


## Article

# Research on the Openness of Digital Platforms Based on Entropy-Weighted TOPSIS: Evidence from China

Wei Fu <sup>1,2,\*</sup> , Jie Sun <sup>3,\*</sup> and Xiaodong Lee <sup>1,2</sup><sup>1</sup> School of Public Policy & Management, Tsinghua University, Beijing 100080, China<sup>2</sup> Fuxi Institution, Heze 274000, China<sup>3</sup> Business School, Beijing Normal University, Beijing 100032, China

\* Correspondence: fuw@tsinghua.edu.cn (W.F.); jiesun@bnu.edu.cn (J.S.)

**Abstract:** Regarding digital platforms in recent years, the abuse of a platform's dominant position, applications monitoring user behaviour, the difficulty of exiting digital platforms, and the inability of users to transfer data on platforms have become increasingly acute, which makes the evaluation of the openness of digital platforms extremely urgent. This paper applies the relatively objective entropy-weighted TOPSIS method to construct a digital platform openness index (DPOI) to evaluate the openness of 22 digital platforms in China. The research found that there are certain institutional constraints and obstacles in the access, transaction, exit, and transfer of different types of digital platform, and it is necessary to sustainably improve the openness of digital platforms to bring convenience to users in the future. Our results not only update the practical data on the openness of emerging digital platforms, but also enrich the literature in the field of digital platform openness, which has significant implications for evaluating the openness of digital platforms in emerging markets such as China.

**Keywords:** digital platform; openness; entropy-weighted TOPSIS



**Citation:** Fu, W.; Sun, J.; Lee, X. Research on the Openness of Digital Platforms Based on Entropy-Weighted TOPSIS: Evidence from China. *Sustainability* **2023**, *15*, 3322. <https://doi.org/10.3390/su15043322>

Academic Editor: Evangelos Katsamakas

Received: 6 December 2022

Revised: 2 January 2023

Accepted: 9 February 2023

Published: 10 February 2023



**Copyright:** © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

Digital platform openness refers to the degree of restriction and severity that digital platforms allow in terms of different users participating in the use, development and commercialisation of the platform [1–3], and includes four aspects: access openness, transaction openness, exit openness, and transfer openness. Openness is of great significance to the healthy development of digital platforms and the construction of a whole new economic ecology [4]. The functions and roles of platforms have changed dramatically with the development of technology, the economy, and society [5]. Digital platforms have become the “key business infrastructure” in the era of the digital economy, and their openness not only concerns the interests of the platforms, but also affects the development of the whole new economic ecology [6,7]. Thus, this study aims to investigate the openness of digital platforms in emerging markets such as China, providing a comparison of the openness of digital platforms from the perspective of different types of platforms, with the aim of answering the following question: What is the degree of openness of leading digital platforms in China?

Prior studies have measured the openness of digital platforms, but in general, there exist three gaps: First, measurement indicators are not comprehensive enough. On the one hand, the existing studies are mainly one-dimensional in the selection of measurement indicators and lack the development of two-dimensional indicators. For example, Benlian, Hilker and Hess [2] adopted two one-dimensional indicators of accessibility and transparency as the openness measurement criteria, and Broekhuizen, Emrich, Gijsenberg, Broekhuis, Donkers and Sloot [3] focused on the one-dimensional indicators of access and authorization degree. On the other hand, the existing studies still need to be improved in

terms of the comprehensiveness of openness indicator selection. Second, there is a lack of research in the Chinese context. A considerable number of studies have focused on digital platform openness studies abroad [2,3,8,9], while the investigation of openness of digital platforms in China is urgent and essential. Third, the measurement methods of the existing studies in Chinese contexts are not objective enough. For example, XU et al. [10] used semi-structured interviews to investigate platform openness. To this end, this paper comprehensively constructs a digital platform openness index including four dimensions and 10 sub-dimensions, to objectively measure the openness of 22 leading digital platforms in China using the entropy-weighted TOPSIS method.

The contributions of this paper lie in two key points. From theoretical contributions, the results of this paper not only contribute to the literature on digital platform openness by adding to the objective empirical experience of indicators, but also extend the application of the entropy-weighted TOPSIS method to the measurement of digital platform openness. From practical contributions, the measurement of 22 major Chinese digital platforms' openness in this paper provides a practical basis for both suppliers and customers, offers directions for the development of the openness quotient of the platforms themselves, and presents a basis for policy making on the openness of Chinese digital platforms.

## 2. Literature Review

### 2.1. Literature on Digital Platforms

The term “platform” was initially applied in engineering, referring to the workbench needed for operation, and with the meaning of “support for the operation of certain activities and work”. Later, it was extended to economics to refer to a space or place for trading, and it was even referred to as the materialisation of the market, meaning the result of the manifestation of the traditional trading market [11]. Digital platforms represent the dominant method of resource distribution and organisation in the digital economy [12]. Digital technologies have changed platforms in fundamental ways, allowing them to host an almost unlimited number of interactions [13]. Compared with traditional platforms, digital platforms have two significant differences: one is the high-speed flow and rapid feedback of digital information streaming continuously creating new information, and the other is the huge social connection of innumerable individuals, which makes it possible for massive social collaboration at the individual level. For example, myriad users and merchants interact on digital platforms such as Facebook, Twitter, WeChat, and Taobao. Firms, as builders and operators of platforms, have gained unprecedented economic and social power in market transactions. The platform changes the social power structure, and the openness of digital platforms is a strong basis for measuring this power [14]. Therefore, it is significant to evaluate the openness of digital platforms.

In the context of today's internet era, concepts such as digital platform, internet platform, online platform, and network platform are generic and directly refer to platforms. Given the openness of digital society and the trend of pervasive platformisation of internet products and services, we adopt the concept of a digital platform to embrace platforms with significant social impact as widely as possible [15]. In this article, digital platforms refer to the online space that provides bilateral or multilateral users with behavioural interaction conditions to create value based on internet information technology. Digital platforms provide a common set of design rules and digital infrastructure to enable communication and generate interactions and transactions between multiple users who may never have the opportunity to communicate with each other [16]. In a broad sense, platforms include commercial platforms for social life, e-government platforms for public services, and industrial internet platforms for production. It should be pointed out that the digital platform object studied in this paper refers to social life-oriented commercial platforms, which can be mainly divided into e-commerce trading platforms, social media platforms, life service platforms, content and entertainment platforms, and other types according to their functional attributes and application development (Table 1).

**Table 1.** Digital platform type.

Platform Type	Representatives
E-commerce trading	Taobao, JD.com, Pinduoduo, Vipshop.com, Suning.com, Dangdang, RED
Social media	WeChat, Sina Weibo
Life service	Meituan.com, Ele.me, 58.com, Didi Chuxing, Ctrip, Qunar, BEKE, Alipay
Content and entertainment	TikTok, Kwai, iQiyi, Bilibili, Baidu

Source: Centre for Internet Governance, Tsinghua University, 2021.

## 2.2. Literature on Digital Platform Openness

The concept of openness is long-standing, and the deep integration of digital technologies with industries has completely changed the connotation and extension of openness in terms of degree [17]. Scholars have evaluated platform openness in terms of organisations, product lines, market intermediaries, and platform ecosystems and have argued that platform openness consists of two layers: the first is the pursuit of the number of edges, whereby a potential platform must choose whether to be unilateral, bilateral, or multilateral; the second is how the platform deals with other competing platforms, which may include incompatibility, compatibility, or an integration of the two, to a given degree. A greater quantity of platform edges indicates a greater openness of the platform, and the more compatible platforms are to each other, the more open the platform will be [4,18,19]. Some scholars have also argued that platform openness is a result of the participation, development or usage restrictions imposed by the platform on different actors (either developers or end-users), and the fewer usage restrictions there are, the more open the platform is, or the degree to which all actors have the ability to access and utilize the platform resources once they enter the platform and the stringency of the platform specifications [14,20].

