Research on Urban Interconnection Index of Transportation Card Industry

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Abstract. In order to intuitively reflect the operation situation and forecast the future trend of the traffic card industry, and enhance the data support ability for the service evaluation of the traffic card industry. Referring to the relevant research results, this paper combines the operating needs of the card companies and the construction principle of the index system, and constructs the service index system of the card industry based on the big data of the card industry, which can be used to monitor the operation situation of the card industry and the service status of the bus trip. It can also be applied to the industry supervision, business monitoring and users. Travel service. Then, taking the traffic card interconnection index as an example, this paper evaluates the status and causes of the provincial traffic card interconnection by using the data analysis platform of Guangdong Province's traffic card, and puts forward the prospects for the construction of the comprehensive service index of the traffic card industry.

1. Introduction
The service level and quality of transportation card industry are related to people's travel and life well-being, and affect the survival and development of transportation card operation service enterprises.

How to monitor the operation situation and forecast the future development of the transportation card industry intuitively and efficiently, and how to effectively deal with the impact of new technologies, new modes and new formats brought by the deep integration of mobile Internet and traditional transportation travel payment, innovate the products and services of the transportation card industry, optimize the development strategy for the transportation card operation service enterprises, and has important direction guidance and decision support significance for business models. The industry service index is a popular way to evaluate the industry status under the background of big data application. Many experts and scholars try to measure and evaluate the industry development status by constructing the index. For example, Guan Jinping Equality (2016) built a city routine bus service index based on traffic data, which reflected the real-time dynamic operation of bus system before and during bus trip. Wei Qingbo et al. (2016) constructed the evaluation system of public transport operation service, taking bus congestion index, congestion index, comfort index and reliability index as the core indicators, reflecting the actual operation status of public transport network from different angles. Jia Shanshan (2008) put forward the urban traffic evaluation index system, constructed the urban traffic index through the linear weighted model, and systematically studied the level of urban traffic grade and so on. Up to now, although there are many index systems in the field of public transport industry, most of them focus on the evaluation of public transport service quality and passenger experience, such as speediness, comfort, safety, etc. The research and application of traffic card industry index is still blank. In addition, in terms of data acquisition and its
application for index design and construction, the previous data acquisition methods were mainly manual acquisition and market research, with high acquisition cost and strong subjective influence, and the application of data processing was difficult to quantify and too theoretical. In order to intuitively reflect the operation situation of the traffic card industry and enhance the ability of the industry data service industry. Referring to the relevant research results, based on the big data of the traffic card industry, combined with the business needs of the card enterprises and the construction principle of the index system, this paper constructs the service index system of the card industry which is used to monitor the operation situation of the traffic card industry and the service status of the bus trip, and applies it to the industry supervision, business monitoring, and user travel service.

2. Big Data Resource
Public transport travel payment has the characteristics of "rigid demand, high frequency, small amount". Transportation card is widely used in public transport travel, public management, small amount payment, e-commerce and other scenarios. Daily large-scale card issuance, daily recharge, daily transaction, daily clearing and settlement, daily customer service data, public transport data and so on, constitute the big data of all-in-one traffic card together. The big data of traffic card carries the information of users' travel and consumption behavior, shows the changes of traffic card business scale and growth rate, reflects the development trend and trend of the industry, and lays a data foundation for the construction of traffic card industry service index. Although the traffic card industry standards are constantly changing, the data structure has not yet been unified, and the data form is increasingly diversified, the traffic card big data presents the characteristics of "multi-source heterogeneity", but the application of big data extraction, cleaning, conversion, loading technology can effectively avoid data quality problems and ensure the accuracy of the industry service index. It can be said that the traffic card big data provides sufficient and high-quality data sources for the construction and application of the service index of the card industry.

3. Construction of Service Index System of Transportation Card Industry
It is a complicated system process to construct the service index system of the traffic card industry, which includes three basic elements: the determination of the index system, the determination of the weight and the evaluation model. In order to ensure the scientific and reliable index system, the construction principle of the service index system of the traffic card industry should be established, and it should select evaluation criteria, which can reflect the development level and quality evaluation indicators of the transportation card industry from different dimensions and perspectives, under the guidance of the principle.

3.1. Principles for the Construction of Industry Service Index System

3.1.1. Data is easily obtained.
That means it is easy to data acquisition, easy to storage and easy to guarantee continuity. Easy data acquisition means that traffic card data can be invoked and crawled through big data acquisition technology; easy data storage means that traffic card data can be stored in large quantities through cloud storage and multi-source heterogeneous distributed storage technology; data continuity means that the data acquisition process and data itself are continuous rather than discontinuous.

