 (The system of the service provider can monitor the dynamic data of the production process in real time.) is 0.227, which is a type of service quality that customers pay much attention to, but its score is quite low. The professional ability to monitor dynamic data in the production process in real time still needs to be further improved. The weight of X17 (The software system of the service provider can provide support services at any time.) is 0.173, which is also an important content of customer concern, but its score is only 6.27, and it still needs further improvement. The weight of X20 (The service provider can achieve predictive maintenance of our production equipment.) is 0.264, which is a dimension that customers pay most attention to in service professionalism. The score is 6.34, which basically meets the customer's service needs. The importance of X19 (The service implementation methodology of the service provider convinces us.) is relatively low, but the customer's evaluation is high, which exceeds the customer's service needs. The score of X18 (The professional skills of the service provider employees are trustworthy.) is 6.35, which is the highest, indicating that the professionalism of the employees has been recognized. The score of X23 (The service provider supervisor has sufficient knowledge to understand the information provided by the machine.) is also high, indicating that the professionalism of the company supervisor has been recognized. The score of X22 (The software system of the service provider is powerful and can give us very good support on site.) is 6.32, indicating that service provider obtains recognition from the customer. The score of X21 (Employees of the service provider have strong communication skills.) is high, indicating that the employees' communication skills meet the service needs. The score of X14 (The service provider can provide our company with a detailed service plan timetable.) is 6.29 and the weight is 0.118, which basically meets the needs of clients.

(3) Service customization

As for service customization, the overall score of the dimension is 6.38, ranking first, indicating that the customized service provided by industrial service software has been widely recognized by clients, but the overall weight of the dimension is 0.195, and the importance of customer attention is average. Specifically, the weight of X4 (The service provider can provide personalized analysis support for the company's production status monitoring data.) is 0.299, which is relatively important, but its score is relatively low, indicating that its ability to provide personalized analysis support for the monitoring data still needs to be further improved. The score of X2 (The service provider and its employees can clearly understand our needs.) is 6.38, which is relatively high, indicating that the service provider's employees can have a relatively accurate grasp of customer needs. The score of X1 (The purpose of the service provider is customer-centric.) is 6.49, which is the highest, indicating that the industrial service provider has indeed implemented the customer-centric purpose in the service process and has been widely recognized by customers. The score of X3 (The service provider will provide customized services for us.) is 6.36, which is relatively high, indicating that the service provider can indeed provide personalized industrial service software support according to the needs of different customers.

(4) Service digitization

As for service digitization, the overall score of the dimension is 6.33, which is high, indicating that the digitalized level of the service has been recognized by the customer. However, the weight of service digitization is 0.138, ranking fourth, which is relatively low. Specifically, the score of X5 (The service software system of the service provider has a friendly interface.) is 6.32, but its weight is 0.349, indicating that the friendliness of the service software system interface still needs to be further improved. The score of X6 (The service provider has automated data collection tools.) is 6.35 and the weight is 0.351, indicating that the service provider's automated data collection tools can basically meet the needs of the customer. The score of X7 (The software system functions of the service provider can cover the needs of the company in equipment management.) is 6.33, indicating recognition by the customer, and its importance is 0.175, which is relatively low, indicating that the software system functions can basically meet the company's equipment management demands.

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Chapter 5: Influence of Industrial Maintenance Service Quality on Customer Behavioural Intention

5.1 Model building

Behavioural intention is an important indicator to predict whether a customer will continue to keep in touch with the company (Zeithaml et al., 1996). When the perceived service quality is high, the customer's behavioural intention is positive, which will strengthen the relationship between the customer and the company; on the contrary, when the perceived service quality is low, the customer's behavioural intention is negative, which will weaken the relationship between the customer and the company. Studies have shown that service quality is an important factor that affects customer behavioural intention. However, there are obvious differences between existing studies on whether service quality directly affects customer behavioural intention. According to Cronin and Taylor (1992), there is no direct relationship between service quality and customer behavioural intention, and the mediating effect of customer satisfaction is needed to have an impact. Studies by a large number of scholars (Lu et al., 2006; Taylor & Baker, 1994) also support this view that the influence of service quality on customer behavioural intention is exerted through the mediating effect of customer satisfaction. The research of Zeithaml (1988) found that the influence of service quality on customer behavioural intentions needs to be realized through the mediation of perceived value. Murray and Howat (2002) also support the mediating role of perceived value between service quality and customer behavioural intention. Contrary to the above research, Parasuraman et al. (1985, 1996) have repeatedly pointed out that service quality is closely related to customer behavioural intention, and service quality will directly affect customer behavioural intention. Ravald and Grönroos (1996) pointed out that if the company provides valuable products or services to customers, then the chances of repurchase will increase, which shows that the improvement of service quality is conducive to increasing the customer behavioural intention of repurchase. Taylor (2001) found that service quality has no significant impact on recommendation intention of customers, but has significant impact on repurchase intention through research on the American life insurance industry. The research of Cronin et al. (2000) also shows that the service quality perceived by customers has a significant and direct impact on customer behavioural intention. It is known that the research on the influence of service quality on behavioural intention has all clarified the strong correlation between service quality and behavioural intention, and there are differences in whether the influence is direct or not. In addition, the existing explorations on the relationship between service quality and behavioural intention are mainly concentrated in the field of consumer services, while there are few discussions on industrial maintenance service. Based on this, this thesis studies the relationship between service quality and behavioural intention in the field of industrial maintenance service.

Service quality is a cognitive variable, which is the attitude formed by the contrast between expected service and perceived service (P. G. Patterson & Spreng, 1997a). This attitude of will affect purchase intention of customers, and will further change their attitudes based on the evaluation of service experience (Grönroos, 1984). In the field of consumer services, existing studies have explored the direct impact of service quality on behavioural intention, or indirect impact of service quality on behavioural intention using customer satisfaction or perceived value as the mediator, which is closely related to the characteristics of consumer services. In the field of consumer services, companies and consumers have more emotional and social connections. However, in the field of industrial services, due to the large purchase amount, customers of industrial maintenance services are often more rational, and their purchasing behaviour tends to be collective decision-making, which is less driven by emotional factors. Sheth (1973) pointed out that in the field of industrial maintenance services, purchasers often make purchases based on economic reasons, and the decision-making process is often driven by cognitive factors, so cognitive variables should be used as the predictor of outcome variables. In this thesis, service quality is considered as the cognitive variable and customer behavioural intention is considered as the outcome variable to explore the influence of service quality in the field of industrial maintenance services on customer behavioural intention. Service quality in industrial maintenance services is measured in four dimensions: service professionalism, service reliability, service digitization, and service customization. Customer behavioural intention is measured in two dimensions: repurchase intention and recommendation intention. The conceptual model is shown as per Figure 5.1.

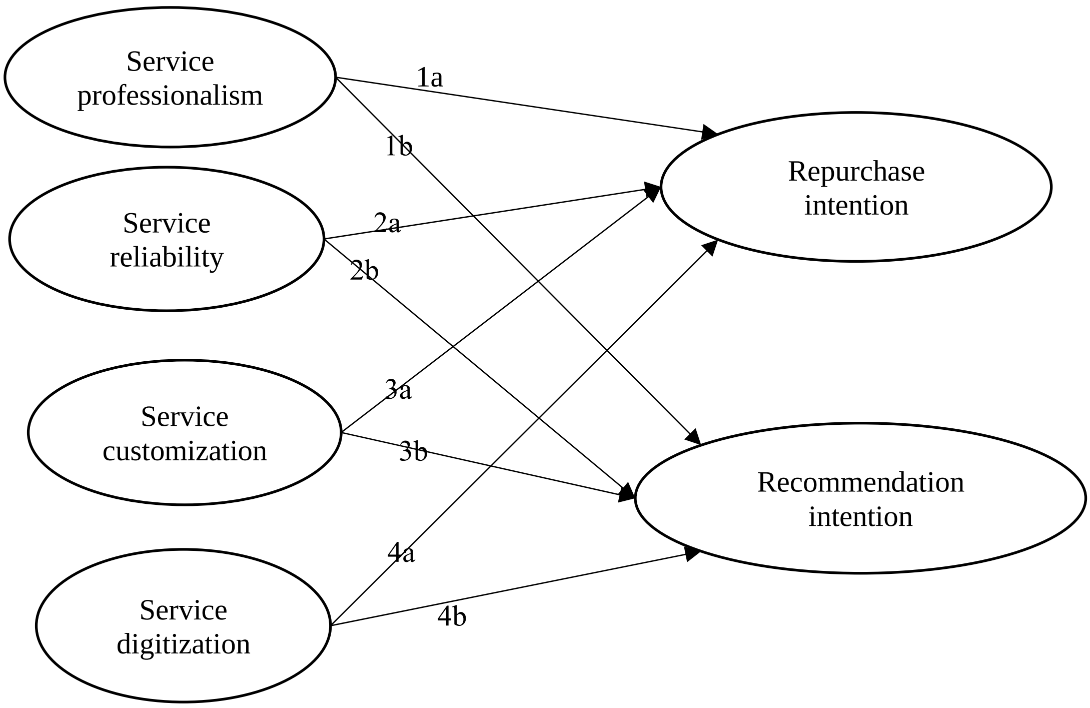

Figure 5.1 Conceptual model

5.2 Hypothesis deduction

5.2.1 Relationship between service professionalism and customer behavioural intention

Unlike consumer services, industrial maintenance services involve more professional knowledge and require more people with professional capabilities and expertise, including professional personnel, professional equipment and professional methods (Homburg & Garbe, 1999). Therefore, service professionalism is particularly important for industrial services. In industrial maintenance services, the service professionalism is reflected in the fact that service personnel have professional knowledge and skills to complete the service, service equipment and systems are powerful to meet customer needs, and service methodology and implementation plans can be recognized by customers. Studies have found that there is a positive correlation between service professionalism and behavioural intention of customers. The more professional the service personnel, service equipment and service methods are, the more likely the customers will be to trust the service provider to complete the service goals, and the stronger their repurchase intention and recommendation intention will be (Parasuraman et al., 1996; Taylor, 2001; Barnes et al., 2016). In consumer services, researchers often use the professional perception of service personnel to measure the overall service professionalism, but the intangibility of the professionalism of service personnel causes deviations in perceived professionalism of customers, which negatively affects the overall evaluation of service by customers (Nguyen & Leblanc, 2002). However, in industrial maintenance services, the service professionalism is measured by more tangible equipment and methods, so that professional personnel, equipment and methods will be able to more accurately predict the impact of professionalism on behavioural intention. In industrial maintenance services, customers pay attention to continuous high-quality service capabilities. Due to the complexity and technology-driven nature of industrial services, industrial maintenance services must be highly dependent on professionally qualified service personnel. The professional knowledge and skills of service personnel are key to continuous delivery of high-quality service.

To sum up, we believe that on the basis of providing professional personnel, industrial maintenance service providers can increase tangible professionalism such as the professionalism of service equipment and professionalism of service methods to gain the recognition of customers, so as to increase their recommendation intention and repurchase intention. Specifically, the tangible professional evidence makes the service professionalism more prominent and obvious in the service scenario, which helps customers to make a positive evaluation of the service quality. As a result, in industrial maintenance services, when the overall perceived professionalism of customers is improved, it will enhance the customer’s positive emotions such as the recognition and trust of the service provider, thereby increasing their repurchase and recommendation intention. Therefore, the following hypotheses are proposed.

Hypothesis 1a: In the field of industrial maintenance services, service professionalism is positively related to customer repurchase intention.

Hypothesis 1b: In the field of industrial maintenance services, service professionalism is positively related to customer recommendation intention.

