Evaluation and Analysis of Shandong Digital Economy Construction

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Abstract. The wave of global informatization is surging. Shandong seized the great opportunity of a new round of scientific and technological revolution and industrial transformation, comprehensively promoted the digital transformation and development of various economic and social fields. This paper selected data related to the digital economy development of cities in Shandong from 2018 to 2022, focused on digital infrastructure, digital economy, digital government, digital society, etc., and built a Shandong digital construction evaluation index system. Quantitative analysis and qualitative analysis were used to measure the index data, and the digitalization level of 16 cities in Shandong Province was compared and evaluated. The research results shew that Shandong's digital development had reached a new height. Digital infrastructure, digital economy integration development, and digital government developed well. However, there still was room for improvement in digital industrialization, and digital technology innovation capabilities. At the same time, cities' digital economy developed unbalanced.

Keywords: Digital Economy, Shandong, Evaluation

1 Introduction

In recent years, the digital economy has developed rapidly. All countries in the world regard the promotion of economic digitalization as an important driving force for realizing innovation and development [1,2]. China implements the major strategy of "Digital China". Shandong, as a major economic province, is also actively promoting the digital construction of the province, taking the construction of Digital Shandong as a major measure to accelerate the transformation of new and old kinetic energy. While, the effect of any government decision-making and policy implementation need to be evaluated from an objective and fair perspective [3-6]. Since Shandong has fully implemented digital construction, various work has achieved remarkable results, Since

Shandong has fully implemented digital construction, various work has achieved remarkable results, but the development of digital economy among the 16 cities under the jurisdiction of Shandong were different. How to comprehensively and systematically evaluate the digitalization process in Shandong? What are the dimensions of digital construction? What are the differences among different regions? This series of important practical problems needs to be studied.

Different scholars and institutions gave different statements about how to calculate the development of the digital economy. Most scholars used direct measurement to calculate the size of the digital economy to judge the degree of digital development [7-19]. According to the United Nations Digital Economy Report 2021, global data flows grew rapidly, but it was difficult to accurately measure the size of data flows. It can be seen that it is more reasonable to evaluate the level of development of each region by index than to measure the scale of the digital economy [20]. At present, many institutions used the comprehensive indicator method for measurement, such as CCID Consulting published the National Digital Economy Development Index every year [21]. Alibaba Research Institute proposed the index structure of the digital economy development [22]. Many domestic experts and scholars analyzed the digital economy in different angles, however, most of them only introduced the development of the digital economy based on the existing research results in Western countries. Most of the studies were divorced from the actual situation of the digital economy in our country, especially for the development degree and development trend of regional digitalization. The existing measurement methods were not comprehensive and cannot objectively and truly evaluate the effectiveness of digital Shandong. Therefore, we need to develop a set of measurement methods that will be in line with the actual development of Shandong and can comprehensively measure the existing digital economic formats in the local area.

2 Construction of digital construction evaluation index system

2.1 Contents of the evaluation index system

The evaluation index system was divided into five first-level indicators, namely digital infrastructure construction, digital economy development, digital government construction, digital society construction, and digital Shandong development ecology. Statistics were as of the end of December 2021. Each first-level indicator included 22 second-level indicators and 84 third-level indicators, reflecting the requirements of different aspects of the construction and development of digital Shandong. The specific evaluation contents are as follows.

Table 1. PART OF the evaluation index system

First-level indicator	Second-level indicator
1.Digital infrastructure construction	Network infrastructure
	Popularization of digital networks
2.Digital economy development	Integrated development of digital economy
	Digital industrialization

	Industrial digitalization
	Service industry digitization
	Agricultural digitalization
3. Digital government construction	Government services digitization
	Government governance digitization
	Government work process reengineering
4. Construction of digital society	Smart human resources and social security
	Smart Education
	Digital recreation and sports
	Smart health care
	Smart old-age care
	Smart Transportation
	Smart urban and rural
	Digital social assistance
5. Digital Shandong development environment	Policy and organization guarantee
	Talent support
	Financial support
	Development environment optimization

2.2   Data sources

The main targets of the investigation were the relevant responsible organizations involved in the construction and implementation of "Digital Shandong", such as the Provincial Big Data Bureau, the Provincial Department of Industry and Information Technology, and local municipal governments, and so on. Scores were calculated by collecting statistical data from various departments.

2.3   Evaluation method

The weight of each evaluation index was determined by the expert survey method according to the importance, and then, the score was calculated by the comprehensive weighting method. The specific calculation method was as follows [23]:

2.3.1 Index dimensionless.

In order to eliminate the problem of different index units, we first performed dimensionless processing on the data. Choosing different dimensionless methods according to the different types of indicator data. Noting the original value of each evaluation index as Xij (i represented the index object, j represented the index number), the dimensionless value as Zij, and the base value of the index j as $\overline{X_j}$.

