Research into the Innovative Development of Digital Economy in Binhai New Area, Tianjin

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ABSTRACT As a developing economic form with strong growth potential, the digital economy is supported by the coordinated development of digital industrialization and industrial digitization, and plays an important role in regional economic growth and industrial restructuring. In engineering-oriented regions, this transformation is increasingly reflected in advanced manufacturing fields such as communication equipment, antenna manufacturing, electromagnetic components, and intelligent sensing devices, where computing power, data resources, and digital platforms directly affect design efficiency and production coordination. The digital economy in Binhai New Area, Tianjin has developed over many years and has become an important factor supporting sustainable regional development. Based on the theory of new quality productivity, this study explores the supporting role of computing power resources in digital economy development. SWOT analysis and grey relational analysis are used to examine the relationship between the digital economy, its sub-industries, and the real economy. The results are intended to provide a reference for Binhai New Area to strengthen digital infrastructure, improve the integration of digital technologies with advanced manufacturing, and release the development potential of the digital economy. These efforts can support the upgrading of engineering industries related to electromagnetic wave applications, antenna systems, and communication technology.

INDEX TERMS digital economy, new quality productivity, grey relational analysis, antenna manufacturing, electromagnetic components

I. INTRODUCTION

THE 20th National Congress of the Communist Party of China indicated that efforts should be made to hasten the construction of a cyber power as well as a digital China. The Third Plenary Session of the 20th Central Committee of the Communist Party of China focused on deepening the digital China strategy . It comprehensively planned to expedite the establishment of systems and mechanisms that would support digital economy development. Moreover, it aimed to optimize the policy framework so as to facilitate the transformation of the digital industry and the digitalization of industries [1]. In February 2024, General Secretary Xi Jinping visited Tianjin. He highlighted the crucial position of Tianjin in the National-level Advanced Manufacturing and R&D base. He also believed that Tianjin was at the forefront of the progress of the times. The scientific, educational and resource advantages of Tianjin have provided a robust driving force for the development of new productive forces. In the face of the wave of the latest round of scientific and technological revolution and industrial transformatio, Tianjin needed to adopt a forward-looking strategic vision. It had to seize the initiative and strive for excellence in developing new productive forces. It also had to lead the high-quality development of the regional and even national economy with outstanding practical achievements. This included actively promoting the deep integration of digital technology with traditional manufacturing. Specifically, it involved using AI and big data to upgrade and modernize cornerstone sectors. This would drive innovation in product customization and efficiency. In particular, in August 2024, the State Council issued the "Several Policy Measures on Further Supporting the High-Quality Development of Tianjin Binhai New Area", This move strongly supported the development of Binhai New Area. As the main engine of Tianjin's economic development, Binhai New Area has a solid foundation for developing the digital economy. Whether in the accumulation of digital technology or the layout of the digital industry, it demonstrates vigorous development potential. During this important opportunity period for the development of the digital economy, priority should be given to promoting the growth of new productive forces based on local conditions. Efforts should be accelerated to develop the digital economy and inject new momentum into the sustainable development

of the region.

II. CURRENT STATUS OF DIGITAL ECONOMY DEVELOPMENT IN TIANJIN BINHAI NEW AREA

A. OVERVIEW OF DIGITAL INFRASTRUCTURE

1) Information Service Infrastructure

The Northern Big Data Trading Center has been officially registered and commenced operations. By the end of 2024, the center had attracted over 500 data providers and third-party service institutions, with more than 1,500 data products listed. It has achieved mutual recognition and interoperability with 23 data trading institutions nationwide, with cumulative transaction volume surpassing the 600 million yuan threshold. Additionally, branch centers and service bases have been established in Shenyang City (Liaoning Province), as well as Hexi District, Hebei District, Hedong District, and Tiankai Park in Tianjin, forming a multi-point layout and collaborative development pattern. This accelerates the cultivation of the data factor market and gradually establishes a comprehensive data factor ecosystem.

2) Computing Power Infrastructure Status

The overall computing power in the region by 2024 will be around 3900P, which comprises 55% usage of general-purpose computing power 3007.78P and supercomputing, and 780 P of intelligent computing power 883.5 P (with 780 P being constructed and it is anticipated to be in operation within the year). The Tianjin Binhai Computing Power Scheduling Platform has been established, and the China Computing Power Network has been launched, which can allocate 1200P of general-purpose computing power, 7400P of intelligent computing power, and 1000P of supercomputing power. In collaboration with the Northern Big Data Trading Center, it achieves real-time and flexible cross-regional and cross-architecture computing power scheduling, forming an integrated service model of "computing power trading + large model trading + data trading".

3) Development of New Network Infrastructure

As of the end of 2024, Binhai New Area had deployed 15,3445G base stations, accounting for nearly 30% of the city's total, achieving full 5G network coverage. Approved as a national pilot city for IPv6 technology innovation and integrated applications, the area has fully upgraded to IPv6. It became Tianjin's first to establish an integrated government cloud and industrial cloud platform combining information innovation and IPv6, with all newly added home network communication terminals supporting IPv6. Government applications now achieve full IPv6 coverage, while smart ports are equipped with 5G+IPv6 support environments.