5.2.2 Relationship between service reliability and customer behavioural intention

Parasuraman (1998) defines service reliability as the ability of an enterprise to correctly realize the service promised by itself without a mistake, and believes that the more reliable the service is, the more loyal customers will be to the service enterprise, and the stronger their repurchase and recommendation intention will be. In the construction of e-commerce service quality dimensions, Swaid and Wigand (2009) consider the reliability of the website perceived by customers (such as order tracking function, email confirmation function) and the correct fulfilment of service promises (such as correct delivery of purchased products) as a measure of service reliability, and it is believed that the higher the service reliability, the stronger the repurchase and recommendation intention. On the one hand, in the field of industrial maintenance services, customer purchase of services is often based on utility purposes and functional reasons (P. G. Patterson & Spreng, 1997b). Therefore, the correct fulfilment of service promises is particularly important. For example, the ability to effectively reduce equipment failure rate after purchase of services, effective reduction of equipment cost level and timely satisfaction and resolution of service demands will directly affect the customer's post-purchase behavioural intention. On the other hand, the completion of industrial maintenance services is mainly done through the equipment of service providers. Compared with consumer services, industrial maintenance services will not be able to provide the promised services without the equipment, and the stability and compatibility of the equipment will directly affect the quality of services provided (Y. H. Xu et al., 2013). In addition, the results of industrial maintenance services are highly uncertain. Customers can only draw conclusions through a period of experience and observation. Therefore, customers need some tangible equipment elements to perceive the service provider's services in advance to reduce uncertainty (Groth, 1995). Therefore, the perceived reliability of service equipment is also particularly important. For example, the software system of the service provider has advanced scientific, professional and reliable analysis tools, the software system of the service provider can record the service information in a standardized and complete manner, and the software system of the service provider has good compatibility and openness, all of which will directly affect customers' repurchase intention.

To sum up, in the field of industrial maintenance services, service reliability has an important influence on the customer behavioural intention. Among them, the correct fulfilment of service promises and the customer perceived equipment reliability directly affect the repurchase intention and recommendation intention of customers. Therefore, the following hypotheses are proposed.

Hypothesis 2a: In the field of industrial maintenance services, service reliability is positively related to customer repurchase intention.

Hypothesis 2b: In the field of industrial maintenance services, service reliability is positively related to customer recommendation intention.

5.2.3 Relationship between service customization and customer behavioural intention

Service customization is generated based on the customization of needs. Customized services are conducive to the establishment of intimate connections between enterprises and customers so as to achieve mutual benefit and win-win results (H. Wang et al., 2007; Lyu, 2001). Providing customers with customized services is more obvious in the field of industrial maintenance services. P. G. Patterson and Spreng (1997a) pointed out that what customers of industrial maintenance service companies need to buy is a specific solution to a certain problem, and service customization is one of the important manifestations of providing industrial services. As far as industrial maintenance services are concerned, one of its major features is the need to establish a long-term and stable cooperative relationship between service buyers and service providers. To maintain long-term cooperation, industrial maintenance service companies need to have an in-depth understanding of customer needs. Through frequent and close interactions between service company employees and customers, the company should provide customers with unique and customized services, and effectively satisfy customer service needs, which will directly determine customer perceived service quality and subsequent behavioural intention (Hausman, 2003). The delivery of customized services will promote the interaction between the two parties, which will help form friendship between the service provider and the customer, and promote the establishment of a closer cooperative partnership between the two parties (Christy et al., 1996). In addition, industrial maintenance services are more complex, with relatively high trust attribute, and the transaction process between the two parties is more complicated, requiring both parties to have a higher willingness and ability to share information. In this context, industrial maintenance service providers should have a deeper understanding of the customers they serve, develop customized services on the basis of frequent communication, take customer-centricity as the enterprise purpose, and allow employees to conduct in-depth exploration and analysis of customer needs. The production status monitoring data of the customer company should provide customized analysis support to meet the customized needs, which will directly affect the perceived service quality and behavioural intention of the customer company. Therefore, the following hypotheses are proposed:

Hypothesis 3a: In the field of industrial maintenance services, service customization is positively related to customer repurchase intention.

Hypothesis 3b: In the field of industrial maintenance services, service customization is positively related to customer recommendation intention.

5.2.4 Relationship between service digitization and customer behavioural intention

In the field of consumer services, a large number of studies have explored the impact of service digitization on customer behavioural intention. Qi (2013) analysed the case of service digitization in the catering industry. KFC has launched an interactive game on the mobile terminal to transform its 24-hour service concept to a specific activity mechanism. KFC captures the characteristic of consumers using mobile phones and attracts consumers to participate in the game so as to influence their subsequent behavioural intention. With the publishing industry as an example, D. D. Wang and Niu (2011) believe that the publishers shall provide affiliated network information with publications as the core, and the construction of digital databases, and establishment of online classrooms and user communities can help them get rid of homogenized competition and enhance user value and user experience. It is found that in the field of consumer services, service digitization will create more customer value and enhance customer experience, so as to affect customer perceived service quality and repurchase behavioural intention. In the field of industrial maintenance services, with the advancement of the Industrial Internet and Industry 4.0, industrial enterprises are required to realize the circulation and interaction between data, hardware, and software, collect data through smart devices and networks, and achieve analysis, storage and visualization through big data analysis tools, so as to support intelligent decision-making. In this context, industrial maintenance service customers have gradually increased their demands for informatized and digitalized services, which has put forward higher requirements for the service digitization of industrial maintenance service companies. It is hoped that the provision of digitalized services can reduce business costs and generate higher business value. Therefore, the provision of digitalized services by industrial maintenance service companies, for instance, industrial maintenance service companies have automated data collection tools, industrial service software systems have a friendly interface, and industrial service software system functions can cover the needs of customer company equipment management, directly affects customer repurchase intention and recommendation intention. Therefore, the following hypotheses are proposed.

Hypothesis 4a: In the field of industrial maintenance services, service digitization is positively related to customer repurchase intention.

Hypothesis 4b: In the field of industrial maintenance services, service digitization is positively related to customer recommendation intention.

5.3 Research design

5.3.1 Variable measurement

5.3.1.1 Independent variable

In Chapter 4, the measurement scale of industrial maintenance service quality has been developed. Through a combination of literature review, enterprise interview, and expert discussion, the initial items were sorted and collected, and a preliminary industrial maintenance service quality scale was formed. In order to verify whether the preliminary scale can explain the quality of industrial maintenance services, we conducted a reliability test on the preliminary scale, followed by an exploratory factor analysis using the Varimax method to extract the scale factors, and finally conducted a confirmatory factor analysis to verify that the scale has good reliability and validity. Finally, it was concluded that the maintenance service quality measurement scale of industrial service software developed by this research can measure the quality of industrial maintenance services. Therefore, the independent variables in this section are service professionalism, service reliability, service customization, and service digitization. The specific measurement items are not repeated here. The measurement scale is shown as per Table 4.8.

5.3.1.2 Dependent variable

As an important predictor of customer behaviour in the future, there are currently many studies on behavioural intention, and one-dimensional, two-dimensional or multi-dimensional measurement of customer behavioural intentions has been proposed according to different scenarios. There is relatively little attention paid to the behavioural intention of customers in the field of industrial maintenance services. Y. H. Xu et al. (2013) believe that industrial services are generated in the downstream production or processing process of enterprises, and the service results of industrial service enterprises will have an important influence on customer behavioural intention. However, based on existing research, it can be found that whether it is in the field of consumer services or in the field of industrial services, the use of customer repurchases intention and recommendation intention to reflect customer behavioural intention has been widely recognized. Based on this, this research divides customer behavioural intention into two dimensions of repurchase intention and recommendation intention. The specific measurement items are shown as per Table 5.1.

Table 5.1 Customer behavioural intention scale

Variable	Dimension	Number	Item	Reference basis
Customer behavioural intention	Repurchase intention	D1	I am willing to choose the software service of the service company again	Zeithaml et al., 1996; Lu et al., 2006; Y. H. Xu et al., 2013
		D2	The service company is my first choice in the same field	
		D3	I will do more business with the service company in the next few years	
	Recommendation intention	D4	I will speak well of the service company to other enterprises	
		D5	I will recommend the service company to other enterprises	
		D6	I will encourage other businesses to do business with the service company	

5.3.1.3 Control variable

(1) Department

The service software users will have different service requirements for the service software if they are in different departments. The experience of different software functions will also form different cognition and perception of service quality to affect their behavioural intention. Therefore, department of the software users is regarded as a control variable.

(2) Job position

Different categories of personnel, such as managers, technicians, and workers, will use different functions of the service software, and thus have different views and perceptions on the software. On the other hand, different categories of personnel have different behavioural intentions due to different division of labour. For example, managers are more willing to make recommendations than workers. Therefore, job position is regarded as a control variable.

(3) Years of working experience

The difference in years of working experience represents the difference in familiarity and knowledge of the industry. In the field of industrial maintenance services, those who are more familiar with the industry and profession have more in-depth understanding and mastery of industrial service software, and are more likely to generate constructive suggestions and service demands. In addition, those with longer years of working experience generally have more industry experience, and are more likely to think from a long-term perspective. Those with long years of working experience tend to establish long-term and stable cooperative relations with service customer companies, thereby affecting their repurchase intention and recommendation intention. Therefore, years of working experience is regarded as a control variable.

(4) Gender

A large number of empirical studies have taken gender as an important control variable, so as to better discover the influencing mechanism of the independent variable on the dependent variable. In the research of industrial maintenance service quality on customer behavioural intention, gender also needs to be controlled. The use of gender as a control variable is mainly based on the following two considerations. Software users of different genders have certain differences in the interface, functions, demands and expectations of the service software. Software users of different genders have different levels of involvement in the service software and equipment. In enterprise interview, it is found that the level of involvement of male customers in software is much higher than that of female customers. Therefore, to accurately grasp the impact of service quality on behavioural intention, gender must be used as a control variable.

(5) Age

A large number of studies have shown that customer age is an important factor affecting judgment and behaviour. Generally speaking, young customers are more likely to accept and master new things, while older customers are relatively slow to accept new things. For users of service software, young customers may be easier to master the operation and use of the software, and are more inclined to put forward more service requirements for industrial service software. Customers of different ages also have different views on industrial service software. Therefore, age is regarded as a control variable.

(6) Educational background

The educational background affects the individual cognition and behaviour. Customers who use the service software with a high level of education may have a higher level of involvement in the software and will pay more attention to it. Customers with lower levels of education may be slower to master the software or are less familiar with the functions. There are differences in the perception and cognition of service software users with different educational levels on the software system. Therefore, educational background is regarded as a control variable.

5.3.2 Pre-test and modification of scale

The data for scale test in this part comes from the test data in the development of the industrial maintenance service quality scale in Chapter 4. Since the industrial maintenance service quality scale has good reliability and validity, this part mainly tests the scale measuring the two variables of repurchase intention and recommendation intention.

5.3.2.1 Reliability analysis

In this study, the CITC value and Cronbach’s α value of repurchase intention and recommendation intention are calculated respectively, and the internal consistency of each scale is analysed. The results are shown as per Table 5.2 and Table 5.3.

Table 5.2 CITC value and Cronbach's α value of customer repurchase intention

Item	Scale mean if item deleted	Scale variance if item deleted	Corrected item-total correlation	Cronbach's α if item deleted
D1	11.67	6.613	.810	.940
D2	11.73	6.809	.863	.895
D3	11.65	6.762	.905	.863

N of case=313, N of items=3; Cronbach's α=0.930

Table 5.3 CITC value and Cronbach's α value of customer recommendation intention

Item	scale mean if item deleted	scale variance if item deleted	corrected item-total correlation	Cronbach's α if item deleted
D4	11.73	7.189	.888	.953
D5	11.74	6.866	.939	.915
D6	11.73	7.181	.902	.943

N of case=313, N of items=3; Cronbach's α=0.957

The analysis results of the above two scales show that the CITC values of all items are greater than 0.5. In the consistency reliability analysis of all items, the Cronbach's α values of all items are greater than 0.8, indicating that this scale has good internal consistency reliability.

5.3.2.2 Validity analysis

Validity refers to the degree of which the scale can represent the truth of things it measures, and it reveals the relationship between structure variables and their measurement indicators. Among them, content validity and construct validity are the most commonly used.