Openness is of great significance to the healthy development of digital platforms and the construction of a whole new economic ecology. The functions and roles of platforms have changed dramatically with the development of technology, the economy, and society. Digital platforms have become the “key business infrastructure” in the era of the digital economy, and their openness not only concerns the interests of the platforms, but also affects the development of the whole new economic ecology. Open platforms can stimulate growth by leveraging network effects, reducing end-users’ fear of lock-in, and stimulating downstream production to achieve healthy and sustainable platform development. In parallel, open platforms typically reduce user switching costs, increase bifurcation and competition, and decrease the ability of digital platforms to acquire rent, thereby increasing the level of consumer and producer welfare. The openness of digital platforms allows multiple users who may never have the opportunity to communicate with each other to generate interactions and transactions through ICTs, determining the willingness of merchants to join the platform and the net benefits users derive from potential interactions, reflecting the trade-off between retaining and relinquishing control of the platform [21]. In cyberspace, with the participation of equal-status economies, it is significant to determine whether products can be traded equally and openly on the platform [22].

Although many studies have examined platform openness based on objective evaluation criteria, there is no consistent concept or valid metric to assess platform openness. Some scholars measure the openness of software platforms in terms of four perceptual dimensions: access and transparency of both the platform itself and distribution channels [2]. Other scholars have measured the openness of different actors, such as suppliers, customers, complementary service providers, product categories, and channels, in terms of dimensions such as access and authorisation. Some studies suggest that platform openness metrics should clearly define the level of measurement (at what level: organisation, market intermediary, or ecosystem), how openness is measured, and who are the users that reflect openness [3]. Wang et al. [23] decomposed platform openness into supply side openness and demand-side openness and found that high demand variability and high supply-side

openness of platform users would lead to improved platform performance. Ramos and Blind [24] conducted a comparative study of three platforms, Spotify, Google, and Facebook, around the impact of GDPR granting users the right to portability of their personal data on data-driven innovation on digital platforms. They found that data portability, in which users are allowed to move their personal data to other platforms, leads to two types of innovation through the development of new technologies: those achieved by improving existing technologies, and “discovery innovation”, both of which lead to an increase in user engagement and retention.

A comparison of concepts and measures of digital platform openness is shown in Table 2. Drawing on these studies, this paper argues that digital platform openness refers to the degree of restriction and severity that digital platforms allow in terms of different users participating in the use, development and commercialisation of the platform, including four aspects: access openness, transaction openness, exit openness, and transfer openness. It is worth noting that digital platform openness is influenced by factors including the field in which it is located, the competitive environment, and the stage of development, as well as the associated business environment.

**Table 2.** Comparison of platform openness concepts and measurement methods.

Author (Year)	Digital Platform Openness Concept	Primary Indicators	Measurements
West and O’mahony [25]	Openness is related to the structure of participation of the developer community	Transparency and accessibility	Not available
Boudreau [26]	Openness is defined as the relaxation of restrictions on the use, development, and commercialisation of technology	Access and Delegated Control	One-dimensional
Schlagwein, Schoder and Fischbach [13]	Openness is defined as access, use, and control of information resources	Resource access vs. resource control	Not available
Arakji and Lang [27]	Openness is the degree of access and involvement of users and third-party developers in value-creating activities	Access to Participation vs. Control of Exclusion	Not available
Anvaari and Jansen [28]	Openness is the degree to which a software platform approaches an open identity, which relies on both accessibility and licensing	Accessibility vs. Licensing	Not available
Laffan [1]	Openness is related to the governance model created around the platform, which determines the extent to which its decision-making process is open to the community		
Benlian, Hilkert and Hess [2]	Openness is the extent to which the platform places fewer restrictions on the participation, development or use of different actors, whether they are developers or end users	Accessibility and Transparency	One-dimensional
Broekhuizen, Emrich, Gijsenberg, Broekhuis, Donkers and Sloot [3]	Openness refers to the extent to which the platform places fewer restrictions on participation, development or use by different actors, whether for developers or end users	Level of access and authorisation	One-dimensional

Source: Center for Internet Governance, Tsinghua University, 2021.

### 2.3. Literature on the Application of the Entropy-Weighted TOPSIS Method

Entropy-weighted TOPSIS is a comprehensive evaluation method that combines the entropy and TOPSIS methods. Among them, the entropy method aims at objectively assigning weights to each index. The concept of “entropy” is derived from physics, which indicates the degree of disorder inherent in a system. Drawing on the idea of information entropy, the higher the entropy is, the more chaotic the system is, the higher the uncertainty,

the less information it carries, and the lower the weight. The weight calculation criterion of the entropy method is set exactly according to the degree of numerical dispersion between indicators, which can effectively exclude human interference factors and make the research results more objective and fair [29]. The TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) method, also known as the “superior–inferior solution distance method” and the “ideal point method”, both aim at ranking; thus, the TOPSIS method ranks a finite number of evaluation objects according to their proximity to the idealised target among the existing objects. The TOPSIS method is a method for evaluating the relative merits of a limited number of objects based on their proximity to an idealised target [30,31]. Entropy weighting, combined with the TOPSIS method, has been widely used in various evaluation-based studies [32].

The entropy-weighted TOPSIS method is suitable for this paper’s work on objectively measuring digital platform openness levels. Compared to the Analytic Hierarchy Process (abbreviated as AHP, which requires expert scoring to determine the weights), the entropy weighting method is more objective [33]. It uses the information carried by the entropy value of the data itself to calculate the weights, combines the degree of variation of each index, and calculates the weights of each index using the tool of information entropy to provide a basis for the comprehensive evaluation of multiple indicators. With reference to the existing literature on the application of the Entropy–AHP-Weighted TOPSIS method in the selection of construction material suppliers, entropy AHP weights were used instead of subjective weights [34]. In addition, with reference to the Chinese context, Shi and Xue [35] used the entropy-weighted TOPSIS method to quantitatively measure and evaluate the level of energy security in China from 2005 to 2024. Ren [36] constructed a five-dimensional evaluation system of smart city development level indicators and used the entropy-weighted TOPSIS method to assess the development level of smart cities in China. Based on the above studies, this paper evaluates the openness of 22 digital platforms in China using the entropy-weighted TOPSIS method.

### 3. Construction Steps of Entropy-Weighted TOPSIS on Digital Platform Openness

The analysis process of the research framework consisted of three phases, as shown in Figure 1.

#### 3.1. Constructing, Measuring, and Validating DPOI

Combining the existing measurement methods of digital platform openness [1,3,37], this study divides the behaviour of different users on digital platforms into four dimensions of access, transaction, exit, and transfer, constructs the Digital Platform Openness Index (DPOI) model, and further refines 10 secondary indicators to depict the digital platform. Its basic significance and elements are as follows.

A. Openness of access: It is used to indicate whether multiple roles are open when accessing the platform, including three secondary indicators, such as the restrictive conditions of merchant (B-side) access, the marketability of the promotion mechanism, and the readability of the privacy policy.

