HIM: A Systematic Model to Evaluate the Health of Platform-Based Service Ecosystems

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Abstract. With the vigorous development of the platform-based service ecosystem represented by e-commerce, service recommendation is used as a personalized matching method. There exist some service recommendation strategies that mainly focus on high popularity services and ignore non-popular ones. This will not only lead to oligopoly, but also be detrimental to the health of the platform-based service ecosystem. In addition, the health evaluation indicators for this kind of ecosystems are mostly qualitative and single. In view of the above phenomenon and based on the system view of balance and health, a health index model (HIM) is proposed to measure the health from two aspects quantitatively: stability and sustainability. Specifically, the model includes the system activity and organizational structure reflecting stability, as well as the productivity and vitality reflecting sustainability, which helps to illustrate the health status of the platform-based service ecosystem from the perspective of multi-dimensional integration. Additionally, this paper analyzes the factors affecting the health of this ecosystem based on HIM. In this work, a platform-based service ecosystem simulation model is constructed by using the computational experiment method to verify the effectiveness of HIM. The simulation results show that the HIM can reasonably measure the health of such ecosystems, which has guiding significance for the overall management and sound development of e-commerce platforms.

Keywords: Health index model · Platform-based service ecosystem · Recommendation strategies · Computational experiment

1 Introduction

With the rapid development of e-commerce [11], a platform-based service ecosystem with service providers, services, consumers and service operators as the core is gradually formed. In the real world, Alibaba's Taobao is a very typical platform-based service ecosystem. In the ecosystem, service providers refer to those who are in possession of resources, and provide services to consumers. Services are products that can be provided by service providers. Consumers can

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use the platform to choose services that meet their needs. The platform operators can connect multi-party services and formulate marketing strategies, thus to increase the efficiency of value creation.

As the development of the platform-based service ecosystem, the recommendation strategy as a marketing method plays an important role in it [16,22]. It promotes the healthy development of the platform-based service ecosystem while meeting the individual needs of users [14]. Nowadays, some recommendation strategies focus on services with high popularity, ignoring services with low popularity and cooperation between services [2,17], which is not conducive to the healthy development of platform service ecosystem. Studying its health is not only helpful in deepening the understanding of the ecosystem but also beneficial to its sound development. Therefore, measuring the health of the platform-based service ecosystem has become an important research topic.

In recent years, correlative research efforts have been posed to study the health of the ecosystem [21]. Gini coefficient [4] and Shannon-Weiner index [18] are recognized indicators that can reflect the state of the ecosystem, but they can only reflect one aspect of the system. The traditional Quality of Service [3,12] and system performance evaluation [10] also have the above problems, which are weak and single for measuring the health of the ecosystem. Therefore, how to measure the health of the platform-based service ecosystem from multiple dimensions is an urgent research issue to be solved.

To tackle the aforementioned issues, first of all, this paper proposes a health index model to describe the health of the platform-based service ecosystem from the two aspects of stability and sustainability [13,15]. System activity and organizational structure reflect system stability; Productivity and vitality reflect sustainability. Then, the computational experiment [20,24] is used to design models of consumers, service providers, and the platform operator to ensure the construction of the platform-based service ecosystem. The evolution of the platform-based service ecosystem under the three recommendation strategies of random, collaborative filtering and bundling are simulated. Finally, the proposed health index model is used to measure the health of the ecosystem dynamically.

The main contributions of this paper are as follows:

- A health index model is proposed, which can evaluate the health of the platform-based service ecosystem in multiple dimensions. This contributes to our understanding and the healthy development of the platform-based service ecosystem.
- By comparing the two indicators of Gini coefficient and service survival rate, the rationality of the health index model is verified through the computational experiment.
- The factors that affect the healthy development of the platform-based service ecosystem are studied and analyzed. This can provide new ideas for the analysis of the platform-based service ecosystem.

