Evaluation of the Innovation Capability of Import Borderless E-commerce Platform Based on Factor Analysis and TOPSIS Method

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Abstract: Borderless e-commerce originated within the international trade domain and has been significantly shaped by the societal backdrop of economic globalization and the rapid advancement of internet technologies. This evolution has given rise to numerous B2C borderless e-commerce platforms. While there has been a growing recognition of the importance of service innovation, there remains an incomplete understanding and a need for further refinement in the service evaluation system. Consequently, the scientific assessment and enhancement of service innovation capabilities have become focal points of research both domestically and internationally. Existing research has predominantly focused on the development models and challenges of import e-commerce retail platforms, with theoretical studies taking precedence. However, there is relatively limited emphasis on the evaluation and empirical analysis of service innovation capabilities in borderless e-commerce platforms. This study aims to bridge the existing research gap by constructing a scientifically accurate evaluation framework and employing statistical methods to comprehensively investigate and assess the service innovation levels of Chinese import borderless e-commerce retail platforms. To address this gap in understanding, this study has selected four import borderless e-commerce retail platforms in China as research subjects. Subsequently, an evaluation model for these import borderless e-commerce retail platforms was constructed through factor analysis to establish an evaluation index system. Then, the service innovation abilities of these four platforms were calculated and ranked within this index system using the TOPSIS model. This process facilitates a deeper exploration of the underlying reasons for their differences and provides clear developmental pathways for these platforms to bolster their service innovation capabilities. The results indicate that there exists a direct correlation between the market share and popularity of e-commerce platforms and their service innovation capabilities. Furthermore, luxury brand marketing and high market share can significantly enhance their service performance. These findings carry valuable implications for guiding the development of borderless e-commerce import platforms.

Keywords: borderless e-commerce; factor analysis; import platform; service innovation ability; TOPSIS method

1 INTRODUCTION

In recent years, there have been significant developments in Internet technology, updates in payment methods, and continuous advancements in infrastructure, particularly in areas like logistics and warehousing [1, 2]. Borderless e-commerce, as a technical means to promote economic integration and trade globalization, has truly broken through trade barriers and ushered in unprecedented development opportunities. At the same time, the efforts of the Chinese government to popularize the Internet, increase the income and living standards of its citizens and make information and communication more accessible, have resulted in a considerable difference in the shopping behaviors of consumers and the acceptability of borderless e-commerce [3]. According to the data, the transaction volume of China's imported products through borderless e-commerce reached 1.5 trillion RMB in 2017. In 2018, this number increased to 1.9 trillion RMB, and in 2019, the value went up to 2.4 trillion RMB. As can be gleaned from the data, borderless e-commerce has led to a rapid growth trend in the import transaction scale and an increasing demand of domestic residents for imported products. While the growth rate of world trade is gradually converging, China's transaction scale is continuously expanding; this situation indicates that borderless e-commerce plays a pivotal role in China's trade structure [4]. Moreover, through borderless e-commerce platforms, the trend of purchasing imported products has gradually become a part of Chinese shopping behaviors.

Based on the established advantages, many domestic e-commerce giants have recently deployed the business topology of cross-border trade. These giants, including Tmall, JDcom, NetEase, Vipshop, and Amazon, have launched an overseas shopping section, which has resulted in a competitive environment dominated by the B2C model and has developed rapidly in the field of borderless e-commerce. The import market through borderless e-commerce has been expanding continuously and entering the booming years of expansion [5], making it one of the non-negligible markets in China at present. It not only plays a role in enabling consumers to connect and communicate with international suppliers but also has a very important practical significance in optimizing the process of international trade.

At present, Chinese borderless e-commerce is swarming with numerous platforms, and a relatively mature market has been developed. However, fast-growing segments of import borderless e-commerce platforms do not match well with the demand of the market and the consumers. This discrepancy is mainly reflected in two aspects. One, from the market-demand perspective, the tendency of product homogeneity remains serious among e-commerce platforms. As the demographic dividend in the network decreases, it becomes more difficult for online business platforms to keep their users compared to the traditional mode of transaction. If the competition is a cent or two cheaper and no attention has been directed to service innovation, then every borderless e-commerce import platform is bound to gradually lose its competitiveness in the market.

Too, from the perspective of consumer demand, with the rapid increase in their economic strength and demand, consumers are more inclined to choose borderless e-commerce platforms with high quality and more experience. However, due to the later start of the business platform or funding constraints, most of the current e-commerce platforms engaged in cross-border trade are still relatively weak in their service construction and innovation, resulting in the low service satisfaction of many consumers with the platforms. Hence, to further explore the growth potential of borderless e-commerce platforms, it is crucial to place particular focus on improving their service infrastructure and fostering

innovation. It is an inevitable requirement for the development of the borderless e-commerce market and a necessary condition for better meeting consumer needs and improving their shopping experience. Building upon this foundation, the scientific evaluation of service development and innovation in borderless e-commerce is the primary focus of this research.

The research of relevant scholars has mainly focused on the selection and development issues of platform development models, with a predominance of theoretical studies. However, research on the service innovation of import borderless e-commerce platforms is relatively limited. Therefore, building upon the existing body of research, this study aims to further explore the primary factors influencing the service innovation capabilities of import borderless e-commerce platforms and the effective measures of these capabilities. Through in-depth research, we have identified a lack of integration regarding internal organizational factors, consumer perspectives, and the actual industry landscape in current studies. There is also a deficiency in constructing a comprehensive evaluation index system for the service innovation of borderless e-commerce platforms. This has resulted in a lack of both rationality and scientific validity in service innovation assessments.