4) Data Resource Development

The district established a Data Bureau to strengthen resource coordination, enabling 27 organizations to complete classification and grading of government data across 96 information systems. A catalog of 1,060 entries was published on the municipal unified information resource platform, achieving near-complete sharing of government data. High-quality datasets from 25 enterprises spanning 42 industries were collected, including the Binhai New Area Ring Expressway Vehicle Traffic Transaction dataset. As Tianjin's first listed highway data asset, it has registered over 10 million yuan in transaction value with an estimated worth exceeding 50 million yuan. This achievement not only demonstrates the critical value of data assets in transportation but also provides new data-driven support and value extraction pathways for cultivating new productive forces in Binhai New Area. It serves as a positive model for advancing regional economic digital transformation and high-quality development.

B. CURRENT STATUS OF DIGITAL INDUSTRY DEVELOPMENT

In 2024, the digital economy in Binhai New Area achieved steady and robust development. The number of enterprises above designated size in the core digital economy sectors reached 1,013, an increase of 96 compared with 2023. Collectively, these enterprises posted an operating revenue of 363.78 billion yuan, representing a year-on-year growth of 7.2% and accounting for nearly 60% of the city's total. Meanwhile, they realized a total profit of 16.02 billion yuan. Some of its key features are:

1) The Development Zones Demonstrated Exceptional Performance in Both Supporting and Leading the Digital Economy

In the Economic Development Zone, the core digital economy industries earned 147.58 billion yuan, which was an increase of 10.9 percent compared to the previous year, and accounted for 40.6 percent of the total, making it the leader in the market. The bonded zone's core digital economy industries achieved 71.15 billion yuan in revenue, up 17.2% year-on-year and contributing 19.6%, reflecting strong growth momentum. The high-tech zone core digital economy industries had revenue of 92.36 billion yuan, up 0.9% over the previous year and accounting for 25.4% of the overall revenue. The Sino-Singapore Tianjin Eco-City's core digital economy industries generated 28.05 billion yuan in revenue. Meanwhile, the North Big Data Trading Center was established here, which has facilitated the efficient cross-regional circulation of data elements. The Dongjiang Comprehensive Bonded Zone's core digital economy industries achieved 17.23 billion yuan in revenue, up 11.3% year-on-year and contributing 4.7% of the total. The sub-districts' core digital economy industries generated 7.41 billion yuan in revenue, up 11.4% year-on-year and contributing 2% of the total.

2) The Digital Product Manufacturing Sector Has Rapid Growth

With revenues reaching 171.23 billion yuan (a 14.2% year-on-year increase), it now accounts for 47% of the total dig-

ital industry revenue. Backed by the Xinchuang Haihe Laboratory, this sector has attracted over 1,000 enterprises and established two national new industrialization demonstration bases, specializing in electronics and software/information services respectively. China has developed a leading GPU operating system database full industrial chain under the leadership of such pioneers in the industry as Phytium and Kylin, which has led to the accelerated growth of digital technology application, factor-driven digital industries, and digital product-service sectors.

3) The Industrial Digitalization Market Holds Tremendous Growth Potential

Driven by artificial intelligence, this sector has attracted over 500 related enterprises, with an industry scale exceeding 300 billion yuan and generating approximately 300 AI-integrated application scenarios. The region boasts 103 municipal-level digital workshops and smart factories, where digital transformation accounts for over 40% of operations, spanning four major industries: consumer goods, raw materials, equipment manufacturing, and electronics. To date, it has been recognized as a national smart manufacturing demonstration zone (6 factories), an outstanding smart manufacturing scenario (12), and nurtured 28 industrial internet platforms. Leading enterprises like Yunju and Didi Chuxing have clustered here, fueling the sector's development.

4) The Xinchuang Industry Is the Most Prominent One

During the initial 10 months of 2024, the size of Tianjin Xinchuang industrial chain was over 110 billion yuan in history, with an increase rate of 24.4 percent. The High-tech Zone plans to build a 58-square-kilometer "China Xinchuang Valley", releasing 9 supportive policies, allocating 1 billion yuan in special funds annually, and establishing a 10-billion-yuan industrial fund to promote development. It constructs a "three zones and one core" spatial structure and implements five major projects. Under the leadership of leading enterprises such as Sugon, the High-tech Zone has formed a complete industrial chain covering "CPU, operating system, database, server, peripheral terminals, supercomputing, and information security". It releases "100 benchmark scenarios" and "100 high-quality products" annually to promote the deep application of Xinchuang products.

C. SWOT ANALYSIS OF THE INNOVATIVE DEVELOPMENT OF THE DIGITAL ECONOMY IN TIANJIN BINHAI NEW AREA

The digital economy in the Binhai New Area has taken shape over a period exceeding 10 years, ever since it was raised to the national level in 2009.