The structure of this paper is organized as follows. Section 2 shows the health index model of the platform-based service ecosystem. Sect. 3 presents the details

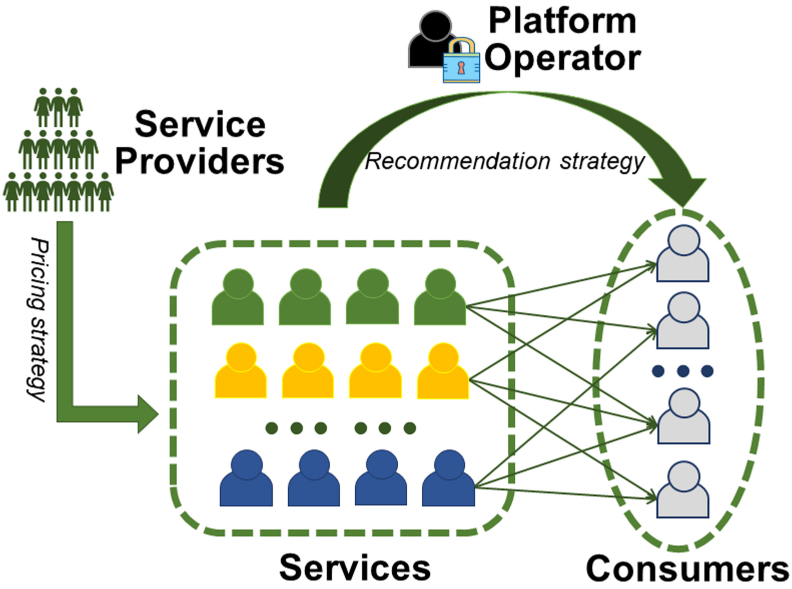


Fig. 1. The platform-based service ecosystem

and results of the experiments. Section 4 reviews the related work. Section 5 summarizes the whole paper.

2 The Health Index Model of Platform-Based Service Ecosystem

2.1 The Platform-Based Service Ecosystem

The platform-based service ecosystem is a complex and interdependent system mainly composed of the service providers, services, consumers and platform operator. Service providers can use the resources of the platform to improve their own value, continue to develop new products for consumers; Services are products that can be provided by service providers; Consumers can use the platform to choose services that meet their needs; The platform operators can connect multi-party services and formulate marketing strategies. In the real world, Alibaba's Taobao is consistent with the platform-based service ecosystem, so it is of considerable significance to study such ecosystems.

Based on the characteristics of the platform-based service ecosystem, this paper constructs the ecosystem from four main aspects: service providers, services, consumers and platform operators, as illustrated in Fig. 1.

Service Providers. A service provider is an enterprise or individual that provides services to consumers through the platform. The pricing behavior of service providers is mainly considered.

Two pricing strategies are considered in this paper. The pricing strategy 2 is a commonly used pricing method. The pricing strategy 1, based on the pricing strategy 2, considers the impact of the frequency of service purchase on the price. The difference between Pricing Strategy 1 and Pricing Strategy 2 is that the commodity prices set by Strategy 2 are fixed, while the commodity prices set by Strategy 1 decrease as the number of consumers increases.

See formula (1) for the pricing strategy 1 and formula (2) for the pricing strategy 2.

$$P_1 = (C_1/m + C_2)/(1 - tax\_rate - sales\_p\_m) \tag{1}$$

$$P_2 = (C_1 + C_2)/(1 - tax\_rate - sales\_p\_m) \tag{2}$$

where C_1 is the production cost (fixed cost); C_2 is the sales cost; m is the number of consumers buying goods; tax_rate is the tax rate, and $sales\_p\_m$ is the sales profit margin; P_1 is the price under the pricing strategy 1 and P_2 is the price under the pricing strategy 2.

Services. Services link service providers, consumers, and the platform operator to form a platform-based service ecosystem. The main characteristic properties of the service are shown in Table 1.

Consumers. In the experiment system, agent model is used to depict the behavior features of various consumers, which is the individual with independent decision and cooperative competition ability. The formal description of consumer agent is shown as formula (3).

$$Consumer = < S, Et, Yt > \tag{3}$$

where S represents consumer attributes; Et represents perceived events; Yt represents decision-making mechanism.

Consumer attributes S: The attributes of consumers includes four aspects.

(1) Willingness to pay(V_i): The willingness of consumers to pay refers to the valuation of the service goods or the price they are willing to pay, where the willingness to pay obeys a uniform distribution of [0, a].
(2) Consumer demands(Cd): Different consumers have different demands for service goods. The demand here corresponds to the type of service goods.
(3) Consumer satisfaction(Cs): Consumer satisfaction is the degree of satisfaction of consumers after enjoying the service, and the initial consumer satisfaction is set to a fixed value.
(4) Purchase history(Ph): Records of service goods purchased by consumers.

