Assessing the Development Level of the Digital Economy Using Fuzzy Comprehensive Evaluation: A Comparative Study of the Yangtze River Delta and Kyushu Region

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Abstract. In the context of economic development, the role of the digital economy is increasingly prominent. To deeply understand this phenomenon, this paper constructs a digital economy development evaluation model and applies the Analytic Hierarchy Process (AHP) to assign weights to 15 key indicators. Furthermore, the Fuzzy Comprehensive Evaluation Method is used to measure and compare the development of the digital economy in the three provinces and one city of the Yangtze River Delta in China and nine counties of the Kyushu area in Japan. The results show that Shanghai and Zhejiang provinces have the most outstanding performance in digital economy development, while Miyazaki Prefecture is relatively lagging. Based on these findings, this paper proposes to focus on the growth rate of patent numbers and strengthen the construction of innovative entrepreneurial ecosystems as recommendations to provide useful references for the future development of the digital economy.

Keywords: Digital Economy, Analytic Hierarchy Process (AHP), Fuzzy Comprehensive Evaluation, Influencing Factors.

1. Introduction

In the current context of vigorously developing the digital economy, the world is entering a new era of economic development dominated by the digital economy. Xi Jinping emphasized during the thirty-fourth collective study session of the Politburo of the 19th CPC Central Committee: "Digital technology and the digital economy are the vanguards of the world's scientific and technological revolution and industrial transformation, and are key areas in the new round of international competition." The "Asian Digital Economy Report" shows that China leads Asia in the scale of its digital economy, reaching USD 7.47 trillion in 2022, with Japan in second place at USD 2.37 trillion. This indicates the rapid development of the digital economy. Specifically, the Yangtze River Delta region, as a highland for China's digital economy development, accounts for nearly 30% of the national digital economy's scale, with over 493,000 5G base stations built by 2022, representing approximately 21% of the national total. Similarly, Japan's Kyushu region, closely linked to the Yangtze River Delta, ranked fourth nationally in the Digital Capability Index (DCI) in 2022. However, during the development of the digital economy, both China and Japan have encountered issues such as uneven digital economic development and low awareness of digital transformation among enterprises. Therefore, exploring the development of the digital economy in the Yangtze River Delta and Kyushu regions of Japan is particularly important.

Based on this, the paper first constructs a digital economy evaluation model, comprising four secondary indicators and fifteen tertiary indicators. The Analytic Hierarchy Process (AHP) is initially applied to assign weights to these indicators, where factors such as the internet user ratio, e-commerce employment, and online shopping transaction volumes are deemed significant. Subsequently, the model measures and compares the overall scores of four cities in the Yangtze River Delta of China — Shanghai, Zhejiang, Jiangsu, and Anhui — and seven prefectures in Japan's Kyushu region — Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, and Kagoshima. This comparison aims to provide policy recommendations to the government.

2. Literature Review

2.1. Study on Factors Influencing the Digital Economy

Zdrazil P, Kraftová I, and others [3] used a combination of Revealed Comparative Advantage (RCA), Multi-Factor Productivity (MFP) analysis, and a modified displacement share analysis to explore the factors influencing the economy. They identified global impacts and cross-industry regional characteristics as significant factors. Based on this, they suggested detailed analysis at the national level to properly support tools for the development of the digital economy in Europe. Zhouhuo Wang and others [4] analyzed the factors affecting the digital economy using edge computing and fuzzy clustering techniques, finding that the construction of digital infrastructure and advances in information technology are crucial. They recommended increasing investment in digital infrastructure in underdeveloped areas, accelerating innovation, dissemination, and application of new digital technologies, and enhancing the pace of digital innovation to improve the application levels of digital technology in these regions. Run Luo, Nianxing Zhou, and others [5] used Markov chains, the Gini coefficient, and geographical detectors to analyze the digital economy's influencing factors, identifying economic conditions and R&D expenditures as important. They proposed optimizing the allocation of monetary resources, increasing investments in digital technology research and development, and addressing the key shortfalls and bottlenecks in digital technology. Haita Wang, Xuhua H, Ali, Najabat, and others [6] utilized OLS and GWR methods to study the economic factors, finding that human capital, ICT personnel, telecommunications revenue, and internet access are crucial for economic development levels. They suggested increasing investments in human capital and technological innovation, reducing regional disparities, and promoting coordinated regional development.