(1) Content validity

This research mainly uses the following procedures to ensure the content validity of the scale. The scale is first based on the research results of domestic and foreign scholars, and related measurement items are collected and sorted from previous research. Then after key interviews with customers, as well as expert analysis and discussion, the items of the scale are identified. Therefore, the scale has a relatively high content validity.

(2) Construct validity

In this study, exploratory factor analysis is used to test the discriminant validity of the two variables of repurchase intention and recommendation intention. The KMO test shows that the KMO value is 0.914, and the significance of Bartlett's test of sphericity is 0, indicating that it is suitable for factor analysis. After rotation, this study extracts two factors of repurchase intention and recommendation intention, which explains 91.208% of the variance change. The specific analysis results are shown as per Table 5.4/5.5. The results of exploratory factor analysis show that each item has relatively high factor load, and can well distinguish the measurements between various dimensions. This shows that the various variables have good discriminant validity and convergence validity.

Table 5.4 KMO Test and Bartlett's Test of Sphericity

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.914
Bartlett's Test of Sphericity	Chi-square	2458.046
	df	15
	Significance	0.000

Table 5.5 Exploratory Factor Analysis

Observed variable	1	2
D1		.895
D2		.633
D3		.644
D4	.734	
D5	.866	
D6	.883	

5.3.3 Formation of the formal questionnaire

The difficulty of questionnaire items should be gradual, with some simple questions at the beginning, which not only makes the survey smooth, but also attracts the interest of the interviewees. Sensitive items, such as demographic variables, should be placed at the end of the questionnaire (Vincent & Zikmund, 1976). The design of the questionnaire in this thesis is based on the above principles. We put some simple items in the beginning part of the questionnaire, including the purpose of service, and the professionalism of employees. In case that respondents cannot understand the content of the questionnaire, we add auxiliary explanations under each item. All scale items are in the form of seven-point Likert scale, with personal data at the end of the questionnaire, as shown in the appendix. The data collection in this part is carried out simultaneously with the data collection in Chapter 4. The collection process and collection method are the same, which will not be repeated here.

5.4 Data analysis

5.4.1 Data normality test

Before performing structural equation model analysis, it is necessary to verify whether the data conform to the normal distribution (Kline, 1998). The kurtosis and skewness of the sample data are important indicators to test whether the sample conforms to the normal distribution. If the absolute value of the skewness coefficient is less than 3, and the absolute value of the kurtosis coefficient is less than 8, then the sample data are considered to conform to the normal distribution. This study performs skewness and kurtosis analysis on all measured variables, and the results in Table 5.6 show that the maximum absolute value of skewness is 1.816, which is less than 3, and the maximum absolute value of kurtosis is 4.016, which is less than 8, indicating that all measured variable meet the conditions of normal distribution and are suitable for structural equation model analysis.

Table 5.6 Descriptive statistics of items

	Mean	Standard deviation	Skewness	Kurtosis	Minimum	Maximum
X1	6.49	.840	-1.646	2.014	3	7
X2	6.38	.929	-1.469	1.460	3	7
X3	6.36	.927	-1.361	1.019	3	7
X4	6.31	.979	-1.321	.836	3	7
X5	6.32	.984	-1.327	.814	3	7
X6	6.35	.950	-1.364	.941	3	7
X7	6.33	.959	-1.336	.860	3	7
X8	6.27	1.031	-1.493	2.244	1	7
X9	6.29	1.026	-1.520	2.341	1	7
X10	6.29	1.042	-1.530	2.161	1	7
X11	6.30	.999	-1.536	2.574	1	7
X12	6.28	1.037	-1.736	3.855	1	7
X13	6.32	.974	-1.577	2.940	1	7
X14	6.29	1.020	-1.355	.868	3	7
X15	6.31	.921	-1.266	1.015	3	7
X16	6.27	.957	-1.157	.359	3	7
X17	6.27	.959	-1.123	.246	3	7
X18	6.35	.893	-1.232	.543	4	7
X19	6.34	.919	-1.263	.579	4	7
X20	6.34	.950	-1.392	1.088	3	7
X21	6.34	.917	-1.326	.926	3	7
X22	6.32	.941	-1.312	.895	3	7
X23	6.32	.945	-1.282	.673	3	7
X24	5.85	1.432	-1.816	3.401	1	7
X25	5.80	1.338	-1.615	3.167	1	7
X26	5.88	1.308	-1.807	4.016	1	7
X27	5.87	1.371	-1.747	3.372	1	7
X28	5.86	1.384	-1.636	2.763	1	7
X29	5.88	1.359	-1.693	3.229	1	7

5.4.2 Test of theoretical model and hypotheses

5.4.2.1 Introduction of structural equation model

Structural equation model is a method of analysing the relationship between variables based on the covariance matrix or correlation matrix. To analyse the relationship between variables, especially the relationship between multiple variables, and the influence paths between correlated variables, structural equation is the best approach. The generation and application of the structural equation model is an important methodological breakthrough in the exploration of the complex relationship between variables, and a powerful tool to solve the complex multiple relationship. The standard structural equation is composed of measurement equation and structural equation, and is generally set as a linear model. The measurement equation is used to identify the reliability between the measurement index and the latent variable, while the structural equation is used to test the path relationship between variables.

The formula of measurement equation is usually as follows.

$$\begin{cases} X_m = A_X \xi + \delta \\ Y_n = A_Y \eta + \varepsilon \end{cases} \tag{5.1}$$

The formula of structural equation is usually as follows.

$$\eta = \mathrm{B}\eta + \Gamma\xi + \gamma \tag{5.2}$$

The core of structural equation model analysis is to substitute the collected sample data into the equation for calculation, and verify whether the constructed model is consistent with the actual data and the effect of the consistency through the calculation results. The statistical principle is to use the maximum likelihood method to calculate the model parameters with the smallest difference between the covariance matrix and the theoretical covariance matrix. If the research hypothesis proposed by the researcher is logical and the data collection method is scientific, there should be little difference between the sample covariance and the theoretical covariance, indicating that the constructed model has a high degree of fit with the actual data. On the contrary, if there are certain differences between the theoretical model and actual data, the model needs to be further modified.

5.4.2.2 Path diagram of structural equation model

Figure 5.2 is the path diagram of the structural equation model for this study. There are six variables in the model, service professionalism (ξ1), service reliability (ξ2), service customization (ξ3), service digitization (ξ4), repurchase intention (η1), recommendation intention (η2). The first four variables are hypothesized independent variables (exogenous latent variables), and the latter two variables are hypothesized dependent variables (endogenous latent variables). The six hypotheses in this study are represented by the six causal relationships in the model.

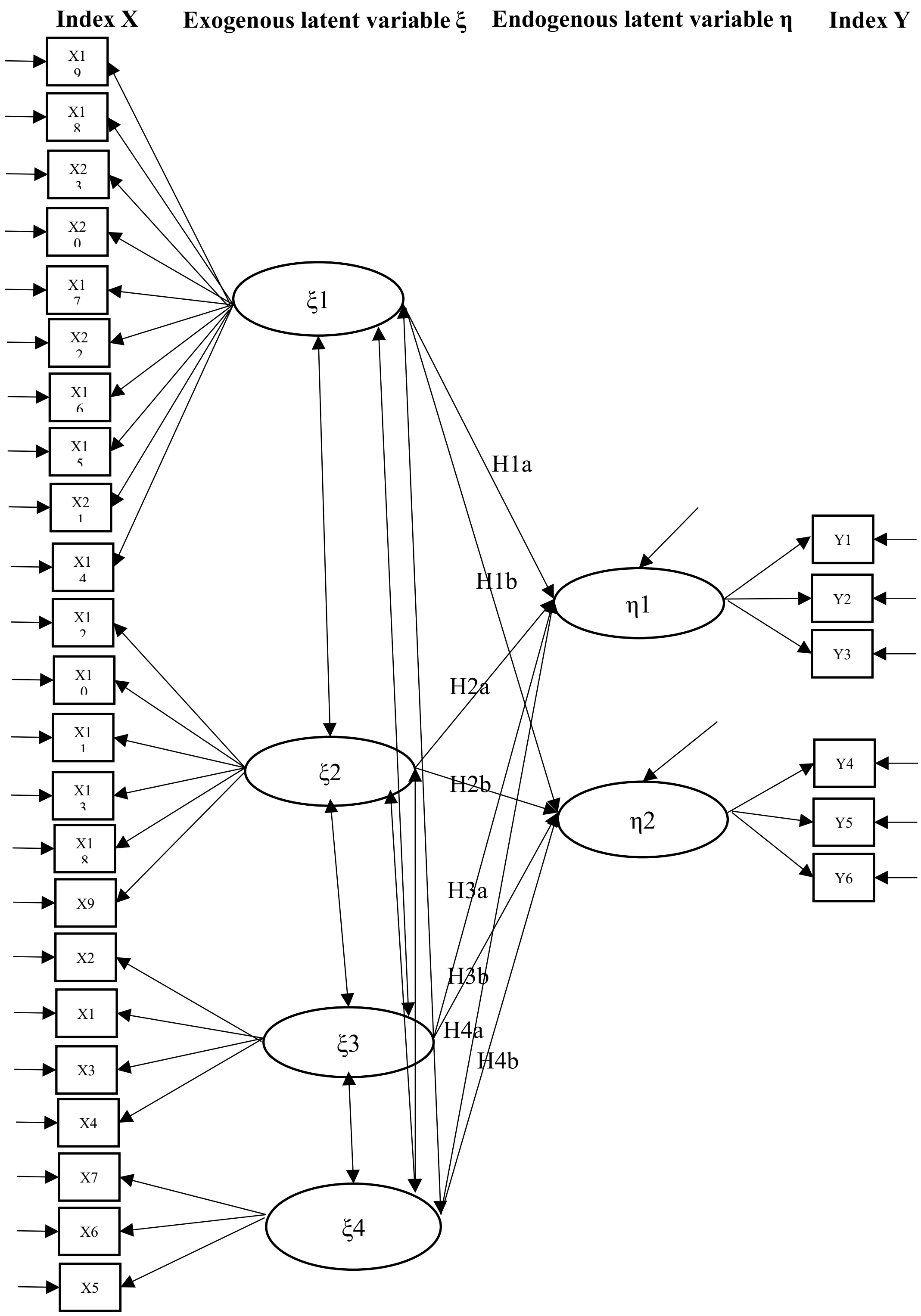

Figure 5.2 Path diagram of structural equation model

5.4.2.3 Control variable analysis

We first need to test the homogeneity of variances. If Sig. is greater than 0.05, it means that the variances are homogeneous and one-way analysis of variance can be performed. Otherwise, the subsequent results will be meaningless. The larger the F value, the greater the difference between the groups. In order to verify the impact of different control variables on service quality evaluation and behavioural intention, we use SPSS20.0 to perform the one-way ANOVA, and the analysis results are shown as per Table 5.7. The following results show that control variables such as department, job position, years of working experience, gender, and educational background have no significant influence on the evaluation of service quality and behavioural intention. There are significant differences in the evaluation of service professionalism, service reliability, and service customization in terms of age. Users aged 25 to 35 have the lowest evaluation of service professionalism, service customization, and service reliability, and users over 45 have the highest evaluation of service quality.

Table 5.7 One-way ANOVA of control variable

Dimension		Department	Job position	Years of working experience	Gender	Age	Educational background
Service professionalism	F value	0.356	0.928	1.190	0.032	**4.451****	2.048
	Sig.	0.389	0.524	0.535	0.067	**0.295**	0.175
Service reliability	F value	0.573	0.795	0.469	0.006	**2.570**$^{+}$	2.058
	Sig.	0.193	0.435	0.795	0.139	**0.300**	0.264
Service customization	F value	0.245	1.200	1.553	0.001	**3.456***	1.500
	Sig.	0.948	0.397	0.364	0.086	**0.052**	0.030
Service digitization	F value	0.242	1.312	1.911	0.100	**4.343***	**3.491***
	Sig.	0.756	0.280	0.082	0.051	**0.015**	**0.004**
Repurchase intention	F value	0.827	0.198	0.100	0.389	1.274	1.046
	Sig.	0.421	0.897	0.802	0.415	0.771	0.755
Recommendation intention	F value	1.203	0.307	0.477	0.421	1.458	1.171
	Sig.	0.131	0.994	0.916	0.168	0.743	0.412

Note: +, *, **, *** represents significance at the level of 0.1, 0.05, 0.01, and 0.001.