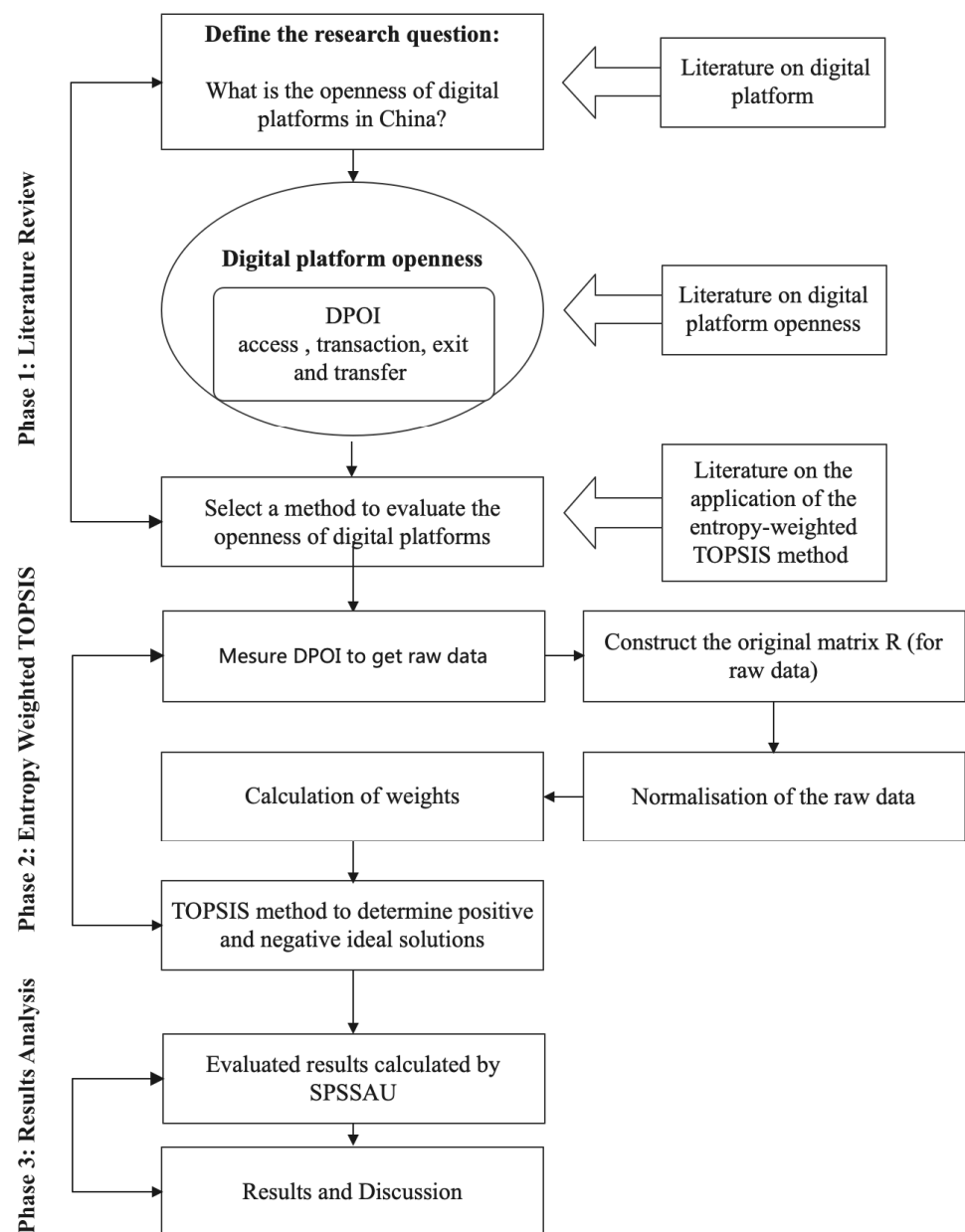
A.1 Restrictive condition for B-side registration to the platform: whether there is a mandatory exclusivity clause for dealer access.

A.2 Marketability of the promotion mechanism: whether the search, filtering, and ranking mechanisms fully follow market principles.

A.3 Readability of the privacy policy: the size of the privacy policy text and the number of nested rules.

B. Transaction openness indicates the openness of the platform when diverse actors are using the digital platform for transactions. It includes three secondary indicators: the diversity of payment methods available at the B/C (merchant/user) side, the flexibility of third-party service providers, and the mandatory transaction behaviour of the platform.

B.1 Diversity of payment methods available on the B/C side: the number of payment platforms available to dealers/consumers when making payments.



**Figure 1.** Research framework analysis process and steps.

B.2 Diversity of third-party service providers: the threshold and difficulty of third-party service providers in accessing the platform.

B.3 Compulsory transaction behaviour of the platform: whether there is compulsory transaction behaviour on the B/C side of the platform.

C. Exit openness: It is used to indicate the openness presented by the platform when multiple actors exit from the digital platform. Including two secondary indicators: B/C-side exit additional terms and B/C-side exit channel complexity.

C.1 B/C-side exit rider: whether the conditions required for cancellation from the host platform are stringent.

C.2 B/C exit channel complexity: the number of bounces of the cancellation operation and whether human intervention is needed.

D. Transfer openness: used to measure the openness of the platform in dealing with user data and business transfer requirements. It includes two secondary indicators of data transferability and business transferability.

D.1 Data transferability: the feasibility and cost of transferring consumer data (login information/personal information/historical transaction information/payment account information/browsing information/preference setting information).

D.2 Business Transferability: The feasibility and cost of business transfer for merchants.

Referring to previous approaches to measuring the openness of digital platforms [2,27], we designed the measurement process for the raw data after identifying the openness indicators. The raw data for this study were initially obtained from the evaluation scores of 22 digital platform apps from China in 2021.

First, the evaluation environment involved the use of a mobile phone to download digital platforms and execute the tests. In order to ensure the validity of the data as much as possible, we invited a total of 10 statisticians, including staff and experts, to evaluate each of the digital platforms for the subjective indicators, and finally calculated the average.

Second, data were collected from the latest version of each digital platform available when the study was carried out. We set each indicator with a full score of 10 points in five grades: 2, 4, 6, 8, and 10, determined the scoring conditions for each grade, and scored 1, 3, 5, 7, and 9 points if the actual scoring was between the two grades. Subsequently, in the scoring process, for the index items with objective evidence (such as readability of privacy policy, diversity of payment methods, additional terms of exit, complexity of exit channels, data transferability, business transferability), the researchers scored them by simulating the access, transaction, exit, and transfer behaviour of digital platforms for the index items containing subjective judgement or data from diverse sources (such as the restrictive conditions for registering the platform, the marketability of the promotion mechanism, the compulsory trading behaviour of the platform, and the diversity of third-party service providers). Researchers conducted comprehensive scoring by simulating the access, trading, exit, and transfer behaviour of the digital platform, along with expert interviews, merchant research, and information retrieval.

Finally, researchers cross-checked the scoring table while inviting experts to evaluate and calibrate the holistic scoring table and offer their professional opinions. In addition, the more controversial scores were individually re-evaluated, and the above four steps were repeated before finally taking the scoring results as the primary data. It is worth noting that the current data for the openness measurement of digital platforms were largely obtained through the latest platform versions released by each platform, while some of the restricted behaviours involving access, transaction, exit and transfer in the actual operation of the platform cannot be fully expressed from this. More comprehensive sample data will be obtained through a considerable amount of questionnaires and interviews of consumers and merchants on the platform in the future.

### *3.2. Application of Entropy-Weighted TOPSIS Method*

This study adopts the entropy-weighted TOPSIS method with SPSSAU (a software tool) to quantitatively analyse the openness index of digital platforms to evaluate their level of openness. The processing of raw data of digital platform openness with the entropy-weighted TOPSIS method covers three steps: The first is standardisation of data related to evaluation indices. Due to the zero score in the sample scoring data, normalisation was used in the standardisation process. Second, weights were assigned to each index using the entropic weighting method. Ten secondary indices were chosen for weighting in this paper, and the weight of each index was calculated using the tool of information entropy as shown in Table 3. Third, as a result of the new data assigned by the above entropy-weighted method, the openness of the digital platform was measured according to the TOPSIS distance function method and ranking. In this study, the evaluation index of the digital platform openness was formulated. The number of factors of the second-level

indicators as the openness of the digital platform is  $n$ , and the number of digital platforms is  $m$ . The original matrix  $R$  (for the raw data) is constructed:

$$R = (r_{ij})_{m \times n} = \begin{bmatrix} r_{11} & r_{21} \cdots & r_{m1} \\ r_{12} & r_{22} \cdots & r_{m2} \\ \vdots & \vdots & \vdots \\ r_{1m} & r_{2m} \cdots & r_{mn} \end{bmatrix} \quad (1)$$

(1) Normalisation of the raw data.