Numerical index processing method: in order to avoid the unbalanced index discrimination caused by the large difference of original values, we used the logarithm method to dimensionless the indicators.

$$Z_{ij} = \left(\ln \left(1 + \frac{X_{ij}}{\overline{X_j}} \right) \right) * 50$$

Index indicators processing method: normalizing the data.

$$Z_{ij} = \frac{X_{ij}}{\overline{X_j}} * 50$$

Calculation of base value $\overline{X_j}$: The base value of the indicator system was the average of 16 cities.

$$\overline{X_j} = \frac{\sum_{i=1}^{16} X_{ij}}{16}$$

2.3.2 Indicator Weight Determination and Index Calculation.

In this study, the expert scoring method was used to determine the weight of evaluation indicators [24]. The weight of the three-level indicators in the evaluation index system was scored by the expert group. The whole scoring process adopted a back-to-back model. Each expert gave 1 (very unimportant) to 5 (very important) without any prior discussion or communication with each other. After all expert group members finished scoring, the weight λ_j of the final indicator j was determined by the following formula:

$$\lambda_j = \left. \sum_{\kappa=1}^{n} \lambda_{\kappa j} \middle/ \sum_{\kappa=1}^{n} \sum_{j=1}^{m} \lambda_{\kappa j} \right.$$

κ: the κ-th expert
j: the j-th indicator
$\lambda_{\kappa j}$: the score of the κ-th expert for the j-th indicator
n: total number of members of the expert group
m: total number of scoring indicators

The weighted average method is used for the calculation of the index indices at all levels of each object.

$$Z_i = \frac{\sum \lambda_j Z_{ij}}{\sum \lambda_j}$$

3   Evaluation results

3.1   Assessment of digital infrastructure construction indicators

The construction of new infrastructure in Shandong was accelerated, and digital empowerment achieved remarkable results. Through the evaluation of the infrastructure index, we found that the development of digital infrastructure in various regions was uneven (Figure 1). Qingdao and Jinan achieved obvious advantages. Linyi and Yantai also surpassed the provincial average of 49.98 in Shandong. The construction of digital infrastructure in other cities should continue to be strengthened. Some cities were not included in the list due to serious lack of statistical data.
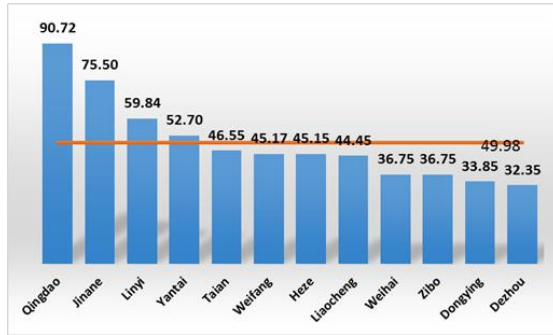
Fig. 1. Ranking of digital infrastructure assessment in Shandong

3.2   Assessment of digital economy development indicators

The digital economy development in Shandong made a new leap, but the digital economy development index varies greatly among cities. The three cities, Jinan, Qingdao, and Yantai developed best, their digital economy development indexes were far ahead, especially Qingdao and Jinan were 137.79 and 118.63 respectively., while the rest of the cities were all below 40 points. Compared with the top three cities, although the rest of the cities had some gaps, they all shew a trend of competitive development. With the increasing emphasis on digital construction in various cities, the overall development level of the digital economy in various places has improved to varying degrees. Some cities were not included in the list due to serious lack of statistical data.
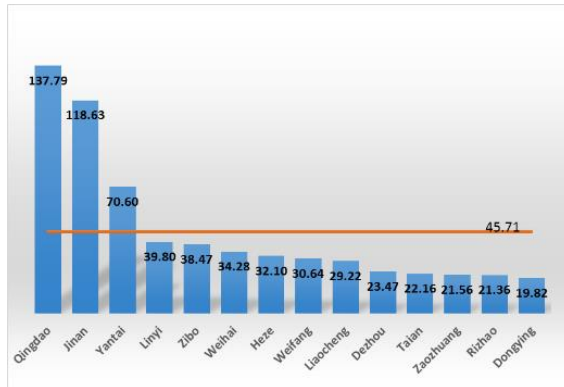