The focal point of this study is the scientific construction of an evaluation index system and model for platform service innovation capabilities to effectively assess the current level of service innovation in import borderless e-commerce platforms. In this process, we particularly emphasize the importance of the evaluation framework for the innovation capabilities of Chinese e-commerce platforms. This framework not only helps address the current deficiencies in the research field but also provides a practical tool for a thorough understanding and enhancement of the service innovation level of Chinese e-commerce platforms. By clarifying the impact of internal and external factors, we can offer a comprehensive and accurate evaluation method for both the industry and academia, promoting the sustainable development of Chinese e-commerce platforms in service innovation and further enhancing their competitiveness in the global market.

2 STATE OF THE ART

Borderless e-commerce first appeared in the development process of international trade, and its essence was the digitization, electricizing, and networking of traditional international trade and business processes. However, the import borderless e-commerce platform generally acts as an intermediary without participating in the transactions between buyers and sellers, instead only providing a purchase platform for buyers [6].

From the perspective of e-commerce platforms, due to the short development history of import borderless e-commerce platforms, scholars have mostly focused on the exploration of the development model of import borderless e-commerce platforms and the problems arising from them. For instance, in the exploration of the development model, Liu [7] divided import borderless e-commerce platforms into B2B overseas online shopping, self-employed, tripartite mixed operation, and other modes

from the perspective of transactions, which was based on the different combinations of import borderless e-commerce platforms and logistics, customs clearance, and sales, respectively. Based on the new national tax policy, Sun et al. [8] explored the innovative form of import borderless e-commerce platforms and proposed to promote its development in reverse by offline mode and other ways. Starting from the existing import borderless e-commerce platforms in the market, Li [9] divided them into several operation modes, such as overseas direct mail mode and self-employed plus investment mode, and explained the pros and cons of import borderless e-commerce platforms under each operation mode. Yahia et al. [10] emphasized that consumer trust is crucial to the development of the platform and believed that improving the shopping experience of consumers will promote its development. In addition, in the exploration of various problems of import borderless e-commerce platforms, Hörnle believed that the legal supervision of the government on borderless e-commerce platforms is not sound enough, which has caused many adverse consequences [11]. Williams [12] believed that the development of the platform would be restricted if we did not take the users' payment security seriously. Gong et al. believed that borderless e-commerce payment is the key link of cross-border transactions and pointed out its high management qualification standards [13]. On this basis, he pointed out various problems existing in the development of borderless e-commerce platforms. From the perspective of market supervision, Li believed problems such as insufficient supervision in the import borderless e-commerce market exist and suggested that the government should establish a negative list directory to change the differentiation of supervision [14].

Service innovation refers to the behavior and activities of enterprises to improve services [15]. As the evaluation of the service innovation ability of enterprises is a decision-making issue that requires a basis and criterion for choice, scholars can divide the evaluation research into two parts: evaluation index research and evaluation method research.

In terms of the research on the service innovation evaluation index, because current academia has not yet formed a generally accepted evaluation index system, most scholars built a customer-centered service innovation evaluation index system from the perspective of consumers. For instance, Feng, who believed that the object of enterprise service innovation should be customers, explored service innovation from multiple dimensions by combining customer needs with enterprise service capabilities, brand quality, and other factors [16]. Li et al. [17] took advantage of the NK model to conduct a comprehensive analysis of resource investment, customers, corporate leadership, and so forth and calculated the adaptability of service innovation capabilities under the influence of different dimensional combinations as a way to improve the ability of enterprise service innovation. Meanwhile, based on the perspective of service provision and the belief that strengthening the service innovation of enterprises will help optimize customer experience, Aron et al. [18] divided customer experience into three measurement dimensions, namely, environmental facility experience, service attitude experience, and core quality experience. Aligned with this viewpoint, Anker et al. [19] believed that customer demand is a vital factor influencing

service innovation and verified the importance of customers toward enterprise service innovation with examples.

Nowadays, scholars at home and abroad use numerous methods to evaluate service innovation ability, such as BP neural network, principal component analysis, AHP analysis, regression test, and factor analysis, including the multi-level analysis adopted by Chen et al., who believed that customer participation enables enterprises to improve their service innovation ability [20]. Kindström et al. adopted the multi-indicator trust measurement to evaluate the service innovation ability of enterprises as a whole [21]. Based on the characteristics of the tourism service industry, Lai et al. evaluated the service innovation capability of an online tourism platform using the BP neural network to eliminate the fuzziness of the evaluation index [22]. Xin et al. constructed an evaluation system of service innovation ability based on social network theory and knowledge-based view theory, adopting the regression test method to explore the service innovation ability of knowledge-intensive service enterprises [23]. Liu et al. built an evaluation model based on correlation analysis and other methods to evaluate the relevance of the service innovation capabilities of customer enterprises [24]. In conducting the evaluation research on borderless e-commerce, Yang et al. modified the evaluation indexes with factor analysis and obtained a two-level evaluation index system with weight, which made up for the deficiency of subjective weighting to some extent [25]. Owing to the capability of factor analysis to describe, understand, and analyze the indicators by reducing the variable dimension, as well as extract a comprehensive index to explain the model when the number of variables is large, in the research on borderless e-commerce, an increasing number of researchers are using factor analysis to conduct weight determination and evaluation. For instance, Wang et al. adopted factor analysis to construct a measurement model for the development level of borderless e-commerce and then conducted a relatively rigorous analysis and discussion on the development of borderless e-commerce in the Yangtze River Delta region of China [26]. Bi et al. tested the industrial competitiveness of borderless e-commerce via factor analysis as well [27]. Taking the borderless e-commerce in Zhejiang Province as an example, Lin et al., who believed that the level of e-commerce development in this area was relatively high, also adopted factor analysis to make a systematic evaluation [28]. Therefore, the present study will take advantage of factor analysis to assign the weight of the service innovation ability of import borderless e-commerce enterprises in an objective manner.