Table 1. The main characteristic properties of the service

Property name	Brief description	Remarks
P	The selling price	P is the selling price of the service. Different pricing strategies lead to different prices of services
C_1	Production cost	C_1 refers to various production costs incurred in providing services
C_2	Selling cost	C_2 refers to the production cost of the service sold or the labor cost of the labor service provided and the business cost of other sales
T	Type of service	T is the category of the service that the service provider can provide to the customer
Qos	Quality of service	Qos refers to the sum of the characteristics and characteristics of services that can meet the requirements and potential needs, and refers to the extent to which services can meet the needs of the served
R	Service reputation	R refers to the reputation of the service, which will not change during the experiment
Rt	Response time	Rt is the time that the customer has to wait for the service
L	Service life	The initial life value of the service is fixed. The rules for updating the life value are as follows. If the consumer currently chooses to use this service, the service life remains unchanged; If no consumer chooses the service, the service life decreases; If the service life value becomes 0, the service is dead
Re	Service revenue	Re refers to the benefits of services
Ce	The cross-elasticity coefficient of demand	Ce reflects the complementarity between services

Decision mechanism Yt: The consumer's decision mechanism mainly reflects the behavior of consumers. There are two main behaviors: Selecting recommended services and satisfaction evaluating of the purchased services.

(1) Select recommended services: Consumers decide whether to purchase a service based on their willingness to pay and the average satisfaction of the service.
(2) Satisfaction evaluation of services: Consumers rate services after using them. Satisfaction evaluation is related to service attributes (quality of service, response time and service reputation). Evaluate the service according to formula (4).

$$Satisfactory = \alpha \times Qos + \beta \times Rt + \gamma \times R \quad (\alpha + \beta + \gamma = 1) \tag{4}$$

where Qos is the quality of the service; Rt is the response time; R is the service reputation.

Perceived Events Et: The external events perceived by consumer can affect their decision-making behavior. The perceived events of consumers are as follows.

Perceive the Service Price and Average Satisfaction: Consumers can perceive the price and average satisfaction of the current candidate service.

Table 2. Three ways of the bundling strategy

Ways	Applicable conditions
Pure bundling	The absolute value of the demand cross-elasticity of bundling parties is small (the degree of complementarity is low) and the service quality is good
Mixed bundling	The absolute value of the demand cross-elasticity of bundling parties is at the center (the degree of complementarity is in the middle) and the service quality is average
Separation strategy	The absolute value of the demand cross-elasticity of bundling parties is high (the degree of complementarity is high)

The Platform Operator. The platform operator mainly regulates and controls the entire platform through marketing strategies, so as to make the whole ecosystem healthy and stable. The followings are common recommended strategies.

The Bundling Strategy: The bundling strategy is a marketing strategy commonly used by e-commerce platforms. The relevant content of this strategy is as follows.

(1) Price of bundled services: The price of the bundled service is shown in the following formula.

$$P < P1 + P2 \tag{5}$$

where $P1$ and $P2$ are the prices of two bundled services sold separately; P is the price of the bundle.

(2) Three ways of the bundling strategy are shown in Table 2.

(3) Profit distribution for bundled services: Game theory is used for profit distribution of bundled services. Formula (6) uses the Shapley's law in cooperative games for profit distribution.

$$\begin{aligned} \phi_i &= \sum_{i \in S \in I} W(|S|)[V(S) - V(S \setminus \{i\})] \\ W(|S|) &= \frac{(n-|S|)!(|S|-1)!}{n!} \end{aligned} \tag{6}$$

where I={1,2,...,n} is the set of all the people participating in the game; S is a subset of I; $|S|$ is the number of elements in the set S; $V(S)$ represents the profit of set S; $V(S\backslash\{i\})$ represents the profit of other individuals in the set S except i; ϕ_i represents the profit that individual i should earn.

The Collaborative Filtering Strategy: The collaborative filtering recommendation strategy is the currently popular recommendation algorithm. It is mainly divided into the following two steps:

(1) Building a service similarity matrix: Use the Pearson correlation coefficient to calculate the similarity between services based on the history of all users, and build a similarity matrix. This is shown in formula (7),

$$sim_1(i_1, i_2) = \frac{\sum_{u \in u_{i_1} \cap u_{i_2}} (r_{u_{i_1}} - \overline{r_{i_1}}) \times (r_{u_2} - \overline{r_{i_2}})}{\sqrt{\sum_{u \in u_{i_1} \cap u_{i_2}} (r_{u_{i_1}} - \overline{r_{i_1}})^2} \times \sqrt{\sum_{u \in u_{i_1} \cap u_{i_2}} (r_{u_2} - \overline{r_{i_2}})^2}} \quad (7)$$

where $r_{u_{i_1}}$ and r_{i_1} indicate the rating of the items (i_1 and i_2) by user u; $\overline{r_{i_1}}$ and $\overline{r_{i_2}}$ represent the average of the scores of items i_1 and i_2; $sim_1(i_1, i_2)$ indicates the similarity of items i_1 and i_2.

