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Research on the Measurement of Digital Economy Development Level Based on the Entropy Weight Model and TOPSIS Method

--Taking Xinjiang Uygur Autonomous Region as an Example

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Abstract: The rapid advancements in digital technology have brought about significant changes across the globe. However, remote regions face distinct challenges in developing their digital economies, influenced by factors such as geography, economics, and technology. The Xinjiang Uygur Autonomous Region is an exemplar of such remote areas in China. This research paper utilizes the region as a case study, gathering data from prefecture-level cities within Xinjiang Uygur Autonomous Region between 2011 and 2019. Through the implementation of an index system, the Entropy Weight Model and TOPSIS Method were utilized to evaluate the digital economy index and examine potential development pathways. The findings indicate that the digital economy in the Xinjiang Uygur Autonomous Region is presently in a developmental stage, but there are concerns regarding sluggish growth, an unbalanced economic structure, and a digital divide. These results can offer a scientific foundation for local economic expansion and serve as a point of reference for devising strategies to promote digital economy development in remote regions.

Keywords: digital economy, remote areas, economic development, entropy weight model and TOPSIS method

1. Introduction

The Digital Economy is an emerging industry that reshapes the distribution of resources and restructures of the economy. General Secretary Xi stressed the critical importance of digital technologies and the digital economy in propelling global science and technology change and a major battlefield in the next round of global competitiveness [1]. Nowadays, the digital economy has become a crucial driver of economic growth.

The China Academy of Communications Technology estimates that in 2021, it will account for 45 percent of world GDP. The digital economy is projected to account for 55.7% of GDP in advanced countries, while the Chinese digital economy will account for 39.8% of GDP. This data shows that the Chinese still lag behind the advanced economies [2]. During the 18th National Congress of the Communist Party of China, much attention was given to the importance of fostering the digital

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economy. A range of strategies were put forward, and with the support of the government, China's digital economy has seen remarkable growth. In 2012, it was valued at RMB11 billion, but by 2021, it had soared to RMB45.5 billion, cementing its position as the world's second-largest digital economy. This remarkable increase highlights the digital economy's critical role in boosting the Chinese economy as a whole.

Though the Chinese digitized economy has a powerful developing tendency, its geographic development is not uniform. Nowadays, there are three kinds of regional digital economic development modes: integrated dominant, distinctive innovative, and latent enhanced [3]. Regions can be classified into two primary groups: the eastern and central regions including Beijing, Shanghai, Guangdong, and Shenzhen, and the remote western regions that are presently exploring their respective locations and comparative advantages. As of 2021, Beijing's digital economy has an added value of 1.6, while Xinjiang's is only 0.43. Moreover, the digital economy's share in Beijing's GDP is 40.4%, compared to Xinjiang's 27.4% [4]. This shows that there is a great disparity between the numerical economic performance of Xinjiang and the eastern representative cities, and there is much space for further development.

At present, when the economy is growing slowly and the Silk Road Economic Belt is being built, it is a key issue for related researchers, specialists, and policymakers to develop it. In the west of China, a large area of West China, there are comparatively perfect industry structures and various nationalities. The present situation and the developing route of digital economic development have some typical influences in the countryside. So the research on the present situation and developing route of the digitized economy in Xinjiang has important realistic meaning.

Ever since the conception of the Digital Economy came into being, many studies have been done to measure and develop the process of digital economic. Mr. Liu believes that measuring the level of digital economic development requires the integration of ICT and the digital economy [5]. Liu and Yang set up an indicator system based on information technology, network exploitation, and digital trade. Then they applied the NBI Index to compute a Digital Economy Composite Index [6]. Zhao and Zhang chose the percentage of network penetration, relevant staff, relative production, and cell phone usage as indexes. Based on PCA, we can get the result that we can greatly enhance the quality of our city [7]. Based on TOPSIS, Guo has determined the numerical economic growth indicators of Hebei Province from 2011-2020. The results indicate that Hebei Province significantly impacts industry, investment, finance, and government intervention [8]. Based on Shijiazhuang City Panel Data, Lee and his team built an assessment indicator system and then applied TOPSIS to analyze the influence of a high-quality economy [9].