To sum up, to date, scholars have found that the studies on import borderless e-commerce platforms and the evaluation of service innovation are still in their infancy. The majority of these studies mainly focused on the development of borderless e-commerce platforms and the evaluation of the service innovation capability, paying insufficient attention to the evaluation of the service innovation capability of import borderless e-commerce platforms. Therefore, aiming at the shortcomings of existing research, this study will take consumers as the core of the evaluation index system of import borderless e-commerce platforms and combine this system with the idea of enterprise service innovation in ways that build a

scientific and reasonable model concerning the above evaluation. In doing so, effective suggestions for improving service innovation capability toward import borderless e-commerce platforms will be put forward accordingly.

3 METHODOLOGY
3.1 Model Construction of Factor Analysis

Factor analysis, a common statistical method, was first proposed by the British psychologist C. E. Spearman [29]. It refers to the statistical technique of extracting common factors from variable groups to find hidden representative factors among many variables, classify variables with the same essence into one factor, reduce the number of variables, and test the hypothesis of the relationship between variables. This method is mainly applicable to the situation where the number of variables is large and the correlation information is difficult to determine.

Assuming that $X_1, X_2, \cdots, X_p$ may be an association relationship between, these p variables contain m independent common factors $F_1, F_2, \cdots, F_m (m \leq p)$. For each variable X_i, the special factor $e_i (i = 1, 2, \cdots, p)$ and common factor $F_j (j = 1, 2, \cdots, m)$ are not correlated with each other, the common factors are not correlated with each other, the variance is 1, and the special factors are not related. Each X_i can be composed of m common factors and its own corresponding special factor e_i linear combination. The mathematical model expression of factor analysis is as follows:

$$X = AF + e \tag{1}$$

A is the factor load, F can be called a factor variable or common factor, and e is a special factor.

a_{ij} represents the projection of X_i on the F_j axis.

$$X = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_p \end{bmatrix}, A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1m} \\ a_{21} & a_{22} & \cdots & a_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ a_{p1} & a_{p2} & \cdots & a_{pm} \end{bmatrix}$$
$$F = \begin{bmatrix} F_1 \\ F_2 \\ \vdots \\ F_P \end{bmatrix}, e = \begin{bmatrix} e_1 \\ e_2 \\ \vdots \\ e_p \end{bmatrix} \tag{2}$$

3.2 Construction of an Evaluation Index System for the Service Innovation Capabilities of Import Borderless E-commerce Platforms

This study consults relevant research journals and refers to the research results of many authoritative scholars in the field of constructing an evaluation index system for enterprise service innovation capability. For China's import borderless e-commerce platform, the construction of such a system follows the principles of purposefulness, scientificness, comprehensiveness, practicability, and operability. It analyzes from the internal organizational

structure of the import borderless e-commerce platform and the consumer's perspective, as well as the actual situation and characteristics of the borderless e-commerce industry and its service innovation capabilities. The evaluation index system of import borderless e-commerce platform service innovation capabilities is divided into five aspects: customer value, e-commerce platform channels, platform product construction, platform market performance, and network information technology.