Fig. 2. Ranking of digital economy assessment in Shandong

3.3   Assessment of digital government construction indicators

Shandong accelerated the construction of digital government, further promoted "online service", vigorously promoted "online office", strengthened the "integrated management" of data, and consolidated basic platform support. Local governance combined

resource and local needs, and made scientific plans in three aspects, government services, government governance, and digital government basic support, to form local models and experiences of digital governance. Linyi, Rizhao, Jinan, Zibo, and Qingdao all exceeded the average of 49.96, while, in general, the gap among cities was not very large (Figure 3), they all showed strong vitality. Some cities were not included in the list due to serious lack of statistical data.
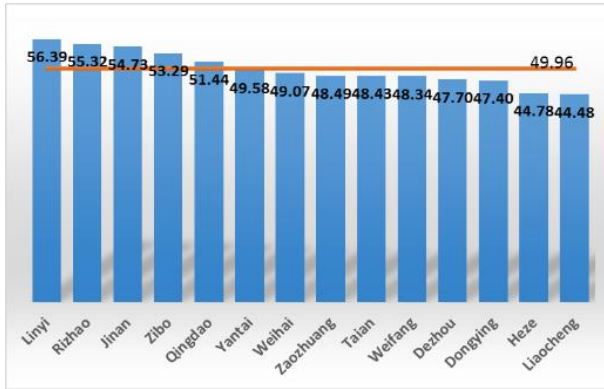

Fig. 3. Ranking of digital government assessment in Shandong

3.4   Assessment of digital society construction indicators

Shandong accelerated the construction of a digital society, emphasized on the construction of a new smart city, promoted the deep integration of big data and economic society, focused on fully exploring the innovative applications of digital technology in the fields of social security, culture and sports, medical care, transportation, assistance, etc., strengthened the supply of digital services, gradually improved the happiness of the people, and comprehensively promoted the digital development in the all areas of society. At present, Shandong created more than 2,000 application scenarios, moreover, a number of typical scenarios had been promoted across the province. 13 cities were selected into the top 100 digital cities, the number ranked first in the country [25]. In particular, Yantai, Qingdao, Jinan, Dongying and other places achieved remarkable results, with scores exceeding the provincial average (Figure 4). Some cities were not included in the list due to serious lack of statistical data.
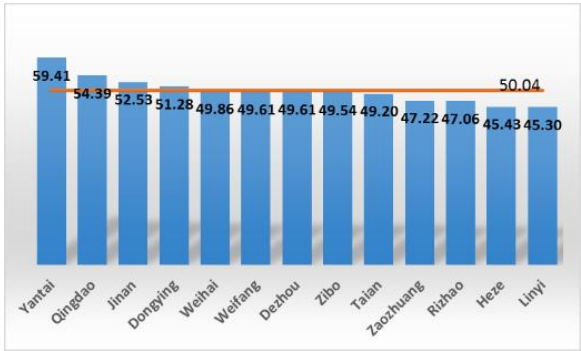
Fig. 4. Ranking of digital society construction assessment in Shandong

3.5   Assessment of Digital Shandong Development Environment Indicators

Shandong attached great importance to the construction of digital Shandong. All cities had set up leading groups for digital city construction to coordinate the promotion of the city's digital, networked and intelligent development, and strictly implement various tasks and goals. Shandong actively implemented strategies in policy guarantees, talent support, business environment, and financial support to create a good development environment for digital construction. Qingdao, Yantai, Jinan, and Dezhou were more outstanding than others, exceeding the provincial average of 46.79 (Figure 5).
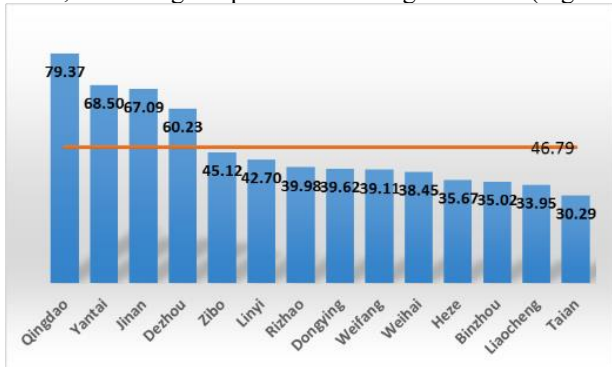

Fig. 5. Ranking of digital development environment assessment

4   Conclusion

4.1   Development advantages

The overall construction and development of Digital Shandong reached a new height. Shandong actively deployed and built digital infrastructure. At present, the Shandong network terminals fully supported IPv6, besides, Shandong achieved remarkable results in 5G, Internet of Things, and Internet construction, as well as, built a data resource

ecosystem. Shandong made effort to promote digital industrialization and industrial digitization, and strived to make the digital economy bigger and stronger. According to the "Digital China Construction and Development Report (2020)", Shandong ranked seventh in the field of informatization development, ranked third in the level of industrial digitalization in China. What's more, Shandong was in the forefront of the whole country in the construction of new smart cities and digital infrastructure systems, scientific research on the core track of the information industry, and digital transformation pilot demonstrations, and sort of that [26].