(2) Make a recommendation: According to the similarity matrix of the service and the user's historical purchase record, the user's service recommendation is made.

The Random Recommendation Strategy: The random recommendation strategy is to randomly select services for consumers to recommend.

The dynamic change of the platform-based service ecosystem depends on the match between the service and the consumer driven by the recommendation strategy. In practice, the service is recommended to consumers. If the service cannot be selected by consumers for a long time, its life value will decrease and gradually die; Consumers select services from the list of candidate services based on service prices and service evaluations, and then evaluate the service. Under different circumstances, the different matching of consumers and services will affect the healthy development of the entire ecosystem.

2.2 The Health Index Model

Nowadays, with the rapid development of e-commerce, many platform-based service ecosystems with extensive influence have been formed. Assessing the health of the platform-based service ecosystem is a great help for its research methods and establishment approaches. A healthy platform-based service ecosystem is of high stability, which means it can resist changes in the external environment, and of high sustainability, which means it can continuously tap its inherent potential to achieve sustainable development. Based on the definition of platform-based service ecosystem, this paper draws on the health research of ecosystems, and

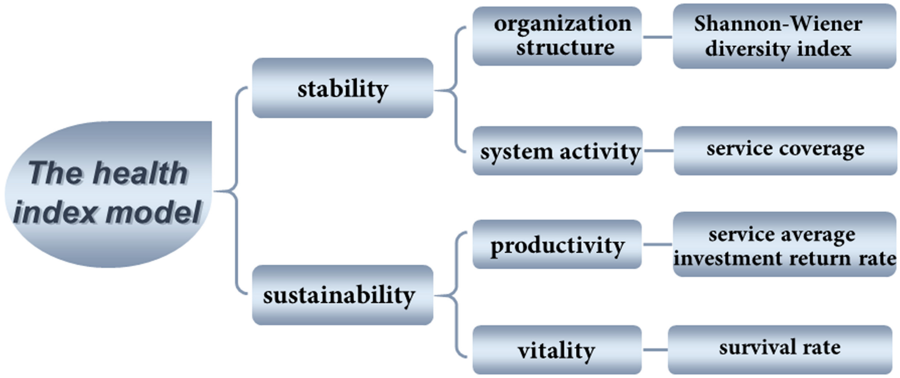


Fig. 2. The health index model

provides a platform-based service ecosystem health index model as shown in Fig. 2. The service ecosystem health index is expressed as formula (8).

$$HI = S_1 \times \alpha + S_2 \times \beta \tag{8}$$

where HI is the system health index; S_1 is the stability of the system; S_2 is the sustainability. The shares of S_1 and S_2 in the entire index formula are α and β, which are divided based on the importance of stability and sustainable development to the health of the service ecosystem. For a platform-based service ecosystem, stability determines the existence of the ecosystem, and sustainable development determines the development prospects of the system. This paper considers the significance of existence is more important than development. Therefore, $\alpha > \beta$ is set in the experimental part.

Stability. Platform-based service ecosystems' stability is referred to as the ability to maintain itself after being interfered, which means minor fluctuations and random disturbances would not change the system. Drawing on the relatively mature research on health in the ecosystem, this paper divides the factors that affect the stability of ecosystem into the following two factors: system activity and organization structure. The stability of the ecosystem can be expressed by the formula (9).

$$S_1 = O \times A \tag{9}$$

where S_1 is referred as the stability of the service ecosystem; O is the organization structure; A is the system activity.

(1) Organization Structure. It means the complexity of ecosystem's structure. This paper draws on the Shannon-Wiener diversity index in the biosphere to reflect the organizational structure. This method can reflect the types of services in the platform-based service ecosystem and the uniformity of the distribution

of various services, as shown in formula (10).

$$O = -\sum_{i=1}^{m}(Pi)(lnPi) \tag{10}$$

where m is the number of types of services; $P_i = n_i/N$; N means the total number of services in ecosystem, and n_i means the number of the i-th type of service.