Based on the five aspects above, some representative indicators have been selected that consider the practical significance of the development of import borderless e-commerce platforms and the perspective of consumers. These include the degree of satisfaction of customers' needs and improvements based on customer's suggestions. Fig. 1 shows the construction of the evaluation index system for the service innovation capability of import borderless e-commerce platforms in this study.
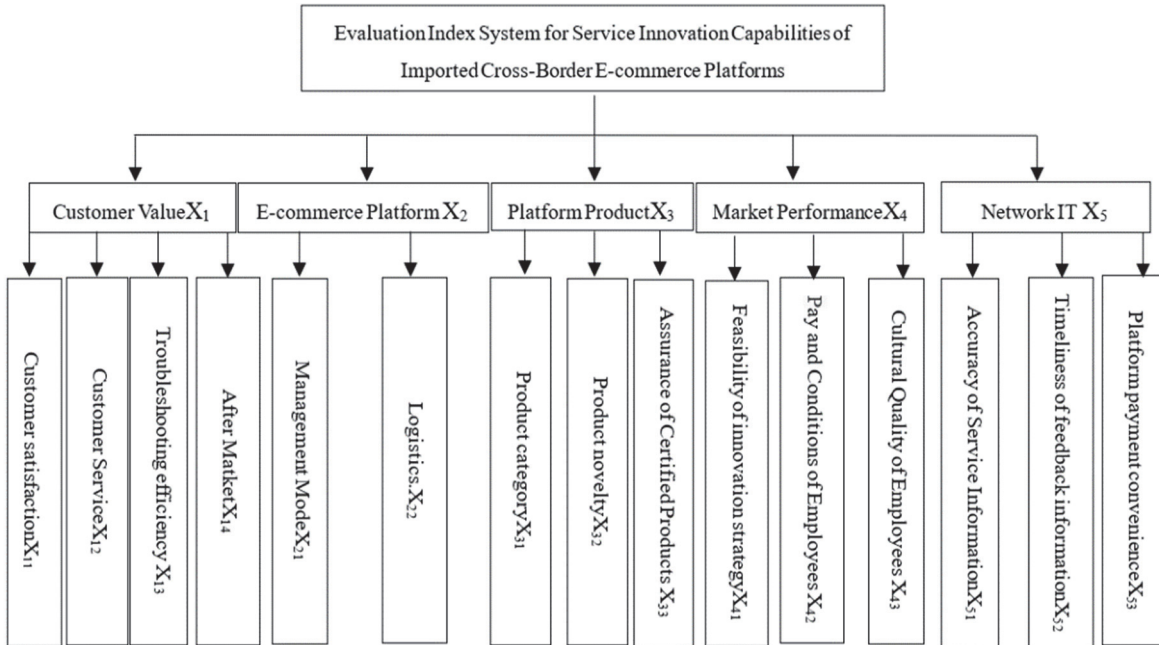

Figure 1 Evaluation index system for the service innovation capabilities of import borderless e-commerce platforms

3.3 TOPSIS Evaluation Moded

The TOPSIS evaluation model is a commonly used and effective method in multi-objective decision analysis. It ranks a finite number of evaluation objects based on their proximity to idealized targets, serving as an evaluative approach for determining the relative merits of existing entities. The TOPSIS evaluation model imposes no strict restrictions on data distribution, sample size, and number of indicators. It applies to both small sample data and extensive system data involving multiple evaluation units and numerous evaluation criteria. It can be used for both horizontal (between multiple units) comparisons and vertical (across different years) analyses [30]. It is characterized by its flexibility in application, simplicity in computation, and the objectivity of its quantified results, which have garnered significant acclaim among scholars.

This study employs the TOPSIS method to comprehensively assess the service innovation capabilities of four import borderless e-commerce retail platforms within China. The specific calculation method and steps are as follows:

(1) Constructing the weighted decision matrix (Z).

$$Z = Y \cdot F = \left(Z_{ij} \right)_{m \times n} \tag{3}$$

In the above formula, the standardized matrix $Y = \left[y_{ij} \right]_{m \times n}$, where F represents the scores calculated for

each indicator obtained through factor analysis, serving as the weight vector. Z_{ij} represents the weighted and normalized values of the j-th indicator for the i-th e-commerce platform.

(2) Utilizing the TOPSIS evaluation model to establish the positive ideal solution (Z^+) and the negative ideal solution (Z^-).

$$Z^+ = \left\{ \max z_{ij} \mid j = 1, 2, \cdots, m \right\} = \left\{ Z_1^+, Z_2^+, \cdots, Z_m^+ \right\}, \tag{4}$$

$$Z^- = \left\{ \min z_{ij} \mid j = 1, 2, \cdots, m \right\} = \left\{ Z_1^-, Z_2^-, \cdots, Z_m^- \right\}. \tag{5}$$

(3) Calculating the Euclidean distance, which includes the distance from the evaluation criteria to the positive ideal solution (D^+) and the distance from the evaluation criteria to the negative ideal solution (D^-).

$$D_j^+ = \sqrt{\sum_m^{j=1} (Z_j^+ - Z_{ij})^2}, \tag{7}$$

$$D_j^- = \sqrt{\sum_m^{j=1} (Z_j^- - Z_{ij})^2}. \tag{8}$$

$$Q_j = \frac{D_j^-}{D_j^+ + D_j^-} \tag{9}$$

In the formula, where $0 \leq Q_j \leq 1$, a larger Q_j value indicates closer proximity to the maximum value, signifying a higher level of innovative service; conversely, a smaller Q_j value implies lower innovation service levels.

4 RESULTS ANALYSIS AND DISCUSSION

This study selected four representative cross-border e-commerce platforms in the Chinese market, each with significantly different market shares. The total market share of these four platforms accounts for 80%. A case analysis of the constructed indicator system and evaluation model was conducted. The primary sources of data for this research are as follows: (1) Company-level data are derived from expert scoring and internal data. (2) Platform-level data are obtained through web data scraping and consumer questionnaire surveys. The specific sources of data for each indicator are detailed in Tab. 1. Due to the diversity of data sources, a uniform standard was applied for data preprocessing after data acquisition. This was done to standardize the data dimensions, facilitating subsequent data analysis tasks. During the analysis of cross-border e-commerce platforms, the use of anonymized platforms is not directly related to the construction of the innovation service capability evaluation index system. To protect the privacy and data security of the platform companies, we opted for the anonymized processing of the analyzed platforms, designating them as Platform A, Platform B, Platform C, and Platform D, respectively. The table below provides an overview of the basic information for each platform in this study.