4.2   Development problems and deficiencies

Digital innovation capability was insufficient. Shandong had insufficient innovation capability in key core technologies such as high-end chips and operating systems, and lacked sufficient technical reserves and intellectual property rights. Compared with other advanced area, the R&D and commercialization of emerging digital technologies such as artificial intelligence, big data, and block chain lagged behind. **The competitive advantage of the digital economy was not obvious**. First, the proportion of the core industries of the digital economy was not high, the leading role of industries such as electronic information and the Internet in regional economic growth should be improved urgently. Second, the development of e-commerce also needed to be improved. Although the online retail sales in Shandong Province showed a rapid growth, the e-commerce model was backward, there were few new e-commerce companies and platforms. In terms of cross-border e-commerce, the development mode of special customs supervision areas was relatively extensive, the cross-border e-commerce payment policy was not perfect, and the development of logistics lagged behind. **The level of digital governance was low.** The sense of experience brought by the "digital dividend" for government departments and the people did not achieve the expected effect, moreover, the ability of sharing data resources and business collaboration across levels, regions, systems, departments still should be improved urgently. **Digital technology applications were ineffective.** In some digital society application scenarios, the level of equalization, inclusiveness, and convenience of public services were not high, besides, some of smart applications actually were "unsmart" to a certain extent. **Regional digital development was uneven.** Jinan, Qingdao, Yantai were relatively advanced in digital development, but there was still a big gap among 16 cities in Shandong. In the disadvantaged areas, there were absence of innovative and leading enterprises in the field of digital industrialization, outstanding innovation abilities, and adequate digital infrastructure. **The pressure of capital investment was high.** The contradiction between the high demand for informatization construction and capital scarcity was prominent. At present, financial funds at all levels were relatively difficult, there was a lot of pressure on expenditure. While, there was absence of financial guarantees in planning formulation, smart communities, and digital platforms, etc., which restricted informatization construction and digital transformation.

5   Development suggestions

5.1   Strengthen scientific and technological innovation

Improving the ability of scientific and technological originality, aim at the goal of advanced industrial foundation and modern industrial chain, strengthening basic and forward-looking digital technology research, especially in key core technologies such as big data, cloud computing, and the Internet of Things, etc., as well as virtual reality, artificial intelligence, block Chain and other cutting-edge emerging technology fields, to increase the supply of primitive technology. Deeply excavating the value of digital technology, cultivating and developing emerging industries, transforming and upgrading traditional industries, to promote the extension of the industrial chain and value chain to high-end.

5.2   Promote the integration and sharing of government information and data resources

The first is to promote the integration and sharing of resources, integrate the self-built business systems, government service mobile terminals, and independent business private networks of various localities and departments. The second is to release the potential of government information resources, actively explore the application of big data, cloud computing and other information technologies in data sharing, encourage and guide social forces to widely develop value-added development and innovative applications of information resources.

5.3   Optimizing the regional development layout of the digital economy

Promoting the scientific layout of the digital economy in various regions, strengthening the role of the main force of innovation in leading regions such as Qingdao, Jinan, and Yantai, supporting the cross-regional construction of industrial chains, and deepening regional coordinated development. Encouraging relatively backward regions to start from industries with lower thresholds, accelerate digital transformation,   at the same time, promoting the implementation of applications related to local key industries, improving the layout of the digital industry, and expanding the scale of the digital industry. Besides, strengthening the construction of digital infrastructure and digital skills training for talents in backward regions, to eliminate the digital divide, and promote the coordinated development of the province's digital economy.

5.4   Explore and cultivate the market of data elements

Firstly, accelerating the improvement of the digital economy market system, ensuring the safe and orderly use of data, promoting the formation of a data elements market, meantime, using the flow of data to guide the optimal allocation of production factors such as technology, capital, and talent, so that, to achieve coordinated development. Then, establishing a revenue distribution mechanism for data elements, building a data

supervision and governance system, strengthening data application supervision, and building a data trust system.

5.5   Increase financial support

Increasing investment in the weak links of the digital economy, and establishing a long-term mechanism to promote the development of the digital economy. The first is to formulate more favorable policies and measures, use financial capital to guide and attract social capital to participate, so as to form a diversified and integrated investment and financing situation. The second is to increase the financial and tax incentives for the digital economy, and use the preferential supply of finance and taxation for digital economy enterprises to promote enterprises to increase investment in digital research and development. The third is to increase the support of special funds for the digital economy, and reduce the cost of using digital infrastructure and land use costs for enterprises.

Acknowledgment

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