1) Strengths (S)

1. A robust industrial foundation provides strong support for the growth of the digital economy. As the largest advanced manufacturing base in northern China, the new district boasts a comprehensive industrial structure, with 41 industrial categories covering 35 sectors. During the 14th Five-Year Plan period, it has established a "1 + 3 + 4" key industrial layout. The area is home to five billion-yuan industrial clusters, including petrochemicals, with the added value of large-scale industries growing by 5.5%, demonstrating strong industrial vitality. The district focuses on upgrading manufacturing towards intelligent, and green development, driving the transformation of pillar industries like green petrochemicals and fostering the rapid expansion of sectors such as biomedicine. Additionally, eight emerging industries, including cell and gene therapy, have begun to take shape, injecting new momentum into the region's sustainable economic development.

2. The thriving digital economy is driven by a growing number of innovative entities. By the end of 2024, the new district had won 6 National Science and Technology Awards and recognized 1,756 National High-Tech Enterprises, demonstrating enhanced technological capabilities. It boasts a multi-tiered enterprise ecosystem including fledgling startups, high-growth companies, and technology leaders (in cultivation). The district has achieved significant progress in research platform development, featuring national and municipal key laboratories that provide robust innovation infrastructure. Throughout the year, 4,191 technology contracts were signed, generating 80.46 billion yuan in transaction value—a 11.5% increase—reflecting notable achievements in technology commercialization. The establishment of the District Intellectual Property Office spearheaded reforms in IP management systems. By year-end, the district maintained a strong portfolio of valid invention patents and high-value patents, with over 130 valid inventions per 10,000 population, significantly enhancing IP protection and technology transfer capabilities.

3. A favorable business environment has become fertile ground for digital economy development. In 2024, the new district successfully implemented 8 national and municipal-level reform and innovation pilot programs, adding 60,300 new business entities—including domestic industrial ecosystem enterprises, foreign-funded enterprises, and individual businesses—fully unleashing market vitality. Significant progress was made in major project introductions, including the establishment of China's first central-level headquarters for resource recycling utilization and Tianjin's first central-level headquarters, injecting new momentum into regional economic growth. Additionally, the nation's first centralized fair competition review office for free trade zones was established, with supporting review measures issued to fill domestic policy gaps and create a more equitable and transparent competitive environment for market entities.

2) Disadvantages (W)

1. The digital economy remains relatively underdeveloped. Despite years of progress, Binhai New Area has achieved significant growth in this sector, now holding a pivotal position citywide. However, it still trails behind leading

regions. For instance, in 2024, the core digital economy industries accounted for 28.8% of Hangzhou's GDP [2], 27% of Guangzhou's, and 18.5% of Suzhou's, while Binhai New Area's share stood at only 11%, indicating room for further enhancement in its digital economy competitiveness.

2. Weak corporate competitiveness. First, the lack of leading enterprises. Currently, Binhai New Area lacks pillar enterprises with annual revenues exceeding 100 billion yuan to drive industrial development, with only six companies reaching the 10-billion-yuan threshold, resulting in a shortage of core-competitive industry leaders. Second, low industrial sophistication. Most enterprises remain at the front end of the industrial chain and the lower end of the value chain, with weak foundations in strategic emerging industries like intelligent equipment manufacturing related to cutting-edge digital economy technologies.

3. Significant disparities exist in the digital transformation progress of traditional industries. Large enterprises generally demonstrate strong commitment to digital transformation, actively building platforms to connect upstream and downstream enterprises. In contrast, most small and medium-sized enterprises (SMEs) face challenges such as reluctance, hesitation, and lack of expertise due to limited hardware upgrades, weak digital infrastructure, and high uncertainty about ROI.

3) Opportunities (O)

1. Central and local leaders attach great importance to it. The CPC Central Committee and State Council released the Overall Layout Plan for Digital China Construction in February 2023 [3], which focused on the importance of constructing Digital China as a means of promoting Chinese-style modernization and creating new competitive advantages for the country, offering planning guidance to Binhai New Area to follow the spirit of the center and encourage the combination of digital and real economies [4]. In January 2024, General Secretary Xi Jinping made an inspection tour in Tianjin, which offered new prospects for the development of the digital economy. The General Secretary stressed that Tianjin is a leading base for manufacturing and R&D in the country and should fully utilize its advantages to actively strive for new heights in cultivating new productive forces and demonstrating its capabilities. This provides clear direction and strong impetus for Binhai New Area to promote the development of the digital economy.

2. Deepening reforms have injected new momentum. In January 2024, the General Office of the Tianjin Municipal People's Government issued the Interim Measures for the Administration of Public Data Authorized Operation Pilots in Tianjin, which clarified the practical pathways for public data authorized operation and promoted the integration, sharing, development and utilization of data resources. On the same day, the Tianjin Municipal Data Bureau was officially established, further coordinating the management of data resources across the city. In August 2024, the State Council issued the Several Policy Measures to Further Support the High-Quality Development of Tianjin Binhai New Area, which urged the area to promote industrial development through technological innovation. The continuous introduction of favorable policies has created a sound market environment for the development of the digital economy in Binhai New Area.

4) Challenges (T)

1. Financial support for the digital economy remains relatively inadequate. The core industries of the new district's digital economy focus on digital technology applications, where technology is undoubtedly the key driver of development. However, in actual financial operations, the use of intellectual property as loan collateral has not been widely adopted. Many startups primarily rely on incubator policy support to sustain operations, but such support policies typically have a 3-year validity period. Once the policy expires, if the company's development prospects are poor, funding support may abruptly cease, leaving the company at risk of capital chain rupture and development stagnation. Many investors are optimistic about the digital economy but refrain from investing, adopting a wait-and-see approach, which results in the digital economy failing to expand rapidly.