3.1.2. The index reflects Sensitive
The purpose of constructing the service index of the transportation card industry is to find out whether the operation strategy and marketing strategy of the transportation card operation service enterprises are suitable in time, so as to make corresponding adjustments according to market changes and user needs. Therefore, the selected industry index must have a strong sensitivity in reflecting market changes, and really play the role of "barometer" and "early warning".
3.1.3. The index can be quantified.

Index quantifiable means that the selected index can be calculated and analyzed by traffic card big data algorithm or model statistics, and the quantified results are consistent with objective facts and users' subjective feelings. Quantitative index is the key to reflect the value of the service index of the traffic card industry. It can show the development trend of the traffic card industry by measuring and calculating, look back on the past market trend, and predict the future development trend.

3.1.4. Complete index system.

In order to achieve the goal of comprehensively and comprehensively reflecting the operation status of the transportation card industry, it is very important to build a complete index system of industry services. Traffic card industry service index should be oriented to industry supervision, business monitoring and user service to construct index service ecosystem, play the guiding role of industry index, promote the interconnection of traffic card industry, enhance market vitality, and optimize bus travel services.

3.2. Construction and explanation of industry service index system

Guided by the construction principle of industry service index system and service demand, considering the difficulty of data acquisition and actual practice, this paper selects eight secondary indicators such as urban attractiveness, card issuing market vitality, Carriage congestion and three first-level indicators such as interconnection index, market vitality index and bus travel service index. To jointly construct the service index system of traffic card industry to meet the needs of traffic card industry supervision, business monitoring and passenger service.

3.2.1. Transportation Card Interconnection Index

As shown in Table 2, the traffic card interconnection index is defined by the two secondary indexes of urban attractiveness index and inter-city tightness index. It reflects the "One Card Pass" or "One Code Pass" status of public transport travel between cities in the province and is the effective industry characteristic index to measures the "benefiting people" project of traffic card-to-card interconnection, namely "golden card engineering". The larger the index is, the higher the degree of interconnection of all-in-one traffic cards will be.

3.2.2. Transportation Card Market Vitality Index

As shown in Table 2, the traffic card market vitality index is an industry characteristic index reflecting the core business status of the traffic card. It is defined by three secondary indicators: the vitality of the card issuing market, the vitality of the recharging market and the vitality of the consumer market. The higher the index is, the better the overall business condition of the Transportation card will be.

3.2.3. Bus Trip Service Index

As shown in Table 1, the Bus Travel Service Index is an industry characteristic index to measure the degree of convenience and comfort of the general users of the transport card. It is defined jointly by three secondary indicators, the convenience of public transit, the speed of transfer, and the congestion of the carriage. The bigger the index is, the better the experience of bus travel service will be.
Table 1. List of Service Index System of Transportation Card Industry

| Primary index          | Secondary indicators | Brief Introduction of Measuring Indicators                                                                 |
|-----------------------|----------------------|------------------------------------------------------------------------------------------------------------|
| Interconnection Index |                      |                                                                                                           |
|                       | Urban Attraction     | In the same period, the proportion of the number of cross-regional credit card users in urban transport accounts for the total number of cross-regional credit card users in our province. |
|                       | Urban Tightness      | In the same period, the proportion of the number of cross-district credit card brushes in urban transport in this province is the total number of cross-district credit card brushes. |
| Market Vitality Index |                      |                                                                                                           |
|                       | Enrichment Market Vitality | The annual growth rate of card issuance this month is larger than the average growth rate of card issuance in the past three months. |
|                       | Vitality of Consumer Market | The Ring-to-Ring Growth Rate of Consumption Pen Number in this month is larger than the average Ring-to-Ring Growth Rate of Consumption Number in the past three months. |
| Bus Travel Service Index | Convenience of transfer | Average Distance of Bus Exchanges in the Districts of the City                                             |
|                       | Rapidity of transfer  | Average time of public exchange in each district of the city                                             |
|                       | Carriage congestion  | Actual number of passengers/number of vehicles checked                                                   |

Note: Because of the instability of card issuance, the growth rate of card issuance is the average annual growth rate of this month's card issuance and the past three months' card issuance.