(2) System Activity. In an ecosystem, activity refers to all the energy that can be measured according to the nutrient cycle and productivity. Drawing it into a platform-based service ecosystem, activity means production, that is, service coverage or resource utilization. This satisfies the formula (11).

$$A = \sum_{i=1}^{m}\frac{n_l}{N} \tag{11}$$

where m is the number of types of services; N means the total number of services in ecosystem, and n_l means the number of services used by consumers in the i-th service goods.

Sustainability. Service ecosystem's sustainability refers to the trend of constantly development with the change of time and environment. Considering the sustainability of service ecosystem, this paper divides the factors affecting sustainable development into the following two aspects: productivity and vitality. The following formula can express the sustainability of the ecosystem.

$$S_2 = P \times R \tag{12}$$

where S_2 is the sustainability of the system; P is the productivity; R is the vitality.

(1) Productivity. Productivity refers to the ability to transform the technology and other innovative raw materials to low cost and new productions. The simplest and most effective measure of this ability is the average return on investment. This paper uses the service average investment return rate to evaluate the service ecosystem's productivity. It satisfies the following formula.

$$P = \frac{1}{N} \times \sum_{i=1}^{N}\frac{Pr_i}{C_i} \tag{13}$$

where N is the total number of services; Pr_i is the ith service products' price; C_i is the ith service's cost; Pr_i/C_i is the investment rate.

(2) Vitality. For the platform-based service ecosystem, vitality refers to the ability to provide lasting benefits for services that depend on it. In the face of external shocks, the mutual relationship between the members of the ecosystem can play a certain role in buffering. Therefore, the most straightforward measure of vitality is the survival rate of ecosystem members.

$$R = \frac{n}{N} \tag{14}$$

where N is the total number of services; n is the number of the survived services.

The above is the platform-based service ecosystem health index model proposed in this paper.

3 Experiments and Evaluation

This paper studies a platform-based service ecosystem similar to Taobao. In reality, the relevant source data sets cannot be obtained. Therefore, the method of computational experiments is used to conduct simulation experiments.

The computational experiment has the advantage of accurate control, simple operation and repeatability, and has been widely used in analyzing various complex systems, such as transportation system, ecological environment, socioeconomic system, political ecosystems, etc. Hence, computational experiment can be used to design various experiment scenarios to compare the performance of different strategies. This paper aims to simulate and compare bundling strategy, collaborative filtering strategy and random recommendation strategy under the same experimental environment.

3.1 Experimental Parameter Settings

The computational experiment system is constructed as an artificial society laboratory, see Sect. 2.1 for details. In order to make the experiment easy for readers to understand, the prototype of this model is based on Taobao. The experimental parameters are shown in Table 3.

3.2 Experiment Results and Analysis

Based on the proposed evaluation model, the evolution of the platform-based service ecosystem under the three recommendation strategies is simulated. The service diversity index, resource utilization rate, average investment return rate and service survival rate in each state of the system are corresponded to the calculation of the health index formula, and are normalized to get the health value of the system. This paper uses a five-level evaluation scale to quantify the various evaluation results.

From Table 4, it is known that 0.4 is the alert value of the ecosystem health index. When the health index is above 0.4, ecosystem's health level is at least

Table 3. The experimental parameters

System variables	Experimental setup
System variable settings	50*50
Consumer number	It can be set up according to experiment acquirements
Consumers' Willingness to pay	V_i represents consumers' wiliness to pay. V_i follows uniform distribution in[0,a]. In this paper, it is set in [0, 100]
Consumers' shopping history	This paper generates consumer score data according to Weibull distribution
Service number	The service is divided into long tail service and popular service. According to the pareto principle, set the number of the two to 2: 8. The number of services varies from 20 to 2000 according to experimental needs
Type of service	The number of service types is positively correlated with the number of services. In the experimental part, we use Arabic numerals to mark the service types, and the same number means the same service type
Service cost	The service cost contains production cost and sale cost. The two individual cost are floats lying in [1, 6]
Service price	Service prices are set according to two pricing strategies
Quality of service	Service quality refers to the sum of the characteristics and characteristics of services that can meet specified and potential requirements, in other words, the extension that the service can meets. It follows a random distribution in [10, 20]. {(10∼12) means bad, (12∼15) means normal, (15∼18) means good, (18∼20) means perfect.}
Service reputation	It means the prestige of the service. It follows a random distribution in [10, 20]. {(10∼12) means bad, (12∼15) means normal, (15∼18) means good, (18∼20) means perfect.}
Service initial life value	Initial values: random from the range of [40,50]
Response time	It means the time to wait before enjoying the service. Usually, hot service's responding time is longer. It follows a random distribution in [10, 20]. {(10∼12) means bad, (12∼15) means normal, (15∼18) means good, (18∼20) means perfect.}
The cross-elasticity coefficient of demand	The absolute value of the cross-elasticity coefficient between services follows a random distribution in [0, 15].{(0∼5) means the value is small, (5∼10) means the value is centered, (10∼15) means the value is large.}
Service satisfaction score	Initial values: random from the range of [10,20]
Consumer satisfaction	Consumers will score the service in the end. A satisfactory score is related to service property. The calculation is shown in formula (4)