2. The development of the digital economy is constrained by talent shortages. With the accelerated iteration of emerging fields such as artificial intelligence, big data, cloud computing, and the industrial internet, the market demand for digital technology professionals has witnessed explosive growth. However, the curriculum design of digital economy-related programs in many universities remains theoretically oriented, lacking in-depth integration with enterprise practice scenarios. This has resulted in an insufficient supply of digital economy talents, particularly a shortage of interdisciplinary talents. Consequently, many high-quality digital technologies and products struggle to break through the predicament of "successful piloting yet stalled scaling-up" and be transformed into the actual productive forces of enterprises.

III. MECHANISM ANALYSIS OF NEW PRODUCTIVITY EMPOWERING THE DEVELOPMENT OF DIGITAL ECONOMY

As per the National Bureau of Statistics, industrial digitalization is an important part of the digital economy, and so is digital industrialization. In industrial digitalization, digital technology holds significance, and in digital industrialization, digital elements are a crucial driving force for the digital economy. Industrial digitalization can be viewed as the integration of digital technology with the real economy [5], aiming to enhance production efficiency in traditional industries and assist in developing new industrial systems.

TABLE 1. SWOT Matrix of Digital Economy Situation in Binhai New Area

Strengths (s)	Weaknesses(W)
1. A strong industrial foundation supports the development of the digital economy; 2. The business environment is favorable, and market entities are active; 3. Strong scientific and educational strength and strong innovation ability.	1. The scale of the digital economy is small; 2. The enterprise has no obvious advantage in the competition; 3. The degree of digital transformation of traditional industries is uneven.
Opportunities (O)	Threats (T)
1. The central and local governments attach great importance to it; 2. Deepening reform brings new impetus.	1. Insufficient financial support for the digital economy; 2. The development of the digital economy is constrained by talent shortages.

1) The Effective Utilization of Computing Resources Drives Digital Economic Growth

Industrial digitization and digital industrialization constitute the fundamental pathways for the evolution of the digital economy. [6], which are supported strongly by sustainable computing resources. As industrial digitization unfolds and data assets are being created, computing resources act as the core underpinning that enables enterprises to conduct internal digital management, smart production, and networked operations. This enables enterprises to increase production intelligence and automation, increase efficiency, decrease costs, and enhance core competitiveness and market adaptability. With abundant computing resources harnessed in the process of advancing digital industrialization, the efficiency of information-to-data conversion can be increased, promoting further industrial development based on data elements. For instance, in fields like intelligent technology and blockchain, computing resources are crucial for supporting intelligent development and ensuring data security and credibility.

2) The Urgent Need for Computing Power Is Driving the Creation of Network Infrastructure

Computing resources and network infrastructure are interdependent and mutually reinforcing. With continuous advancements in network technology, data transmission speeds have significantly improved. The rapid development of technologies like blockchain, big data, and artificial intelligence has created broader applications for computing resources. Meanwhile, increased computing power has driven the optimization of network infrastructure, enabling more refined digital and industrial division of labor. Digital industrial clusters are continuously emerging and strengthening, forming a solid foundation for the development of the digital economy through this two-way synergy.

3) The Computing Power Has Emerged as One of the Most Important Measures of Digital Economy Growth

High level of computing power is an indication of high technology, effective use of resources and promising opportunities but also indicates that a city has high productivity and regional competitiveness. Consequently, nations and regions are racing to enhance their computing power capabilities to gain greater developmental advantages and competitive edges. With the continued development of the digital economy, the role of computing power resources will become even more significant. Thus, enhancing computing power infrastructure and enhancing computational abilities have been critical issues in the development of the digital economy across the globe.

In summary, the interconnection of data elements has created a mutually reinforcing and co-developing network among computing power resources, digital industrialization, and industrial digitalization. Computing power resources are a foundational infrastructure, offering both technical support and resource assurance for the digital transformation of various industries as well as the growth of the digital economy. Digital industrialization entails processing data into data assets by leveraging computing power resources, hence it is pioneering new industries, which represents a unique direction that differentiates the digital economy from traditional economies. Industrial digitalization serves as a crucial pathway for enterprises within traditional sectors to undergo transformation and upgrade, while also offering data support for digital industrialization. These three facets collectively propel the progress of the digital economy, establishing a robust foundation for industrial transformation, upgrading, and digital transformation. The three facets mentioned earlier collaborate to drive the advancement of the digital economy, laying a solid foundation for industrial transformation, upgrading, and digital transformation.

