

Study on the Development Level and Influencing Factors of Digital Economy in Shanwei City

Hongai Shi*, Xiaolong Ye^a

Guangzhou Xinhua University, Guangzhou, Guangdong Province, China

*shihongai03@163.com, ^a76677658@qq.com

Abstract. The digital economy, an emerging cornerstone of global economic progress, harnesses digital technologies and leverages data as its primary production catalyst. Operating within a framework of advanced information networks, it fosters the fusion and implementation of information and communication technologies, alongside the digital transformation of all contributing factors, thereby propelling a novel economic paradigm that balances fairness with efficiency. The present research endeavors to delve into the developmental status and the underlying determinants influencing the digital economy's trajectory in Shanwei City. Drawing upon data spanning from 2013 to 2022, a comprehensive assessment index for the digital economy's advancement in Shanwei is devised through a methodical blend of entropy weighting and weighted summation techniques. Subsequently, the study employs the gray correlation analysis to untangle the intricate relationship between these factors and the development level of the digital economy in Shanwei. The findings underscore the collective contribution of various elements in fostering digital economic growth, with independent innovation emerging as the most potent catalyst. In light of these insights, this paper proposes a suite of strategic recommendations tailored to propel the sustained advancement of the digital economy in Shanwei City, ensuring its role as a dynamic force in the region's economic landscape.

Keywords: Digital economy; entropy weight method; weighted sum method; gray correlation analysis; Shanwei City

1 Introduction

Amidst the relentless expansion of the global digital economy, diverse regions are vigorously charting their digital landscapes to foster high-quality economic growth. Within this backdrop, scrutinizing the developmental milestones and influencing dynamics of the digital economy holds paramount importance for discerning its evolutionary trajectory and crafting strategic blueprints for its advancement. As a pivotal city within Guangdong Province, examining the developmental status and underlying factors of Shanwei City's digital economy not only sheds light on the region's current digital landscape but also serves as a beacon of inspiration and guidance for comparable areas striving towards digital prosperity.

Shanwei City's digital economy has witnessed remarkable strides in recent years, yet it confronts a myriad of challenges. Hence, a pressing agenda lies in scientifically assessing the extent of its digital development, delving into the pivotal factors that shape its progression, and furnishing a foundation for government and enterprises alike to formulate informed policies that bolster the digital economy. This research endeavor endeavors to comprehensively appraise the current state of Shanwei's digital economy, employ empirical methodologies to uncover the primary drivers of its growth, and offer both theoretical underpinnings and practical directives aimed at fostering the sustainable evolution of Shanwei's digital economy.

Ultimately, this study will prove to be a vital decision-making compass for the government and enterprises of Shanwei City, expediting the digital economy's trajectory within the city limits. Furthermore, it possesses inherent theoretical and practical merits, offering invaluable insights and guidance to other regions embarking on similar digital development paths.

2 Literature Review

In recent years, the ascendance of the digital economy has ignited a surge of scholarly inquiry domestically, with researchers delving into various facets of this transformative landscape. The focus of their endeavors primarily revolves around the theoretical underpinnings, quantifiable metrics of development, and the multifaceted factors influencing the digital economy's evolution.

With respect to theoretical explorations, scholars such as Gong Chunzi et al.^[1] have conceptualized the digital economy as an expansive information system permeating society, politics, and economics, wherein information and business transactions undergo digitalization. Xu Xianchun and Zhang Meihui^[2], on the other hand, emphasize the digital economy's emergence as a harmonious fusion of advanced digital technologies and the intricate workings of the national economy, underpinned by digital platforms and empowered infrastructure.

Regarding the assessment of the digital economy's developmental trajectory, researchers like Liu Jun, Yang Yuanyun, and Zhang Sanfeng^[3] have devised an elaborate evaluation framework encompassing the Internet, informatization, and digital transaction advancements, providing insights into China's provincial disparities, with the eastern regions leading the way. Jiao Shuaitao and Sun Qiubi^[4], further analyzing these disparities, underscore the spatial heterogeneity and its contributing factors.

Scholarly consensus underscores the pivotal role of technological innovation, policy environments, market dynamics, human capital, and other elements in shaping the digital economy's growth trajectory. Cai Shaohong et al.^[5] employ innovative methods to evaluate digital development across four dimensions: foundation, innovation, applications, and environment. Zeng Yan et al.^[6] highlight the transformative potential of data and digital technologies in consumer finance, while Ma Deji et al.^[7] delve into the intricate interplay of supply-demand dynamics, infrastructure, economic fundamentals, and talent pools.

