Consumer Perceptions to Support IoT Based Smart Parcel Locker Logistics in China

Abstract

In recent years, the adoption of Internet of Things (IoT) based smart parcel lockers has developed very rapidly in Asia due to the wider applications from retailers, e-commerce companies, logistics companies, and consumers. The revolution of smart technologies has transformed the traditional way of last-mile delivery from logistics outlets to IoT-based parcel lockers due to the flexibility, convenience, and 24/7 accessibility. However, there are still many obstacles affecting the transformation of last-mile delivery especially in consumers perceptions towards the smart technologies. Therefore, in this study, we performed research based on the theory of service quality and customer satisfaction in the adoption of relevant technologies. This article divides the smart parcel lockers' service quality into five dimensions: service price, service reliability, convenience, fault handling capability, and service diversity. In this study, 272 valid questionnaires were collected from China to investigate consumer satisfaction with the smart parcel locker services. Statistical analysis, including the reliability and validity, was performed, followed by confirmatory factor analysis (CFA). The correlation between variables and the degree of influence on customer satisfaction and regression analysis was also undertaken in this study. The results revealed that the service price does not positively affect consumer satisfaction, and the other four underlying factors have a positive effect on consumer satisfaction. This research has significant impacts by determining the parcel lockers' core factors so as to foster the further development of last-mile services in the future.

Keywords:
Consumer Behaviour; Service Quality; Last-Mile Delivery; Internet of Things; Smart Parcel Locker

1 Introduction

Globally E-commerce has been developed very rapidly since 2015 and the COVID-19 pandemic has brought unprecedented growth to e-commerce recently (Bhatti et al., 2020). The rapid development of online shopping is inseparable from the offline support of logistics services. After decades of development, the express delivery market has gradually penetrated into people's daily lives and has become a significant part of life under the joint promotion of the Internet and e-commerce (Farooq, Fu, Hao, Jonathan, & Zhang, 2019). Final distribution of express transportation is usually the most problematic and consumes the most material and human resources (C.-F. Chen, White, & Hsieh, 2020). Therefore, smart parcel lockers based on the Internet of Things (IoT) technology are gradually entering people's lives under the impetus of express companies and investors (Sa-ngiampak et al., 2019). The IoT-based smart parcel locker is a self-service pickup device with high flexibility in providing 24h service (Mostakim, Sarkar, & Hossain, 2019). It is a secure, economy and convenient package delivery and retrieval solution for multifamily communities, retail stores, commercial buildings, and university campuses (C.-F. Chen et al., 2020).

According to some government reports, the IoT-based parcel locker approach has been improved and has grown worldwide (Reyna, 2013; *Statistical Bulletin on the Development of the Postal Industry in PRC in 2019*, 2020). For instance, in China, the number of IoT-based parcel lockers has increased from 15 000 to 406 000 from 2014 to 2019 (*Statistical Bulletin on the Development of the Postal Industry in PRC in 2019*, 2020). Moreover, due to the impact of the pandemic, it is expected that the IoT-based parcel locker market value may reach to1438.9 million USD by 2027 (Mazareanu, 2021). Therefore, the future of the IoT-based parcel locker has received a lot of attention and the function of the locker has also lead further requirements.

Although the development of IoT-based smart parcel lockers has brought certain benefits to all parties, to a certain extent, there are still many problems (Lin, Han, Yan, Nakayama, & Shu, 2019). Many researchers believe that the development of the IoT-based locker is still facing a series of problems due to the limited anticipation of consumers (Y. Chen, Yu, Yang, & Wei, 2018; M. Zhou et al., 2020). The literature reveals that customers are reluctant to use IoT-based lockers, because of the indiscriminate charging, inconvenient locations, unreasonable design and possible technological problems, etc. (Y. Chen et al., 2018; Zhang, Zhou, Cao, & Wu, 2020; M. Zhou et al., 2020). Consequently, this research attempts to quantify customer satisfaction by evaluating the service quality of the IoT-based parcel locker to obtain

more definitive results and to recognize the critical factors that influence customer satisfaction and to solve the problems of existing IoT-based parcel lockers.

Recently, there have been increasing numbers of researchers investigating smart parcel locker development based on customer satisfaction. Most studies focued on the improvement of new technology (Mostakim et al., 2019; Park, Kang, & Kang, 2017; Sa-ngiampak et al., 2019), and some academic papers identified the customer intentions of using smart counters (C.-F. Chen et al., 2020), whereas others perceived positive and negative factors that impact on the consumer behavior of self-service parcel service (M. Zhou et al., 2020). However, different from the previous studies, we propsed a integrated model by combining the theory of e-service quality and logistic service quality (LSQ). The approach incorporates the modified service quality (SERVQUAL) and LSQ models to present a conceptual framework, organises the dimensions as a research model, and then conducts explanatory research to measure and verify the dimensions. Moreover, as the mobile phone has become the new normal, this study addresses IoT-based parcel locker technology from the perspective of customer satisfaction, which is the combination of IoT technology and marketing (Elazhary, 2019). In addition, to create smart marketing, enhancing the utilization of the IoT-based parcel locker is of highly significant. IoT-based lockers can help researchers and industry to have a better understanding of customer intentions by collecting data while people use the lockers, thus enabling promotional strategies, such as the location and the number of the lockers, via analyzing these data (Zhi & Kamsin, 2020).

The research is organized as follows: Section 2 contains a brief literature review of the technology of the IoT-based parcel locker and the theory of customer satisfaction, together with the theory of service quality; Section 3 and Section 4 describe the questionnaire survey and analyze the data statistically. Section 5 describes the key factors affecting IoT-based parcel lockers' service quality and puts forward corresponding suggestions to improve the service quality of IoT-based parcel lockers. Finally, the paper summarizes the research content and explains the shortcomings of the article and suggests further research.

2 Literature Review

2.1 Technologies of smart parcel lockers

With the development of the internet and IoT technologies, parcel lockers operated by smart devices have developed dramatically in recent years. Indeed, the process of using the smart parcel locker is simple, quick and convenient. To receive a package via the smart parcel

locker, the recipient is given a unique delivery code usually sent by a mobile message notification. Recipient can retrieve their packages whenever best suits their schedule, and utilize the mobile application to manage and track the locations of the packages. The mobile application can also be used for opening the lockers via Bluetooth or bar scanning, and retrieving package delivery history (Shang, 2017).