Table 4. Five-level evaluation scale

Health level	Very low	Low	Normal	High	Very high
Threshold	0.2	0.4	0.6	0.8	1

normal and even better; when the health index is below 0.4, ecosystem's health level is low or worse.

The experimental results in this paper include two aspects. First, the rationality of the health index model is verified by comparison with the Gini coefficient and service survival rate. Secondly, this paper analyzes the factors that affect the long-term healthy development of the platform-based service ecosystem.

The Rationality of the Health Index Model

The Relationship Between Gini Index and Health Index. The Gini coefficient is a commonly used indicator to measure the income gap and reflect the state of the system. It is introduced into this paper to measure the service income gap. Comparison with the accepted Gini coefficient can verify the rationality of the proposed health index model. The Gini coefficient is shown in formula (15).

$$G = 1 - \frac{1}{n} \times (2\sum_{i=1}^{n-1} W_i + 1) \tag{15}$$

where n means that the service is equally divided into n groups; W_i reflects the percentage of total service income accumulated to group i as a percentage of total population income.

International practice regards below 0.3 as a relatively average income; 0.3–0.4 is regarded as a relatively reasonable income; 0.4 is a warning value, and when the Gini coefficient reaches 0.5 or more, it means income disparity.

In the simulated platform service ecosystem, the relationship between Gini index and health index under the three strategies can be found. As shown in the Fig.3, when service income Gini index is well, service ecosystem health index is high. Overall, with the continuous increase of the Gini coefficient in the service ecosystem, the health index has first increased and then decreased. When Gini coefficient is less than 0.4, which means service income gap is small, the health index of the ecosystem can be maintained at a relatively healthy value; When Gini coefficient is between 0.4 and 0.5, the health index will decline. However, it is still greater than the alert value; when Gini coefficient exceeds 0.5, the health index will be lower than the alert value, and with the continuous increase of the Gini coefficient, the health index will continue to decline.

From the above analysis, it can be found that the trend of the health index and the Gini coefficient is approximately the same, so it can explain the rationality of the health index model.

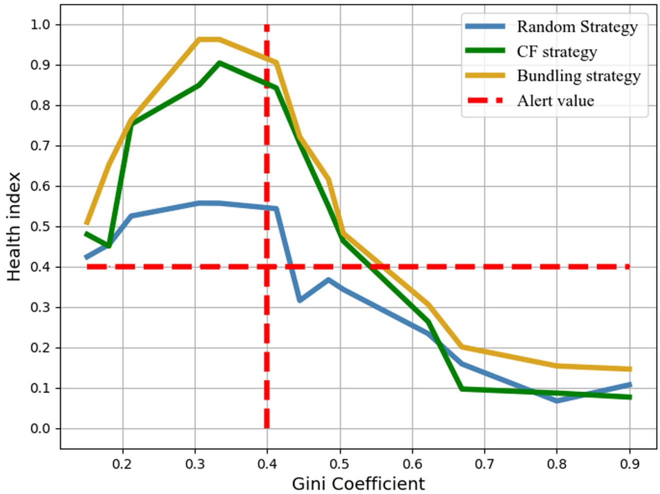


Fig. 3. Relationship between Gini coefficient and the health index

The Relationship Between the Survival Rate and the Health Index. The health index has a certain relationship with the survival rate of services in the ecosystem. The calculation of service survival rate is shown in formula (14). With the dynamic evolution of the platform-based service ecosystem, the service survival rate is constantly changing. As can be seen from Fig. 4, with the increase of service survival rate, the health index of the ecosystem also increases and then stabilizes. When the service survival rate is low, the health index is low; When the service survival rate is high, the health index is also high.

The relationship between health index and service survival rate, Gini index can reflect health index's reasonability to some extent. What's more, the health index proposed in this paper studies the service ecosystem from multiple dimensions, taking into account the ecosystem's service diversity, service survival rate, service coverage rate, and service investment return rate. Compared with a single indicator for measuring ecosystems, our proposed health index model covers multiple aspects of indicators that can more comprehensively and reasonably reflect the health of an ecosystem.