Beyond domestic shores, international scholarship offers valuable lessons in digital economy development. Tapscott^[8] pioneered the concept, elucidating the Internet's economic implications. Bukht et al.^[9] emphasize the digital economy's centrality in contemporary production and service outputs. Turcan et al.^[10] attribute its ascendance to the proliferation of novel products, services, and the ascendancy of innovation as a driving force. Huang H^[11] and Vujica et al.^[12] underscore the pivotal role of information transmission and digital infrastructure in fostering user engagement and transaction frequencies, as well as the indispensable nature of broadband and mobile networks.

While both domestic and international scholars have extensively examined the digital economy's essence, few have adopted a regional lens, particularly focusing on eastern Guangdong or Shanwei City, offering a niche for future research endeavors.

3 Model Construction

3.1 Selection and Interpretation of Evaluation Indicators

This study constructed an evaluation index system for the level of digital economic development in Shanwei City, covering seven secondary indicators from three dimensions: digital infrastructure, digital economic development, and digital technology innovation. The specific indicators are shown in Table 1.

Table 1. Evaluation Index System for Digital Economy Development in Shanwei City.

First level indicators	Second level indicator	Units
Digital infrastructure	mobile phone users	Ten thousand households
	Internet broadband access account	Ten thousand households
	Information transmission, computer services, and software industry professionals	personnel
Development of Digital Economy	Total amount of postal services	Billion
	Output value of computer, communication and other electronic equipment manufacturing industry	Billion
Innovation in Digital Technology	Value added of high-tech industries	Billion
	Invention patent authorization	piece

3.2 Entropy weight method

Calculation of Information Entropy for the i-th Indicator:

$$E_i = -K \sum_{j=1}^n P_{ij} \ln P_{ij} \quad (1)$$

$0 \leq E_i \leq 1$, $K = \frac{1}{\ln(m)} > 0$, $P_{ij} = R_{ij} / \sum_{j=1}^n R_{ij}$ ($i = 1, 2, \dots, m$; $j = 1, 2, \dots, n$), P_{ij} refers to the proportion of the index in year j under the i -th index, When $P_{ij}=0$, let $\ln P_{ij}=0$.

$$W_i = \frac{1 - f_i}{\sum_{j=1}^n f_j} \quad (2)$$

$0 \leq W_i \leq 1$, $\sum_{j=1}^n f_j = 1$, N is the number of indicators under the i -th indicator, $f_i = 1 - E_i$.

3.3 Weighted Summation Method

The weighted sum method is used to calculate the level of digital economic development in Shanwei City, and the formula is as follows:

$$T = \sum_{j=1}^m Z_{ij} W_j \quad (3)$$

In the formula, T is the evaluation value of the level of development of the digital economy; Z_{ij} is the standardized value of each evaluation indicator; W_j is the weight of j indicators.

3.4 Grey Correlation Model

The system feature sequence that has been initialized is denoted as X_0 , and the related factor behavior sequence is denoted as X_i . The correlation coefficient between the two sequences can be calculated using the following formula:

$$\varepsilon_{oi} = \frac{\Delta \min + p \Delta \max}{\Delta_i(t) + p \Delta \max} \quad (4)$$

In this equation, $\Delta_i(t) = |y_0(t) - y_i(t)|$, $\Delta \min = \min_{i=1,2,\dots,m} \min_{t=1,2,\dots,n} \Delta_i(t)$, $\Delta \max = \max_{i=1,2,\dots,m} \max_{t=1,2,\dots,n} \Delta_i(t)$, $i=1, 2, \dots, m$; $t=1, 2, \dots, n$, p is the resolution coefficient, generally ranging from 0.1 to 0.5. In this analysis, p is taken as 0.5.

The correlation between the reference sequence and the comparison sequence is calculated by taking the average of the correlation coefficients at each time step of these two comparison sequences, that is:

$$y_{oi} = \frac{1}{n} \sum_{t=1}^n \varepsilon_{oi}(t), i = 1, 2, \dots, m \quad (5)$$

Sort by the size of y_{oi} and distinguish their degree of association. The larger the y_{oi} value, the greater the degree of correlation; On the contrary, the smaller the value of y_{oi} , the lower the degree of correlation.

4 Empirical Analysis

4.1 Evaluation of the Development of Digital Economy in Shanwei City

Based on the raw data of various indicators in Shanwei City from 2013 to 2022, the entropy weight method was used to calculate the weights of each indicator, as shown in Table 2:

Table 2. Weight of evaluation indicators for the development of digital economy.

First level indicators	Second level indicator	Indicator weight
Digital infrastructure	mobile phone users	0.1744
	Internet broadband access account	0.1251
	Information transmission, computer services, and software industry professionals	0.0830
	Total amount of postal services	0.1833
Development of Digital Economy	Output value of computer, communication and other electronic equipment manufacturing industry	0.1290
Innovation in Digital Technology	Value added of high-tech industries	0.0820
	Invention patent authorization	0.2232

From the results in Table 2, it can be seen that the indicators of mobile Internet users, postal business volume and invention patent authorization have a large weight, while the indicators of information transmission, computer service and software industry employees and high-tech industry added value have a small weight.