Table 1 Data sources for indicators

Indicators	Data Sources
Customer satisfaction X_{11}	Consumer Questionnaire Survey
Customer Service X_{12}	
Problem-solving efficiency X_{13}	
After-sales capabilities X_{14}	
Construction of operation mode X_{21}	Expert scoring
Logistics services of the platform X_{22}	Data scraping
Types of platform products X_{31}	Data scraping
Product novelty X_{32}	Consumer Questionnaire Survey
Authenticity guarantee rate X_{33}	Consumer Questionnaire Survey
Feasibility of innovation strategies X_{41}	Expert scoring
Pay and conditions X_{42}	Internal data
Staff culture and quality level X_{43}	Internal data
Accuracy of service information X_{51}	Consumer Questionnaire Survey
Timeliness of feedback X_{52}	Consumer Questionnaire Survey
Convenience of platform payment X_{53}	Consumer Questionnaire Survey

Table 2 Situation and market share of each platform

Name	Situation	Market share
Platform A	The platform started early and has attracted a large consumer group by relying on its corporate background.	About 36%
Platform B	The platform has only been online for a short time but has gradually developed and grown by virtue of its product diversification and authenticity guarantee rate.	About 27%
Platform C	The platform relies on its funds and prices that are lower than those of the market.	About 13%
Platform D	The platform started late, and its development is modest.	About 4%

(1) Standardized data processing

The data units selected in this paper are inconsistent, and so data processing is required. To solve this problem, the data must be standardized. The principle is as follows:

$$Z_i = \frac{x_i - \bar{x}}{s} \qquad (10)$$

where Z_i is the data after the variable x is standardized, X_i is the I observation value of the variable, and $\bar{X}$ is the mean x value of the variable. S is the standard deviation of the variable, and the processed data are obtained from this.

(2) Testing the selected factors

Through SPSS software calculation, we know that the value of the KMO statistic is equal to 0.732, and the significance test is equal to 0. The specific calculation results are shown in Tab. 3. The data result is 0.732, which is between 0.7 and 0.8 and also shows the original data. Thus, the correlation is strong and suitable for factor analysis.

Table 3 KMO and Bartlett Spherical Inspection

KMO sampling appropriateness quantity		0.732
Bartlett's Sphericity Test	Previous chi-square	3153.761
	Degree of freedom	53
	Significance	0

(3) Determination of the common factor

The primary objective of employing factor analysis in this study is to conduct a correlation analysis among the 15 indicators, aiming to identify the latent structure or common factors among them. Through this process, an attempt is made to perform a dimensionality reduction analysis on the original set of 15 indicators, aiding in simplifying the data for a more concise interpretation of the observed variability. In factor analysis, the cumulative contribution rate of each common factor extracted should be around 85% to fully explain the whole data. This is evident in the factor contribution rate shown in Tab. 4, where the cumulative variance contribution is listed. Therefore, components 1, 2, and 3 are extracted from the 15 influencing factors. The first three factors can explain 87.30% of variance in the original variable data, which shows that these common factors have a strong ability to explain the original variables. Specifically, the first common factor obtained by factor analysis can explain 42.82% of the variance in the original variable data, which shows that it has a strong explanatory ability and underscores the need to analyze each of its influencing factors. The single cumulative characteristic value of the second component is about 23.98%, and when combined with that of the first component, the total characteristic value is 66.80%. The single cumulative characteristic value of the third component is 20.50%, and when combined with those of the first and second components, the total characteristic value is 87.30%.

Table 4 Factor contribution rate

Component	Total	Variance Percentage of Initial Eigenvalues	Accumulation / %	Total	Variance Percentage of Square Sum of Extracted Load	Accumulation / %	Total	Variance Percentage of Square Sum of Rotating Load	Accumulation / %
1	6.14	42.82	42.82	6.142	42.82	42.82	5.877	40.512	40.512
2	3.32	23.98	66.80	3.324	23.98	23.98	3.862	25.96	66.479
3	2.97	20.50	87.30	2.971	20.50	20.50	2.553	20.826	87.305
4	0.770	3.96	91.26						
5	0.327	2.78	94.04						
6	0.184	1.86	95.90						
7	0.126	1.37	97.27						
8	0.072	0.94	98.21						
9	0.045	0.76	98.97						
10	0.031	0.51	99.48						
11	0.023	0.18	99.66						
12	0.017	0.13	99.79						
13	0.009	0.10	99.89						
14	0.006	0.08	99.97						
15	0.002	0.03	100.00						

(4) Establishment of the factor loading matrix

Tab. 5 shows the factor loading matrix rotated by the varimax rotation method. The first common factor undertakes a relatively large load about customer satisfaction, staff culture, and quality level, construction of operation mode, pay and conditions, logistics services of the platform, feasibility of innovation strategies, customer communication skills, problem-solving efficiency, and after-sales capabilities, with the respective values of 0.916, 0.902, 0.877, 0.834, 0.815, 0.731, 0.707, 0.694, and 0.680. The results show that these nine indicators have a strong correlation and can be classified as class 1 factors. Staff culture and quality level and pay and conditions are internal influencing factors of the enterprise, while customer satisfaction, customer communication skills, problem-solving efficiency, and after-sales capabilities are customer-oriented influencing factors. Constructions of operation mode and logistics services of the platform are factors that affect the marketing channels of e-commerce, and they are aimed at improving the satisfaction of customers in using the platform. Therefore, F1 can be interpreted as a factor that influences service innovation by improving the overall customer experience.