The technologies of an IoT-based smart parcel locker have been widely reviewed in the literature. Pang (2018) defined the smart parcel locker as a device that recognizes, monitors, and manages express shipments based on the Internet of Things technology (IoT), forming an IoT-based parcel locker system with a PC server. Park et al. (2017) developed an IoT-based parcel locker prototype using a weight sensor, shock sensor, the Arduino, and Raspberry-Pi of open-source hardware platforms. Arora, Srivastava, and Majumder (2017) identified existing inefficiencies and suggested adding CCTV camera monitoring, GPS, 3D connectivity, weight capture, and multiple payment ways to the lockers. Mostakim et al. (2019) proposed an IoT-based intelligent smart locker with a one-time password (OTP) and face detection approach, which provides security, authenticity, and a user-friendly mechanism. Sa-ngiampak et al. (2019) focused on improving software development by offering an alternative smart locker solution, which can be unlocked by scanning a QR code. In summary, smart parcel lockers not only adopted mobile technologies and applications to manage the packages, but the IoT technologies are also for wireless communication.

2.2 Service quality model and e-service quality model

Service quality and e-service quality have been extensively utilized in recent studies (Aldatmaz, Sever, Pehriz, Çalışkan, & Çetiner, 2020; Rahi & Ghani, 2016). The research on service quality can be traced back to the late 1970s. Sasser et al. (1978) pointed out that the result of service is not the whole picture of service quality, and the process of providing service is also the central part of measuring service quality. Rohrbaugh et al. (1981) also proposed to divide service quality into three parts: result quality, process quality, and personnel quality. Gronroos (1982) made the initial definition of service quality, proposing that customer evaluation of service quality is essentially a result of comparison, which compares the actual feelings in the service process with the expectations before being served. At present, the SERVQUAL model proposed by Parasuraman, Zeithaml, and Berry (1985)is the most used model. The model divides service-related content into five dimensions and 22 subdivision factors and is a useful tool for service quality evaluation in various industries. The five

dimensions' are reliability, responsiveness, assurance, empathy, tangibility (Parasuraman et al., 1985).

In addition, to compete with the era of e-commerce, e-service quality has received more attention because customers need more precise information and convenience(Rahi & Ghani, 2016). Zeithaml, Parasuraman, and Malhotra (2000) established 11dimensions of e-service quality and this model has been modified by researchers from the point of customer satisfaction and assessment. Raza, Umer, Qureshi, and Dahri (2020) modified the classic service quality model into an E-service quality model, which has profound importance for e-market retailing and provides precise information for companies to enhance e-service quality. The model uses 4 dimensions which are “efficiency, personal need, use friendliness and site organization” to measure the e-service quality.

2.3 Dimensions of Logistics Service Quality

The significance of Logistics Service Quality (LSQ) is profound for both customers and logistic service providers (Kilibarda, Andrejić, & Popović, 2020). Distinct logistic service quality would bring high-level customer satisfaction and lead to successful business results (Kilibarda et al., 2020). Therefore, many academics have evaluated LSQ in regards to customer satisfaction and service quality(Jang, Marlow, & Mitroussi, 2013; Rafele, 2004). Mentzer et al. (2001) proposed an LSQ evaluation model to measure logistics companies' service quality from the customers' perspectives. The model includes the entire process of logistics services and nine key indicators：information quality, ordering procedures, order release quantities, order accuracy, order quality, order condition, order discrepancy handling, and personal contact quality). Sabine et al. (2016) approached the problem from the aspect of target factors, believieing that logistics service management's most critical goal was to minimize costs, and providing customers with higher quality was also a key factor. Moreover, several new dimensions in different industries have been added into the model, which including: reliability, information quality, customer value, flexibility, empathy, etc. (Lan, Zhang, Zhong, & Huang, 2016; Zailani, Jafarzadeh, Iranmanesh, Nikbin, & Selim, 2018).

2.4 Conceptual Framework

Therefore, this paper incorporates the modified model of e-service quality given by Raza et al. (2020), and the SERVQUAL model established by Parashurama et al. (1988) and the logistics service quality evaluation model (LSQ) proposed by Mentzer, Flint, and Hult (2001), with each dimensions elaborated as follows:

2.4.1 Service Price

The service price refers to the charging problems that may arise during the IoT-based parcel locker operation, such as agency fees, overdue fees, and other extended service charges (Lagorio & Pinto, 2020). For a long time, one of the most sensitive and important factors for IoT-based parcel locker users was the additional fees charged for parcel lockers (Shang, 2016). Although the way for IoT-based lockers to acquire profitability is relatively vague (Dang & Yeo, 2018), Lagorio and Pinto (2020) found that the main reason why customers change their parcel delivery service mode is the service price. The survey of Lemke, Iwan, and Korczak (2016) revealed that the service price was 79.29% the most important criterion for customers choosing parcel locker services. Therefore, the cost of IoT-based parcel lockers and customers' acceptance will significantly affect their satisfaction with this service. Herein, it is proposed:

Hypothesis 1. The service price of the IoT-based parcel locker positively affects customer satisfaction.

2.4.2 Service Reliability

Service reliability refers to whether the size, quantity, and providing fast service can meet users' daily needs (Kilibarda et al., 2020). Due to the diversity of the delivered parcels, IoT-based parcel lockers' space is hard to fit due to different sizes (Bouzaabia, Bouzaabia, & Capatina, 2013). Also, parcel lockers may find difficulty in meeting the various special requirements such as fragile or perishable goods (Xiao, Wang, Lenzer, & Sun, 2017). Bai and Wang (2008) believe that logistics enterprise customer satisfaction should include seven indicators: transportation service security, transportation service quality, logistics cost evaluation, employee service level, logistics enterprise brand efficiency, rapid response capability, and customer complaints. Sabine, Ho, and Mario (2016) pointed out that “providing fast service, providing services within the agreed time frame and fulfilling services” are essential. Therefore, it is proposed:

Hypothesis 2. The service reliability of IoT-based parcel lockers positively impacts on customer satisfaction.