5.4.2.4 Hypothesis test results

In this study, AMOS software is used to construct a structural equation model, and the maximum likelihood method is used to calculate the structural equation model to test the model fit. The fitting results in Table 5.8 show that the indexes meet the minimum requirements, indicating a good degree of fit between the model and the data (see Chapter 4 for the specific fitting index standard).

Table 5.8 Fit indexes of the structural equation model

Index	χ^2/df	GFI	NFI	IFI	TLI	CFI	RMSEA
Value	2.950	0.820	0.923	0.948	0.941	0.947	0.079

Through the output structure of the structural equation model, we list the path coefficients and T values as per Table 5.9. It can be seen that the path coefficients are all positive and significant, indicating that the hypotheses proposed in this thesis are all supported.

Table 5.9 Test of model path parameters

Hypothesis	**Relationship**	**Path coefficient**	**T value**	**Hypothesis**
H1a	Service professionalism → Repurchase intention	0.7***	8.941	Support
H1b	Service professionalism → Recommendation intention	0.69***	8.759	Support
H2a	Service reliability → Repurchase intention	0.64***	8.207	Support
H2b	Service reliability → Recommendation intention	0.62***	7.918	Support
H3a	Service customization → Repurchase intention	0.66***	8.245	Support
H3b	Service customization → Recommendation intention	0.63***	7.713	Support
H4a	Service digitization → Repurchase intention	0.67***	8.451	Support
H4b	Service digitization → Recommendation intention	0.63***	7.75	Support

Note: ***, **, * represents significance at the level of 0.001, 0.01, and 0.05.

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Chapter 6: Improvement Strategies for Industrial Maintenance Service Quality

Through the above analysis, we can find that in the industrial maintenance service market, service professionalism, service reliability, service customization and service digitization are important dimensions of service quality measurement for industrial maintenance service providers. Among them, the importance of service professionalism and service reliability are particularly prominent. In addition, service professionalism, reliability, customization, and digitization all exert an important impact on customer behavioural intention, namely, repurchase intention and recommendation intention. Therefore, in order to improve the service quality of industrial maintenance service providers so that customers have stronger repurchase intention and recommendation intention, it is necessary to improve the service professionalism, reliability, customization and digitization. To improve the professionalism, reliability, customization and digitization of industrial maintenance service quality, it is necessary to explore the key influencing factors behind them, and propose precise improvement strategies for industrial maintenance service quality based on the influencing factors.

6.1 Key factors

6.1.1 Customer relationship

6.1.1.1 “Product plus service” orientation

Industrial maintenance service providers provide customers with “product plus service”, and customers expect to obtain more added value from the services. Unlike consumer services, which mainly rely on intangible services to evaluate the reliability and professionalism of service quality, industrial maintenance services rely on tangible equipment, system operation stability, reliability and other intuitive observations and feelings to make relatively objective evaluation of industrial maintenance service quality. Therefore, in addition to the advantages of service capabilities, the core competitiveness of products is also very important for the delivery of high-quality industrial maintenance services. Through the above empirical analysis, it is known that the reliability of industrial maintenance services is the most important factor in the evaluation of industrial service quality, and is closely related to tangible products.

The reliability of industrial maintenance services is mainly divided into early-stage inherent reliability and operation and maintenance reliability. In the equipment planning stage, reliability is very important. The relationship between the design life and reliability needs to be clear, and the reliability of the equipment within the design life needs to be guaranteed. The guarantee of early-stage reliability mainly relies on design and manufacturing, and equipment bidding and factory inspection. In terms of design and manufacturing, in addition to the consideration of basic factors such as the selection of product parts and materials, stress-strength analysis, and derating, complex equipment also needs to consider structural optimization. In the redundant design of failure modes, it is necessary to consider listing preventive maintenance contents based on failure analysis. In terms of equipment bidding and factory inspection, in addition to clarifying technical requirements, industrial maintenance service providers should also issue a Reliability and Maintainability Demonstration as a technical appendix and basis for acceptance. When digital operation and maintenance is applied in factories, fault handling will incentivize the MTBF value of customers. In the context of the Industrial Internet, the scope of the manufacturing system is not only limited to the equipment itself, but also includes integrated systems of industrial equipment, industrial control, and industrial software, and the coverage of reliability is more extensive. The operation and maintenance reliability mainly includes reliability protection and repair, reliable industrial product supply, reliability calibration and verification of maintenance, and dynamic adjustment of preventive maintenance cycle. Preventive maintenance projects are maintenance projects proposed based on cycle time through experiment and model analysis during design. For complex systems, preventive maintenance is an important means to ensure reliability. In order to ensure the supply of reliable industrial products, new technologies such as the Industrial Internet are needed. On the one hand, the MTBF value recorded by digital operation and maintenance can be used to measure the quality of the supply of industrial products. On the other hand, blockchain technology can be used to trace the logistics distribution process. As for the quality problems of industrial equipment itself, another key factor affecting operation and maintenance is maintenance quality. Industrial maintenance service providers can introduce digitalized operation and maintenance tools, in which engineers will issue test reports after maintenance, and if necessary, the customer’s quality department and process department will simultaneously check and accept the repair to ensure the reliability of maintenance. However, excessive reliance on preventive maintenance will disrupt the production plan and increase maintenance costs, so it is necessary to use digital operation and maintenance technology to find the law of periodic damage, so as to realize the dynamic adjustment of the preventive maintenance cycle and promote the stability of the production system.

6.1.1.2 Long-term stable relationship

Compared with consumer services, industrial maintenance service providers and their customers expect to establish long-term and stable relationships. Since industrial maintenance service providers need to provide customers with corresponding products and services, they must not only ensure product reliability, but also ensure service professionalism. There is a strong interdependence between industrial maintenance service providers and customers, and the switching cost of industrial maintenance services is relatively high. Consumer services are random and short-term, while industrial maintenance service providers and customers are both looking for stable long-term cooperation. Once customers choose, it will be difficult for them to easily change brands and services. On the one hand, industrial customer companies need long-term and stable industrial services to support their productive operations. Industrial customer companies need not only the early-stage introduction of equipment and software, but also later-stage operation and maintenance. Only by establishing a long-term and stable cooperative relationship can they meet the needs of customers' industrial services. On the other hand, service reliability and professionalism are also the basis for industrial maintenance service companies to establish long-term and stable relationships with customers. Only when industrial maintenance service companies provide reliable products and professional services, can they maintain a long-term stable relationship with customers.

The professionalism of industrial maintenance services corresponds to the professionalism of products and services required by customers of industrial maintenance service companies. Therefore, customers often manifest the following characteristics. First, it is difficult for customers to independently make high-quality service purchase decisions; second, product use training for customers is one of the important service contents; third, generally speaking, for customers, there will be many people or even multiple departments participating in the decision-making; fourth, since it involves the choice of long-term partners and the amount of investment is large, the attitude of customers will be very cautious. Due to the above characteristics, industrial maintenance service providers need to show super professional service, and the most important manifestation is the professionalism of service personnel. The professionalism of service personnel means that the personnel who provide services to customers have service-related capabilities, knowledge and skills. In industrial maintenance services, the professionalism is mainly reflected in whether the professional knowledge and skills of equipment installers, software debuggers, training personnel, and communication personnel can meet the customer's service needs. Generally speaking, service personnel are not only the conveyer of professional service quality of industrial maintenance service enterprises, but also the direct maintainer of the relationship between industrial maintenance service providers and customers. Sufficient professional knowledge and strong professional capabilities of service personnel are an important guarantee for the professionalism of industrial maintenance service providers, and are directly related to the establishment of long-term and stable cooperative relations between industrial maintenance service providers and customers. In addition, employees with professional knowledge and professional capabilities can effectively communicate to promote the relationship between industrial maintenance service providers and customers, allowing companies to grasp, explore and lead customer needs faster and more accurately, and pass customer needs to the R&D team for product development and design. It can not only improve customer relationships, but also improve customer satisfaction and behavioural intention.

6.1.1.3 Classified customer management

The customers of industrial maintenance service companies are basically corporate customers, and the daily operations of various corporate customers are not the same. According to whether they encounter problems in daily operation and maintenance and whether they report to the industrial maintenance service provider, customers can be classified into three categories. (1) The daily operation and maintenance are smooth, and it is rare for them to encounter problems and submit them; (2) The daily operation and maintenance is not smooth, and they encounter problems but not submit them; (3) The daily operation and maintenance is smooth, and they submit problems when encountering them (R. Guo, 2015). When the customer uses the equipment and software, if the system runs well and there is no usage problem, the customer satisfaction will be relatively high, and their repurchase intention and recommendation intention will also be high. If the customer encounters some problems that have little impact during the operation, such as cumbersome system processes and low use efficiency, the customer will adopt some methods to work around or ignore the problem, and will not submit the problem to the industrial maintenance service provider. In this case, customer satisfaction will be affected, thereby affecting behavioural intention to a certain extent. If the user encounters some unavoidable problems during use that make the normal production process unable to continue, the customer will first try to use some independent channels to solve the problem, such as software training documents, professional forums, and personnel from the enterprise engineering department, and the problem will not be submitted to the industrial maintenance service company, either. However, if the problems encountered by customers cannot be solved through self-service methods, they will proactively contact the industrial maintenance service provider to submit problems and seek help. In this process, if the industrial maintenance service provider can effectively solve the problems faced by the customer and provide professional and reliable services to satisfy customers, it will make up for the loss of customer satisfaction caused by equipment problems to a certain extent. However, if the problem is not solved properly, or the customer's expectations are not met in the process, the customer satisfaction will be further reduced, and the recommendation intention and repurchase intention will be further reduced.

It can be found that the industrial maintenance service providers with the highest service quality are those whose customers have smooth usage of equipment and software and good customer experience. For industrial maintenance service providers with the second highest service quality, although customers encounter certain problems in the use of equipment and software, they can solve them through self-service. If customers encounter problems in the usage of the equipment and software, but do not point them out, or if it is difficult to solve the problems and they choose submit them to the industrial maintenance service providers, there will be loss of satisfaction and the customer's behavioural intention will be reduced. This situation is very unfavourable for industrial maintenance service providers. Therefore, industrial maintenance service providers should further improve the reliability and professionalism of their services, increase the proportion of the first two situations, and improve customer self-service problem-solving channels.

6.1.2 Brand management

6.1.2.1 Brand appeal

Customer appeal for industrial service brand is more rational. Industrial maintenance service companies provide customers with industrial services. Unlike consumer services, the decision-making chain of industrial maintenance services is longer. Different links of procurement decision-making have different personnel to conduct needs assessment, and the interaction of each link affects the assessment and procurement results. The consumer services are affected more by perceptual factors, while customers of industrial maintenance services pay more attention to factors such as function, cost performance, service reliability and professionalism. In addition, in industrial maintenance service companies, salesmen and technicians, rather than the medium, have the most contact with customers. The service team has become an important link in the value chain of industrial maintenance service companies, and plays an important role in brand building. The rational appeal of customers for industrial service brands mainly stem from the following aspects. First, in the purchase of industrial maintenance services, quality and price are the two key factors to be investigated. That is, the economy and practicality of industrial maintenance services are very important. In the procurement process of industrial maintenance services, the quality is often compared first, and then the price is compared, while the influence of sentimental value is relatively small. Second, industrial maintenance services tend to place more emphasis on push rather than pull. Industrial maintenance service companies often emphasize the development of key accounts, and focus on launching aggressive sales and service campaigns to customers. Third, the brand marketing of industrial maintenance service companies is often based on professional media, rather than mass media. Therefore, when industrial maintenance service companies are building their brands, they must closely focus on the rational appeal of customers, which can not only help them gain greater profit margins and market opportunities, but also help companies gain long-term competitive advantages.