IV. CORRELATION ANALYSIS OF THE INNOVATIVE DEVELOPMENT OF THE DIGITAL ECONOMY IN TIANJIN BINHAI NEW AREA

A. RESEARCH METHODS

The Grey Correlation Analysis (GCA) falls under the category of multivariate statistical techniques, and its primary purpose is to gauge the degree of relationships existing among variables within a given system. Geometrically, this method transforms data samples into sequence curves, assessing their correlation by comparing curve similarities with a reference sequence. Stronger curve similarity indicates higher correlation, while weaker similarity suggests lower correlation [7] The detailed calculation procedures are outlined as follows:

(1) Determine the reference column and comparison column. The reference column is denoted as $X_0(k) = \{X_0(1), X_0(2), \ldots, X_0(n)\}$, where $k = 1, 2, \ldots, n$; the sequence of comparison numbers is denoted as $X_i(k) = \{X_i(1), X_i(2), \ldots, X_i(n)\}$, where $i = 1, 2, \ldots, n$;

(2) Data are dimensionless by the initial value method.

$$X_0'(k) = \frac{X_0(k)}{X_0(1)}$$

$$X_i'(k) = \frac{X_i(k)}{X_i(1)}, \qquad i = 1, 2, \ldots;\ k = 1, 2, \ldots, n;$$

(3) Calculate each comparison sequence separately. The absolute difference $\Delta_i(k)$ between X_i and the reference sequence X_0:

$$\Delta_i(k) = \left|X_0'(k) - X_i'(k)\right|, \quad i = 1, 2, \ldots; \qquad k = 1, 2, \ldots, n;$$

(4) Let $\Delta_i(k)$ be the maximum value and $\Delta_{\min}$ the minimum value, where $i = 1, 2, \ldots;\ k = 1, 2, \ldots, n$.

(5) The correlation coefficient $\zeta_i(k)$ for each associated sequence X_i at point k is calculated using the following formula:

$$\zeta_i(k) = \frac{\Delta_{\min} + \rho\Delta_{\max}}{\Delta_i(k) + \rho\Delta_{\max}}$$

ρ is the resolution coefficient, which is in the range of 0–1. In this study, ρ is 0.5.

(6) Calculate the grey relational degree of each comparison sequence X_i.

B. SELECTION OF INDICATORS

According to the grey relational analysis theory, as well as the classification of the digital economy by the National Bureau of Statistics, the research data shows that the development of Tianjin in various sectors of the digital economy, such as digital product manufacturing, digital product services, digital technology applications, digital factor-driven industries, and digital efficiency enhancement, is still in an underdeveloped state [8]. Using Tianjin's Digital Economy Development Index since 2018 as a reference variable, multiple industry indicators from Tianjin's National Economic and Social Development Statistical Bulletin and national digital economy data across provinces and cities have been extracted to replace the aforementioned industrial variables, which are considered key factors influencing digital economy development. For details, please refer to the table below. (To ensure data continuity, quantitative analysis was conducted using data from 2018 to 2024.)

TABLE 2. Factors Influencing the Development of the Digital Economy in Tianjin

estate	trade	name of index	2018	2019	2020	2021	2022	2023	2024
digital economy	Digital industry	Tianjin Digital Economy Development Index x0	0.732336	0.757146	0.72072	0.782854	0.775908	0.816914	0.804056
digital industrialization	electronic information manufacturing industry	Number of manufacturing enterprises in the electronic information industry (x1)	443	518	495	523	499	568	541
	Software industry	Revenue scale of software products (billion yuan) x2	5179.7515	5227.5884	5314.289	5302.1397	5311.3489	5479.8591	5992.0263
	Telecommunications industry	Total telecom business volume (billion yuan) x3	1634.757	1622.526	1593.6921	1681.1985	1677.2027	1705.7164	1764.2798
	Internet and related services	Number of top 100 internet companies (x4)	5	5	5	5	5	5	6
industrial digitization	Digital Efficiency Enhancement Industry	Integration Development Level Index of Informatization and Industrialization (x5)	0.613961209	0.619580143	0.610031822	0.653886632	0.65243776	0.706320183	0.64553636
exotic environment	social environment	Employment rate of digital knowledge workers (%) y1	93.81542248	94.39106243	93.76829452	96.08103288	93.14834441	92.32876908	93.55669724
	technical environment	R&D expenditure (in billions of yuan) y2	1181.8292	1333.2887	1236.1501	1322.9293	1329.7822	1439.3535	1398.2534
	financial environment	Digital Inclusive Finance Index y3	328.97	327.03	308.89	344.03	324.69	353.38	358.28
	economic environment	GDP (billion yuan) y4	18809.64	14104.28	14083.73	15695.05	16132.16	16737.3	18024.32
		Value Added of the Primary Industry (in billions of yuan) y41	172.71	185.23	210.18	225.41	273.15	268.53	284.28
		Value Added of the Secondary Industry (in billions of yuan) y42	7609.81	4969.18	4804.08	5854.27	6038.93	5982.62	6214.27
		Value Added of the Tertiary Industry (in billions of yuan) y43	11027.12	8949.87	9069.47	9615.37	9999.26	10486.15	11525.77

Data sources: Tianjin Municipal Statistical Bulletin on National Economic and Social Development (2018–2024), National Bureau of Statistics, China Academy of Information (Data sources: Data city: http://www.caam.org.cn/house-a093-b07385/chn/3/cate_17/con_5236826.html)