In addition, Yao and Deng have put forth recommendations for the advancement of Xinjiang's digital economy based on the white paper. Their suggestions include delving into the platform economic model, advancing the digital infrastructure of unique industries, and reinforcing the cultivation of skilled professionals [10]. Zhang gave suggestions for developing online transactions based on "block chain + big data" according to the development status of Wenzhou City [11]. Zhang focused on enhancing rural revitalization by developing the digital economy at the county level. His findings highlighted a gap in the current state of the rural digital economy, emphasizing the need to strengthen its foundation, foster digital talent, and promote the integration of industries at the county level by leveraging their comparative advantages [12]. Lu and Guan classified the digital economy based on big data, explored the impact model of industrial structure on the digital economy, and suggested that my country should speed up the construction of Internet communication facilities, increase investment in digitalization, and cultivate relevant talents.

Based on this, this article uses the entropy weight TOPSIS method to analyze the development status of the digital economy in the Xinjiang Uygur Autonomous Region. This study provides a significant contribution to both theoretical insights and practical applications in the realm of the

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digital economy. It serves as a critical resource for comprehending the progress of the digital economy in Xinjiang's prefecture-level cities and offers recommendations for its future development.

The structure of this paper includes an introduction of methods and data (Section 2), results (Section 3), and summary (Section 4).

2. Construction of Digital Economy Development Evaluation Index System and Selection of Measurement Methods

2.1. Index System Construction

This article draws on the digital economy development indicators constructed by influential experts and scholars such as China Academy of Communications Technology, Liu et al. (2020), Sheng and Liu, and considers the availability of data to construct an indicator system (Table 1).

2.2. Measurement Method Based on Entropy Weight TOPSIS

In this paper, a numerical economic assessment indicator system is built based on TOPSIS, which is based on the theory of entropy. It is applied to Xinjiang Uygur Autonomous Region. Entropy weight TOPSIS integrates objective weighting method, entropy weight method and multi-objective decision-making analysis method TOP-SIS method. After determining the weight according to the variation degree of standardized processing data, by calculating the relative distance between the evaluation object and the optimal point, the Quantitative ranking of target objects can effectively avoid the subjective arbitrariness of weighting and enhance the credibility and accuracy of measurement results.

2.3. The Data Shows

This study delves into the statistical analysis of four municipalities within the Xinjiang Uygur Autonomous Region, spanning from 2011 to 2019. Before this period, information was scarce. The data was sourced from reputable outlets including the China Statistical Yearbook, China City Statistical Yearbook, and Peking University's Digital Finance Research Center. To address gaps, interpolation was employed and the data was standardized.

Table 1: Indicator system for measuring the level of the digital economy.

	Level 1 indicators	Level 2 indicators	Level 3 indicators
Comprehensive development level of digital economy	digital industrialization	Infrastructure	Number of villages with broadband access
			Number of international Internet users per 100 people
		Development of information transmission service industry	Total Telecom Services Per Capita
			Number of mobile phone users per 100 people
		Digital innovation and development	the percentage of workers employed in the industries of information transmission
			Number of scientific and technological institutions run by enterprises
			Number of effective invention patents
		Future industrialization	Internal expenditure of R&D funds
			Number of graduates from ordinary colleges and universities

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Table 1: (continued).

	Industrial digitization	The extent of digitalization in the primary industry	Gross output value of rural animal husbandry and sideline fisheries
		Secondary industry digitalization level	Gross output value of industrial enterprises above designated size
		Digitalization level of the tertiary industry	The total retail sales of social consumer goods
			Digital Financial Inclusion Index

3. Analysis of Empirical Results

3.1. Determination of Weight Coefficient

Using the entropy-weight method, the weights of the 1st, 2nd and 3rd indices were given (Table 2).

Table 2: Weight of objective evaluation method for evaluation indicators.

Level 1 indicators	Index Weight	Secondary indicators	Index Weight	Level 3 indicators	Index Weight
digital industrialization	77.00%	Infrastructure	9.72%	Number of villages with broadband access	5.22%
				Number of international Internet users per 100 people	4.50%
		Development of information transmission service industry	12.20%	Total Telecom Services Per Capita	6.25%
				Number of mobile phone users per 100 people	5.95%
		Digital innovation and development	24.33%	the percentage of workers employed in the industries of information transmission	4.82%
				Number of scientific and technological institutions run by enterprises	7.64%
				Number of effective invention patents	11.87 %
		Future industrialization	30.74%	Internal expenditure of R&D funds	14.31 %
				Number of graduates from ordinary colleges and universities	16.43 %

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Table 2: (continued).