Therefore, in the process of brand building, industrial maintenance service companies must follow the following principles. First, the principle of functional value first, supplemented by sentimental value. Communication appeals can be divided into rational appeals, emotional appeals, and image appeals. The focus of rational appeals lies in core technology, materials and equipment, core components, software systems, and implementation standards, and the purpose is mainly to establish rational values. Second, the principle of integrated communication. On the whole, the brand building behaviours of industrial maintenance service companies are relatively extensive and fragmented, which are mainly manifested in lack of strategic communication, old-fashioned communication strategies, single communication methods, and narrow communication strategies, which lead to lack of effective integration of communication. Third, the principle of creating maximum value for customers. For industrial maintenance service companies, the most important work is not brand building. In other words, brand building is not the goal, and the focus should be on creating value for customers. Specifically, how industrial maintenance service companies can help customer companies reduce equipment failure rates and how to help customer companies reduce their operation and maintenance costs require scientific empirical data. This is also the core of brand building of industrial maintenance service companies. Fourth, the principle of long-term brand communication. Like consumer services, if the industrial maintenance service companies choose to carry out brand building, they must go on unremittingly. Brand management needs to be strategic, resource investment needs to be long-term, and management institution needs to be permanent. This is a process of continuous adjustment and gradual improvement.

6.1.2.2 Purchaser group

The supply of industrial maintenance services basically belongs to B2B. Considering the influence of factors such as the development stage of the industry and the region, the number of customers in the later development will be as few as several or a dozen, and as many as hundreds or thousands. Compared with the huge number of customers of consumer services, the customers of industrial maintenance services are rarer and more scattered. This is also an important reason why many industrial maintenance service brands invest in professional media rather than mass media. Therefore, key accounts are very important for industrial maintenance service providers.

Key accounts have certain differences with general customers in terms of purchase, decision-making, and focus, and the differences are mainly manifested in the following aspects. First, key accounts are very concerned about the technology provided by industrial maintenance service companies. If industrial maintenance service companies have superior technical advantages, key accounts will be attracted to actively call for services. Second, timing is very important in the sales of industrial maintenance service companies to key accounts. The internal management personnel of major customer companies will be re-positioned. When the service project is operating normally, if the leader changes, the service contract should be signed as soon as possible. Otherwise, the new leader may have other ideas after taking office. When the service project is not operating smoothly, if the leader changes, there will be a new sales opportunity and it should be seized tightly. Third, key accounts also value the quality of later operation and maintenance services. The introduction and installation of equipment and software in the early stage of industrial maintenance services are only the first step of the service. Timely response to and maintenance of failures by the industrial maintenance service companies in the later stage directly affects the decision-making of key accounts. Fourth, key accounts need written contracts to strengthen the trust of both parties. In the industrial maintenance service market, in order to reduce the misunderstanding of both parties, written contracts or agreements are often used. Fifth, key accounts emphasize negotiation. In most cases, the price of industrial maintenance services can be negotiated, especially for key accounts. The price generally needs to be negotiated by both parties in order to achieve a win-win result. Sixth, key accounts put more emphasis on long-term cooperative relationships in the acceptance of industrial maintenance services. If industrial maintenance service companies can establish long-term relationships with customers and continue to provide high-quality services, they can form brand advantages and resist the intrusion of competitors. Seventh, key accounts all have a certain budget for purchase of industrial services. The purchase of industrial maintenance services is one of the important operating expenditures of an enterprise. It is included in the corporate balance sheet, and key accounts need to undergo purchase approval. Eighth, key accounts have a certain procurement process for the purchase of industrial maintenance services. The difference in the procurement process is based on the difference in business management. Generally speaking, the application may be proposed by the engineering design department or the affiliated factory and then submitted to the purchasing department, if the procurement service is out of routine, the manager will intervene. Ninth, key accounts have different purchasing motives for industrial services. Industrial maintenance services pay more attention to the practical value of the service, and the reliability and professionalism of the service are the first things that need to be considered.

6.1.2.3 Brand control

Brand control is an important factor affecting competition among industrial maintenance service companies. Consumer services are geared towards the mass consumer market, and brand awareness will determine consumer memory and influence consumer purchasing decisions. The brands of industrial maintenance service companies are different. The market for industrial maintenance services is more complex. Industrial maintenance service companies pay close attention to upstream and downstream companies in production and operations, and their impact on the industrial chain and the power of speech directly determine the quality of business operations. Therefore, strengthening the control of value chain through core technology and building brand control is the key to competition.

The development of brand control mainly involves four aspects of brand positioning, brand identity, brand personality, and brand association. Excellent brand building often takes brand positioning and brand personality as motivation factors, and brand identity and brand association as hygiene factors. Brand positioning is the “soul” of a brand and the core value brought to customers. In the process of dissemination of brand positioning, customers will form the most basic cognition of industrial maintenance service companies. Brand positioning must follow three principles. First, positioning should be based on the true advantages of the service. In other words, industrial maintenance service companies should position themselves based on what they are good at, rather than flashy concepts such as “dream” or “infinity”. An enterprise should bravely position itself to win the “first” position, making it difficult for competitors to surpass. Second, positioning should be able to be passed to target customers. Industrial maintenance service companies convey the positioning concept to target customers in the process of brand building, so that customers can actually feel and recognize it. Third, positioning should be distinguished from competitors. For industrial maintenance service companies, the uniqueness of the brand is very important and differentiated development should be valued. Brand identity is the auxiliary value that supports brand positioning, and it plays a positive role in promoting customers' rational perception. It usually involves three aspects: geographic or cultural characteristics, product characteristics, and user characteristics. Geographical or cultural characteristics mean that the brand has certain geographic and brand benchmarks, such as "Siemens in Germany" and "GE in the United States". The identification of geographical or cultural advantages can promote brand recognition. Product characteristics refer to the service recognition brought to customers in addition to brand positioning, which is the icing on the cake for positioning. User characteristics refer to the characteristics of the target customers of the industrial maintenance service companies, and the brand positioning meets the appeals of the target customers. Brand personality is a kind of style feeling that the brand brings to customers, and it is the main emotional appeal. There is a potential connection between brand personality and brand positioning. When brand positioning of the service provider converges with that of the competitors, the importance of brand personality will become more prominent. Brand association is a cognition that is difficult for companies to control in the connotation of a brand. It is the associated memory and feeling brought to customers after brand communication, and it has a positive role in promoting customers' emotional appeals. In brand building, although brand association cannot be controlled, it can be guided. Corporate image guidance, service image guidance, symbolic image guidance and employee image guidance are common methods used to guide brand association. Through the planning of the above four parts, the "rational appeal" and "emotional appeal" of the brand are formed, thereby enhancing brand recognition and brand loyalty and influencing customers' behavioural intention.

6.1.3 Information technology

6.1.3.1 Industrial big data

Industrial big data refers to the big data generated in the application of information technology in the industrial field. The production lines of industrial enterprises, as customers of industrial maintenance service companies, are in high-speed operation, and the amount of data generated, collected, and processed by industrial equipment far exceeds the amount of data generated by computers and humans. In addition, the data is mostly unstructured, and the high-speed operation of the production line also has high requirements for the real-time nature of data. The challenges faced by customer companies in industrial big data provide considerable potential development opportunities for industrial maintenance service providers, and industrial big data plays a greatly significant role in between. First of all, industrial big data can accelerate enterprise service innovation. Industrial maintenance service companies generate a lot of data in transactions and interactions with customers. Mining and analysing these dynamic data can more accurately grasp customer demand trends and apply them to service innovation, enabling industrial maintenance service companies to better understand customers, formulate service improvement plans, and implement service innovations. Second, industrial big data can help customers diagnose and predict faults. The introduction of a large number of sensors and Internet technologies has enabled the implementation of product fault diagnosis. The application of big data, modelling, and simulation technologies have made it possible to predict dynamics. Third, the Industrial Internet of Things has also been widely applied. Modern industrial production lines have a large number of small sensors to detect temperature, heat, pressure, vibration, and noise of industrial equipment, and collect these data to achieve power consumption analysis, energy consumption analysis, equipment diagnosis, and quality accident analysis, so as to help industrial customers reduce failure rates and production costs. Fourth, the application of big data technology can manage industrial service sales prediction and demands. Industrial big data is a good sales analysis tool. Through the multi-dimensional combination of historical data, it is possible to find out the proportion and change of regional demands and customer level, so as to adjust the service strategy. Fifth, big data technology can help client companies to schedule production plans. Industrial enterprises are faced with a variety of small-batch production models. Big data can collect detailed data information, discover the probability of historical predictions and actual deviations, consider personnel constraints, material constraints, capacity constraints, and tooling and mould constraints, through intelligent optimization algorithms, make plans and schedules, monitor the deviations between the plan and the actual on-site situation, and dynamically adjust the schedule. Sixth, big data technology can help industrial enterprises manage and analyse product quality. Traditional industrial enterprises are facing the impact of big data, and they are in urgent need of innovative methods in process design, product development, quality management, and production operations.

As a result, the importance of industrial big data in the industrial maintenance service market has become increasingly more prominent, and the provision of digitalized services by industrial maintenance service companies is an inevitable trend. For example, Siemens has clearly proposed to provide digitalized industrial maintenance services to facilitate the digital transformation of industrial enterprises, covering the entire process from planning, engineering, installation, debugging, operation, and modernization to ensure plant safety. Siemens can help industrial customers improve the effectiveness of overall equipment, improve resource and maintenance management, and its comprehensive service portfolio can help customers realize the gradual digitization of infrastructure, integrate physical equipment and analyse big data, and generate intelligent data to realize efficient, safe and flexible operation.

6.1.3.2 Industrial software

Industrial software refers to software that is specifically applied in the industrial field. There are roughly two categories. The first category is embedded software embedded in hardware products such as production equipment, which can be subdivided into operating systems, embedded databases, development tools, and application software. Through embedding in hardware products, they can achieve automation, intelligent control, detection, management of equipment and system operation. The other category is special engineering software in various industrial fields, mainly for business management of production and manufacturing. For example, product life cycle management system (PLM), computer-aided design (CAD), computer-aided manufacturing (CAM), and computer-aided engineering (CAE). Industrial software covers all aspects of the manufacturing industry, including systems, applications, and embedded systems. In Industry 4.0, intelligentization and digitization are its main characteristics. Intelligentization is only a tool, while customization is the essence, which is closely related to industrial software. This shows that it is very important for industrial maintenance service companies to provide customers with customized services through industrial software.

Industrial software runs through the entire manufacturing process of industrial enterprises, and improves the production efficiency of the factory and optimize the production process from the dimensions of supply chain management, product design, production management, personnel management, and enterprise management. In Industry 4.0, software systems and digital processing systems such as production data management (PDM), supply chain management (SCM), product life cycle management (PLM) are involved, which can aggregate and analyse scattered data to improve the production efficiency of customer enterprises. At this stage, many industrial maintenance service companies provide impetus for the innovation and development of manufacturing technology of industrial enterprises through the provision of industrial software. Industrial software technology supports most of the manufacturing process, and industrial software will determine the future development of the manufacturing industry.

Industrial maintenance service companies can only take advantage in the fierce competition by further providing customized services and help customers solve individualized problems.