4. Algorithms and Application Practice of Service Index of Transportation Card------Industry: A Case Study of Interconnection Index

4.1. Interconnection Index Algorithms of Transportation Card

4.1.1. Setting the corresponding relationship of measurement indicators
Traffic card interconnection index is a comprehensive reflection of urban attractiveness and urban tightness. Firstly, according to the number of cross-regional users, the distribution characteristics of cross-regional transactions and the usual setting of index intervals, this paper establishes the corresponding relationship between urban attractiveness and the proportion of cross-regional travel users, urban tightness index and the proportion of cross-regional transactions, as shown in tables 2 and 3.

Table 2. Correspondence between the proportion of cross-regional users and urban attractiveness

| The proportion of cross-regional users | Urban Attraction | Urban Attraction Level |
|---------------------------------------|------------------|-----------------------|
| 0                                     | 0                | none                  |
| (0.3%,10%)                            | (0,2)            | weak                  |
| (3%,10%)                              | (2,4)            | commonly              |
| (10%,50%)                             | (4,6)            | secondary             |
| (50%,100%)                            | (6,10)           | Strong                |

Table 3. The corresponding relationship between the proportion of cross-regional transactions and urban tightness

| The proportion of cross-regional transactions | Urban Tightness | Urban Tightness Level |
|----------------------------------------------|-----------------|-----------------------|
| 0                                            | 0               | none                  |
| (0.1%,10%)                                   | (0,2)           | weak                  |
| (1%,10%)                                      | (2,4)           | commonly              |
| (10%,50%)                                     | (4,6)           | secondary             |
| (50%,100%)                                    | (6,10)          | Strong                |
4.1.2. Establishing Linear Conversion Model

According to the piecewise linear relationship, the linear conversion model between the proportion of cross-regional users and urban attractiveness and the linear conversion model between the proportion of cross-regional transactions and urban tightness are established, as shown in Formula (1) and Formula (2).

\[
I = \begin{cases} 
  0, & (K = 0) \\
  \frac{200}{3} K, & (0 < K \leq 3\%) \\
  200 K + \frac{8}{7} (3\% < K \leq 10\%) \\
  5K + 3.5(T) (10\% < K \leq 50\%) \\
  8K + 2(T) (50\% < K \leq 100\%) 
\end{cases}
\]

\[
L = \begin{cases} 
  0, & (T = 0) \\
  \frac{200}{9} T + \frac{16}{9} (1\% < T \leq 10\%) \\
  5T + 3.5(T) (10\% < T \leq 50\%) \\
  8T + 2(T) (50\% < T \leq 100\%) 
\end{cases}
\]

Among them, K and I in Formula (1) represent the proportion of cross-regional users and the attractiveness of cities respectively; T and L in Formula (2) represent the proportion of cross-regional transactions and the tightness of cities respectively.

4.1.3. Weighting and calculation

According to industry experience value, weights of city attractiveness index and city-to-city relationship tightness index are 0.52 and 0.48 respectively, which can be adjusted by periodic manual survey results. From this, we can get the formula of the traffic card interconnection index: the traffic card interconnection index = 0.52 * City attractiveness index + 0.48 * City tightness index.

4.1.4. Index evaluation

Based on the current research results and the actual development of the transport card industry, this paper gives the evaluation suggestion value of the transport card interconnection index, as shown in Table 4.

| Traffic Card Interconnection Index | 0        | (0,2]   | (2,4]   | (4,6]   | (6,10]  |
|-----------------------------------|----------|---------|---------|---------|---------|
| Interconnection Grade of Transportation Card | none     | weak    | commonly | secondary | strong  |

4.2. Application Practice of Transportation Card Interconnection Index

Taking Guangdong Province's traffic card as an example, this paper collects and analyses the clearing and settlement data of cross-regional transactions from 2017 to 2018 by using the big data analysis platform of traffic card, and evaluates and analyses the interconnection status of the province's traffic card.