2.4.3 Service Convenience

Service convenience refers to the ease of clients or users is accessing the services(Berry, Seiders, & Grewal, 2002). The location, operating hours, and convenience can be three significant dimensions for IoT-based parcel lockers' service convenience (Yuen, Wang, Ma, & Wong, 2019). As Bulmer, Elms, and Moore (2018) stated in their research, the perceived value of offering IoT-based parcel lockers is to provide convenience to the customer. Moreover, (Yuen et al., 2019) pointed out that connecting service convenience with IoT-based parcel

lockers can level-up their perceived value by improving the appropriate geographic location and functional utility. Therefore, the layout planning and location convenience of parcel lockers will significantly impact the enthusiasm of customers. Therefore, it is proposed:

Hypothesis 3: The service convenience of IoT-based parcel lockers positively impacts customer satisfaction.

2.4.4 Fault Handling Capability

Fault handling capability refers to the emergency handling capability of relevant operating personnel when the IoT-based parcel locker malfunction (Mentzer et al., 2001). If the IoT-based parcel locker has many faults and errors, it will seriously affect the possibility of reuse. Fu (2014) believes that the quality of after-sales handling includes whether the merchant's reasons for handling product discrepancies are adequate, whether the response has a quick correction, whether the handling measures are convenient, and whether the consumer is satisfied. (Uvet, 2020) stated that the wrong facilities and poor quality would dramatically decrease customer satisfaction, and the staff's response speed to the failure and the failure handling ability were essential to customers. Therefore, it is proposed:

Hypothesis 4. The fault handling capability of IoT-based parcel lockers positively impacts on customer satisfaction.

2.4.5 Service Diversity

Service diversity refers to the value-added functions of IoT-based parcel lockers in addition to essential functions and extended service capabilities such as mobile applications service levels (Shang, 2017). In order to increase the turnover rate of the lockers and reduce the vacancy rate, developers can add more convenient services to the IoT-based parcel locker function, which significantly improves user satisfaction and guarantees express delivery (Zurel, Van Hoyweghen, Braes, & Seghers, 2018). According to Pang (2018), some smart parcel lockers in Shanghai are used as breakfast pick-up points, by integrating the functions of the APPs in mobile phones. Therefore, it is proposed:

Hypothesis 5. The service diversity of IoT-based parcel lockers positively impacts on the customer.

3 Methodology

This research involves a descriptive study that combines with the quantitative and qualitative analyses. The primary data was collected through questionnaire surveys, while the data was analyzed using the statistical tool, SPSS. The research model is indicated in Figure 1.

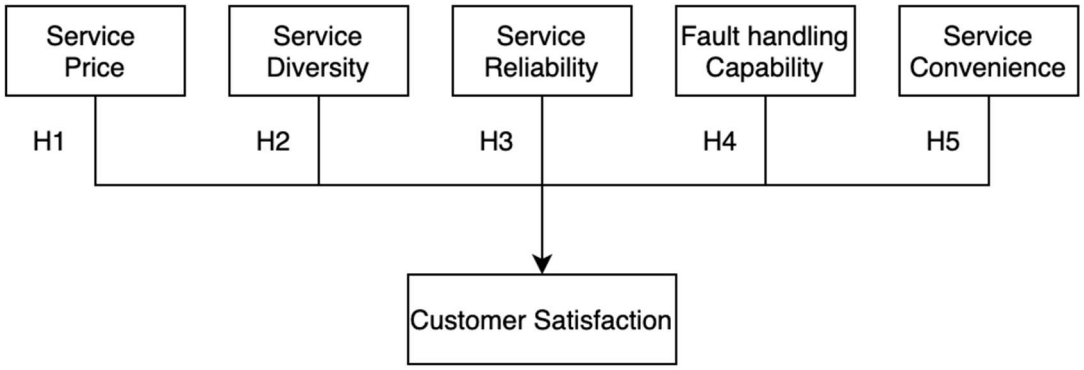

Figure 1 The research model

3.1 Questionnaire Design

This research used the dimensions related to the customer satisfaction factors of IoT-based parcel lockers according to the dimensions of the SERVQUAL model, e-service quality model and LSQ model. It combines the national standards of parcel lockers and the feedback results of related surveys, summarizes the possible influencing factors, and resulting in an indicator system of customer satisfaction factors for parcel lockers.

After analyzing the features, development status, existing problems, and other aspects of parcel lockers, combined with relevant theories and academic research on the former, a customer satisfaction impact index system for parcel locker services has been established, as shown in Table 1. The entire system is divided into five dimensions and 20 indicators.

Table 1 The Index System of Influencing Factors of Customer Satisfaction for IOT-based Parcel Locker Service

Dimension	Question	Source
SP Service price	SP-1 - The charge of the IoT-based parcel locker is reasonable and transparent	Shang et al. (2016)
	SP-2 - I can accept reasonable charges for IoT-based parcel lockers	
	SP-3 - Overall evaluation of the charge	
SD Service Diversity	SD-1 -The size of the IoT-based parcel locker can meet daily needs	J. zhou and Wang (2005); Bai and Wang (2008)
	SD-2 -The number of small cabinets can meet daily needs	
	SD-3 - Compared with other pickup methods, the IoT-based parcel locker helped me save more time	
	SD-4 - The number of violent deliveries is reduced	
	SD-5 -The IoT-based parcel locker will not leak or misappropriate relative information.	
	SD-6 - The courier has hardly been lost	

SR Service Reliability	SR-1 - The number of IoT-based parcel lockers and the coverage is sufficient	Lemke(2016)
	SR-2 - The operation process of the parcel locker is simple	
	SR-3 - I can easily find the location of the IoT-based parcel locker	
	SR-4 -The function of picking up is greater than sending	
	SR-5 -The information processing is mature	
	SR-6 - No longer limited by the time and place	
FHC Fault handling capability	FHC-1 -Service attitude of IoT-based parcel locker service staff	Fu (2014)
	FHC-2- The staff handles complaints and faults in a timely manner	
	FHC-3 -The information processing is relatively mature	
SC Service Convenience	SC-1 - The IoT-based parcel locker is highly intelligent	Pang (2018)
	SC-2 - The additional service of the IoT-based parcel locker can bring convenience to your life	
CS	CS-1 - Your overall evaluation of the IoT-based parcel locker service	