The normalised matrix is obtained after processing:

$$R_{ij} = \frac{r_{ij}}{\sum_{i=1}^m r_{ij}} \quad (2)$$

$$\bar{R} = (R_{ij})_{m \times n} = \begin{bmatrix} R_{11} & R_{21} \cdots & R_{m1} \\ R_{12} & R_{22} \cdots & R_{m2} \\ \vdots & \vdots & \vdots \\ R_{1m} & R_{2m} \cdots & R_{mn} \end{bmatrix} \quad (3)$$

(2) The entropy weight method is used to calculate index weights:

$e$  is the entropy value of indicator  $j$ , which  $e$  should not be above 1,  $\ln m$  should be above 0.

$$e_j = -\frac{1}{\ln m} \sum_{i=1}^m r_{ij} \ln r_{ij} \quad j = 1, \dots, n \quad (4)$$

(3) Calculation of weights:

$$\alpha_j = g_i / \sum_{j=1}^n g_i \quad (5)$$

$$g_i = 1 - e_i \quad (6)$$

where  $\alpha_j$  is the weight of the  $j$  indicator, and  $g_i$  is the coefficient of variability of the  $j$ th indicator. The larger the entropy value of the indicator, the more chaotic the system; the higher the uncertainty, the less information it carries; the less discrete the indicator is, the lower the indicator weight is, and the less information it carries in the evaluation of the openness of the digital platform.

The weight matrix  $A$  is shown as follows:

$$A = \begin{bmatrix} \alpha_{11} & 0 \cdots & 0 \\ 0 & \alpha_2 \cdots & 0 \\ \vdots & \vdots & \vdots \\ 0 & 0 \cdots & \alpha_n \end{bmatrix} \quad (7)$$

Construct the normalised weighting matrix  $V$ .

The normalised matrix is multiplied by the corresponding weights of each indicator to generate the normalised weighting matrix:

$$V = A \times \bar{R} = \begin{bmatrix} \alpha_1 R_{11} & \alpha_1 R_{21} \cdots & \alpha_1 R_{m1} \\ \alpha_2 R_{12} & \alpha_2 R_{22} \cdots & \alpha_2 R_{m2} \\ \vdots & \vdots & \vdots \\ \alpha_n R_{1m} & \alpha_n R_{2n} \cdots & \alpha_n R_{mn} \end{bmatrix} \quad (8)$$

(4) TOPSIS method to determine positive and negative ideal solutions:

$$V^+ = \{ \max_j V_{ij} \mid i = 1, 2, \dots, m \} \quad (9)$$



$$V^- = \{ \min_j V_{ij} \mid i = 1, 2, \dots, m \} \quad (10)$$

The distance between each digital platform and the positive and negative ideal solutions  $d_i$  is:

$$V^- = \{ \min_j V_{ij} \mid i = 1, 2, \dots, m \} \quad (11)$$

$$V^+ = \{ \max_j V_{ij} \mid i = 1, 2, \dots, m \} \quad (12)$$

This is the distance between each digital platform and the ideal solution after the squared-off process. Relative closeness:

$$d_i^+ = \left\{ \sum_{j=1}^n (V_{ij} - V_j^+)^2 \right\}^{1/2} \quad (13)$$

$$d_i^- = \left\{ \sum_{j=1}^n (V_{ij} - V_j^-)^2 \right\}^{1/2} \quad (14)$$

Finally, the relative proximity  $D_i$  value of each digital platform is obtained; the larger  $D_i$  is, the higher the openness level of the digital platform is. The ranking is sorted according to the size of the  $D_i$  value, the ranking of each digital platform in each dimension is calculated first, and then the comprehensive ranking of each digital platform is calculated based on the ranking of each dimension.

$$D_i = \frac{d_i^-}{d_i^+ + d_i^-} \quad (i = 1, 2, \dots, m) \quad (15)$$

**Table 3.** Weighting results of digital platform openness index indicators.

First-Level Indicators	Second-Level Indicators	Definition	Information Entropy Value e	Information Utility Value d	Weighting Factor w
A. Access Openness (36%)	A.1 Constraints of B-side registration platform	Is there a mandatory exclusivity clause for dealer access?	0.9338	0.0662	11.14%
	A.2 Marketability of promotion mechanism	Are the search, filtering, and ranking mechanisms fully compliant with market principles?	0.9019	0.0981	16.49%
	A.3 Readability of privacy policy	Size of privacy policy text and number of nested rules	0.9515	0.0485	8.15%
B. Transaction openness (21%)	B.1 Diversity of payment methods available on the B/C side	The number of payment platforms available to operators/consumers for payment	0.9794	0.0206	3.46%
	B.2 Diversity of third-party service providers	The threshold and difficulty of access to the platform by third-party service providers	0.9492	0.0508	8.55%
	B.3 Mandatory trading behaviour of the platform	Are there any forced transactions on the platform for the B-side/C-side?	0.9453	0.0547	9.19%

Table 3. Cont.

First-Level Indicators	Second-Level Indicators	Definition	Information Entropy Value e	Information Utility Value d	Weighting Factor w
C. Exit Openness (18%)	C.1 B/C-side exit additional terms	Are the conditions required for exit of the main platform harsh? How many times does the exit operation jump and is manual customer service intervention required?	0.9255	0.0745	12.53%
	C.2 Exit channel complexity on B/C side		0.9671	0.0329	5.53%
D. Transfer Openness (25%)	D.1 Data transferability	Data transfer feasibility and cost	0.9346	0.0654	10.99%
	D.2 Business transferability	Business transfer feasibility and cost of traders	0.917	0.083	13.96%

Source: Centre for internet Governance, Tsinghua University, 2021.

#### 4. The DPOI Analysis of Digital Platforms

This study first picked 22 the mainstream digital platforms with wide social influence as evaluation objects and divided them into four categories by function: e-commerce transactions, social media, life services, and content entertainment. Then, the initial data were obtained based on four dimensions of digital platform openness measurement and 10 secondary indicators (set the maximum 10 points for each secondary indicator). Finally, the data were standardised by Formula (2) to lay the foundation for subsequent data processing. Table 4 shows the evaluation results of China digital platform openness.

Table 4. China digital platform openness results.

Platform Type	Digital Platform	Overall Openness				Access Openness		Transaction Openness		Exit Openness		Transfer Openness	
		D	D-	C	Rank	C	Rank	C	Rank	C	Rank	C	Rank
E-commerce trading	Taobao	0.183	0.24	0.567	9	0.57	11	0.578	15	0.285	19	0.732	4
	JD.com	0.163	0.243	0.6	8	0.651	8	0.655	13	0.311	17	0.633	7
	Pinduoduo	0.136	0.27	0.666	4	0.911	2	0.763	5	0.266	20	0.633	6
	Vipshop.com	0.183	0.211	0.535	12	0.667	7	0.302	20	0.594	14	0.4	17
	Suning.com	0.119	0.271	0.694	2	0.854	3	0.832	3	0.548	15	0.562	12
	RED	0.147	0.225	0.605	7	0.62	10	0.761	6	0.627	12	0.494	16
	Dangdang	0.135	0.279	0.674	3	1	1	0.496	17	0.871	3	0.494	15
Content and entertainment	Baidu	0.205	0.206	0.501	17	0.62	9	0.673	10	0.827	7	0	22
	TikTok	0.185	0.214	0.536	11	0.363	19	0.672	11	0.802	9	0.562	11
	Kwai	0.176	0.215	0.55	10	0.399	16	0.832	2	0.746	10	0.562	10
	iQiyi	0.227	0.19	0.456	20	0.137	22	0.665	12	0.827	5	0.562	9
	Bilibili	0.151	0.249	0.623	5	0.544	13	0.87	1	0.871	1	0.562	8
Social media	WeChat	0.21	0.225	0.518	15	0.736	6	0.478	19	0.351	16	0.367	18
	Sina Weibo	0.216	0.178	0.452	21	0.546	12	0.748	8	0	22	0.303	19

Table 4. Cont.

