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Measurement and Research on the Development Level of Digital Infrastructure in Guangdong Province

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Abstract: The digital economy is in the ascendant, and Guangdong Province has achieved remarkable results in the construction and development of digital infrastructure. The article first draws on relevant literature to construct an indicator system for measuring the level of digital infrastructure development, and then adopts principal component analysis to measure the level of digital infrastructure development in Guangdong Province in the past ten years to analyse the construction and development of digital infrastructure in Guangdong Province. Finally, the article proposes countermeasures for the development of digital infrastructure in Guangdong Province in terms of narrowing the "data divide" and developing cutting-edge digital infrastructure.

Keywords: Digital economy, Digital infrastructure, Principal component analysis.

1. Introduction

With the booming development of information technology, data has begun to penetrate all aspects of production and life, gradually becoming a key production factor and driving economic development. The emergence of technologies such as big data, artificial intelligence, and the Internet of Things has had an unprecedented impact on our production and life. Today's digital economy is developing rapidly and gradually becoming an important engine of economic growth. Relying on digital infrastructure, digital economy, as a new quality of productivity, significantly reduces the cost of information access, significantly improves the efficiency of economic operation, promotes the transformation and upgrading of the manufacturing industry, and continues to inject new impetus into the weak economic situation. At present, the definition of digital infrastructure is a relatively broad concept, and a unified statement has yet to emerge. Digital infrastructure includes both digitised traditional infrastructure and new information infrastructure. With the continuous development of the new round of scientific and technological revolution, Xiaojing Chao (2021) believes that digital infrastructure is an infrastructure system that relies on a new generation of information technology, such as artificial intelligence, 5G networks, data centres, industrial internet, and internet of things, which are constantly and organically combined and upgraded. A perfect digital infrastructure provides important support and a solid base for the high-quality development of the digital economy. As the frontier of reform and opening up, Guangdong Province is at the forefront of the competition for the development of digital infrastructure. For the construction of digital infrastructure, Guangdong Province attaches particular importance to, in the "Digital Guangdong Construction 2024 Work Points" article pointed out that we should consolidate the construction of digital infrastructure, improve the network facilities, optimise the arithmetic facilities, and build a data sharing infrastructure to provide a solid base for the digital development. 2024 early, Guangdong Province, the cumulative number of 5G base stations reached 326,000, the total number of 5G subscribers was 86,821,000, fibre optic subscribers were 45,985,000, and IoT end-users exceeded 400 million, all of which ranked first in the country in terms of scale.

2. Literature Review

In the existing research literature on the measurement of the level of digital infrastructure development, scholars mainly consider the following two aspects, on the one hand, what indicators are used to accurately measure the level of digital infrastructure development, and on the other hand, what methods are used to measure the level of digital infrastructure. Jinhu xu(2023) synthesises the research results from various parties, divides digital infrastructure into six dimensions: new industry infrastructure, new application infrastructure, new network infrastructure, digital economy infrastructure, convergence infrastructure, and innovation infrastructure, constructs a comprehensive and integrated indicator system, and then uses the entropy value method to measure it. Qi wang(2023) used principal component analysis to condense 10 secondary indicators of long-distance fibre-optic cable line length, long-distance automatic switch capacity, bureau telephone switch capacity, mobile telephone switch capacity, mobile telephone subscribers, the number of domain names, the number of websites, the number of webpages, the number of people accessing the Internet, and the number of ports of Internet broadband access into two principal components, and then calculated the weights of each principal component to comprehensively evaluate the level of development of digital infrastructure of each province and city in China. infrastructure development level. Shenbiao pan (2023) measured the quantity and quality of digital infrastructure level through the number of fixed telephone users and broadband, the number of mobile telephone users and broadband, and the number of other Internet device users and broadband. Hejun fan (2022) innovatively introduces the average rate of fixed broadband ports and the exit bandwidth of city (provincial) networks to evaluate digital infrastructure. The existing literature mostly measures and evaluates digital infrastructure from the national level, and few studies the development level of digital infrastructure from the provincial level, which provides some research space for this paper. Based on the broad connotation of digital infrastructure, this paper refers to the existing literature and related studies to construct a set of index system for evaluating the development level of digital infrastructure, and measure the development level of digital infrastructure in Guangdong Province, in order to make up for the lack of research on the development of digital infrastructure construction in Guangdong Province.

3. Construction and Evaluation of Indicators of The Level of Development of Digital Infrastructure

3.1. Construction of indicators of the level of development of digital infrastructure

Digital infrastructure is a comprehensive infrastructure system, and it is difficult to use a single indicator to describe the development of digital infrastructure and measure the development level of digital infrastructure. Therefore, this paper refers to existing relevant literature and research reports on measuring the development level of digital infrastructure, follows the relevance, scientificity and representativeness of indicators, and constructs a comprehensive indicator system to measure the development level of digital infrastructure.