Zhang Jiaxing and others [7] used panel entropy methods, Audi analysis, kernel density analysis, Gini coefficient analysis, spatial autocorrelation analysis, social network analysis, spatial econometric models, and geographical models to analyze the economic influencing factors. They found that the levels of economic development, government industrial structure, and industrial development are significant factors and proposed enhancing industrial structure levels, industrial development, government intervention, and consumer spending levels. Chen Fang and others [8] applied entropy methods, statistical and geographical information-based spatial analysis, and grey relational analysis to explore economic influencing factors. They identified the human resource index, the proportion of college-educated employment in the total workforce, and the share of R&D internal expenditure in GDP as crucial factors, suggesting reducing the disparities in digital economy development quality among regions. Jia Qi [9] used an improved CRITIC-entropy method combination, BP neural networks, and spatial econometric models to analyze economic factors, finding that the density of long-distance optical cable routes, the number of employees in the digital economy sector, and the proportion of R&D expenditure in the digital economy sector to GDP are important. They proposed improving intellectual property laws and absorbing talent development mechanisms. Zhang Fan and others [10] used volatility tests, VAR models, Johanson cointegration tests, and Granger causality tests to analyze the factors affecting the economy, finding that economic growth, government behavior, and human capital are significant factors. They suggested strengthening policy and institutional construction, accelerating the deepening of digital transformation in industries, increasing local government focus on digital economy development, seizing development opportunities, and enhancing the training of skilled and innovative talent, as well as reducing educational disparities across provinces.

2.2. Study on Digital Economy Development Trends

Pongsakorn Limna, Tanpat Kraiwanit, Supaprawat Siripipatthanakul, and others [11] employed a narrative synthesis approach to analyze the trends in digital economy development. They discovered that the concept of the digital economy supporting national development in various sectors has increasingly become a necessity. The digital economy, by providing goods and services through electronic communications and digital technologies, has become a continually growing economic activity. From this analysis, they proposed closely monitoring the digital economy, considering empirical and quantitative research. Evgeny E. Shvakov, Elena A. Petrova, and others [12] used correlation analysis methods, regression analysis, and the simplex method to formulate future scenarios for the sustainable development of the digital economy. They identified a new trend where digital economy development conflicts with global sustainable development goals, suggesting that achieving these goals may require limiting the growth rate of the digital economy. E.S. Markova, N.N. Zyuzina, P.A. Krovopuskov, and others [13] developed operational conceptual tools for "Digital Economy" and "Industry 4.0," uncovering negative outcomes such as the disappearance of traditional markets, replacement of some professions by automation systems, growth in cybercrime, vulnerability of human rights in digital spaces, threats to digital user data, and low levels of trust in digital environments. They suggested fostering public demand for digital technologies, particularly in the B2C sector.

Tsunekawa Kikumi and others [14] described the current state of Japan's digital transformation from a core technology perspective, noting the trend of specialization and complication in science and technology. They recommended skillfully mastering and responding to the trends of digital transformation (DX) and creative disruption, achieving multi-domain integration that transcends traditional fields. Wang Weiling, Wang Jing, and others [15] observed that competitive factors in the digital economy are shifting from user traffic to data, and the push for enterprises to massively empower is shifting towards on-demand production, with increasing regulation being a trend in China's digital economy development. They proposed establishing market systems adapted to digital development, enhancing information transparency and data openness, strengthening information property rights protection, encouraging business model and technological innovation, and promoting a nationwide awareness of information. Huang Jie, Cai Ying, and others [16] by analyzing the new trends proposed during China's "Fourteenth Five-Year Plan" period for the digital economy, suggested enhancing the design of development, innovating policy service tools, accelerating the digital transformation of industries, fostering new business forms and models in the digital economy, pushing new breakthroughs in core digital technologies, promoting data circulation, and advancing digital infrastructure construction. Zhang Pengfei, Li Yongjian, and others [17] found that the development of the industrial internet is an important trend promoting the integration of the digital and physical economies, and that strengthening core technology research to enhance the resilience of the digital economy and governing the digital economy to promote its regulated development are crucial. They proposed policies to promote the sustainable and healthy development of China's digital economy. Qian Minghui, Pan Fei, Qi Yue, and others [18] using demographic methods, discovered post-pandemic trends in the rural digital economy shifting from quantitative to qualitative growth, from supply-side to demand-driven, from singular to diverse development, and from unregulated to standardized and scaled operations. They suggested ensuring high-level investments in rural digital economy infrastructure, emphasizing logistical goods, organizational flows, promoting deep integration of digital technologies with agriculture and rural areas, and strengthening talent development in the rural digital economy sector.