3.2 Data Collection

This questionnaires were collected in the form of an online platform, conducted as a public quantitative questionnaire survey in the Yaohai District, Hefei, Anhui Province. Hefei is the deputy center of the Yangtze River Delta cluster and is also a double node city of "One Belt, One Road" and Yangtze River Economic Belt strategy (HSB, 2020). The research was conducted in Hefei because it represents the average level of social and economic development in China and is well-known in the manufacturing, transportation, and modern service industry. The Yaohai District is the core district and traffic centre of Anhui, which implies a high maturity level of the logistics companies.

In order to ensure that the data results of the questionnaire survey are more scientific and accurate, the participants in the survey were random IoT-based parcel locker users in the Yaohai District. The data obtained in this study adopted the third-party questionnaire survey platform Qualtrics to distribute the questionnaire. We adopted the online approach to distribute the questionnaire through social media channels. It was suggested that although collecting data via the internet is not perfect, it can still reduce biases compare with traditional approaches (Gosling et al., 2004). On the other hand, the online transmission is not limited by space, and can increase the diversity of samples and reduce the deviation of measurement results caused by sample homogeneity (Buhrmester, Kwang, & Gosling, 2016). The data collection phase of this study was from September 15, 2020, to September 30, 2020, and a total of 298 questionnaires were returned, a total of 26 invalid questionnaires were screened out, and 272

valid questionnaires were retained. The questionnaire response rate was 91.3%, which met the quantity requirements of the document survey and can be followed up for analysis.

3.3 Data description

3.3.1 Sample Characteristics Statistics

After screening the quality of the questionnaire, the attributes of the 272 valid sample data were analyzed. According to Table 2, in terms of gender, the number of men and women in the survey was the same. In terms of age structure, the highest proportion was 46 years old and above, accounting for 29.8%, followed by 36-45 year olds, accounting for 27.9%, and the overall distribution was uniform. As for the number of packages, the number of people with less than three packages per month accounted for the largest proportion, followed by 4-7 packages per month, 40.1% and 30.9% respectively. In terms of education level, the proportion of people with a bachelor's degree was the largest at 68.8%; the number of people with a monthly income of 2000-5000 yuan was the largest, accounting for 39%.

In summary, the gender distribution of the survey samples in this study was uniform; the age distribution was relatively wide, which was in line with the distribution of the applicable population of IoT-based parcel lockers. Monthly income was mainly distributed above 2,000 yuan; the education level was primarily concentrated at the bachelor degree level. On the whole, the sample range was widely distributed and had a certain degree of representativeness and persuasiveness, which can be followed-up in the analysis.

Table 2 Distribution of basic characteristics of valid samples

Item	Category	Frequency	Rate
Gender	Male	136	50.0%
	Female	136	50.0%
Age	Under 25	62	22.8%
	26-35	53	19.5%
	36-45	76	27.9%
	Above 46	81	29.8%
Packages/month	0-3	109	40.1%
	4-7	84	30.9%
	8-9	43	15.8%
	Over 10	36	13.2%
Education level	High school and below	39	14.3%
	Undergraduate	187	68.8%
	Master's degree	43	15.8%

Ph.D. and above	3	1.1%

3.3.2 Descriptive Analysis of measurement items

Descriptive statistical analysis examines the data characteristics in order to understand the overall satisfaction of customers with each part of the IoT-based parcel locker service. In Table 3, the average CS was 3.54, which does not reach a satisfactory level, indicating that there are many problems in the IoT-based parcel locker. The top three in terms of satisfaction were FHC-1, SD-6, and SR-4. The lowest satisfaction ratings were SP-2, SP-3, and SD-1, with an average of 2.99, 3.04, and 3.21, respectively. It indicates that the current charging and specification problems of the IoT-based parcel lockers seriously affect customer satisfaction. The mean and standard deviation of each dimension is illustrated in Table 4. The IoT-based parcel locker is currently in the transition slage, from free to charge. From a long-term perspective, a charging policy is necessary for the operation of the IoT-based parcel locker, therefore, an acceptable policy must be implemented. In addition, the size of the cabinet also greatly limits the scope of use.

Table 1 Mean and STD of each indicator

SP	Mean	STD	SD	Mean	STD	SR	Mean	STD
SP-1	3.24	1.024	SD-1	3.21	0.969	SR-1	3.26	1.087
SP-2	2.99	1.138	SD-2	3.22	1.011	SR-2	3.47	0.968
SP-3	3.04	1.077	SD-3	3.40	1.004	SR-3	3.45	1.022
			SD-4	3.29	0.98	SR-4	3.64	0.999
			SD-5	3.49	0.964	SR-5	3.49	0.96
			SD-6	3.56	1.004	SR-6	3.48	1.013
FHC	Mean	STD	SC	Mean	STD	CS	Mean	STD
FHC-1	3.52	0.888	SC-1	3.49	1.073	CS	3.54	0.828
Q13-2	3.32	0.858	SC-2	3.47	1.005			
FHC-3	3.42	0.885						

Table 4 Mean and STD of each dimension

Factor	Mean	STD
SP	3.09	.954
SD	3.36	.782
SR	3.46	.808
FHC	3.42	.770
SC	3.48	.975

CS	3.54	.828

3.4 Reliabliaty and validity analysis

We adopted several data analyses to ensure the reliability and validity of the results. The level of reliability is an important indicator to measure whether a questionnaire is stable. For Likert scale questionnaires that investigate the degree of opinion, it is more appropriate to use Cronbach's alpha coefficient(α). When Cronbach's α coefficient of each variable exceeds 0.8, it indicates that the scale used in the questionnaire is stable and the data results are consistent. In addition, we used the KMO test (KMO > 0.8) and Bartlett-Test (P < 0.05) of Sphericity to determine whether the questionnaire survey results are suitable for factor analysis. Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were used to examine the five dimensions of the variables. Moreover, we adopted average variance extracted (AVE > 0.5) and composed reliability (CR > 0.8) to reflect the convergence validity; and for discriminant validity, the square root of AVE test was conducted. Furthermore, regression analysis was used to study the internal dependence of the observational indicators and to analyze which factors have a more significant impact on the results among multiple factors that affect the results. Finally, correlation analysis was adopted to describe the degree of correlation between the objectives and the direction of the target. The measurement of correlation analysis generally uses the Pearson coefficient (>=0.8) to indicate the index of relevance.