The second common factor has a larger load on product novelty, authenticity guarantee rate, and types of platform products, with values of 0.981, 0.873, and 0.850, respectively. These three indicators reflect the impact of borderless e-commerce platform products on service innovation. Therefore, F2 can be explained as a product-driven factor that influences service innovation.

The third common factor has a relatively large load on the convenience of platform payment, accuracy of service information, and timeliness of feedback, with corresponding values of 0.914, 0.906, and 0.877. These three indicators mainly reflect the effects of network technology. Therefore, F3 can be interpreted as a factor

that influences service innovation capabilities driven by technology.

Table 5 Composition matrix after rotation method

	Components		
	F1	F2	F3
Customer satisfaction	0.916	0.051	−0.148
Staff culture and quality level	0.902	−0.02	0.213
Construction of operation mode	0.877	−0.143	−0.081
Pay and conditions	0.834	−0.290	−0.138
Logistics services of the platform	0.815	0.218	0.023
Feasibility of innovation strategies	0.731	0.536	−0.317
Customer service	0.707	0.592	−0.285
Problem-solving efficiency	0.694	0.711	0.210
After-sales capabilities	0.680	0.192	0.257
Product novelty	0.220	0.981	0.029
Authenticity guarantee rate	0.113	0.873	0.003
Types of platform products	0.078	0.850	0.072
Convenience of platform payment	0.026	0.037	0.914
Accuracy of service information	−0.174	−0.172	0.906
Timeliness of feedback	−0.218	0.213	0.877

Note: Rotation method: Kaiser's standardized varimax.

(5) Calculating the scores of each component

From the component score coefficient matrix (table) output by the software, we can provide the data for the following calculations, as shown in Tab. 6. Three common factors can be obtained through the operational processing of various data by SPSS software, expressed as a linear function of 15 statistical indicators. The coefficients of each function can also be further calculated. The specific component score function is shown in Tab. 6.

The function expression of each common factor can be obtained, which is specifically expressed as follows:

$$F_1 = 0.115X_1 + 0.072X_2 + 0.063X_3 + 0.081X_4 + 0.137X_5 + 0.128X_6 - 0.076X_7 - 0.019X_8 - 0.023X_9 + 0.088X_{10} + 0.178X_{11} + 0.176X_{12} + 0.039X_{13} + 0.023X_{14} - 0.005X_{15} \quad (11)$$

$$F_2 = -0.017X_1 + 0.108X_2 + 0.135X_3 + 0.040X_4 - 0.087X_5 + 0.003X_6 + 0.213X_7 + 0.205X_8 + 0.197X_9 + 0.192X_{10} - 0.091X_{11} - 0.062X_{12} - 0.037X_{13} - 0.030X_{14} - 0.004X_{15} \quad (12)$$

$$F_3 = -0.011X_1 + 0.077X_2 + 0.049X_3 + 0.062X_4 + 0.001X_5 + 0.021X_6 + 0.002X_7 + 0.004X_8 - 0.007X_9 - 0.150X_{10} - 0.006X_{11} + 0.076X_{12} + 0.301X_{13} + 0.278X_{14} + 0.282X_{15} \quad (13)$$

From the above equations, the comprehensive expression of platform service innovation capability is obtained as:

$$F = \frac{4.31}{4.31+2.87+2.16} \times F_1 + \frac{2.87}{4.31+2.87+2.16} \times F_2 + \frac{2.16}{4.31+2.87+2.16} \times F_3 \quad (14)$$

$$F = 0.46F_1 + 0.31F_2 + 0.23F_3 \quad (15)$$

Table 6 Component score function

	Components		
	F1	F2	F3
Customer service	0.072	0.108	−0.077
Problem-solving efficiency	0.063	0.135	0.049
After-sales capabilities	0.081	0.040	0.062
Construction of operation mode	0.137	−0.087	0.001
Logistics services of the platform	0.128	0.003	0.021
Types of platform products	−0.076	0.213	0.002
Product novelty	−0.019	0.205	0.004
Authenticity guarantee rate	−0.023	0.197	−0.007
Feasibility of innovation strategies	0.088	0.192	−0.15
Pay and conditions	0.178	−0.091	−0.006
Staff culture and quality level	0.176	−0.062	0.076
Accuracy of service information	0.039	−0.037	0.301
Timeliness of feedback	0.023	−0.03	0.278
Convenience of platform payment	−0.005	−0.004	0.282

(6) TOPSIS model

This study calculates the positive and negative ideal solutions for the indicators by utilizing the TOPSIS evaluation model and the previously mentioned formula. The specific results obtained are presented in Tab. 7.