Platform Type	Digital Platform	Overall Openness				Access Openness		Transaction Openness		Exit Openness		Transfer Openness	
		D	D-	C	Rank	C	Rank	C	Rank	C	Rank	C	Rank
Life service	Meituan.com	0.255	0.175	0.407	22	0.31	21	0.239	21	0.306	18	0.633	5
	Ele.me	0.22	0.195	0.469	19	0.31	20	0.224	22	0.627	11	0.732	3
	BEKE	0.18	0.199	0.526	13	0.529	14	0.809	4	0.827	8	0.244	21
	58.com	0.089	0.269	0.752	1	0.762	5	0.751	7	0.594	13	0.855	2
	Ctrip	0.209	0.197	0.485	18	0.371	18	0.532	16	0.827	6	0.506	14
	Qunar	0.2	0.208	0.511	16	0.385	17	0.673	9	0.871	2	0.506	13
	Didi Chuxing	0.16	0.246	0.606	6	0.452	15	0.478	18	0.845	4	0.855	1
	Alipay	0.211	0.234	0.526	14	0.775	4	0.655	14	0.238	21	0.268	20

Notes: Positive ideal solution distance D; negative ideal solution distance D-; relative proximity C.

#### 4.1. Overall Openness

With the four dimensions and 10 secondary indicators determined in this study, the maximum score of each secondary indicator was set at 10 points, the four dimensions were given equal weights (25%), and the overall openness of the sample platforms was ranked in descending order by conducting a comprehensive scoring evaluation for the 22 digital platforms, which were the focus. The measurement results showed that the average value of the 22 digital platforms' openness index was 55.7 points (on a percentage scale), with a median value of 55.2 points, and the overall openness of digital platforms was average. Among them, Dangdang had the highest score of 65.9, followed by Suning.com with 64.5 points, both within the top 20% of the overall openness along with 58.com and Bilibili. The renowned digital platforms with a massive user base, such as TikTok, Ele.me, JD.com, Meituan.com, Taobao, WeChat, Ctrip, Sina Weibo, and Alipay, were not ranked within the top 50% of the openness index (Table 5).

Table 5. Overall openness ranking range of digital platforms.

Ranking Range	Name of Digital Platform
Top 20% (4)	Bilibili, Dangdang, Suning.com, 58.com
20%~50% (7)	Baidu, BEKE, Didi Chuxing, Kwai, Pinduoduo, Qunar, RED
Lower 50% (11)	iQiyi, TikTok, Ele.me, JD.com, Meituan.com, Taobao, Vipshop.com, WeChat, Ctrip, Sina Weibo, Alipay

Note: Sorted phonetically within each district range.

Regarding the classification of different platforms, the overall average scores of e-commerce transaction platforms and content entertainment platforms were higher, while the overall average scores of social media platforms were lower (Figure 2). There may be a certain correlation between the openness of digital platforms and platform type. Specifically, the overall openness difference between e-commerce transaction platforms is primarily reflected in the two dimensions of access and exit. Among content entertainment platforms, video platforms such as iQiyi, TikTok and Kwai have low openness scores, mostly due to the lack of openness in both access and transfer; the openness difference between life service platforms is significant, with the highest score of 58.com exceeding 60. The openness scores of Meituan and Ele.me were below 50. Both social media platforms, WeChat and Sina Weibo, revealed low openness.

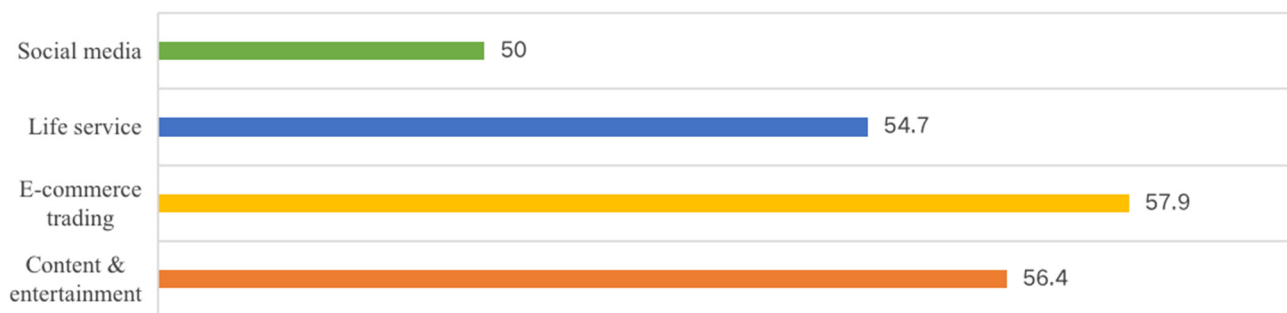


Figure 2. Overall openness of digital platform types.

4.2. Access Openness

Access openness measurement shows that the average value of the access openness index of 22 digital platforms is 61.7 points (percentage system), with a median value of 60.5 points, which is higher than the overall openness. Differences in access openness among platforms are obvious (Figure 3). Among them, Dangdang has the highest openness of access with a score of 85.4, followed by Pinduoduo with a score of 80.0; others in the top 20% of rankings are Suning.com and Alipay (Table 6). From the perspective of platform types, e-commerce transactions, social media, and life services platforms all have higher overall average scores for openness of access, while content entertainment platforms have lower overall average scores for openness of access, mainly in terms of the existence of exclusive agreements and poor readability of privacy agreements. As a new industry in recent years, short-form video platforms in the content and entertainment category are subject to fierce competition to capture the market, and accordingly, the platforms set harsh access thresholds to limit the market share of competitors. Thus, it is necessary for content entertainment platforms represented by TikTok to improve the openness of their platforms, especially in terms of store transfer use for merchants on other platforms such as Taobao, to bring more convenience to users and merchant access.

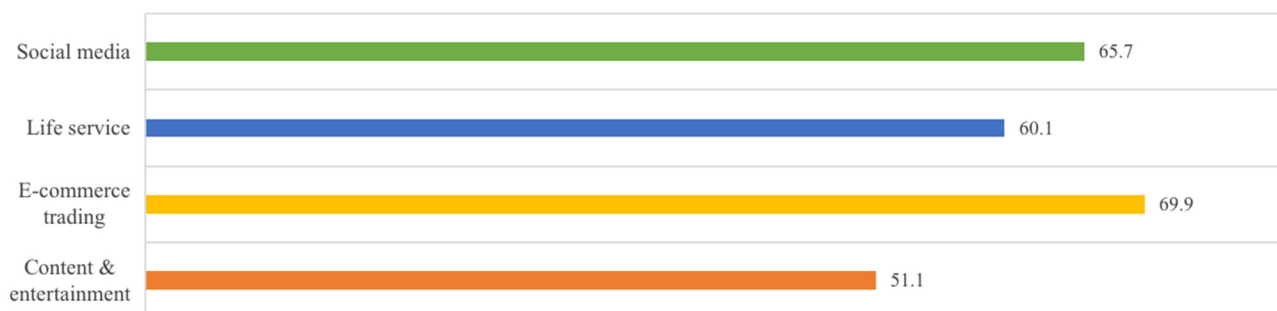


Figure 3. Access openness of digital platform types.