4 Results

4.1 KMO and Bartlett-Test

Before performing factor analysis, it was necessary to test the collected data to make sure that the sample is suitable for factor analysis. According to Table 5, the KMO of all questions was 0.906, which is significant at the level of 0.001 (sig.=0.000). Therefore, it passing the test also shows that the overall validity of the questionnaire is good. It also shows that the KMO of each variable in the questionnaire is greater than 0.7 and is significant at the level of 0.001, so that many variables meet the validity test standard and can be factored in. In addition, because SC service convenience has only two measurement items, the KMO and Bartlett-test results that reflect this variable are not shown in the table.

Table 5 KMO and Bartlett test

Variable	SP	SD	SR	FHC	Overall

KMO	0.715**	0.868**	0.892**	0.724**	0.906**

**p < 0.01

4.2 Exploratory Factor Analysis

Five common factors were extracted through SPSS factor analysis. And the explanation table of the total variance was obtained (see Table 6). 71.508% of the information of all factors can be expressed by the extracted common factors, indicating that the validity of the questionnaire is high. In addition, according to the scree plot (Figure 2), a transition occurs between 3-5, so it is reasonable to choose five common factors.

Table 6 Total Variance Explained of the 1-6 items

Item	Total Variance Explained								
	Initial eigenvalues a			Extraction Sums of Squared Loadings			Sum of the squares of the rotating loads		
	Total	Variance %	Accum %	Total	Variance %	Accum %	Total	Variance %	Accum%
1	8.085	40.522	40.522	8.085	40.522	40.522	3.961	19.852	19.852
2	2.069	10.369	50.891	2.069	10.369	50.891	3.461	17.347	37.199
3	2.004	10.045	60.936	2.004	10.045	60.936	2.151	10.783	47.982
4	1.232	6.175	67.111	1.232	6.175	67.111	2.839	14.23	62.211
5	1.087	4.397	71.508	1.087	4.397	71.508	1.855	9.297	71.508
6	0.713	3.576	75.084						

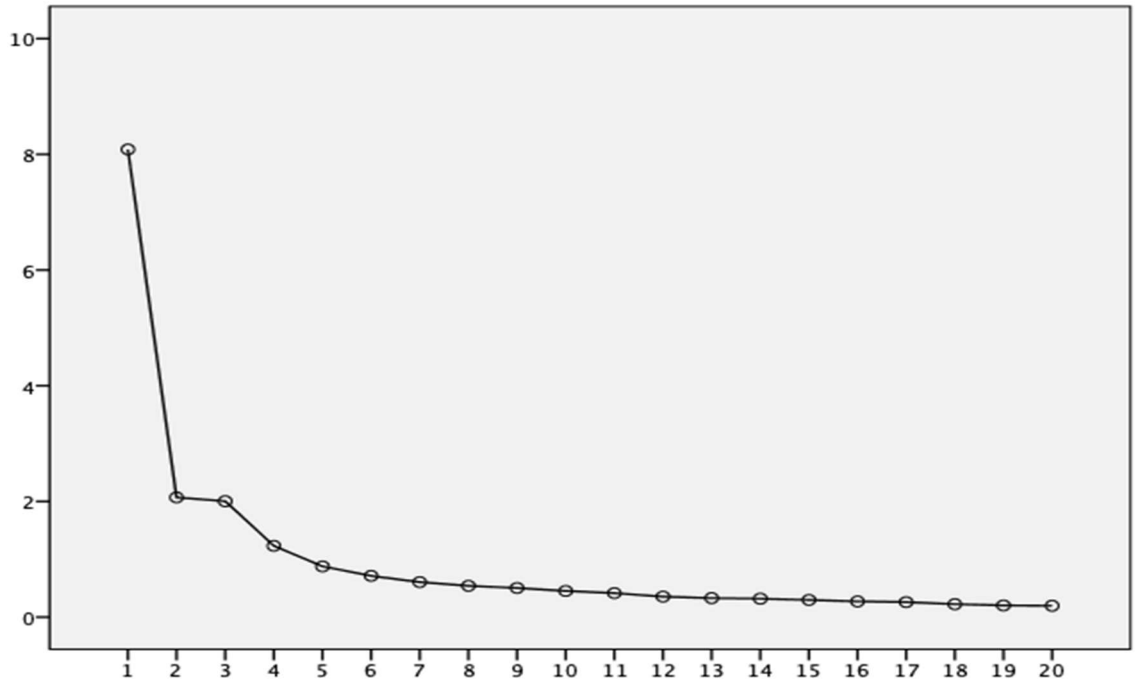

Figure 2 The scree plot

According to the factor load matrix after the rotation, the structure is divided according to the classification of common factors. A factor load greater than 0.5 indicates that this factor can be represented by the common factor to a greater extent. The results are shown in Table 7. It was determined that the factor loading of item SP-2 was higher than 1, however, based on the research from Jöreskog (1999) and Deegan (1978), the value is still justified.

Therefore, through factor analysis, the above set of influencing factors of customer satisfaction is divided into five aspects, namely SP=service price, SD= service diversity, SR= service reliability, FHC=fault handling capability, SC= service convenience.