Industrial digitization	23.00%	The extent of digitalization in the primary industry	3.96%	Gross output value of rural animal husbandry and sideline fisheries	3.96%
		Secondary industry digitalization level	5.07%	Gross output value of industrial enterprises above designated size	5.07%
		Digitalization level of the tertiary industry	13.97%	The total retail sales of social consumer goods	12.17 %
				Digital Financial Inclusion Index	1.80%

The digitalization of industry has contributed significantly to the overall development of the digital economy, accounting for an impressive 77.00%. This highlights the Xinjiang Uygur Autonomous Region's successful adoption of digital industry development, which has been widely implemented across diverse sectors, offering strong support to the growth of the digital economy. In the course of developing digitized industry, we can see that the most important part is "Future Industrialization". Therefore, research and development and personnel cultivation are the main impetus to develop the digitized economy.

The digital industry makes up 23.00 percent of the total number of developing countries in Xinjiang Uygur Autonomous Region, but it's not enough to realize the unreasonableness of its economy. This shows that the penetration of digitalization into the industry is still relatively lacking, and the application of digital technology is not paid enough attention.

Among all the secondary index coefficients, the highest proportion is future industrialization, accounting for 30.74%; followed by digital innovation and development, accounting for 24.33%; the digitalization level of the tertiary industry, the development of information transmission service industry, and infrastructure construction respectively account for The ratios are 13.97%, 12.20%, and 9.72%, which shows that talent training, enterprise innovation, and industrial development are important contents of digital economy development. Along with the increasing influence of the digitized economy on a high-quality economy, it is urgent for us to resolve the coordination between digitalization and digitalization.

4. Empirical Research on Digital Economy Development Level of Xinjiang Uygur Autonomous Region Based on TOPSIS Algorithm

The TOPSIS method is applied to compute the numerical economic performance of 4 towns in Xinjiang Uygur Autonomous Region between 2011 and 2019.

Figure 1 shows a mostly consistent upward trend in the digital economy of Xinjiang Uygur Autonomous Region from 2011 to 2019 with minor fluctuations. The overall development is relatively slow. Among them, Urumqi City increased from 0.495 in 2011 to 0.803 in 2019, Karamay City increased from 0.161 to 0.263, Turpan City increased from 0.085 to 0.191, and Hami City increased from 0.132 to 0.227. The degree of digital economic development is significantly different from that of other prefectural cities. Urumqi's digitized economic level is far superior to the other three.Among the four cities, Urumqi and Karamay belong to the northern region, while Turpan and Hami belong to the southern region. There is a large difference in digital economic development between them, and there is a digital divide phenomenon, which is tending to widen. The reason may be that Urumqi is the provincial capital of Xinjiang and the location of the Xinjiang Software Park.

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Its development has obvious policy advantages, while the digital economic foundation of other urban areas is still relatively weak.

At the same time, it can be concluded from Figure 2 that the development of industrial digitalization has been fluctuating. For example, due to the adjustment of the industrial structure in Karamay, industrial digitalization showed a downward trend in 2014-2016. From figure 3, it's evident that digital industrialization has been consistently trending upwards from 2011 to 2019. While Urumqi experienced minor rebounds in 2011-2012 and 2017-2018, the other cities displayed steady progress. These results are in line with Xinjiang Uygur Autonomous Region's focus on developing a digitized economy. In recent times, the region's adoption of digital technology has produced encouraging outcomes, with new strategies supporting the expansion of digital industrialization and industrial digitization in the area.

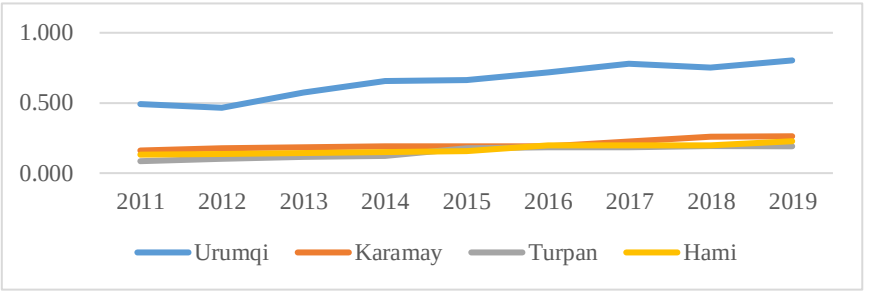

Figure 1: Digital economy development levels in the cities in the Xinjiang.