6.1.3.3 Smart factory

With the rise of a new round of scientific and technological revolution and the rapid development of new-generation artificial intelligence technologies such as knowledge graph and deep learning, industrial intelligence has also ushered in a new stage. With the development of industrial intelligence, smart factories have become the future development goals of industrial enterprises. Through massive data real-time sensing, deep inheritance and intelligent modelling, the overall decision-making ability of industrial enterprises is improved. Industrial maintenance service companies help industrial customers in the construction of smart factories through the provision of digital services. First of all, in the smart factory, close connection is established between people and people, people and equipment, and equipment and equipment through data. All production data can be collected, uploaded, analysed, and used to facilitate decision-making in real time. The historical data can be recalled and improved at any time. The equipment realizes real-time monitoring through software and hardware such as sensors and industrial software, and provides early warning of possible failures. Secondly, in the smart factory, animation technology, information processing, intelligent reasoning, prediction, multimedia technology, and simulation are integrated in the central control room. Through the virtual display of the production process via sensing devices and audio-visual equipment, the manager can master the entire production status as a whole only on the digital screen. Furthermore, in a smart factory, product model switching is more frequent and easier, and better coordination can be achieved among equipment. The smart factory can conduct self-learning in practice, expand the knowledge base, and provide a basis for corporate decision-making. Finally, all production activities in the smart factory are controlled by the automated production integrated system, which can complete the target tasks with quality and quantity in an unattended manner around the clock. On the whole, smart factories can bring the following advantages to industrial companies. First, through the intelligent analysis and tracking of production information, smart factories can continuously explore the operational potential of equipment and improve management goals to achieve a doubled increase in production efficiency. Second, smart factories can collect and record production data, monitor production processes, pay attention to product quality, and implement post-mortem analysis to continuously promote product quality improvement. Third, quality management methods such as prevention, monitoring, and analysis are used during production, so that products can be controlled to improve product quality. Fourth, through triggered automatic data collection, data entry links can be reduced, and the required implementation data can be provided to production personnel at all levels to achieve lean production. Fifth, through the implementation of production information collection, it is possible to fully understand the production progress and realize the fully transparent management of production. Sixth, through the adoption of standardized management of advanced manufacturing IoT technology, the transparency of the workshop can be realized, which can enhance the production execution ability and improve the core competitiveness of industrial companies.

6.2 Improvement strategies

6.2.1 Maintain customers and keep long-term stable relationship

6.2.1.1 Ensure core technical advantages and improve service reliability

In the field of industrial services, industrial maintenance service companies must have a solid technical foundation and core technological advantages if they want to achieve steady and sustainable development. Supercomputing terminals, software, and knowledge work automation are the three key technical components for industrial companies to achieve development in the context of the Industrial Internet. Supercomputing terminals are some new intelligent devices, and the core of these products is to have a powerful chip. An example is the industrial operating system Predix launched by GE. In the industrial field, software-defined hardware has gradually become the norm. With the increasingly low threshold and homogeneous competition of mechanical equipment and hardware products, software is the source of differentiation. The automation of knowledge work refers to the automation of information processing. It involves cutting-edge technologies such as information interaction, artificial intelligence, and machine learning, and is closely related to the breakthrough of algorithm technology. Only when an industrial maintenance service company masters one or a few key technologies, can it gain a competitive advantage in the field of industrial maintenance services and improve service reliability while maintaining its core technical advantages.

On the one hand, industrial maintenance service companies should improve their independent innovation and independent research and development capabilities, and continue to maintain their core technological advantages. Independent research and development means that enterprises mainly rely on their own strength to develop new products, new materials, and new processes through high-tech, so as to master relevant core technologies. Companies hoping to acquire core technologies through independent research and development should meet the following conditions. First, companies must have strong R&D capabilities. Second, companies must have sufficient R&D capital investment. Third, companies must have core businesses to support the cash flow needs. On the other hand, industrial maintenance service companies can adopt the approach of outsourcing to introduce core technology from outside, mainly by purchasing a core technology through funds, or directly poaching talents with core technology to achieve core technology mergers and acquisitions and reorganization. Companies that outsource core technologies often have the following characteristics. First, the companies lack scientific research or innovation capabilities. Second, the companies lack the core pillar business to help them with R&D transition. Third, the companies urgently need core technology to help them out of the predicament, and the urgency of time does not allow companies to carry out long-term funded research and development. In addition, companies can also adopt the method of establishing technology alliances, and jointly develop new technologies through agreements between two or more enterprises. Technology alliances often have clear R&D schedules, and they will be carried out based on specific R&D goals. Although the method of alliance development can enable enterprises to quickly obtain the needed technology and resources and reduce development costs, there may be huge intellectual property risks and competition risks. Industrial maintenance service companies can adopt corresponding core technology acquisition strategies based on their actual conditions to improve service reliability while ensuring technical advantages.

6.2.1.2 Ensure core talent advantages and improve service professionalism

Compared with consumer services, industrial maintenance services are human capital and knowledge capital intensive industries, with stronger professionalism, knowledge-orientation and otherness. Due to the increasing proportion of service-related personnel in the industrial field, the proportion of added value of industrial products created by service activities continues to rise, and the demand for specialized services within industrial enterprises has increased (Gann & Salter, 2000). As a result, specialized industrial maintenance service companies have emerged. With the support of information technology, they can deliver new technologies and knowledge to industrial companies, thereby promoting the development of the industrial economy. Especially in some industrial fields with diverse needs, large market scale, and obvious individualized needs, specialized industrial services appear to be particularly important. At the same time, industrial maintenance services are also knowledge-intensive and differentiated. The acquisition of knowledge requires a large amount of initial investment, after which the marginal cost will gradually decrease, and the role of economies of scale will be prominent. Therefore, industrial maintenance service companies capable of achieving product differentiation can have a stronger competitive advantage. Due to the professional requirements of industrial services, ensuring professional service personnel with knowledge and ability is essential for industrial maintenance service companies to provide professional services.

The production and transaction of industrial maintenance services have very prominent requirements for human capital, that is, the non-renewability of services enhances the role of service personnel's knowledge and ability in the service process, and the high requirements of service production on innovation determines the requirements for the innovation of service personnel. Industrial maintenance service personnel need to meet the following professional requirements. First, industrial maintenance service personnel need to have a wealth of knowledge accumulation. Industrial maintenance service is a high-end service industry with a large amount of knowledge contents that runs through the entire process of industrial production, and it is beneficial to improving the production efficiency of industrial enterprises. Industrial maintenance service personnel need to be familiar with the relevant business processes of industrial enterprises, and effectively connect all production links through manpower and knowledge services to improve production efficiency. Only with a profound accumulation of intellectual capital, can the companies provide satisfactory services to customers. Second, industrial maintenance service personnel need to have cross-disciplinary and cross-industry knowledge. Industrial maintenance service personnel must not only master the relevant knowledge and understand business processes of industrial enterprises, but also need to consider the entire industry chain to improve efficiency, reduce costs, avoid or reduce the losses caused by overstock, work being held up for lack of material, out-of-stock, and dull sale. Third, industrial maintenance service personnel need to combine professional knowledge with general knowledge. Industrial maintenance service personnel need to carry out innovative industrial service activities based on the characteristics of different industries and regions. Therefore, industrial maintenance service personnel must have not only general knowledge of related production services, but also professional knowledge of subdivided industry fields. Fourth, industrial maintenance service personnel need to have sophisticated skills. Industrial maintenance service personnel require a large amount of knowledge accumulation, covering a wide range of fields, and possessing complex knowledge and capabilities. The huge benefits that industrial services bring to industrial production determine the demand for high-skilled and knowledge-intensive talents by industrial maintenance service companies.

6.2.1.3 Ensure maintenance of customer relationship and establish stable service relationships

In the field of industrial maintenance services, to establish a long-term and stable service relationship, it is necessary to ensure the maintenance of customer relationship, that is, the business behaviour to maintain mutual trust and communication between industrial maintenance service companies and customers, with value service and value pursuit as the return. The maintenance of customer relationships by industrial maintenance service companies helps new technologies, new products, and new services of the industrial maintenance service companies to attract customer attention and acceptance, and obtain rapid feedback in the market. First, the maintenance of customer relationships can effectively increase the focus on customer share, thereby increasing the income of industrial maintenance service companies. To manage customer relationship, it is necessary first to recognize its importance, analyse the its composition and value. To ensure long-term stable customers, it is necessary to spend more manpower and time on maintaining long-term stable customer relationship, even special personnel should be designated for this task. In addition, the service strategy can be adjusted according to the importance of customers to the market share. More favourable service price can be offered to attract customers to maintain long-term cooperative relations. Second, by maintaining customer relationship, industrial maintenance service companies focus on the value mining and cultivation of potential customers, and gradually form a sustainable development capability. First of all, in the customer relationship management, the company needs to select customer enterprises that may become key accounts. These customers have the ability and conditions to require a wider range of industrial services. The industrial maintenance service provider should spend time on such customers, make them reliant on the industrial maintenance service, strengthen return visits and feedback to customers, and develop them to be potential customers. Second, the sustainable development ability of industrial maintenance service provider is the basis for realizing competitive advantage. The key to the formation of sustainable development ability is effective management and maintenance of customers. The continuity of the customer relationship is the foundation for companies to achieve steady development. Third, the effective maintenance of customer relationship is conducive to enhancing customer loyalty and behavioural intention. On the whole, the good maintenance of customer relationship is the in-depth communication of the supply and demand relationship between the industrial maintenance service company and the customer, and it is the expression of the company's user-centric purpose. The maintenance of customer relationship is conducive to the good development of the enterprise in the industrial maintenance service market, and it is also the customer's affirmation on the quality of industrial service. From the perspective of enterprise development, the maintenance of good customer relationship is conducive to the connection between service trust and users, and it is conducive for the enterprise to providing more services and gaining benefits. From the perspective of customers, a good customer relationship means customers can be more assured of the service, and there is no need to worry about after-sales and quality.

In order to establish a good customer relationship, on the one hand, a comprehensive customer relationship management is required. Industrial maintenance service companies need to do a good fundamental job. They not only need to maintain the customer-centric concept, but also need a comprehensive and systematic maintenance, and use scientific and effective means to conduct customer relationship operation and maintenance. First of all, it is necessary to collect customer information and establish a customer database. In addition, professionals must communicate with customers and treat them with sincerity. Furthermore, it is necessary to keep abreast of customer feedback on product and service information, and communicate and interact with customers. Finally, it is necessary to actively consider customer opinions and propose corresponding solutions based on the actual situation of customers. On the other hand, the industrial maintenance service company must focus on emotional management to maintain customer relationships. Industrial maintenance service companies cannot just rely on some software to achieve the purpose of customer relationship management. No matter how advanced the technology is, it cannot replace the emotional role of humans. Therefore, sincere communication between people and maintenance of customers with emotion is also the focus of customer relationship management.

6.2.2 Strengthen brand building and promote brand communication

6.2.2.1 Introduction of brand building new mindset

In the context of the rapid development of digitization and informatization, industrial maintenance service companies must first introduce new mindset such as the Internet, ecologicalization, humanization, and globalization to carry out brand building. Internet mindset is a re-examination and thought of users, products, markets, value chains, and the entire business ecosystem under the continuous development of digital technologies such as big data, cloud computing, and the Internet. For industrial maintenance service companies, user mindset and socialized mindset are the most important in brand building. The most important thing in

Internet mindset is user mindset. Users and customers are not exactly the same. Customers are those who purchase services, while users are those who ultimately use the products and services. User mindset is to establish a customer-centric culture in all links of the value chain, and enterprises can only survive with a deep understanding of users. The communication process of the brand is realized in the process of good user experience and sharing. For example, Intel and GE have adopted “user mindset” in the process of brand building. These companies directly focus on the end user’s experience and continuously improve their products and services, thereby promoting the brand influence. The focus of socialized mindset is to make good use of social media, especially in the post-massification era where brands are no longer the communication of companies to customers, but the communication between customers and between individuals. Only when a corporate brand has an identity accepted by a certain group, can it gain group recognition, and the group members will help promote the brand to achieve effective information dissemination. For example, internationally renowned brands such as GE and Siemens often interact with the public. Therefore, in the Internet age, industrial maintenance service companies should also make full use of social media to communicate with the public.

In addition to Internet mindset, ecological mindset, capital mindset, simple mindset, humanized mindset, and global mindset are also very important in the process of brand building for industrial maintenance service companies. Ecological mindset means that in the process of building a corporate brand, a brand ecosystem containing multiple brands can be established, which can adopt different forms such as diversification, verticality, complementarity, and sharing. Capital mindset means that brands use the power of capital to increase their visibility and influence. Simple mindset means that brands should simplify complex issues so that customers can easily obtain and understand brand information. Humanized mindset means that industrial maintenance service companies should develop new technologies, new products and new services in a more humanized way to achieve user-friendliness. Global mindset means that in the process of brand building, there should be a layout and vision for global development.