Table 7 The rotated component matrix

The rotated component matrix						
Factor	Items	Component				
		1	2	3	4	5
SP	SP-1	0.777				
	SP-2	1.009				
	SP-3	0.935				
SD	SD-1		0.758			
	SD- 2		0.809			
	SD -3		0.724			
	SD- 4		0.677			
	SD -5		0.551			
	SD -6		0.683			
SR	SR -1			0.827		
	SR -2			0.74		
	SR -3			0.845		
	SR -4			0.799		
	SR -5			0.697		
	SR -6			0.613		
FHC	FHC -1				0.645	
	FHC -2				0.692	
	FHC- 3				0.655	

SC	SC -1	0.908
	SC -2	0.825

4.3 Confirmatory Factor Analysis

It can be seen from Table 8 that the value of X2/DF = 1.862 < 3, and the structure is ideal. In addition, RMSEA = 0.056<0.08, CFI = 0.955>0.9, IFI = 0.955 which is close to 0.9, and TLI = 0.946>0.9. On the whole, the service quality of the IoT-based parcel locker fits the model of customer satisfaction well.

Table 8 Degrees of freedom for the chi-square test

CMIN				
CMIN/DF	RMSEA	CFI	IFI	TLI
1.862	0.056	0.954	0.955	0.946

Table 9 presents the reliability of the SP service price α =0.858>0.8, the reliability of SD service diversity α =0.880>0.8, the reliability of SR fault handling capability α =0.888>0.8, the reliability of FHC service reliability α =0.851> 0.8, and the reliability of SC service convenience α =0.862>0.8. Reliability for all the dimensions is high and is favourable in taking the analysis to the next level.

Table 9 Variable reliability analysis table

Factor	Number of questions	α
SP	3	0.858
SD	6	0.88
SR	6	0.888
FHC	3	0.851
SC	2	0.862

According to Table 10, the AVE of each variable is greater than 0.5, and the combined reliability (CR) > 0.8, which also shows that the convergence effect is ideal. Regarding the test of discrimination validity, according to Table 11, it can be seen that the value of AVE between SD to SC is greater than 0.5, while the value of SP to each variable is around 0.36-0.50, which means the validity is acceptable. Moreover, there is a significant correlation between SP service price, SD service diversity, SR fault handling ability, FHC service reliability, and SC service convenience ($p<0.01$). In addition, the absolute value of the correlation coefficient is less than the corresponding square root of AVE, indicating that the variables have a certain degree of

correlation and a certain degree of discrimination between each other, which means that the discriminant validity of the scale data is significant. In addition, the CFA was performed to determine the factor loadings of each variable (Figure 3). It was found that the load factor corresponding to each topic is greater than 0.7, indicating that each variable corresponds to the topic with high representativeness.

Table 1 Convergence validity (AVE and CR)

Factors	AVE	Composite Reliability
SP	0.676	0.862
SD	0.551	0.880
SR	0.578	0.891
FHC	0.660	0.854
SC	0.760	0.863

Table 2 Discriminant validity

Factor	SP	SD	SR	FHC	SC
SP	0.822				
SD	0.444***	0.742			
SR	0.409***	0.553***	0.760		
FHC	0.348***	0.69***	0.532***	0.813	
SC	0.406***	0.506***	0.588***	0.55***	0.872

**$p < 0.01$, and the diagonal line is the square root of AVE

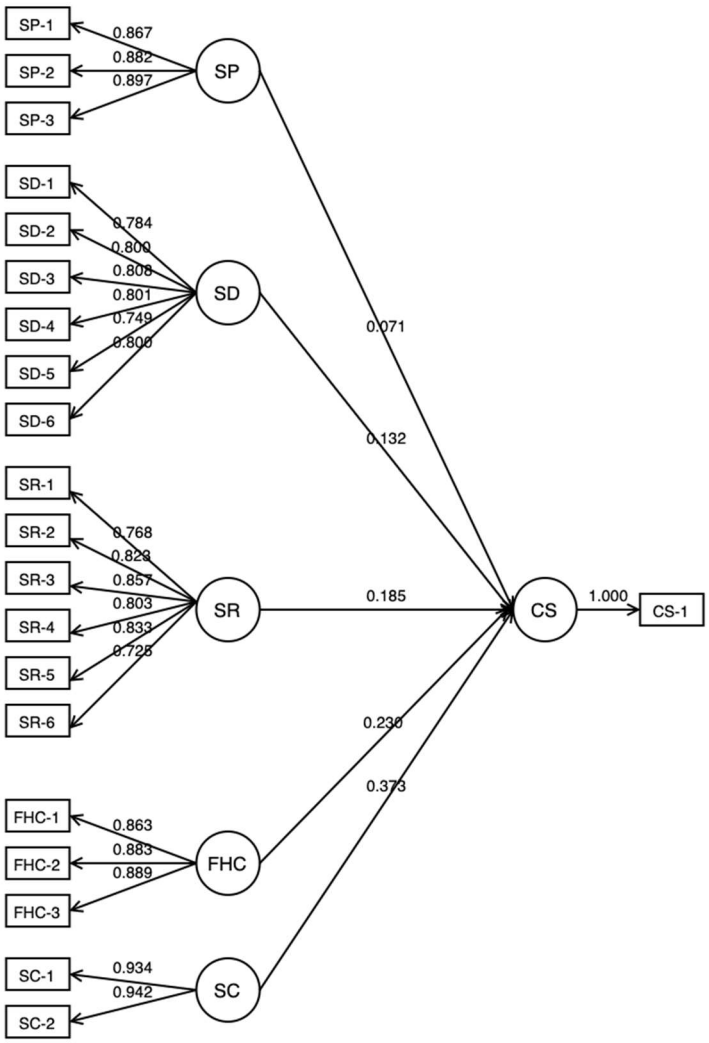

Figure 3 Confirmatory factor analysis results of IoT-based parcel locker service quality

4.4 Empirical Analysis

4.4.1 Correlation Analysis

According to Table 12, the correlation coefficient between SC service convenience and CS customer satisfaction is the highest, at 0.664, and it is significant at the level of 0.001; the correlation between SD, SR, FHC, and CS was higher than 0.5, showing a moderate intensity correlation. The correlation between SP and CS was relatively low (0.403).