Based on the definition of digital infrastructure, this paper sets three first-level indicators for the level of digital infrastructure development: the construction level, the degree of business, and the industrial situation. The length of long-distance fibre-optic cable lines, the number of IPv4 addresses, the number of Internet broadband access ports, the number of mobile phone subscribers, and the penetration rate of mobile phones are selected as the second-level indicators of the level of construction, which mainly reflect the construction of information technology infrastructure. The number of enterprises using e-commerce transaction activities and e-commerce sales are selected as secondary indicators of business level, focusing on reflecting the degree of influence of digital infrastructure on economic activities. Investment in Fixed Assets in Information Transmission, Software and Information Technology Services and Revenue of Information, Software and Information Technology Services are selected as the secondary indicators of industrial status to explain the development environment and future development trend of digital infrastructure. Considering the time trajectory of the development of digital infrastructure and the availability and continuity of relevant data, the data selected in this paper are the relevant indicators for the years from 2013 to 2022.

3.2. Assessment of the Level of Development of Digital Infrastructure

3.2.1. Data Processing

There are large differences in the data of secondary indicators in terms of quantity and magnitude, and in order to eliminate the impact brought about by the differences, it is necessary to standardise the data. In this paper, reference is made to the common methods used by scholars in dealing with data to standardise the data. The formula used is as follows:

$$Z = \frac{x_i - minx}{maxx - minx} \quad (1)$$

Where, is the standard value after standardised treatment, i represents the year, is the original indicator observation value in year i, is the minimum value in the original indicator observation value, is the maximum value in the original indicator observation value. The values of the secondary indicators after the standardisation process are all in the interval 0-1.

3.2.2. KMO and Bartlett's Test

In this paper, the general-purpose software SPSS29.0 measures the development level of digital infrastructure in Guangdong Province using principal component analysis. Before the analysis, it is necessary to pass the KMO and Bartlett's test. the KMO test takes the value between 0-1, the closer the test value is to 1, indicating that the linear correlation between the variables is stronger, the more suitable for principal component analysis. Generally, the KMO test value is more than 0.6 for principal component analysis, between 0.7-0.8 is suitable for analysis, between 0.8-0.9 is very suitable for analysis, and above 0.9 is very suitable for analysis. Bartlett's test requires significance below 0.05 for principal component analysis.The results of KMO and Bartlett's test are shown in Table 1.

Table 1. KMO and Bartlett's test

KMO Sample Suitability Quantity	0.767	
Bartlett's test	approximate chi-square	113.114
	degrees of freedom	36
	significance	<0.001

As can be seen from Table 1, the test results show that the KMO test value is 0.767 and the significance of the Bartlett's test is less than 0.01. The results of this test indicate that the data set passes the test of significance and that the indicators are correlated and not independent of each other, which makes them well suited for principal component analysis.

3.2.3. Determination of Weights

In general, the number of principal components is confirmed by the eigenroot and the cumulative contribution rate. When the characteristic root is greater than 1 and the cumulative contribution rate reaches 85% or more, the number of principal components can be confirmed. The principal component analysis is performed on the indicator system and the results are obtained as shown in Table 2.

Table 2. Total Variance Explained

	Initial eigenvalues Extracted			sum of squares of loadings		
Component	Total	Percentage of variance	Cumulative %	Total	Percentage of variance	Cumulative %
1	6.814	75.716	75.716	6.814	75.716	75.716
2	1.297	14.410	90.126	1.297	14.410	90.126

The results of the analysis, as shown in Table 2, show that there are two principal components with eigenvalues greater than 1, and the cumulative contribution rate reaches 90.12%, which means that Principal Component 1 and Principal Component 2 can represent 90.12% of the information of all indicators. Where principal component 1 can represent 75.72%

of the information and principal component 2 can represent 14.41% of the information. Therefore, 2 principal components are selected as the nascent variables for the subsequent measurement of the level of digital infrastructure development.

Table 3. Coefficients of secondary indicators of principal components

	Component	
Component	1	2
Length of long-distance fibre-optic cable lines	0.961	-0.095
Number of IPv4 addresses	0.668	-0.147
Internet broadband access ports	0.963	-0.064
Mobile phone subscribers	0.830	0.520
Mobile phone penetration rate	-0.230	0.954
Number of enterprises using e-commerce transaction activities	0.949	-0.224
E-commerce sales	0.971	0.058
Transmission, Software and Information Technology Services	0.927	-0.336
Revenue from information transmission, software and information technology services	0.978	-0.176

According to Table 3, the coefficients of the secondary indicators corresponding to each of the 2 principal components can be obtained, and the expressions of the 2 principal components are collated and listed, as shown in Equation (2) and Equation (3):

$$F_1 = 0.961X_1 + 0.668X_2 + 0.963X_3 + 0.83X_4 - 0.23X_5 + 0.949X_6 + 0.971X_7 + 0.927X_8 + 0.978X_9 \quad (2)$$

$$F_2 = -0.095X_1 - 0.147X_2 - 0.064X_3 + 0.52X_4 + 0.954X_5 - 0.224X_6 - 0.058X_7 - 0.336X_8 - 0.176X_9 \quad (3)$$