Index Selection Explanation: x0 represents Tianjin's digital economy development index [9], serving as a benchmark to measure the progress of digital economy development. Other indicators are used to compare with x0, demonstrating their respective correlations. Specifically, x1 (number of manufacturing enterprises in the electronic information industry), x2 (software product revenue scale) [10], x3 (total telecom service volume), x4 (number of top 100 internet enterprises), and x5 (index of integrated development between informatization and industrialization) reflect the development status of five sub-industries: electronic information manufacturing, software industry, telecommunications, internet and related services, and digital efficiency enhancement. Through analysis, the influence relationships between these five sub-industries and the digital economy are explored. y1–y4 reflect the impact of external factors on the digital economy: y1 (employment proportion of digital knowledge workers) indicates the influence of talent constraints on the digital economy; y2 (R&D expenditure) reflects the impact of technological investment on the digital economy; y3 (digital inclusive finance index) demonstrates the influence of finance on digital economic development; and y4 (GDP) serves as a key indicator for evaluating Tianjin's economic conditions. Studying the correlation between the added value of primary, secondary, and tertiary industries and the digital economy (y41, y42, y43) can more accurately reveal the enabling pathways of macroeconomic factors for digital economic development [11]

C. GREY CORRELATION ANALYSIS

1) Dimensionless Data Processing

TABLE 3. Dimensionless Tables

name of index	2018	2019	2020	2021	2022	2023	2024
Tianjin Digital Economy Development Index x0	1	1.033877892	0.984138428	1.068981997	1.05949728	1.115490704	1.097933189
Number of manufacturing enterprises in the electronic information industry (x1)	1	1.169300226	1.11738149	1.180586907	1.126410835	1.282167043	1.221218962
Revenue scale of software products (billion yuan) x2	1	1.009235366	1.025973736	1.023628199	1.025406122	1.05793861	1.15681733
Total telecom business volume (billion yuan) x3	1	0.992518154	0.974880122	1.028408809	1.025964532	1.043406696	1.079230613
Number of top 100 internet companies (x4)	1	1	1	1	1	1	1.2
Integration Development Level Index of Informatization and Industrialization (x5)	1	1.009151937	0.993599943	1.065029227	1.062669352	1.150431285	1.051428576
Employment rate of digital knowledge workers (%) y1	1	1.006135878	0.999497652	1.024149658	0.992889463	0.984153422	0.997242189
R&D expenditure (in billions of yuan) y2	1	1.128156844	1.04596341	1.119391279	1.125189833	1.217903145	1.183126462
Digital Inclusive Finance Index y3	1	0.994102806	0.938960999	1.04577925	0.986989695	1.074201295	1.089096275
Gross Regional Product (billion yuan) y4	1	0.749843166	0.748750641	0.834415225	0.857653841	0.889825643	0.958249068
Value Added of the Primary Industry (in billions of yuan) y41	1	1.07249146	1.216953274	1.305135777	1.581552892	1.554802849	1.645996179
Value Added of the Secondary Industry (in billions of yuan) y42	1	1.033877892	0.984138428	1.068981997	1.05949728	1.115490704	1.097933189
Value Added of the Tertiary Industry (in billions of yuan) y43	1	1.169300226	1.11738149	1.180586907	1.126410835	1.282167043	1.221218962

2) Compare Sequences

TABLE 4. Difference Table

name of index	2018	2019	2020	2021	2022	2023	2024
|x0-x1|	0	0.135422334	0.133243062	0.11160491	0.066913555	0.166676339	0.123285772
|x0-x2|	0	0.024642526	0.041835308	0.045353798	0.034091158	0.057552094	0.058884141
|x0-x3|	0	0.041359738	0.009258308	0.040573188	0.033532748	0.072084008	0.018702576
|x0-x4|	0	0.033877892	0.015861572	0.068981997	0.05949728	0.115490704	0.102066811
|x0-x5|	0	0.024725955	0.009461515	0.00395277	0.003172072	0.034940581	0.046504613
|x0-y1|	0	0.027742014	0.015359224	0.044832339	0.066607817	0.131337282	0.100691
|x0-y2|	0	0.094278952	0.061824982	0.050409282	0.065692553	0.102412442	0.085193273
|x0-y3|	0	0.039775086	0.045177429	0.023202747	0.072507585	0.041289409	0.008836919
|x0-y4|	0	0.284034727	0.235387788	0.234566772	0.201843439	0.225665061	0.139684121
|x0-y41|	0	0.038613568	0.232814846	0.236153779	0.522055612	0.439312145	0.548062989
|x0-y42|	0	0.3808813	0.352837515	0.299676325	0.265925561	0.329318644	0.281320159
|x0-y43|	0	0.222254368	0.161668917	0.197007266	0.152709288	0.164548844	0.05271286

The minimum difference between the two levels is 0, and the maximum difference is 0.548.