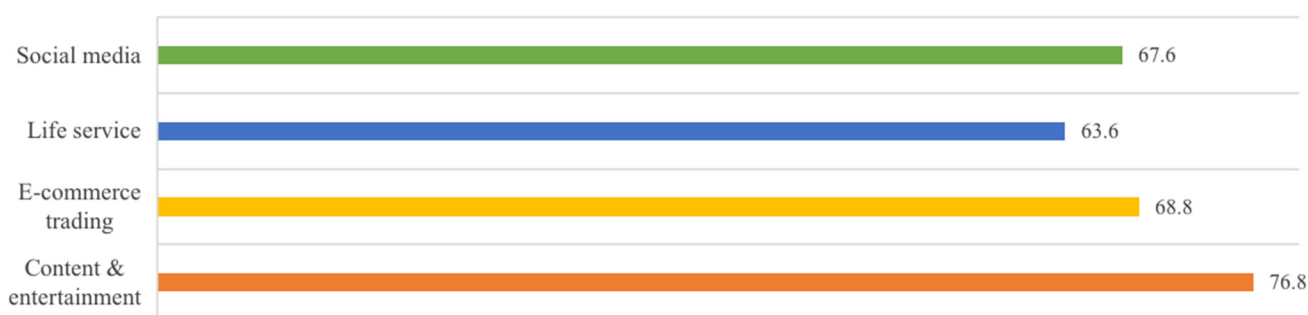
Table 6. Access openness ranking range of digital platforms.

Ranking Range	Name of Digital Platform
Top 20% (4)	Dangdang, Pinduoduo, Suning.com, Alipay
20%~50% (7)	Baidu, JD.com, Vipshop.com, WeChat, RED, Sina Weibo
Lower 50% (11)	iQiyi, BEKE, Bilibili, Didi Chuxing, TikTok, Ele.me, Kwai, Meituan.com, Qunar, Taobao, Ctrip

Note: Sorted phonetically within each district range.

#### 4.3. Transaction Openness

The transaction openness measurement shows that the average value of the transaction openness index of 22 digital platforms was 68.6 points (percentage system), with a median value of 71.5 points, which is significantly higher than the overall openness. The overall average score of transaction openness of all four types of platforms was above 60 (Figure 4). Among them, Bilibili had the highest transaction openness, with a score of 86.0, followed by RED, Kwai, and Suning.com, with points of 81.9, 81.6, and 81.6, respectively (Table 7). The takeaway platforms in the life service category had insufficient transaction openness, reflected not only in payment methods and third-party delivery services but also in a compulsion for merchants to launch online promotions. From the transaction openness we can see that the life service platforms represented by Meituan are highly competitive. The 2021 data indicated the shortcomings of this type of platform in limiting cross-platform transactions, which necessitate improving the openness of the platform in the future in the transaction dimension.



**Figure 4.** Transaction openness of digital platform types.

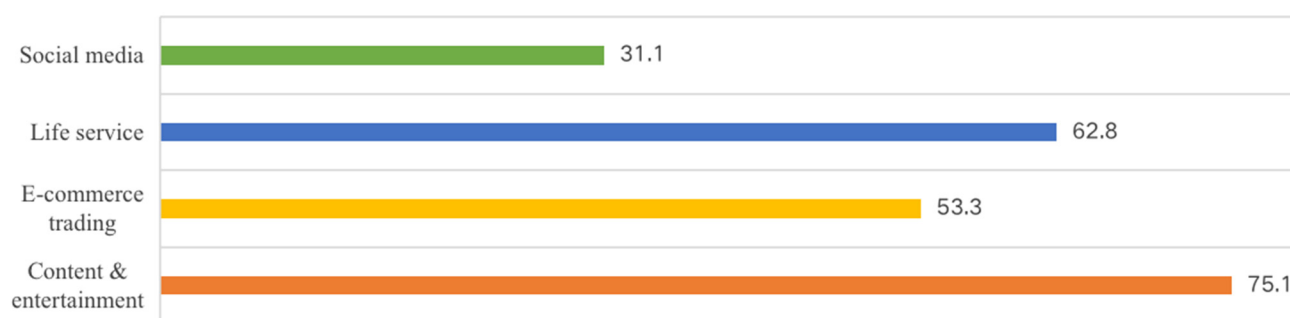
**Table 7.** Transaction openness ranking range of digital platforms.

Ranking Range	Name of Digital Platform
Top 20% (4)	Bilibili, Kwai, Suning.com, RED
20%~50% (7)	iQiyi, BEKE, TikTok, Pinduoduo, 58.com, WeChat, Sina Weibo, Alipay
Lower 50% (11)	Baidu, Dangdang, Didi Chuxing, Ele.me, JD.com, Meituan.com, Qunar, Taobao, Vipshop.com, WeChat, Ctrip

Note: Sorted phonetically within each district range.

#### 4.4. Exit Openness

As shown in Figure 5, from the perspective of platform types, content entertainment platforms had the highest openness score in the exit aspect, with clearer exit mechanisms and simple exit paths, and the overall average openness score of life service platforms was also above 60. The lowest score was for social media platforms, with only 31.1 points. This is a large difference from other platforms, mainly reflected in the complexity of exit mechanisms and conditions. As shown in Table 8, the mean value of the exit openness index of 22 digital platforms was 59.7 points (percentage scale), with a median value of 66.1 points, and there were significant differences in exit openness among platforms. Among them, Bilibili, Qunar, and Dangdang had the highest exit openness score of 80.0, and Didi Chuxing entered the top 20% in terms of the exit openness score. Platforms with openness scores of below 50 include Sina Weibo, Alipay, Pinduoduo, Meituan, Taobao, JD.com and WeChat, among which the openness score of the social media platforms is only 16.9. The lack of openness is reflected in the absence of a clear mechanism and path for active account cancellation.



**Figure 5.** Exit openness of digital platform types.

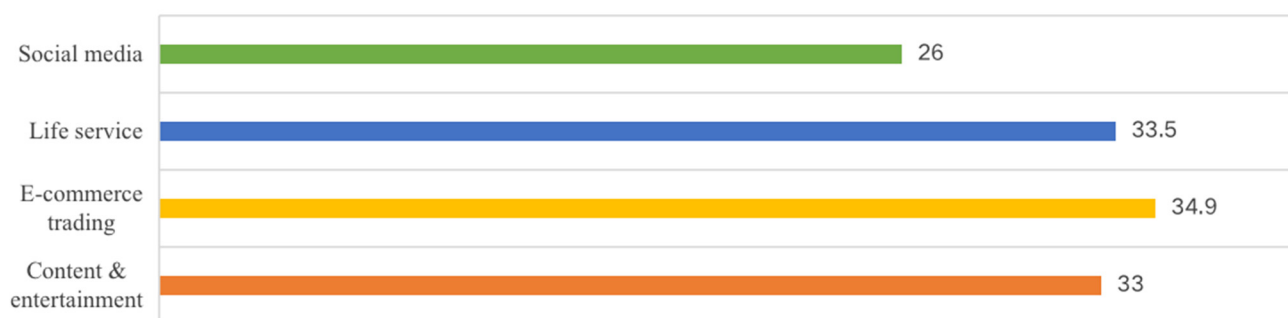
**Table 8.** Exit openness ranking range of digital platforms.

Ranking Range	Name of Digital Platform
Top 20% (4)	Bilibili, Dangdang, Didi Chuxing, Qunar
20%~50% (7)	iQiyi, Baidu, BEKE, TikTok, Ele.me, Kwai, Ctrip
Lower 50% (11)	JD.com, Meituan.com, Pinduoduo, Suning.com, Taobao, Vipshop.com, WeChat, 58.com, RED, Sina Weibo, Alipay

Our results show that compared to other types of digital platforms, the exit openness of social media platforms, which are highly tied to users' accounts, still needs to improve as a whole, and it is essential to explain the active exit path to users in a more open attitude in the future. However, given the virtual nature of each individual on the Internet, arbitrary cancellation may weaken individual discourse accountability and contribute to the security of the Internet environment in general, which requires additional consideration in future research.

#### 4.5. Transfer Openness

The average value of the transfer openness index of 22 digital platforms was 33.1 points (percentile), with a median value of 35.6 points, which is much lower than the overall openness (Figure 6). The transfer openness of Didi Chuxing and 58.com was the highest at only 44.4 points, indicating that the data and business of its platform can be partially transferable. Ele.me and Taobao also entered the top 20% of transfer openness (Table 9). The lowest score belonged to a content entertainment platform with 14.4 points, which does not provide transferable access to data and business. From a platform-type perspective, social media platforms have the lowest overall average transfer openness score of 26.0, with data and business rarely transferable. Thus, the 22 leading digital platforms in China in 2021 exhibited on average a low level of transfer openness in general and social media platforms in particular, which implies a relatively serious platform monopoly environment. It is necessary for Chinese digital platforms and government regulators to notice this in the future and actively guide the development of a healthy digital marketplace to enhance data and business transfer openness.