According to the weighted sum method, the comprehensive evaluation level of digital economy development in Shanwei City from 2013 to 2022 was calculated, and the calculation results are shown in Table 3.

Table 3. Comprehensive evaluation level of digital economy development.

Time	Digital infrastructure	Development of Digital Economy	Innovation in Digital Technology	Comprehensive evaluation level of digital economy development
2013	0.0919	0.0299	0.0765	0.1984
2014	0.1257	0.0550	0.0662	0.2469
2015	0.1267	0.0479	0.0998	0.2745
2016	0.1131	0.1119	0.0934	0.3183
2017	0.1926	0.0855	0.0353	0.3135
2018	0.3119	0.0991	0.1492	0.5602
2019	0.3055	0.2047	0.1065	0.6168

2020	0.2501	0.2781	0.2551	0.7832
2021	0.3103	0.2128	0.1851	0.7082
2022	0.3280	0.2712	0.1315	0.7308

Drawing upon the aforementioned information, it is evident that Shanwei City's digital economy has embarked on an upward trajectory, showcasing a pronounced growth pattern. Over the span from 2013 to 2022, the index of digital economy development in the city has surged from 0.1984 to 0.7308, marking a substantial escalation of approximately 370%. Notably, despite a temporary setback in 2021, the level of development remains elevated compared to pre-2018 levels.

These statistical insights offer a glimpse into the dynamic evolution of Shanwei's digital economy over the past decade, underscoring the city's strides towards digital transformation. The observed expansion underscores the tangible accomplishments achieved in this realm, with the digital economy progressively enhancing its contribution to the overall economic landscape, signifying a shift towards a more digitized and prosperous future.

4.2 Analysis of Factors Influencing the Digital Economy in Shanwei City

The results were obtained using the grey relational model, as shown in Figure 1.

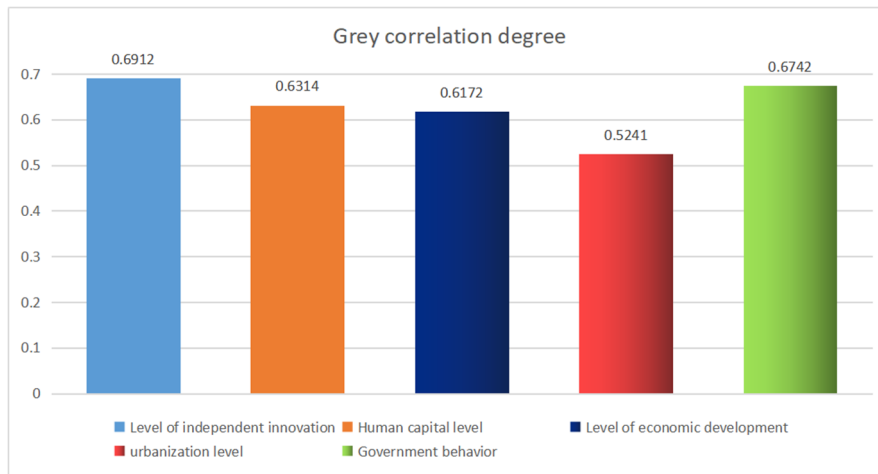


Fig. 1. Grey correlation degree result.

The grey relational analysis reveals a strong correlation between various factors, including the level of independent innovation, human capital, economic development, and government behavior, with the advancement of the digital economy in Shanwei City. This underscores their pivotal role in shaping the digital economy's development trajectory. Conversely, the urbanization level exhibits a comparatively lower grey correlation degree, suggesting a more muted influence on the digital economy's progression. Notably, key drivers like independent innovation display a particularly intimate

linkage with the digital economy, emphasizing their significance as primary catalysts for growth.

5 Conclusion

To comprehensively assess the development level of the digital economy in Shanwei City, we have devised a multifaceted evaluation system encompassing seven indicators across three dimensions: digital infrastructure, digital economic development, and digital technology innovation. By leveraging the entropy weight method and weighted sum approach, our analysis of the comprehensive indicators underscores a steady and upward trend in Shanwei's digital economy over recent years. From a modest 0.1984 in 2013 to a notable 0.7308 in 2022, the digital economy's prominence within the city's economic fabric has become increasingly evident.

This evolution underscores not only the city's economic transformation and upgrading but also underscores the pivotal role the digital economy will play in shaping its future economic landscape. Furthermore, our grey relational analysis delves into the intricate web of factors influencing Shanwei's digital economy, revealing that all factor variables contribute positively to its development. Notably, independent innovation, government behavior, and human capital emerge as the primary drivers, closely followed by economic development and urbanization levels.

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