As shown in Table 5, the interconnection index of Guangzhou Transportation Card and other cities in 2018 is about 0.71, which belongs to the "weaker" level of interconnection and falls by 2 percentage points compared with 2017. The interconnection index of Guangzhou and Guangzhou Transportation Card is about 8.98, which belongs to the "stronger" level of interconnection and falls by 15 percentage points compared with 2017. This shows that: (1) Compared with Guangzhou's one-card traffic system, each city's one-card traffic system plays a relatively significant role in promoting the interconnection of Guangdong's one-card traffic system. The reason is that Guangzhou has relatively strong attraction and relatively developed public transport system, which makes other cities'one-card traffic system used in Guangzhou's credit card trading. Guangzhou is the economic, political and cultural center of Guangdong Province and the largest transportation hub city in South China. The number of traffic card users traveling in Guangzhou is relatively frequent, which makes the number of credit card transactions in other cities in Guangzhou more than in other cities. The number of card-swiping transactions in Guangzhou's transport one-card system in various cities; (2) The interconnection
degree of the transport one-card system has declined, due to the penetration of two-dimensional code payment methods such as bus code in the field of public transport travel, which has replaced the traffic one-card system to a certain extent, resulting in the loss of users and card-swiping transaction pens in the cross-regional traffic one-card system. The number is declining. Because of the different technical standards of two-dimensional code payment, there is no basis for interconnection, it is urgent to popularize and apply the mobile payment methods such as NFC and two-dimensional code of traffic one-card standard and integrate them into the project of traffic one-card interconnection; (3) the interconnection index of Guangzhou traffic one-card and Foshan traffic one-card, and Foshan traffic one-card. The interconnection index of Guangzhou and Guangzhou are all above 9, which belongs to the "stronger" level, which is further improved than in 2017, fully reflecting the significant trend of integration of Guangzhou, Buddha and the same city and public transport.

Table 5. Interconnection Index of Transportation Card in Guangdong Province: A Case Study of Guangzhou and Other Cities

| Ownership - Consumption | Interconnection Index 2017 | Interconnection Index 2018 | Increase or decrease | Ownership - Consumption | Interconnection Index 2017 | Interconnection Index 2018 | Increase or decrease |
|-------------------------|----------------------------|----------------------------|----------------------|-------------------------|----------------------------|----------------------------|----------------------|
| Guangzhou-Foshan        | 9.43                       | 9.49                       | 0.06                 | Guangzhou-Foshan        | 9.92                       | 9.92                       | 0                    |
| Guangzhou-Zhaoying      | 1.49                       | 1.24                       | -0.25                | Guangzhou-Zhaoying      | 9.46                       | 9.40                       | -0.06                |
| Guangzhou-Jiangmen      | 1.29                       | 1.11                       | -0.18                | Guangzhou-Jiangmen      | 9.32                       | 9.33                       | 0.01                 |
| Guangzhou-Shaoguan      | 0.92                       | 0.83                       | -0.09                | Guangzhou-Shaoguan      | 9.24                       | 9.30                       | 0.06                 |
| Guangzhou-Huizhou       | 0.59                       | 0.66                       | 0.07                 | Guangzhou-Huizhou       | 9.30                       | 9.28                       | -0.02                |
| Guangzhou-Maoming       | 0.16                       | 0.13                       | -0.03                | Guangzhou-Maoming       | 9.33                       | 9.27                       | -0.06                |
| Guangzhou-Heuyuan       | 0.07                       | 0.05                       | -0.02                | Guangzhou-Heuyuan       | 9.04                       | 9.11                       | 0.07                 |
| Guangzhou-Zhuhai        | 0.07                       | 0.04                       | -0.03                | Guangzhou-Zhuhai        | 9.17                       | 9.07                       | -0.10                |
| Guangzhou-Zhongshan     | 0.05                       | 0.04                       | -0.01                | Guangzhou-Zhongshan     | 9.01                       | 9.04                       | 0.03                 |
| Guangzhou-Yunfu         | 0.02                       | 0.02                       | 0.00                 | Guangzhou-Yunfu         | 9.03                       | 9.04                       | 0.01                 |
| Guangzhou-Zhanjiang     | 0.02                       | 0.02                       | 0.00                 | Guangzhou-Zhanjiang     | 8.89                       | 9.00                       | 0.11                 |
| Guangzhou-Yangjiang     | 0.01                       | 0.02                       | 0.01                 | Guangzhou-Yangjiang     | 8.86                       | 8.88                       | 0.02                 |
| Guangzhou-Jieyang       | 0.01                       | 0.01                       | 0.00                 | Guangzhou-Jieyang       | 8.69                       | 8.86                       | 0.17                 |
| Guangzhou-Dongguan      | 0.01                       | 0.01                       | 0.00                 | Guangzhou-Dongguan      | 9.04                       | 8.82                       | -0.22                |
| Guangzhou-Qingyuan      | 0.01                       | 0.01                       | 0.00                 | Guangzhou-Qingyuan      | 9.11                       | 8.67                       | -0.44                |
| Guangzhou-Chaozhou      | 0.00                       | 0.00                       | 0.00                 | Guangzhou-Chaozhou      | 8.60                       | 8.49                       | -0.11                |
| Guangzhou-Shenzhen      | 0.00                       | 0.00                       | 0.00                 | Guangzhou-Shenzhen      | 8.98                       | 8.30                       | -0.68                |
| Guangzhou-Shanwei       | 0.00                       | 0.00                       | 0.00                 | Guangzhou-Shanwei       | 9.01                       | 8.15                       | -0.86                |
| Guangzhou-Shantou       | 0.00                       | 0.00                       | 0.00                 | Guangzhou-Shantou       | 7.14                       | 7.33                       | 0.19                 |
| Guangzhou-Mezhou        | 0.00                       | 0.00                       | 0.00                 | Guangzhou-Mezhou        | 8.44                       | 7.29                       | -1.15                |
| average value            | 0.71                       | 0.68                       | -0.02                | average value            | 8.98                       | 8.83                       | -0.15                |