**Figure 6.** Transfer openness of digital platform types.

**Table 9.** Transfer openness ranking range of digital platforms.

Ranking Range	Name of Digital Platform
Top 20% (4)	Didi Chuxing, Ele.me, Taobao, 58.com
20%~50% (7)	iQiyi, Bilibili, TikTok, Kwai, Meituan.com, Pinduoduo, Suning.com
Lower 50% (11)	Baidu, BEKE, Dangdang, JD.com, Qunar, Vipshop.com, WeChat, RED, Ctrip, Sina Weibo, Alipay

## 5. Discussion

The targets of platform openness might be end users, suppliers, app developers, or platform sponsors (Broekhuizen). Previous measurements of platform openness have mainly focused on hardware operating platforms such as Linux, Windows, and Macintosh iPhone, while less attention has been paid to software platforms [38]. Therefore, this paper attempts to fill the gap by adding this content. In addition, previous openness evaluations have mainly focused on platform systems such as Apple's IOS system and Google Android [2], with a lack of openness evaluation data for digital platforms in emerging markets such as China. The latest comprehensive examination data in China was obtained from the "2011 China Internet Platform Openness Survey Report" published by the Network Economy Laboratory of the Graduate School of Management of the Chinese Academy of Sciences, which described the openness of several mainstream Internet platforms in China in four major dimensions, namely users, platforms, supports, and revenues. It showed that the comprehensive score of Baidu was the highest at 4.06, followed by Sina Weibo at 3.78, Tencent at 3.73, 360 platform at 3.57, and Renren 3.5 at. The 2021 openness measurement data in this paper not only updates the practical figures, but also enriches the literature in the field of digital platform openness, with a greater implication for the evaluation of digital platform openness in emerging markets such as China. In the future, it is imperative to track digital platform openness rankings annually and enhance international comparisons in this area to promote the openness of digital markets.

## 6. Conclusions and Limitations

The aim of this study was to construct a model of digital platform openness, measuring the degree of openness of digital platforms of 22 big-tech giants in China, and clarifying the driving factors of digital platform exploitability and their influencing mechanisms. Digital platforms are data-driven economic agents based on their expanding influence, requiring a paradigm shift in competition policy from a traditional focus primarily on price changes to a greater focus on nonprice competition, attention markets, zero prices, and customer data usage. User data are emerging as the key to the enforcement of monopolistic and unfair competitive practices on digital platforms [39]. In addition, the operation of digital platforms is not limited by national borders. Digital platforms have now turned into independent objects of legal regulation, which have their own characteristics and require

regulation by law. The complexity of the relationships arising from the operation of digital platforms determines the complexity of the legal regulation of this target since the activities of digital platforms affect both public (financial, tax) and private law (civil law, commercial, labour). This implies that the development of the digital economy requires a radical change in the general approach to the legal regulation of new types of economic relations. For this purpose, this study constructed the Digital Platform Openness Index (DPOI) using the entropy TOPSIS method to evaluate the openness of 22 digital platforms in China and draws the following research findings.

First, the convenience of user merchants to access the digital platform should be improved. Convenient access to digital platforms for users and merchants is a prerequisite for the healthy and sustainable development of the digital economy and is an important aspect by which measure the openness of digital platforms. Many users and merchants gather on digital platforms and passively accept the trading rules. On the one hand, digital platform operators and users adopt format clauses for contracting. To reduce the responsibility of the platform, digital platform operators have a strong incentive to describe user agreements and privacy policies so that the readability of their texts is greatly reduced, which has a certain impact on users' access to the platform. On the other hand, some digital platform operators exploit their market dominance or competitive advantage to impose higher deposit requirements and conditions, such as exclusive co-operation, to restrict merchants' access, especially among small and medium-sized merchants.

Second, a fair trading environment should be provided for the merchants in the platform. In the practice of operation, digital platforms tend to transfer business risks to in-platform merchants, forcing platform merchants to participate in platform activities at low prices or at a loss, and penalising behaviours that seriously damage the interests of in-platform merchants, such as "the disqualification of stores, the removal of products from shelves and restrictions of customer flow". In addition, some digital platform operators provide both self-operated services and third-party merchant services, with direct competition between the self-operated part and third-party merchants. In addition, some digital platform operators provide both self-operated services and third-party merchant services, with direct competition between the self-operated portion and third-party merchants. Thus, it is necessary for digital platform operators to clarify the competition rules between self-operated and third-party merchants to create a fair competitive trading environment for merchants on the platform.

Third, barriers should be lowered for users and merchants to exit the digital platform. The exit barrier is an important indicator of the cost of participation in economic activities for merchants and users, while a high exit barrier directly reduces the level of economic activity. Digital platform operators tend to retain users and merchants by raising exit barriers, which degrades the user experience and significantly increases merchant costs. We advocating for digital platform operators to facilitate more convenient platform exit channels through nationally recommended standards and industry self-regulatory initiatives. If necessary, legislation can be enacted to restrict the behaviour of unreasonably restrictive exit clauses unilaterally proposed by digital platform operators.

Fourth, more freedom should be provided for data transfer and business transfer. There are still significant problems regarding the transferability of data among platforms and consumers, as well as the transferability of business affairs between platforms and merchants or among different platforms. Some operators allow the transfer of user data among platforms within the system, but ultimately, it is based on the sharing of user data driven by commercial purposes rather than respecting and protecting users' rights to benefit from their personal data. Moreover, business transferability is only reflected, to a certain extent, within several major internet ecosystems. The transferability of data and business is of great importance for the healthy and sustainable development of the entire digital economy, which necessitates giving consumers (individuals) transferable rights to their personal data with respect to their personal data, as well as giving merchants rights to



some of their business data to enhance competition among digital platforms from the rule level.

The results of this article should be viewed in light of its limitations. First, the sample was selected from 22 leading Chinese digital platforms, constrained by labour and investigator effort. Nevertheless, other digital platforms are also essential components in investigating the openness of the digital market in China, and future research requires an enlarged sample size. Second, we chose the Entropy-weighted TOPSIS as a relatively objective ranking method, while other methods such as AHP are also excellent and widely used, and it is possible to pick more ranking methods for comparative analysis in future studies. Thirdly, as mentioned earlier, the openness of digital platforms is multi-faceted, such as towards users' openness, suppliers' openness, and towards platform openness. This paper evaluates the concept of platform openness mainly from the perspective of user and supplier adoption, but future research can extend this scope to evaluate digital platform openness for a broader set of target actors.