6.2.2.2 Build a differentiated brand system

A brand is a name, term, logo, symbol, or a combination of them, and its goal is to differentiate the products and services of the seller from those of the competitors. For industrial maintenance service companies, the establishment of a differentiated brand system is the basis for distinguishing themselves from competitors and establishing their own brand advantages. To establish a differentiated brand system, it is necessary to carry out brand positioning, brand marketing and brand maintenance in sequence.

Brand positioning is to establish a clear image that is needed by the target customer and different from the competitors, so as to establish a favourable position in the mind of the target customer. An industrial service brand can become a strong brand only when it has a positioning, because it has a distinctive concept and thus becomes the first choice for customers when they have relevant needs. In the context of the Industrial Internet, industrial service brand positioning needs to pay attention to the following aspects. The first is clear role cognition. In the era of Industrial Internet and Industry 4.0, the business model of industrial maintenance service companies will change from a simple "service provider" to a "solution provider", and ultimately from a "hardware-defined enterprise" to a "software-defined enterprise". The second is to emphasize the core value of the brand. The core value of the brand is a differentiated value proposition abstracted based on the corporate history and corporate vision to distinguish the company from competitors. Industrial service brand positioning needs to emphasize core values. Brands without core values are always difficult to sustain for a long time. The third is to create differentiated brand advantages. The essence of brand positioning is to show an advantage over competitors. Specifically, by delivering differentiated information to customers, the brand attracts customers' attention and recognition, thereby occupying a unique value position in the hearts of customers. To do well in brand marketing, attention should be paid to the following aspects. The first is to do a good job in brand design, which is the premise and foundation of brand marketing. Brand design should identify the brand name, brand mark, brand colour and brand characteristics on the basis of brand positioning. The second is to formulate brand standards, including unified brand quality standards, brand service procedures, corporate rules and regulations, and unified codes of conduct and norms. The third is to vigorously carry out marketing activities, which mainly involves the identification of brand communication channels and communication media. Finally, brand maintenance is required, which mainly involves the following aspects. The first is to win by quality. Well-known brands are generally a guarantee of superior service quality. If a corporate brand wants to last for a long time, it needs to ensure excellent service quality. Only when the quality of the brand is maintained, can the reputation of customers and brand loyalty be won. The second is to strengthen follow-up services. The development of industrial maintenance services relies on relatively stable industrial enterprise customers, and repeated consumption by customers is an important source of income for industrial maintenance service companies. Therefore, only by ensuring the quality of follow-up services can the brand image be maintained. Third, the enterprise must focus on innovation. In the era of Industrial Internet, the demands for services by industrial enterprises have become increasingly diversified. On the premise of ensuring service quality, services should be adjusted and innovated according to customer needs to ensure brand vitality.

6.2.2.3 Innovative brand communication channels

With the development of the Internet and mobile terminals, the new media represented by the Internet has become a cross-level, cross-regional, and cross-media communication medium. The brands of industrial maintenance service companies should fully apply new technologies and new media to achieve diversification of communication methods and three-dimensional presentation of the brand. First, it is necessary to build a high-end corporate website. Oriented by users, the industrial maintenance service companies establish a corporate website with an international vision to show the company's service brand, service tenet, and service content, and leave a good impression in the minds of customers and the public, so that users and the public can form a preliminary understanding of the company through the corporate website. Second, a "micro" communication system can be constructed. In today's society, new media such as Weibo, WeChat, micro-films, short videos, and live broadcasts are developing rapidly. These platforms have the advantages of low cost, fast dissemination, and accurate audience targets. They have become an important channel for brand communication for many companies, especially consumer service companies. Internationally renowned companies such as Siemens and GE have also begun to increase their investment in new media, and continue to spread their brands through various methods such as event creation and fans interaction. Furthermore, search engines should be fully utilized. Nowadays, people are accustomed to using search engines for information query. To quickly understand the popularity and reputation of a brand, the most convenient way is to search and view the number of search results. The Internet era has brought new mindset and tools, and it has also brought the possibility of rapid brand building. However, the process of brand building and communication of industrial maintenance service enterprises is not accomplished overnight, and it needs to undergo long-term systematic technological innovation and the improvement of industrial service quality.

6.2.3 Improve information technology capabilities and facilitate digital transformation of industrial enterprises

6.2.3.1 Improve big data mining capabilities and offer digital services

Data mining (DM) refers to the process of extracting the data needed by the enterprise from a large amount of redundant data and revealing previously not obvious but valuable information. Data mining is a decision support process that can analyse corporate data in a more humanized manner, make implicit judgments and inferences, and dig out hidden patterns from it to help companies make relatively correct decisions. In the context of industrial big data, industrial maintenance service companies need to help industrial companies achieve digital transformation and help them construct digital factory. The most important thing is to collect relevant production data of industrial companies. Only with strong data mining capabilities can they provide digital services. Strong data mining capabilities can enable industrial maintenance service companies to provide better services. First of all, improving the level of data analysis can ensure that companies make more scientific decisions. Data mining can not only make scientific predictions on the problems to be analysed, but also analyse the implementation of decision-making. During the operation of industrial maintenance service enterprises, all information needs to be represented by data. Through data mining, decision makers can discover the results and rules that cannot be found on the surface, so that they can predict the results more scientifically. Second, it can integrate external information in a timely manner to provide customers with satisfactory services. With the development of society, the importance of customers has become more prominent, and competition gradually presents the feature of "customer" being the centre. Improving service quality to obtain customer satisfaction and influencing customer behavioural intention has become the focus of corporate competition. As a result, customer data has become a top priority. How industrial maintenance service companies can effectively collect and analyse these customer data is critical to gaining a competitive advantage. The more complete and timelier the industrial maintenance service companies have on customer data, the more they can use data mining technology to integrate basic customer information and analyse customer static and dynamic data. Third, through data mining, customer loyalty can also be improved and customer churn can be reduced. Through data mining, the customer consumption preferences and consumption levels are identified to classify and manage customers. As the patterns of various customers are found, customized services can be offered to them, trust is built with customers, and service quality can be improved in a targeted manner to reduce customer churn.

Data mining is a relatively complex process that requires a series of steps. First, identification of the problem. Before data mining, industrial maintenance service companies need to identify the business problem to be solved, and clearly define the data mining problem. Second, data preparation. Data mining is based on a large amount of data. Industrial maintenance service companies can only form a data foundation by focusing on collection of customer data for a long time. Third, understanding and analysis of data sources. Data mining is an iterative process of backtracking, so it is necessary to choose a good research topic, and identify the data package to be studied, and data analysis tools. Fourth, identification of the data. Useful data needs to be identified from a large amount of complex data for data mining. Fifth, reading in of the data and model building. After confirming the input data, it is necessary to select a suitable model to analyse the data. Sixth, mining operations. This process is based on the mining model to filter, analyse and process actual data. Seventh, application and explanation. Information is extracted and analysed based on decision-making objectives. Roughly through the above processes, industrial maintenance service companies realize the data mining to provide customers with digital services.

6.2.3.2 Enhance industrial software development capability and offer customized services

Industrial software is software technology and products rooted in various industrial industries. Only by deep integration with the industry and delivery of customized services can industrial software develop extremely strong vitality. Therefore, industrial maintenance service companies should strengthen the interaction with the industrial industry, explore and lead the needs in continuous interaction, find the shortcomings of the original industrial software products, and make customized improvements based on enterprise differences, so as to improve industrial software market competitiveness. In order to enhance the stickiness of industrial software to the industrial industry, industrial maintenance service companies should carry out innovations to enhance industrial software development capabilities. The development of industrial software should take into consideration the particularity of development process and the particularity of talent training. As far as the development process is concerned, as the entire product life cycle of industrial software involves the scientific research and technological innovation process of the service, the simultaneous participation and long-term intervention of engineering and technical experts and scientists are needed. Without the participation of industry insiders, industrial software cannot be written only by software developers. Therefore, the R&D team needs to be composed of engineering and technical experts as well as software development experts. Before software development, industrial maintenance service companies need to conduct in-depth research to understand the focus and potential needs of industrial customers, so as to offer customized services, and improve the reliability and professionalism of industrial software through product design, management level, process control, and tool support. The serial development route of preliminary research-demand analysis-software development-test verification-design optimization-engineering practice-service feedback should be carried out to provide industrial enterprise customers with industrial software services that closely fit them.

6.2.3.3 Offer a smart factory solution

For industrial maintenance service companies to offer smart factory solution, they need to go through the steps of setting business goals, formulating prototype plans, verifying prototype plans, formulating formal plans, and comprehensively promoting and implementing the smart factory project. Industrial maintenance service enterprise customers want to realize the transformation of traditional factories to smart factories, which stems from the demand for improvement and resolution of related problems in the production workshop. Thus, helping customer companies set goals for smart factory construction is the first step for industrial maintenance service companies to provide solutions. In this process, in addition to digging out the problems that need to be solved, it is also necessary to formulate accurate project goals. The production management of factories and workshops often needs to solve the following problems. (1) How to improve production efficiency and product quality; (2) How to reduce the production cost of the enterprise; (3) How to deal with the pressure of using less resources to achieve more performance; (4) How to create new value for customers. After determining the business objectives, a prototype plan needs to be developed, that is, a project prototype is developed based on the capital budget to verify the concept of the project. The prototype project of a good smart factory requires mutual cooperation between different elements, involving products, components, platform management and users. Among them, platform management includes processes such as the Internet, data analysis, data integration, data storage and analysis, and product management. Users need to carry out problem understanding, scheme planning, project suggestions and effective decision-making, formulation of procedures and rules, participation in the whole process of control and continuous optimization. Next, the prototype solution needs to be verified. When the prototype project runs successfully, it is necessary to collect and verify the problems in the test run. Through the data collected by the intelligent components and sensors in the test run, it is possible to discover where the efficiency is poor, or what factors cause the system to fail, and decision-making personnel can use this information to improve the process and reduce waste. Subsequently, the improved measures require another round of trial operation in the workshop, and it will be evaluated after another iteration. After multiple evaluations, the final effective project plan is determined. After the prototype program has been verified, a large-scale implementation plan for the project needs to be developed. The complexity of large-scale implementation plans will increase significantly, and the amount of data collected will also increase significantly. After formulating a comprehensive implementation plan, the next step is to carry out a large-scale implementation within the customer enterprise according to the existing plan to improve the production efficiency and smart level of the enterprise.

Chapter 7: Conclusions and Suggestions for Future Research

7.1 Research conclusions

This thesis discusses the evaluation system of industrial maintenance service quality and its influence on customer behavioural intentions from the perspective of industrial maintenance service enterprises. It also suggests measures to improve industrial maintenance service quality. The research reaches the following conclusions:

(1) The Industrial Maintenance Service Quality Scale in the context of the Industrial Internet consists of 4 dimensions and 23 items.

This research reviews research on industrial maintenance service, industrial Internet, and service quality, followed by qualitative Research methodology such as interviews with corporation representatives and expert consultation, as well as quantitative research on industrial maintenance service quality evaluation of a service provider. The research reveals four dimensions of industrial maintenance service quality in the context of industrial Internet, namely service professionalism, service reliability, service digitization, and service customization, which are both theoretically logical and empirically verified. The author builds a dynamic and comparable industrial maintenance service quality system in a scientific and systematic way. Firstly, a preliminary scale with 23 items is developed through literature research, interviews with corporation representatives, and expert discussion. A questionnaire survey is conducted based on the preliminary scale, and a total of 313 valid questionnaires are collected. Then, the scale is reconstructed by dimensionality reduction through process iterations, which ensures that the scale has high reliability and validity. The author then constructs the final scale of industrial maintenance service quality in the context of industrial Internet with four dimensions. Based on the final scale, the author uses analytic hierarchy process to evaluate the industrial maintenance service quality of Company A, and finds out that the service reliability dimension is the most important dimension, accounting for 39.1% of industrial maintenance service quality, followed by service professionalism, 27.6%, while service customization and service digitization account for 19.5% and 13.8% respectively. Through in-depth analysis of the service quality of Company A, it is found that there are gaps in its industrial maintenance service quality. The company’s scores in service reliability and service professionalism, the relatively more important dimensions for quality evaluation, are lower than the scores of service customization and service digitization. This indicates that

Company A should improve its service reliability and service professionalism.