5. CONCLUSION
Under the background of applying big data to the service evaluation of transportation card industry, based on big data of transportation card industry, according to the principles of easy access to data, sensitive index reflection, quantifiable index and complete system, this paper chooses city attraction, city compactness, vitality of card issuing market, vitality of replenishment market and vitality of consumer market, transfer convenience, transfer convenience, bus transport capacity saturation and other industry service indicators that meet the industry characteristics and the operating needs of the transport card enterprises are constructed, to establish a service index system for the transportation
card industry, with the traffic card interconnection index, the traffic card market vitality index and the public transport travel service index as the core contents.

Finally, taking the traffic card interconnection index as an example, this paper evaluates and analyses the status and causes of the provincial traffic card interconnection by using the data analysis platform of Guangdong Province's traffic card. The results show that compared with Guangzhou's traffic card interconnection, the other city's traffic card plays a relatively significant role in promoting the interconnection of Guangdong Province's traffic card. The penetration of two-dimensional code payment methods, such as bus code, in the field of public transport travel, has led to a decline in the degree of traffic card interconnection; Guangzhou traffic card and Foshan interconnection index, Foshan traffic card and Guangzhou interconnection index are higher, Guangzhou, Foshan traffic card and Guangzhou interconnection index are higher, Guangzhou, Foshan, Tongcheng and Gonggong. There is a significant trend in the integration of public transport.

In order to further enhance the supporting service ability of big data for public travel, enterprise management and government supervision, the next step is to strengthen the research on the construction of service index for the card industry, enrich the content of index evaluation, optimize the index structure, and strengthen the cooperative application analysis of multiple indicators, based on the large number of traffic cards. According to the construction of a single comprehensive service index with the characteristics of the card industry.

References
[1] Ministry of Transport of the People's Republic of China, National Standards of the People's Republic of China"Evaluation index system for city public transportation development performance"Compilation Notes, 2014(7).
[2] WEI Qing-bo,YANG jing-feng,CHEN Chang-jia.Evaluation Index System for Public Transport Service of Guangzhou[J].Transportation Standardization,2016,2(5):17-23.
[3] Jia Shanshan. Evaluation of urban traffic index based on multi-method combination [D]. Wuhan: Wuhan University of Technology, 2008.
[4] Xie Zhen-dong,Len Meng-tian,Wu Jin-cheng.A Study of the Method of Bus Station Recognition Based on IC Card Data[J].Journal of Guangdong University of Technology,2019,36(01):27-32.
[5] Wu Jincheng, Yu Hongling, Wu Guanhu, et al. Research on the construction of large data platform for traffic card system [J]. Jinka Project, 2017 (5): 63-66.
[6] SUN Ya. Specification of Based on Big Data Urban Public Transport Enterprise Operation Comprehensive Evaluation Study[J]. Traffic Transportation:152-155.
[7] Guan Jinping,Li Binliang, Xu Chengzhong,Guan Zhichao, et al.Real-time Dynamic Releasing of the Regular Bus Service Index Based on Transportation Big Data [C]// The 11th Annual Conference of Intelligent Transportation in China.
[8] Murugesan R, Moorthy N V R. Level of public transport service evaluation: A fuzzy set approach[J]. Journal of Advanced Transportation, 1998, 32(2):216-240.
[9] Anna C, Antonello D, Angelo P. A Panel Data Approach to Evaluate the Passenger Satisfaction of a Public Transport Service [J]. Procedia Economics & Finance, 2014, 17:231-237.
[10] Bryniarska Z, Zakowska L. Multi-criteria evaluation of public transport interchanges[J]. Transportation Research Procedia, 2017, 24:25-