**Author Contributions:** Conceptualization, W.F.; Software, J.S.; Writing—original draft, W.F.; Writing—review & editing, J.S.; Supervision, X.L.; Project administration, X.L. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Not applicable.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

- Laffan, L. A new way of measuring openness: The open governance index. *Technol. Innov. Manag. Rev.* **2012**, *2*, 18–24. [CrossRef]
- Benlian, A.; Hilbert, D.; Hess, T. How open is this platform? The meaning and measurement of platform openness from the complementers' perspective. *J. Inf. Technol.* **2015**, *30*, 209–228. [CrossRef]
- Broekhuizen, T.L.; Emrich, O.; Gijzenberg, M.J.; Broekhuis, M.; Donkers, B.; Sloot, L.M. Digital platform openness: Drivers, dimensions and outcomes. *J. Bus. Res.* **2021**, *122*, 902–914. [CrossRef]
- Thomas, L.; Autio, E.; Gann, D. Architectural leverage: Putting platforms in context. *Acad. Manag. Perspect.* **2014**, *28*, 198–219. [CrossRef]
- Bartels, N.; Schmitt, A. Developing network effects for digital platforms in two-sided markets—The NfX construction guide. *Digit. Bus.* **2022**, *2*, 100044. [CrossRef]
- Scott Morton, F.M.; Crawford, G.S.; Crémer, J.; Dinielli, D.; Fletcher, A.; Heidhues, P.; Schnitzer, M.; Seim, K. Equitable Interoperability: The 'Super Tool' of Digital Platform Governance. 2021. Available online: <https://ssrn.com/abstract=3923602> (accessed on 15 May 2022).
- Fei, L. Regulation under administrative guidance: The case of China's forcing interoperability on digital platforms. *Comput. Law Secur. Rev.* **2023**, *48*, 105786. [CrossRef]
- Schlagwein, D.; Schoder, D.; Fischbach, K. Openness of Information Resources—A Framework-Based Comparison of Mobile Platforms. *ECIS 2010 Proc.* **2010**, *163*. Available online: <https://aisel.aisnet.org/ecis2010/163> (accessed on 15 May 2022).
- Parker, G.; Van Alstyne, M. Innovation, openness, and platform control. *Manag. Sci.* **2018**, *64*, 3015–3032. [CrossRef]
- Xu, H.; Yu, C.; Wang, Y. Research on the Mechanism of Platform Organization Value Creation from the Perspective of Modularity and Openness: The Case of Inspur and Neusoft. *Sci. Sci. Manag. S. T.* **2021**, *42*, 77–95.
- Palmer, M.; Toral, I.; Truong, Y.; Lowe, F. Institutional pioneers and articulation work in digital platform infrastructure-building. *J. Bus. Res.* **2022**, *142*, 930–945. [CrossRef]
- Gawer, A. Digital platforms and ecosystems: Remarks on the dominant organizational forms of the digital age. *Innovation* **2022**, *24*, 110–124. [CrossRef]
- Peruchi, D.F.; de Jesus Pacheco, D.A.; Todeschini, B.V.; ten Caten, C.S. Moving towards digital platforms revolution? Antecedents, determinants and conceptual framework for offline B2B networks. *J. Bus. Res.* **2022**, *142*, 344–363. [CrossRef]
- Şimşek, T.; Öner, M.A.; Kunday, Ö.; Olcay, G.A. A journey towards a digital platform business model: A case study in a global tech-company. *Technol. Forecast. Soc. Chang.* **2022**, *175*, 121372. [CrossRef]
- He, J.; Zhang, S. How digitalized interactive platforms create new value for customers by integrating B2B and B2C models? An empirical study in China. *J. Bus. Res.* **2022**, *142*, 694–706. [CrossRef]

16. Ondrus, J.; Gannamaneni, A.; Lyytinen, K. The impact of openness on the market potential of multi-sided platforms: A case study of mobile payment platforms. *J. Inf. Technol.* **2015**, *30*, 260–275. [[CrossRef](#)]
17. Nambisan, S.; Wright, M.; Feldman, M. The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes. *Res. Policy* **2019**, *48*, 103773. [[CrossRef](#)]
18. Gawer, A. Platform dynamics and strategies: From products to services. *Platf. Mark. Innov.* **2009**, *45*, 57.
19. Rochet, J.C.; Tirole, J. Two-sided markets: A progress report. *RAND J. Econ.* **2006**, *37*, 645–667. [[CrossRef](#)]
20. Eisenmann, T.R.; Parker, G.; Van Alstyne, M. Opening platforms: How, when and why. *Platf. Mark. Innov.* **2009**, *6*, 131–162.
21. Hagiu, A.; Wright, J. Controlling vs. enabling. *Manag. Sci.* **2019**, *65*, 577–595. [[CrossRef](#)]
22. Perren, R.; Kozinets, R.V. Lateral exchange markets: How social platforms operate in a networked economy. *J. Mark.* **2018**, *82*, 20–36. [[CrossRef](#)]
23. Wang, J.; Guo, B.; Wang, X.; Lou, S. Closed or open platform? The nature of platform and a qualitative comparative analysis of the performance effect of platform openness. *Electron. Commer. Res. Appl.* **2020**, *44*, 101007. [[CrossRef](#)] [[PubMed](#)]
24. Ramos, E.F.; Blind, K. Data portability effects on data-driven innovation of online platforms: Analyzing Spotify. *Telecommun. Policy* **2020**, *44*, 102026. [[CrossRef](#)]
25. West, J.; O'mahony, S. The role of participation architecture in growing sponsored open source communities. *Ind. Innov.* **2008**, *15*, 145–168. [[CrossRef](#)]
26. Boudreau, K. Open platform strategies and innovation: Granting access vs. devolving control. *Manag. Sci.* **2010**, *56*, 1849–1872. [[CrossRef](#)]
27. Arakji, R.; Lang, K. An Evolutionary Theory of Innovation and Strategic Platform Openness for Web 2.0 Businesses. *Proc. JAIS Theory Dev. Workshop* **2010**, *10*, 85. Available online: [https://aisel.aisnet.org/sprouts\\_all/377](https://aisel.aisnet.org/sprouts_all/377) (accessed on 22 September 2022).
28. Anvaari, M.; Jansen, S. Evaluating architectural openness in mobile software platforms. In Proceedings of the Fourth European Conference on Software Architecture: Companion Volume, Copenhagen, Denmark, 23–26 August 2010; pp. 85–92.
29. Junguang, Z.; Xiwei, S.; Shuang, Y. Buffer Sizing of a Critical Chain Project Based on the Entropy Method. *Manag. Rev.* **2017**, *29*, 211–219. [[CrossRef](#)]
30. Bin, M.; Siyi, S.; Haibo, K.; Fei, L.; Haoyue, F. Evaluating Model of Corporate Social Responsibility Based on Fuzzy Topsis: Taking Transportation Industry as Example. *Manag. Rev.* **2019**, *31*, 191–202. [[CrossRef](#)]
31. Chunyou, W.; Lingling, G.; Jingtao, Y. Evaluation Model and Empirical Study of Regional Green Growth System Based on TOPSIS and Grey Relational Analysis. *Manag. Rev.* **2017**, *29*, 228–239. [[CrossRef](#)]
32. Han, H.; Trimi, S. A fuzzy TOPSIS method for performance evaluation of reverse logistics in social commerce platforms. *Expert Syst. Appl.* **2018**, *103*, 133–145. [[CrossRef](#)]
33. Sun, C.-C. A performance evaluation model by integrating fuzzy AHP and fuzzy TOPSIS methods. *Expert Syst. Appl.* **2010**, *37*, 7745–7754. [[CrossRef](#)]
34. Chen, C.-H. A Novel Multi-Criteria Decision-Making Model for Building Material Supplier Selection Based on Entropy-AHP Weighted TOPSIS. *Entropy* **2020**, *22*, 259. [[CrossRef](#)]
35. Shi, D.; Xue, Q. Influencing Factors, Evaluation and Outlook of Primary Energy Security in China. *Econ. Rev. J.* **2021**, *1*, 31–45. [[CrossRef](#)]
36. Ren, L. Research on the Evaluation of Development Level of Smart City Based on Entropy TOPSIS Model. *Inf. Stud. Theory Appl.* **2019**, *42*, 113–118+125. [[CrossRef](#)]
37. Jia, X.; Hu, Y.; Xing, Y. IoT platform and the open evaluation of its Cloud platform. *Cyber Secur. Data Gov.* **2018**, *37*, 62–64. [[CrossRef](#)]
38. Guo, L. A Study of the Openness of Platform Firm. Ph.D. Thesis, Jiangxi University of Finance and Economics, Nanchang, China, 2014.
39. Just, N. Governing online platforms: Competition policy in times of platformization. *Telecommun. Policy* **2018**, *42*, 386–394. [[CrossRef](#)]

**Disclaimer/Publisher's Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.