The coefficients of each principal component are obtained by using the initial division of the variance contribution rate by the cumulative variance contribution rate. Finally, each principal component is multiplied by the corresponding coefficients and then summed up to get the evaluation index of the level of digital infrastructure development in Guangdong Province, and the specific calculation process is shown in Equation (4):

$$F = \frac{0.75716 \times F_1 + 0.1441 \times F_2}{0.90126} \quad (4)$$

3.2.4. Analysis of the Level of Development of Digital Infrastructure

According to the digital infrastructure development level indicator system constructed above, after substituting various data, the digital infrastructure development level of Guangdong Province from 2013 to 2022 is measured, and the measurement results are shown in Table 4.

Table 4. Measurement results of the level of digital infrastructure development in Guangdong Province

Year	Level index
2022	5.93
2021	5.04
2020	4.27
2019	4.21
2018	3.65
2017	2.76
2016	2.11
2015	1.94
2014	1.39
2013	0.09

According to Table 4, the analysis of the development level of digital infrastructure in Guangdong Province can be concluded:

The level of digital infrastructure development in Guangdong Province has been showing an upward trend and rapid development. The index of digital infrastructure development level grows from 0.09 in 2013 to 5.93 in 2022, with remarkable development results. The rapid development of digital infrastructure in Guangdong Province is mainly due to factors such as economic level, policy support, and industrial agglomeration. As China's economic leader, Guangdong's economy has always ranked first in the country, and its developed economic level provides sufficient financial guarantee for the construction of digital infrastructure in Guangdong Province. 2013, Guangdong Province issued the "Outline of Guangdong Province's Informatisation Development Plan", in which it was proposed that the information infrastructure should be further improved, and that the in-depth integration of information technology and traditional industries should be accelerated. With the support and effective implementation of relevant policies, the digital infrastructure of Guangdong Province has been developing steadily without interruption. Guangzhou and Shenzhen, as first-tier cities, are home to many high-quality information technology enterprises. These high-tech enterprises have continued to invent and innovate, adding to the digital infrastructure of Guangdong.

4. Recommendations for countermeasures

From an empirical point of view, the article measures the level of digital infrastructure development in Guangdong

Province in the past ten years by combining data closely related to digital infrastructure in Guangdong Province, and puts forward relevant countermeasures and recommendations for improving the level of digital infrastructure development and promoting the development of digital economy in Guangdong Province.

4.1. Narrowing the "Data Divide"

Due to the significant differences in economic level, industrial structure, and resource endowment among the cities in Guangdong Province, a multi-level development pattern centred on Guangzhou and Shenzhen has been formed in the development of digital infrastructure, and there is an imbalance in the development of digital infrastructure in each city. Guangzhou and Shenzhen are far ahead in digital infrastructure development, while other cities are still in an accelerated catch-up stage. Compared with the Pearl River Delta (PRD) region, the development of digital infrastructure in the eastern, western and northern parts of Guangdong is lagging behind, and there is a "data divide" between them and the PRD region. Therefore, the government should actively promote the development of digital infrastructure in non-Pearl River Delta (PRD) regions, and increase investment in public infrastructure such as information and communications, so as to raise the level of digitisation and narrow the "data gap" with the PRD region. At the same time, Guangzhou and Shenzhen, as first-tier cities, are at the forefront of digital infrastructure development in the province and the country. Guangzhou and Shenzhen should play the role of radiation drive, through sharing technological innovation, co-operation and joint construction of cutting-edge digital infrastructure, etc., to drive the construction of digital infrastructure in the surrounding areas, and promote the balanced development of digital infrastructure in Guangdong Province.

4.2. Development of Frontier Digital Infrastructure

With the continuous development of electronic information technology, various new types of digital infrastructure are emerging. Therefore, Guangdong Province should seize the opportunity of the times and vigorously build and develop various types of cutting-edge digital infrastructure. Nowadays, the fourth version of the Internet Protocol (IPv4) is about to exit the stage of history, Guangdong Province can promote the expansion of Internet broadband, comprehensively lay out a new generation of Internet based on the sixth version of the Internet Protocol (IPv6), and promote the upgrading of related facilities and systems. Taking 5G as the starting point, it will vigorously promote the construction of 5G base stations, accelerate the expansion of the coverage of 5G networks, and boost the number of 5G users, so that 5G-related infrastructure can inject new momentum into the next round of investment growth.

Promote the construction of information service infrastructure such as cloud computing, big data centres and industrial Internet, so that data, which has become a new-generation factor of production, can play a better role in production and life, and promote significant growth in the digital economy.

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