In addition, the same consumer will inevitably be subjected to mutual influences between the variables in the measurement process, so there are two sets of correlation coefficients between the variables. If the data is above 0.5, the correlation between SD and FHC is 0.604, and the correlation between SR and SC is 0.522, but both are less than 0.8, so there is no significant collinearity and linear relationship between variables. Through correlation analysis,

we can have a basic understanding of the research content in advance and predict whether the research hypothesis is valid to a certain extent.

Table 3 Correlation coefficient between variables

	SP	SD	SR	FHC	SC	CS
SP	1					
SD	.404**	1				
SR	.376**	.491**	1			
FHC	.319**	.604**	.473**	1		
SC	.364**	.442**	.522**	.479**	1	
CS	.403**	.554**	.575**	.600**	.664**	1

**p<0.01,N=272

4.4.2 Regression Analysis

Through the above test results of the reliability and validity of the questionnaire, it can be seen that the results of the questionnaire data are relatively reliable, and through factor analysis, five common factors representing 71.508% of the original information have been formed.

Regression analysis was used to find the factors that significantly impact on the results through quantitative methods and verify whether the results are reasonable through the analysis of the actual situation. Herein, the overall customer satisfaction is used as the outcome variable, and the five influencing factors are used as explanatory variables to perform regression analysis, as shown in Tables 13 and 14.

Table 4 ANOVA

R	R^2	Adjusted R^2	Standard estimate error	DW	F	Sig.
.770[a]	0.593	0.585	0.53295	2.002	77.513	.000[b]

First, we check whether the regression analysis is statistically significant. R^2 represents the degree of fit of the regression equation. When R^2 is larger or close to 1, regression analysis can explain the research problem better, and the overall fit of the data is higher. In this analysis, $R^2 = 0.593$, and the adjusted $R^2 = 0.585$.

In this study, F=77.513, Sig=0.000 (<0.05), which shows that at least one of the five factors can significantly affect the outcome variable. Moreover, the indicator of Durbin-Watson=2.002, which is very close to 2, which means that the data itself has no auto-correlation, and the above F-test results are valid.

In addition, it is necessary to test whether there is multicollinearity between the index variables and whether there is a mutual influence relationship between the variables because the mutual influence relationship between the variables will make the results of the regression

analysis inaccurate. It is generally believed that when VIF>10, the mutual influence between the data is relatively serious, and the index design has a strong correlation. According to Table 14, the variance inflation factor VIF value of the five factors are all less than 2, and the tolerance is greater than 0.1, indicating that the influence relationship between the variables is weak and does not affect the results of the regression analysis.

Table 14 shows the final regression results. Among them, the Sig. of SP is much greater than 0.05, indicating that SP has no significant effect on the dependent variable, while the Sig. of the remaining four factors are all less than 0.05, indicating that other factors can significantly affect the dependent variable. Regarding the STD coefficient, the larger β is, a small change of the corresponding independent variable can have a greater impact on the dependent variable. According to Table 14, β2=0.131, β3=0.176, β4=0.235, β5=0.376, so the overall satisfaction of the IoT-based parcel locker is affected from large to small: SC, SR, FHC, SD, SP. Herein, the standardized regression equation obtained according to the regression analysis is:

$$CS=0.131*SD + 0.176*SR + 0.235*FHC + 0.376*SC$$

Table 5 Results of regression analysis

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity	
	B	Standard error	β			Tolerance	VIF
(constant)	0.281	0.177		1.583	0.115		
SP	0.062	0.039	0.072	1.618	0.107	0.776	1.289
SD	0.138	0.056	0.131	2.474	0.014	0.549	1.822
SR	0.18	0.051	0.176	3.529	0.000	0.614	1.629
FHC	0.252	0.056	0.235	4.509	0.000	0.565	1.771
SC	0.319	0.042	0.376	7.651	0.000	0.634	1.577

4.5 Summary of Hypothesis Test Results

According to the above analysis, among the five dimensions that IoT-based parcel locker service quality affects customer satisfaction, SD service reliability, SR service convenience, FHC fault handling capability, and SC service diversity are significant at a significance level of 0.01. At the same time, the SP service price did not pass the significance test. The hypothesis test results are summarized in Table 15.

Table 15 Hypothesis Test Results

Hypothesis	Content	Result
H1	The service price of IoT-based parcel locker has a positive impact on customer satisfaction	F

H2	The service reliability of IoT-based parcel locker has a positive impact on customer satisfaction	T
H3	The service convenience of IoT-based parcel locker has a positive impact on customer satisfaction	T
H4	The fault handling capability of IoT-based parcel locker has a positive impact on customer satisfaction	T
H5	The service diversity of IoT-based parcel locker has a positive impact on customer satisfaction	T

5 Discussion

This part integrates the current development of the IoT-based parcel lockers and comprehensively discusses the critical indicators of service diversity, faulty handing capacity, service reliability, and service convivence respectively, followed by a brief comment on service price.

5.1 Developing service diversity

Service diversity (SC) has the most significant impact on customer satisfaction, which indicates that managers should focus on strategies to improve service diversity. First of all, adding large-size parcel lockers to meet various requirements from customers. (Huong & Thiet, 2020)) noticed that most smart lockers are designed in typical sizes as follow: XS (200x300x200 mm), S (400x300x200mm), M (400x600x200mm), L (800x600x200mm), and XL (800x600x400mm). It is necessary to increase the numbers of larger lockers and enhance customer satisfaction. In addition, strengthening the publicity and guidance of IoT-based parcel lockers can deliver a new type of smart community centered on IoT-based parcel lockers (Vakulenko, Hellström, & Hjort, 2018). For example, propaganda can be carried out online and offline simultaneously. Online promotion can show the intelligence and humanization of the IoT-based parcel lockers by using video advertisements on TikTok and other social media Apps(Lin et al., 2019). Offline publicity mainly uses elevator advertisements to show users the development trend of IoT-based parcel lockers, reflecting their convenience and security capabilities. Finally, improving IoT-based parcel lockers' intelligent design to extend their functions (Deutsch & Golany, 2018). APPs can be designed can integrate the function with IoT-based parcel locker (Mitrea et al., 2020). For example, a parcel locker near a mall can cooperate with the shopping center to provide online shopping and offline pickup services (Hayel, Quadri, Jimenez, & Brotcorne, 2016). The smart community centered on IoT-based parcel lockers can also provide users with more comprehensive services (Zhi & Kamsin, 2020).