3) Calculate Correlation Coefficient

TABLE 5. Correlation Coefficients Table

name of index	2018	2019	2020	2021	2022	2023	2024
X1’	1	0.669235	0.672816	0.710571	0.803722	0.621771	0.689677
X2’	1	0.917484	0.867540	0.857982	0.889347	0.826416	0.823109
X3’	1	0.868849	0.967314	0.871021	0.890962	0.791715	0.936103
X4’	1	0.889963	0.945278	0.798875	0.821595	0.703482	0.728593
X5’	1	0.917228	0.966621	0.985778	0.988555	0.886901	0.854901
Y1’	1	0.90806	0.946919	0.859385	0.804444	0.67598	0.731269
Y2’	1	0.744001	0.815901	0.844612	0.806611	0.727924	0.76282
Y3’	1	0.873236	0.858456	0.921929	0.790747	0.869042	0.968756
Y4’	1	0.491008	0.5379	0.538768	0.575819	0.548367	0.662341
Y41’	1	0.876481	0.540631	0.537092	0.344197	0.384123	0.333307
Y42’	1	0.418396	0.437114	0.477621	0.507477	0.454154	0.493409
Y43’	1	0.552136	0.628917	0.581732	0.642123	0.624787	0.838656

4) Calculate the Arithmetic Mean of xi' to Obtain the Grey Relational Values and Their Rankings as shown in the table below

TABLE 6. Gray Correlation Degree and Ranking Table

name of index	Gray correlation	sort
x1	0.738256933	8
x2	0.883125818	4
x3	0.903709513	2
x4	0.841112913	6
x5	0.942855508	1
Y1	0.846579992	5
Y2	0.814553101	7
Y3	0.897452808	3
Y4	0.622029507	10
Y41	0.5736906	11
Y42	0.541167668	12
Y43	0.695479185	9

The computational results indicate that all 12 indicators exceed 0.5, demonstrating statistically significant impacts on the digital economy. The influence rankings are: x5> x3> x4> x2> x1, with Y3> Y1> Y2> Y43> Y4> Y41> Y42. From an industrial perspective, digital transformation serves as the primary driver. The digital efficiency enhancement sector, represented by the integration index x5, acts as the main engine for Tianjin's digital economy development. Within digital industrialization, the telecommunications sector (x3) forms the foundational pillar, its high relevance confirming the critical role of communication networks as a "basic link" for industrial synergy. The software industry (x2) acts as the key carrier for digital technology penetration across sectors, with its top-tier relevance highlighting software's core driving force. The internet and related services (x4) symbolize the ecosystem vitality of the digital economy, showing moderate-high relevance that indirectly indicates insufficient cultivation of leading internet enterprises and potential for ecosystem activation in Tianjin. The electronics manufacturing sector (x1) maintains moderate relevance to the digital economy, yet its industrial agglomeration effect remains inadequate, failing to fully leverage its "manufacturing foundation" support for digital industrialization.

From an external industrial perspective, the financial sector represented by Y3 exerts the most significant impact on digital economic development through its financing support for market entities' digital transformation. In contrast, computing power metrics constitute government-led core new infrastructure, serving as the foundational support for digital economy development. These two dimensions operate in complementary yet distinct roles: "supportive guarantees" and "core drivers". Tianjin Binhai New Area's development exemplifies this dynamic. In 2024, the local government established a 200-million-yuan digital economy fund to incubate upstream and downstream investments centered around the National Supercomputing Center Tianjin (Tianjin Supercomputing Center). The fund prioritizes high-quality enterprises in intelligent technologies, new energy, advanced materials, biomedicine, and precision manufacturing, effectively "adding weight" to the cultivation of new productive forces. This demonstrates the progressive relationship of "computing infrastructure first, financial support follows", which also explains why financial factors show higher correlation in grey relational analysis.

The talent support represented by Y1 and government R&D investment represented by Y2 significantly drive digital economic development, while the macroeconomic trend represented by Y4 exhibits a strong positive correlation with digital economic growth. Notably, the digital economy shows the strongest correlation with the tertiary industry sub-index Y43, surpassing even its relationship with regional GDP. This indicates that services form the core driver of Tianjin's digital economy. In contrast, the correlation between the primary industry sub-index Y41 and the secondary industry sub-index Y42 remains below 0.6, suggesting that digital technology's empowerment effects in agriculture and manufacturing are still limited, leaving substantial room for expanding digital application scenarios in these sectors.

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The basis of the quantitative analysis of grey correlation degree is the qualitative SWOT analysis, and the quantitative analysis of grey correlation degree addresses the issue that the level of the influencing factors is not accurate enough in the qualitative SWOT analysis.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSION

Through SWOT analysis, new quality productivity analysis, and grey relational analysis, it is evident that computing power serves as the core indicator of digital economic growth, establishing a "core foundation-supporting auxiliary" hierarchical relationship between computing power and digital inclusive finance. This increased computing capacity is also crucial for advancing smart manufacturing in sectors, enabling precise, real-time control over processes from fiber to finished garment, improving efficiency and waste reduction. Meanwhile, in the context of digital industrialization, computing power facilitates rapid data flow and the widespread adoption of new technologies, driving data to become a crucial asset in the digital economy. By establishing innovation networks, empowering application scenarios, and aggregating key resources, data elements promote the evolution of digital industrial clusters into more advanced forms. In terms of innovation, data elements eliminate information isolation, facilitate knowledge sharing and technological collaboration, thereby injecting new vitality into digital industrial clusters. From a scenario perspective, data deeply integrates into production, consumption, distribution, and social governance, giving rise to new business models within digital industrial clusters. Regarding resource allocation, data enables the concentration and efficient distribution of critical resources, enhancing cluster synergy and ecosystem interactions, thus forming a new digital industrial cluster ecosystem. The advancement of the digital economy now primarily relies on modern productivity factors such as computing power and information.