(2) Industrial maintenance service quality has a direct and significant positive impact on customer behavioural intentions.

The research identifies service professionalism, service reliability, service customization, and service digitization as the dimensions of industrial maintenance service quality, and repurchase intention and recommendation intention as the dimensions of customer behavioural intentions. Through empirical analysis, it is found that service professionalism, service reliability, service customization, and service digitization all have positive effects on repurchase intention and recommendation intention. To sum up, the quality of industrial maintenance services has a positive impact on customer behavioural intentions. The author identifies service professionalism, service reliability, service customization, and service digitization as independent variables, and repurchase intention and recommendation intention as dependent variables. The department, job position, years of working experience, gender, age, and educational background are assigned as the control variables. The thesis uses structural equation model to explore the influence of industrial maintenance service quality on customer behavioural intentions. The empirical results show that in the field of industrial services, the quality of industrial maintenance services has a direct and significant positive impact on customer behavioural intentions. It shows that the higher the service quality perceived by industrial enterprise customers, the greater the possibility of positive behavioural intentions, which also confirms the importance of service quality in enhancing customer loyalty.

(3) The improvement of industrial maintenance service quality can be realized through enhancing customer relationship, brand management and information technology.

After discussing the relationship between industrial maintenance service quality and customers behavioural intentions, the author explores the key factors that affect service professionalism, service reliability, service customization, and service digitization. It was found that customer relationships, brand management, and information technology are critical to the service quality perceived by industrial enterprise customers. In terms of customer relationship, unlike consumer services, industrial maintenance service companies often provide customers with “products plus services”, and long-term and stable customer relationships are preferred by both parties. As customers of industrial enterprises differ from one another, it is important to manage them in a classified way. In terms of brand management, customers of industrial maintenance service companies prefer to work with companies with strong and reputable brands. As most industrial maintenance services adopt a B2B model, there is a relatively limited number of customers and the key accounts are particularly important. Therefore, it is critical for industrial maintenance service companies to remain well-positioned in the value chain and build their brand image. As far as information technology is concerned, the emergence of industrial big data, industrial software, and smart factories have put forward higher requirements for industrial maintenance service. Therefore, to improve the quality of industrial maintenance service and ensure its professionalism, reliability, customization and digitization, it is essential to address customer relationships, brand management, and information technology. Firstly, industrial maintenance service companies should maintain in-depth, long-term and stable customer relationships. They should not only ensure core technical advantages to enhance service reliability and core talent advantages to enhance service professionalism, but also maintain a stable and robust relationship with their customers. Secondly, industrial maintenance service providers need to strengthen brand building and brand promotion. It is necessary to update the mindset in brand building, develop a differentiated brand system, and be innovative in brand communication channels so as to build unique brand advantages. Last but not the least, industrial maintenance service companies need to improve their information technology capabilities to support their customers' digital transformation. They are expected to provide digital services with strong big data mining capability and customized services with enhanced industrial software development capability. They also need to act as a reliable provider of effective smart factory solutions so as to improve the service quality perceived by industrial enterprise customers.

7.2 Limitations and suggestions for future research

Although the research has made some academic innovation, it still has some limitations:

(1) The limitation of research sample

The author collected sample data just from the users of APIoT industrial software. While the research model and hypotheses are all confirmed in the thesis, the generalizability of the conclusions to all industrial maintenance service companies is not verified. In addition, as the research only involves Chinese industrial maintenance service providers and their customers, it is yet to prove whether the research conclusions are applicable in other countries and regions.

(2) The limitation of a cross-sectional study

The author only collected data of one specific point in time, and conducted static data analysis. This static approach may prevent the author from gaining the insight of the dynamics of how industrial maintenance service quality affects customer behavioural intentions.

(3) The limitation of the selection of variables

The author selected the variables of the model based on existing literature, corporate interviews and expert discussions. While these variables are tested for both reliability and validity, the conclusions would be more solid if the measurement items of the variables can be measured and tested in more rigorous manner.

To address these limitations, it is suggested that future research can be carried out in the following directions:

(1) The development and application of industrial service quality scale

The development of the Industrial Maintenance Service Quality Scale is based on Chinese context, without taking into consideration the impact of country specific factors on the quality of industrial services. As countries differ in their economic environments, cultural backgrounds, technological capabilities and social conditions, there may be other dimensions to measure industrial maintenance service quality, apart from service reliability, service professionalism, service customization, and service digitization. In future research, the dimensions of industrial maintenance service quality can be adjusted, diversified or consolidated to adapt to different contexts.

(2) Research on different types of industrial services

Industrial services, as a broad concept, include different types. This research focuses on the measurement and analysis of service quality of APIoT industrial software service. It is suggested that future research may explore the quality of other types of industrial services, such as industrial control service and industrial equipment service.

(3) Research on the quality of industrial maintenance service in different sectors

Industrial maintenance service requires in-depth integration and close interaction with related industrial sectors. As industrial maintenance service varies greatly among different industrial sectors, successful practices in one sector may not be replicable in another sector. This research focuses on industrial service quality in automotive industry. It is suggested that future research can explore the differences of industrial service quality among different sectors and identify sector-specific dimensions of industrial maintenance service quality.

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Annex

API Industrial Equipment Service Quality Survey Questionnaire

Dear Sir/Madam:

What you are participating in is a survey questionnaire about the service quality of API industrial equipment service. Please answer according to the service you feel. Your evaluation and answer will help us improve the quality of service. Thank you for your cooperation!

1. Evaluation of API industrial equipment service quality (for each question, please rate from 1 to 7, 7 means “strongly agree”, 6 means “agree”, 5 means “relatively agree”, 4 means “neutral”, 3 means “relatively disagree”, 2 means “disagree”, 1 means “strongly disagree”.)

Note: The following “company”, “customer” and “we” represent “your company”; “service company” represents “the company that provides services to you”. If you do not understand the item, you can refer to the “note” under each item.

(1) The purpose of the service provider is customer-centric.____

Note: “Customer-centric” mainly includes: customer needs-orientation; high-quality delivery of products and services; rapid response to customer needs; low-cost operation (high cost-effective products and services). The service provider has effectively fulfilled its service purpose in the provision of services.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(2) The service provider and its employees can clearly understand our needs.____

Note: “Understand the needs” means that the service provider can discover, analyse, guide, and clarify or create our needs by asking questions, listening, and observing.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(3) The service provider will provide customized services for us.____

Note: “Customized service” refers to a targeted service method in which the service provider can understand and meet our customized needs in a timely manner, and provide us with unique products and services that suit our company.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(4) The service provider can provide customized analysis support for our company’s production status monitoring data.____

Note: “Customized analysis support” means that the service provider collects our company’s unique production status monitoring data, is willing and able to analyse these unique data, and provides customized improvement plans.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(5) The service software system of the service provider has a friendly interface.____

Note: “Friendly software interface” means that the software interface is beautiful and graceful, easy to learn, easy to use, and highly manoeuvrable. The software can adapt to multiple operating platforms (such as windows) and process data efficiently and quickly.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(6) The service provider has automated data collection tools.____

Note: It mainly refers to the service provider’s ability to provide automated data collection tools and equipment in the collection of the company’s equipment operation and maintenance data, such as Excel sheets automatically import historical data to the system, sensors obtain vibration, temperature and other data, obtain equipment status data through PLC/DCS integration.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(7) The software system functions of the service provider can cover the needs of the company in equipment management.____

Note: It mainly refers to the comprehensive and powerful functions of its software system, which can meet the needs of the company’s equipment management.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(8) The compatibility and openness of the service provider's software system can meet our company's needs.____

Note: "Software compatibility" means that the software can work stably in a certain operating system, which means that the software is compatible with this operating system; in a multitasking operating system, between several simultaneously running software, if the software can work stably without frequent errors, it means that the compatibility between them is good, otherwise the compatibility is not good.

The "system openness" means that the system is easy to interconnect with other manufacturers' products, and the software system itself is easy to expand.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(9) The service provider can satisfy service needs of our company in time.____

Note: It means that the service provider can respond to customer needs immediately, and quickly and efficiently propose solutions to meet the needs.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(10) The service provided by the service provider can effectively reduce the equipment failure rate.____

Note: It means that after the software system provided by the service provider is adopted, the equipment failure rate is reduced through the tracking and management of the equipment.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(11) The software system of the service provider has advanced scientific, professional and reliable analysis tools.____

Note: It refers to the advanced and scientific analysis tools of the software system, which can conduct professional and reliable analysis of data.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(12) The service provided by the service provider can effectively reduce the level of equipment cost.____

Note: It means that after the software system provided by the service provider is adopted, the company's equipment management cost is reduced through the tracking and management of the equipment.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(13) The software system of the service provider can record service information in a standardized and complete manner.____

Note: It means that the provided software system can store relevant operating data and service information in a complete and standardized manner and can be viewed at any time.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(14) The service provider can provide our company with a detailed service plan timetable.____

Note: In the process of providing services or programs, a complete system of service schedules can be provided to promote the orderly progress of tasks at each stage.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(15) The service provider can provide emergency services to our company in time.____

Note: "Emergency service" means that when some major emergencies occur in the company, the service provider can respond to them and deal with them in a timely manner.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(16) The system of the service provider can monitor the dynamic data of the production process in real time.____

Note: "Real-time monitoring" generally refers to the use of software to monitor the process of system operation synchronously.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(17) The software system of the service provider can provide support services at any time.____

Note: "At any time" means that the software system has no time limit, and can operate, analyse and process relevant data at any time point.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(18) The professional skills of service provider employees are trustworthy.____

Note: "Professional skills" refers to the familiarity and professionalism of the employees of the service provider to the software, and the ability to solve the puzzles and problems of customers.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(19) The service implementation methodology of the service provider convinces us.____

Note: "Service implementation methodology" is a methodology system that guides the implementation of the project step by step. It specifically guides the entire process of project implementation. The project time, resource arrangements, tasks at each stage and acceptance methods will be specified in the implementation methodology.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(20) The service provider can achieve predictive maintenance of our production equipment.__

Note: "Predictive maintenance" is based on "condition monitoring" and emphasizes "fault diagnosis", which refers to the irregular or continuous condition monitoring of equipment, and based on the results, to find out whether the equipment has abnormal status or failure trends, so as to arrange for maintenance at the right time.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(21) Employees of the service provider have strong communication capabilities.____

Note: "Communication capabilities" refer to the strong listening ability, expression ability, and design ability of service provider employees.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(22) The software system of the service provider is powerful, which can give good support to the on-site personnel.____

Note: It mainly means that the software system can provide good support for the frontline personnel's business.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(23) The service provider supervisor has sufficient knowledge to understand the information provided by the machine.____

Note: It mainly refers to the professionalism of the service provider's supervisor, who has the corresponding professional knowledge to understand the data information of the client company.

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(24) I am willing to choose the software service of the service provider again.____

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(25) This service provider is my first choice in the same field.____

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(26) I will do more business with the service provider in the next few years.____

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(27) I will speak good of the service provider to other companies.____

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(28) I will recommend this service provider to other companies.____

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

(29) I will encourage other companies to do business with the service provider.____

1. Strongly disagree 2. Agree 3. Relatively agree 4. Neutral 5. Relatively agree 6. Agree 7. Strongly agree

2. Basic information

Your company name:______________Your department:_____________

Your job position/professional title:__________________Your major:__________________

Your years of working experience:______Age:______Gender:_______Educational level:____

3. Do you have any other comments or suggestions on the industrial equipment services you have obtained?

Thanks again for your participation!