5.2 Enhancing the fault handling capability

Fault handling capability (FHC) ranks second in impacting on customer satisfaction. To improve consumers' willingness to use the lockers, the methods that can be adopted are: a) Posting the most common problems and solutions at the lockers to guide the customers about the relevant issues (Ocicka & Raźniewska, 2016); b) Establish 24h online customer service staff to facilitate consumers to conduct telephone and online consultations at any time (Lin et al., 2019); c) Regular and timely maintenance are necessary for maintenance personnel to ensure the safety and reliability of the lockers (Yuen et al., 2019). d) In addition, maintenance personnel need to ensure that they can deal with hardware problems as quickly as possible (Shang, 2017).

5.3 Improving service reliability and service convenience

Service reliability (SD) and Service convenience (SR) also have a positive impact on customer satisfaction. The parcel locker's original intention was to ensure that users can pick up express delivery anytime and anywhere (Lim, Jin, & Srai, 2018). Therefore, it is necessary to form a differentiated market structure. In the community, the user population may pay more attention to the practical functions of IoT-based parcel lockers, such as adding automatic vending machines, establishing pick-up places for daily grocery purchasing, in order to increase consumers' willingness to use and become a part of the smart internet technology community(Lin et al., 2019). Meanwhile, in the commercial center, IoT-based lockers should attract many office workers by giving them unique functions and location characteristics. For example, self-pickup parcel lockers for breakfast have appeared in Shenzhen, China, most of which are placed near the road that office workers must pass or near the employment (Xiao et al., 2017). People can order their breakfast on their mobile phones, choose the nearest lockers location, and pick up on their way to work. It brings great convenience to customers and allows industry 4.0 into people’s daily lives.

5.4 Considering the service price

From the perspective of descriptive statistics, customers have the lowest evaluation of SP service prices. Therefore, most IoT-based parcel lockers provided free trials in the early stages of development and later began to charge for long-term uncollected express delivery (Limbourg, Giang, & Cools, 2016). In addition, with the continuous promotion of additional services of IoT-based parcel lockers, various other expenses will be incurred in the future

(Halaweh, 2018). Joerss, Schröder, Neuhaus, Klink, and Mann (2016) stated that people prefer to choose home delivery if the cost is less than 3€. Therefore, managers should be aware that the fees for parcel lockers should not be higher than that.

6. Conclusions and Further Research

The IoT-based smart parcel locker is a product of the rapid development of e-commerce and the courier industry, and it has been widely used in recent years. Based on the literature review, this study established a research model of smart parcel locker service quality affecting consumer satisfaction by collating existing literature and data and integrating theories and data on service quality, logistics service and e-service quality. Statistical methods were undertaken for reliability, validity, correlation, and regression analyses to verify the research hypothese. Finally, we revealed five dimensions related to the service quality of IoT-based lockers. Service diversity, faulty handing capacity, service reliability, and service convivence have a positive effect on consumer satisfaction, while service price was not positively connected with customer satisfaction. Moreover, the diversity of services and the fault handling capabilities of the services have a more substantial impact, while service reliability and service convenience are relatively weak.

6.1 Theoretical implications

Through the previous literature, this research found that scholars have paid great attention to research on the technology acceptance model and achieved many results (Lemke et al., 2016; Mostakim et al., 2019; Park et al., 2017). However, with the continuous development of the logistics industry and the continuous emergence of new patterns, such as IoT-based parcel locker, research on how the new terminal distribution model of parcel locker affects consumers is still in its infancy.

Consequently, this research has particular theoretical value for IoT-based parcel lockers' future development and the exploration of factors affecting consumer satisfaction. To integrate both the technology development and classic service quality theories from the angle of customer satisfaction, this study combines the classic SERVQUAL model and e-service quality model to explore the new dimensions of service quality that affect customer satisfaction. Moreover, it incorporates the logistic service quality theory (LSQ model) to specifically analyze the influence mechanism of IoT-based parcel lockers on consumer satisfaction.

A modified model was proposed to better understand the IoT-based parcel locker service development direction and the influence mechanism on consumer satisfaction. This extended model emphasizes the essence of customer satisfaction, the integration of technology improvement and theory of service quality, and the particularity of logistic service quality.

6.2 Practical implications

Besides the contribution to the literature, this article also has specific practical value due to putting forward reasonable suggestions for improving the service quality of IoT-based parcel lockers from the perspective of customers. Suggestions for strengthening the publicity and guidance and improving the intelligences design are provided for developing the service quality of IoT-based parcel lockers. In addition, four items of advice related to personnel and customer satisfaction are presented in order to enhance the fault handling capability. Moreover, to improve IoT-based parcel lockers' service convenience, a differentiated market pattern can be formed by developing new categories through market segmentation. Finally, fee charges in IoT-based parcel lockers are feasible. Moreover, it can also promote the comprehensive and professional development of IoT-based parcel locker services and promote the development of smart communities, facilitating user groups from multiple perspectives and penetrating all aspects of life, thereby improving participation and presence in daily life.

Hence, this study will help identify how the service level of IoT-based parcel lockers affects consumers' willingness to use the lockers and gives some suggestions for future improvement. The logistic companies and other service providers would benefit from the new model and suggestions in facing the challenge from internet technology.

6.3 Limitation and further research

Although a number of questionnaires have been collected from the community residents to investigate consumers' satisfaction in IoT-based parcel lockers in this study, the data size can be further enhanced by collecting surveys from various target locations such as schools, office buildings, and residential areas. As such, the sample size will not only be enhanced, but we can also determine the demographic difference of different groups of customers. In addition, in-depth analysis for the development of parcel lockers can be made based in the following aspects:

1. Research on the design and location of IoT-based parcel lockers. Consumer groups in different regions have different needs. Other types of places, such as hospitals, industrial areas, and shopping malls, can be considered.

2. The cost and benefit to IoT-based parcel locker companies, is also an important research direction to improve the revenue of IoT-based parcel lockers.

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