B. RECOMMENDATIONS TO THE DEVELOPMENT PLAN OF THE DIGITAL ECONOMY IN TIANJIN BINHAI NEW AREA IN THE 10TH FIVE-YEAR PLAN PERIOD

To give rise to fresh productive forces that are in accordance with local circumstances and lend support to the sustainable development of the digital economy within the Tianjin Binhai New Area during the 15th Five-Year Plan period, the below recommendations are put forward:

1) Proceed with Orderly Digital and Intelligent Reforms

Raise the usage of information technology within the realms of livelihood services and protection, enrich AI+ application scenarios, prioritize the development of the financial industry, empower grassroots bank branches with digital intelligence, implement inclusive finance, fully leverage the policy advantages of the financial reform demonstration zone to focus on developing "stablecoins", facilitate connections with financial centers such as Hong Kong, China and Singapore, and build an intelligent medical and health service system that covers the entire life cycle with precise functions. Develop an intelligent elderly care comprehensive system, utilizing information technology to provide diversified and professional elderly care services. Promote the advancement of intelligent cultural and sports endeavors, offering residents personalized and scientific cultural and fitness guidance and services. Enhance the efficiency of smart education services. We should also promote the extensive application of intelligent technologies and facilitate the development of diversified modern teaching models. Deepen the understanding and consensus on "intelligent transformation and digital transformation" to promote industrial innovation and upgrading. Promote the practical achievements of intelligent transformation and digital transformation projects.

2) Expand the Scale of Digital Core Industries

Focus on building industrial chains around core digital economy sectors, refine industrial blueprints, and formulate development roadmaps. Consolidate the "Three-Table" work-

ing mechanism comprising enterprise operation records, major project inventories, and problem-solving dashboards to promote deep integration between the real economy and digital economy. Actively cultivate leading enterprises. Coordinate efforts in industrial digitalization and digital industrialization, focusing on both attracting investments and nurturing enterprises. Introduce new investments by intensifying investment promotion in the digital economy sector; revitalize existing resources through enhanced field research services for key enterprises. Establish problem lists addressing operational challenges, implement ledger-based management, and drive comprehensive progress. Systematically plan major project reserves. Strengthen coordinated scheduling, continuously update investment promotion ledgers and key project inventories for major enterprises. Target national priorities in data annotation, data governance, and data infrastructure, actively seek support policies including "Two Major" projects and central budget funds, and strategically reserve major projects aligned with national investment directions to drive high-quality development of the new district's digital economy.

3) Expedite the Implementation of Green Digital Infrastructure

Create a Five-Year Plan to Develop Digital Infrastructure that will enhance funding, policy support and human resources in computing power. Keep constructing and enhancing data centers, cloud service platforms and supercomputing networks so as to ensure that the digital infrastructure is able to respond to the needs of the digital economy. Advocate the use of renewable energy and energy-saving practices to minimize carbon emissions in data centers and realize green and sustainable growth. Integrate planning between data centers and power grids, modify energy supply techniques, and motivate green power companies to provide electricity to data centers. Facilitate the creation of renewable energy plants and data center clusters. Be an active participant in the East Data West Computing project and become one of the key nodes in the Beijing-Tianjin-Hebei region.

4) Strengthen the Digital Economy Development

Enhance the joint construction mechanism between ministries and cities, strengthen collaboration among government agencies, universities, and enterprises, and focus on cultivating digital industry talents. Refine the digital skills education system, enhance discipline development in digital fields, and cultivate applied digital professionals in key areas such as big data, artificial intelligence, intelligent manufacturing, integrated circuits, and data security [12]. Support the expansion of Tianjin's digital economy statistics pilot program to district-level areas including Binhai New Area, capturing information on the development of artificial intelligence, big data, and computing power industries to prepare for systematic analysis of digital economy trends. Strengthen international exchanges by regularly hosting global conferences and technical forums to promote global collaboration in digital technology sharing. Research and formulate policies to accelerate the development of large-scale models and artificial intelligence industries, establish a digital economy alliance, and provide solid organizational support for digital industrialization and industrial digitalization.

In conclusion, the 15th Five-Year Plan period marks a pivotal phase for the rapid advancement of the digital economy. Binhai New Area should capitalize on its strengths in industrial infrastructure, innovation capabilities, and pioneering policy initiatives to drive high-quality digital economic development. It must strengthen financial support for the digital sector, deepen its integration with the real economy, uphold green development principles, and establish itself as a national pilot zone for digital economy innovation. These efforts will inject robust momentum into regional economic transformation and modernization [13].

AUTHOR CONTRIBUTIONS

Conceptualization – Jian Zhang and Ranjie Duan; methodology – Jian Zhang and Ranjie Duan; investigation – Jian Zhang and Ranjie Duan; writing-original draft preparation – Jian Zhang and Ranjie Duan. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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