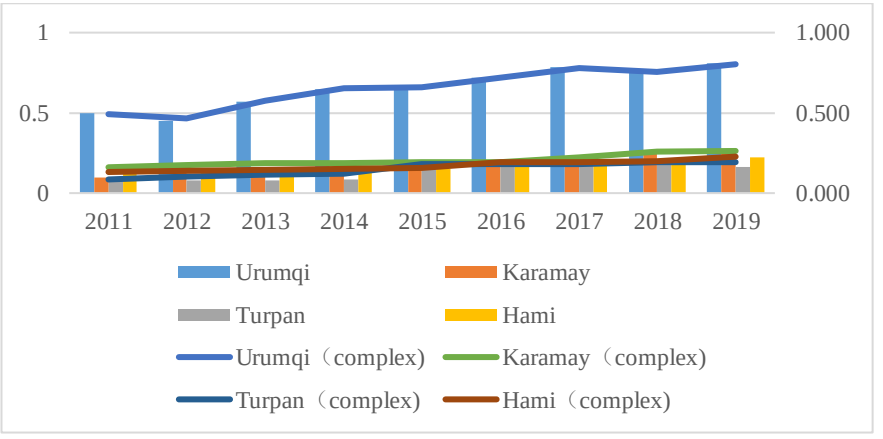

Figure 2: Prefecture-level digital industrialization in Xinjiang.

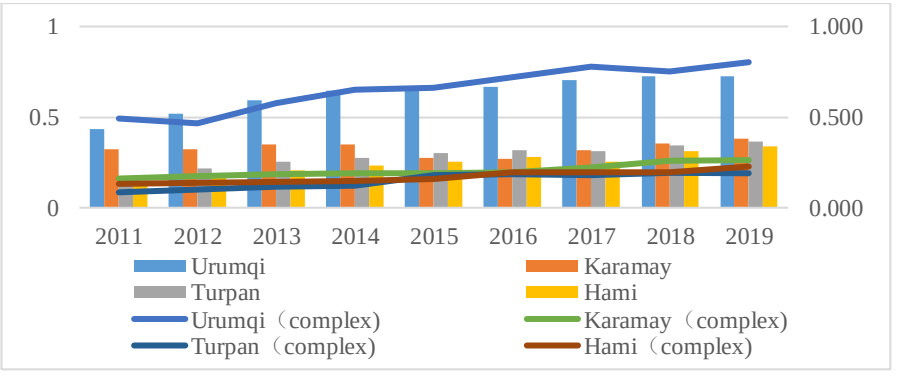

Figure 3: Prefecture-level industrial digitalization in the Xinjiang.

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5. Conclusion

This article delves into the concept of the digital economy and presents a comprehensive evaluation index system consisting of three levels to measure its development. We have analyzed data from the "Xinjiang Uygur Autonomous Region Statistical Yearbook" spanning from 2011 to 2019. Employing the entropy weight method, we have calculated the figures for the four prefecture-level cities in the region.Through empirical research using the Topsis method, the author has analyzed the development and trajectory of the digital economy. The results indicate that progress in the Xinjiang Uygur Autonomous Region's digital economy has been sluggish, its economic structure is suboptimal, and a noticeable digital divide exists.

This article proposes several recommendations for policy makers. Firstly, it suggests improving the current system and ensuring successful implementation of policies in order to effectively manage data, utilize it for projects, and demonstrate applications. Secondly, there is potential to leverage regional advantages to enhance the innovative development of the regional digital economy. Areas such as Xinjiang, Gansu, and Qinghai, which are located along the Silk Road, can utilize the "Digital Silk Road" to facilitate trade in important cities along the route, promote cross-border e-commerce, and establish big data exchanges. Thirdly, it is crucial to prioritize development goals and optimize the digital economic structure. Lastly, national assistance policies should be implemented to strengthen digital infrastructure.

While this article offers valuable insights, it is important to note its limitations. Notably, industrial electricity consumption plays a crucial role in measuring industrial digitalization, but unfortunately, data on such consumption in primary, secondary, and tertiary industries has not been made public, and therefore has not been included in the measurement indicators. Furthermore, the absence of data beyond 2019 makes it challenging to predict trends for the years 2019-2022. As more information becomes available in the future, we will need to reassess these issues.

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