Factors Affecting the Health of the Platform-Based Service Ecosystem. The purpose of this paper is to verify the health index model by evaluating recommendation strategies. The reasons for choosing these three strategies are as follows. The random recommendation strategy is selected as a benchmark for evaluation; The collaborative filtering recommendation strategy is selected as the currently popular recommendation algorithm; The bundling strategy can increase the attention of non-popular products, but also it has brought about problems such as decreased consumer satisfaction. This strategy is currently a marketing strategy commonly used by e-commerce platforms, so it is chosen.

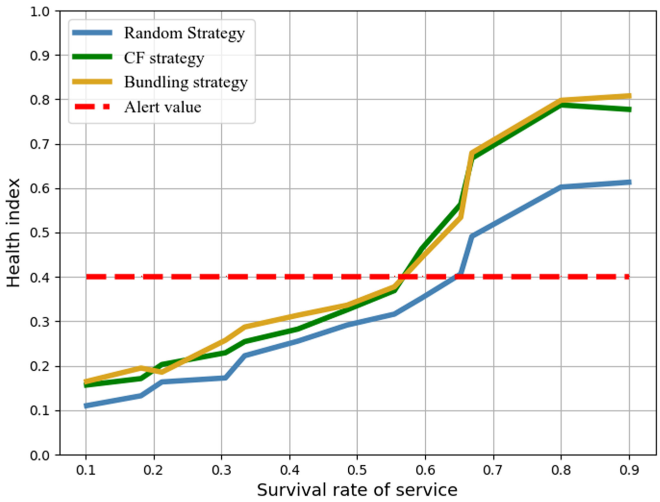


Fig. 4. Relationship between service survival rate and the health index

The Ratio of Consumers to Services and Different Recommendation Strategies. In the experiment, the platform-based service ecosystem health index for the three strategies is shown in Fig. 5, where the x-axis corresponds to the ratio of consumers to services, and the y-axis corresponds to the platform-based service ecosystem health index. On the whole, as the ratio continues to increase, the health indexes of the bundling strategy, collaborative filtering strategy, and random strategy increase sharply; When the ratio of consumers to services reaches a fixed value, the health index of the bundling strategy and collaborative filtering strategy grows slowly and steadily, while the health index of the randomly recommended strategy tends to stabilize; As the ratio continues to increase, the health index of the bundling strategy and collaborative filtering strategy gradually stabilizes.

It can be found from Fig. 5 that when the ratio of consumers to services is less than 3, the health index under the collaborative filtering strategy is higher than the other two strategies, so collaborative filtering is the current optimal strategy; When the ratio of consumers to services is greater than 3 and less than 14, the health index under the bundling strategy is higher than the other two strategies and the bundling strategy is the current optimal strategy; When the ratio of consumers to services is greater than 14, although the health index under the bundling strategy is slightly higher than the collaborative filtering strategy, the health index of the two are not much different, so both strategies are optimal strategies.

In summary, the quantitative relationship between consumers and services has an impact on the health of the platform-based service ecosystem. Moreover, different recommendation strategies should be used at different ratios to make the platform-based service ecosystem healthier.