Table 7 Positive and negative ideal solutions for innovation service evaluation indicators

	Z^+	Z^-
Customer service	0.12735	0.00108
Problem-solving efficiency	0.09632	0.00130
After-sales capabilities	0.10837	0.00021
Construction of operation mode	0.07681	0.00063
Logistics services of the platform	0.06321	0.00052
Types of platform products	0.06417	0.00113
Product novelty	0.10826	0.00215
Authenticity guarantee rate	0.08216	0.00197
Feasibility of innovation strategies	0.03526	0.00363
Pay and conditions	0.04351	0.00168
Staff culture and quality level	0.03214	0.00022
Accuracy of service information	0.05251	0.00069
Timeliness of feedback	0.06261	0.00048
Convenience of platform payment	0.04732	0.00221

(7) Calculating the comprehensive scores and making a rank

By integrating the results of both the TOPSIS model and factor analysis, we can calculate comprehensive ratings for the service levels and innovation capabilities of various e-commerce platforms engaged in import and export trade. As shown in Tab. 8, the scores of the platforms are quite different, indicating a large gap in their service innovation ability. Platform A had the highest comprehensive score with 2.88, and Platform B ranked second with 0.76. The score of platform C differed considerably from the previous two platforms with −1.32, indicating that its service innovation ability needs to be strengthened.

Table 8 Evaluation and ranking of the innovation service level of e-commerce platforms

Names	Comprehensive Scores	Rankings
A	2.88	1
B	1.26	2
C	0.43	3
D	−1.32	4

By utilizing factor analysis in SPSS software, we can obtain the objective weight determination results for the innovation service level evaluation of e-commerce platforms engaged in import trade. This gives the comprehensive evaluation of each platform in this study a certain objectivity and accuracy. Analysis results indicate that when it comes to service innovation in borderless e-commerce platforms, consideration should be given to factors both internal and external to the organization. Internal contributors include the degree of education and quality of the staff, the scientific and technological level of the platform, and various others. External influencers include the transition of the consumers' demands brought by social progress, and so on. The scores of various influencing factors reveal that service innovation in e-commerce platforms engaged in cross-border imports should be directed toward enhancing customer satisfaction.

From the comprehensive score F in the table, the scores of various platforms in the market have a certain gap, indicating that their service innovation ability is uneven. Platform A had the highest score, which was substantially higher than that of other platforms. It was followed by Platform B, and Platform C had the lowest score, which likewise had a certain gap with other platforms.

Platform A has been engaged in export-focused borderless e-commerce services for a longer duration. and ranked first in the above model analysis. Its indicators scored relatively high, and customers were highly satisfied with its customer service. The results indicate Platform A scores relatively high in network technology. Its comprehensive score is three to six times higher than that of other platforms, which indicates its high level of service capability.

Platform B is the second gradient platform in the overall market. However, in the evaluation process, it had a slightly lower score in terms of payment convenience than platform C, which shows its lack of payment convenience. However, platform B had a higher score in the guaranteed rate of authentic products, indicating that it attaches importance to product quality. Therefore, Platform B should focus on improving its network technology to acquire high-level service innovation ability and gain the favor of more customers.

The indexes of Platform C in service innovation are relatively balanced, without outstanding advantages or obvious disadvantages. From the analysis, the two platforms scored higher in problem-solving efficiency, which indicates that they attach more importance to improving customer experience. However, according to the survey, the salary of employees of Platform C is not so competitive. Therefore, it is advisable to raise the salary of employees as an incentive to improve their service.

Platform D is a late starter in the industry. Data show that most consumers rarely use Platform D, whose popularity is low. Survey results show that the reason may

be the lack of novelty and diversity of various products in the platform. The platform can start with the innovation of various e-commerce channels in service to find better logistics and distribution services and expand its popularity. At the same time, according to the analysis, the after-sales service score of the platform was higher than that of other aspects, indicating that the platform attaches importance to customer after-sales guarantee. It can be seen that Platform D still has great room for improvement in service innovation.

A comparison of the rankings of market share and brand awareness of the above platforms with that of service innovation suggests that the platforms that rank higher in service innovation also have a larger market share. The platforms that are well known to most consumers also have stronger general service innovation ability. For example, Platform A has a large market share in the market, a relatively large brand reputation, and a higher score of service innovation ability than that of other platforms in the market. Platform D started late, and it has a small market share with the lowest corresponding score. Therefore, the service innovation model established in this study is considered to be feasible.

5 CONCLUSIONS AND IMPLICATIONS

After the influencing factors of service innovation of the borderless e-commerce import platform model were analyzed, the evaluation index system of service innovation ability was constructed. This study conducted relevant data investigation based on this system. In combination with the factor analysis method, the study constructed the model for evaluating the innovation ability of import borderless e-commerce services and selected four representative platforms in the market to rank them. It also verified the validity of the model by examining the relationship between service innovation ability, market share, and brand awareness.

5.1 Conclusion

This study first analyzes the development status of the import borderless e-commerce platform and the connotation of service innovation. Based on the related literature, it obtains the evaluation index of the service innovation ability of the import platform for borderless e-commerce, including customer demand satisfaction, network marketing methods, after-sales capacity, employee compensation, and so forth. Secondly, in combination with the factor analysis method, this study constructs the evaluation model of borderless e-commerce import service innovation ability through the investigation of related data of each e-commerce platform. It finds that customer satisfaction has the strongest impact on the service innovation capability of the platform, that is, the platform needs to attach great importance to customer satisfaction when building service innovation. The level of network technology will also affect the service innovation ability of the platform.