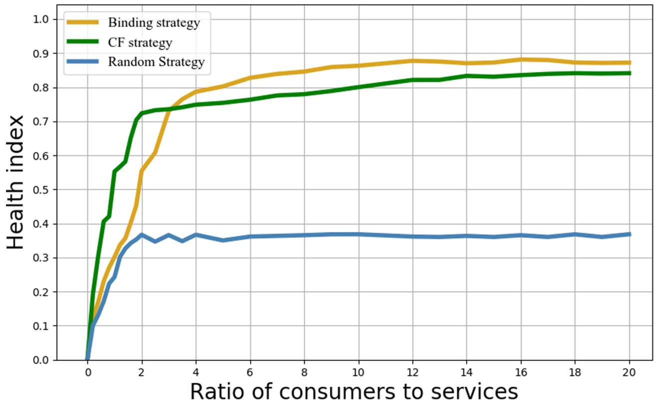


Fig. 5. Relationship between Ratio of consumers to services and the health index

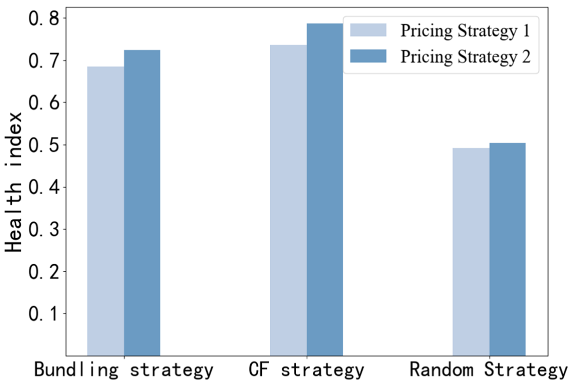
Different Pricing Strategies and Recommendation Strategies. This experiment compares the platform-based service ecosystem health index under two pricing strategies and three recommended strategies. It is shown from the Fig. 6 that when the number of services is much larger than the number of consumers, the collaborative filtering strategy performs best, and the use of pricing strategy 2 is better. If the number of consumers is much larger than the number of services, the bundling strategies will perform best, and the use of pricing strategy 1 is better.

From the above analysis, different recommendation strategies will affect the health of the platform-based service ecosystem. And different pricing strategies should be used under different recommendation strategies to ensure a healthier platform-based service ecosystem.

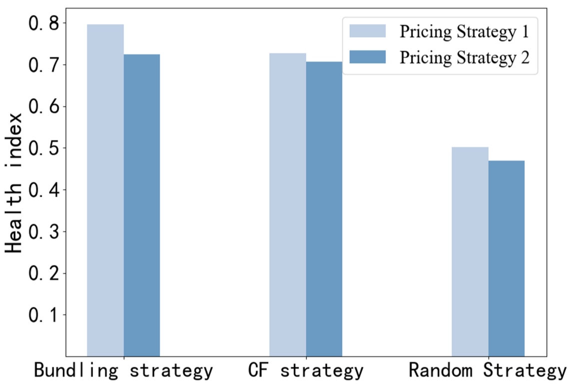
4 Related Work

4.1 Study on the Health of Ecosystems

The new defined service system resembles the concept of business ecosystem largely. A service system is a value-coproduction configuration of people, technology, and other internal and external service systems [19]. The research on the health of service ecosystems can draw on the research on ecosystems in the biosphere. Constanza believes that a healthy ecosystem is stable and sustainable, has vitality, can maintain its organization and maintain its ability to operate itself, and is resilient to external pressures [7]; Rapport et al. Believed that ecosystem health refers to that the ecosystem has no pain reflection, is stable and sustainable development, that is, the ecosystem has vitality over time and can maintain its organization and autonomy, and is easy to recover under external stress [13]. Based on the former research, this paper proposes a health index model based on the service ecosystem.



(a) The ratio of consumers to services is 0.8



(b) The ratio of consumers to services is 5

Fig. 6. Impact of two pricing strategies and recommendation strategies on health index

4.2 Recommendation Strategy

The recommendation strategy is considered as one of the effective methods to alleviate the imbalance between information production and acquisition caused by the information overload problem [9]. In the field of traditional service recommendation, many researchers have done a lot of related work [5]. Collaborative filtering algorithm [6], which is widely used at present, has greatly promoted the development of recommendation systems. This recommendation algorithm can be divided into two forms: user-based recommendation and item-based recommendation [1]. The basic principle of user-based recommendations is as follows. Firstly, user preference is found by analyzing their historical data; secondly, it finds object service's neighbor according to their preference; finally, according to neighbor user's historical preference data, it recommends for object users [8].

The basic principles of item-based recommendations are similar to user-based recommendations. Firstly, the similarities between services rather consumer's similarity is computed; Secondly, the nearest number of the unmarked service is found; thirdly, according to the nearest neighbor's mark, the service's mark is predicted; finally, the service which has the highest predicted mark could be recommended to the users [23].

5 Conclusion

In order to study the health of the platform-based service ecosystem, first, this paper proposes a health index model to measure its health quantitatively. Secondly, a simulation model of the platform-based service ecosystem is constructed by means of computational experiments. Driven by the three recommendation strategies, the platform-based service ecosystem continues to evolve. Finally, this paper uses the proposed health index model to measure the health of the ecosystem dynamically. The results show that the proposed health index model is reasonable and can provide decision support for the management of the ecosystem. In addition, we have also studied and analyzed the factors affecting the healthy development of the platform-based service ecosystem. For future work, we look forward to adding more quantitative indicators to the health index model to measure the health of the platform-based service ecosystem more accurately.

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