This research conducted a thorough examination of four platforms in the market, employing both quantitative and qualitative indicators to comprehensively rank them. The results indicated noteworthy variations in service innovation capabilities among the platforms. Specifically, Platform A emerged with a superior overall score in service innovation capabilities, contrasting with Platform D, which displayed significant room for enhancement in this aspect. Additionally, through a comparative analysis of service innovation rankings and market shares, a positive correlation between platform service innovation rankings and their respective market shares was identified. Consequently, this paper asserts that the evaluation model developed in this study is practically applicable in real-life scenarios, providing robust support for enhancing service innovation efficiency in e-commerce platforms. We emphasize the accuracy of the indicator evaluation system and the scientific nature of the model assessment, underscoring the overarching goal of our research to contribute to a more comprehensive and profound understanding of the e-commerce industry.

5.2 Managerial Implication

(1) Innovate Platform Products and Improve Service Level

Owing to the virtuality of import borderless e-commerce platforms, users need to browse their platform products, such as related portal sites or mobile phone software, when they make purchases on the platform. From the perspective of consumers, the products and services of the platform are an integral whole. Carrying on the service innovation, the platform will certainly contain product innovation. To conduct innovation in the product, the service innovation to satisfy customers' demands should be included. According to the development status of each import borderless e-commerce platform, the guided shopping pages and marketing activities are very similar but the characteristics are not obvious. Many import cross-border platforms rely on low commodity prices to attract customers, but low prices are achieved at the expense of the platform's service quality. Aiming at the virtual shopping website, the platform needs to employ more high-tech talents to carry on the daily maintenance of the shopping platform, upgrade and optimize the relevant interface, as well as design more humanized guides and websites in line with the shopping psychology of consumers. It should establish a business model that is suitable for its development to stimulate the browsing and shopping needs of consumers. At the same time, the platform should strengthen the construction of all kinds of marketing activities and create more marketing activities suitable for its platform development.

(2) Improving the Quality of Products to Meet Customers' Needs

The purpose of platform service innovation is to improve customer satisfaction. Goods with better quality can quickly help consumers form a better impression of the platform. In addition, the cost savings of the platform in solving after-sales problems can be used to improve service innovation ability and strengthen the investment in network technology, customer service training, and so on. According to AI Media Consulting Statistics, Chinese cross-border online shopping users are most concerned about whether the goods are genuine when they purchase imported goods, which shows that improving product

quality can help the platform improve consumer satisfaction. At the same time, according to the survey, consumer trust in the major platforms is still low, showing that the platform pays little attention to product quality. Therefore, the major import borderless e-commerce platforms should increase the guarantee rate of genuine goods, have a better understanding of their scope of responsibility, and strengthen the quality control of goods in each link.

The platform should pay attention to three aspects of quality control. First, in terms of pre-sale, the import borderless e-commerce platform should improve the supply chain management of goods, actively look for high-quality sellers overseas, and ensure the supply source. For suppliers who apply to settle in, the platform also needs to ensure that the qualifications of retailers are sound, ensure the high quality of goods from the source, and eliminate the fraudulent behavior of black-hearted sellers for high profits. Second, in terms of sales, the platform needs to strengthen the image of an "authentic product guarantee", actively cooperate with the government, conduct regular internal and reasonable inspections on the platform, cooperate with external third-party inspections, and do well in sharing of data resources, quality supervision, and other related work tasks. Finally, in terms of after-sales, the platform should improve various service levels, help customers solve various after-sales problems quickly and efficiently, and enhance consumer satisfaction with platform goods.

(3) Innovate Management System and Enhance Service Consciousness

Innovation management mode is one of the key contents of service innovation platforms because the essence of service innovation is to improve the way and content of service, which requires the joint efforts of platform employees. In general, consumers' evaluation of the service quality of import borderless e-commerce platforms is based on their impression when communicating with customer service staff, so it is particularly important to improve the quality of customer service staff. According to the actual operation mode of China's import borderless e-commerce, when consumers browse or buy goods on the platform, they first come into contact with the customer service staff on the platform, which requires a higher level of workability and quality from the staff. Therefore, to improve staff quality, the platforms should provide more training and communication opportunities for their employees so they can learn and absorb various communication experiences. Consumers, in turn, can get a better service experience when shopping. At the same time, the platform should establish a standard service mechanism for customer service staff, optimize the service process, and improve the efficiency of solving problems for customers. In terms of staff salary, increasing the salary can stimulate their enthusiasm to a certain extent. The platform also needs to establish a set of reward and punishment mechanisms for service innovation that adapts to the development of the platform to help the platform maximize its efficiency in service innovation.

(4) Innovate Technical Means to Improve Service Quality

In the last chapter, we can see that network technology has a significant impact on service innovation. Specifically, platform payment is convenient and feedback on relevant service information is timely, such as displaying logistics routes and tips for promotional activities. Network technology can also help the platform solve customer problems more efficiently, provide various intelligent scheme designs, and save more time and cost for the platform. In the data age, diversified marketing methods are inseparable from the support of technology, such as live broadcasts and the sharing of shopping experiences with consumer communities. However, due to the uneven technical level of each platform, the technical application of most platforms is not perfect, and the display effect of marketing methods is not ideal. In addition, although most borderless e-commerce platforms have more information about big data, their application ability has not reached the corresponding level. Sometimes, the platform will recommend the same types of products based on the shopping information after the user makes a purchase, which has little marketing significance. Therefore, major import borderless e-commerce platforms need to improve their network technology to analyze the behaviors and habits of consumers in different contexts and thus improve customer service experience.

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