2.3. Conclution

In summary, recent research shows that foreign scholars tend to focus on global and transnational factors and development trends, whereas Chinese scholars pay more attention to the impact of domestic policies and regulation on the development of the digital economy. However, they have not sufficiently addressed the local horizontal comparative analysis of geographical differences, and a deeper understanding of the heterogeneity and regional characteristics of the digital economy under different geographical contexts remains to be further explored. For example, few scholars have conducted comparative analyses of specific regions in China and Japan. Additionally, the timeliness of data is crucial for understanding the current state and future trends of the digital economy, as previous studies have used outdated data. Based on this, this paper uses the latest data from 2022 and combines the Analytic Hierarchy Process (AHP) with the Fuzzy Comprehensive Evaluation method for quantitative analysis. Initially, the AHP is used to assign weights to indicators, followed by the application of the Fuzzy Comprehensive Evaluation method to score and compare 11 regions studied in Japan and China, thereby addressing the deficiencies in previous studies.

3. Construction of the Analytic Hierarchy Process (AHP)

3.1. Preliminary Construction of Indicators and Data Sources

Based on the review of existing literature, this paper constructs a system of indicators consisting of four secondary indicators and fifteen tertiary indicators. The system of indicators is shown in Table 1 as follows:

Data sources: All data used in this study are cross-sectional data covering the period from January 1, 2022, to December 31, 2022. The data sources include the People's Republic of China Central People's Government (www.gov.cn), Fukuoka Prefectural Office (www.pref.fukuoka.lg.jp), CEIC Database (www.ceicdata.com), Japan Statistics Portal (www.stats.gov.cn), Xinhua News (www.news.cn), iiMedia Research Center (data.iimedia.cn), Wikipedia (zh.wikipedia.org), Microsoft Bing (www.bing.com), Rimaotong (www.rimaotong.com), Zhejiang Provincial Bureau of Statistics (tjj.zj.gov.cn), Zhejiang Provincial People's Government (www.zj.gov.cn), Jiangsu Provincial Bureau of Statistics (tj.jiangsu.gov.cn).

Table 1: Indicator System for Measuring the Development Level of the Digital Economy

Primary Indicator	Secondary Indicator	Tertiary Indicators
Digital Economy Development Overall Level	Digital Economy Infrastructure	Mobile broadband user penetration rate
		Mobile phone base stations
		Active IPv6 users
		Internet users ratio
		Number of internet websites
	E-commerce Scale	E-commerce economic value added
		E-commerce employment
		Online shopping transaction volume
	Digital Transformation Outcomes	Digital economy growth rate
		Proportion of ICT industry (digital industrialization) in GDP
		Digital economy contribution rate
	Innovation and Entrepreneurship	Number of start-ups
		Number of technology incubators
		Patent number growth rate over previous year
		Science and technology relationship funds

3.2. Hierarchical Analysis Method for Weight Construction

The Analytic Hierarchy Process (AHP) is a hierarchical weighting decision analysis method. It involves decomposing decision-making elements into levels such as objectives, criteria, and alternatives, and then performing both qualitative and quantitative analyses. Specifically, it employs the method of solving for the eigenvectors of judgment matrices to determine the priority weights of each element at a given level relative to an element at the preceding level. Subsequently, a weighted summation method is used to aggregate the alternative solutions weights with respect to the overall objective, with the solution having the highest final weight identified as the optimal choice.

3.2.1 Establishing a Hierarchical Structure Analysis Model

This study constructs four secondary indicators, namely digital economy infrastructure, e-commerce scale, digital transformation outcomes, and innovation and entrepreneurship activities, as well as fifteen tertiary indicators, as shown in Figure 1 below:

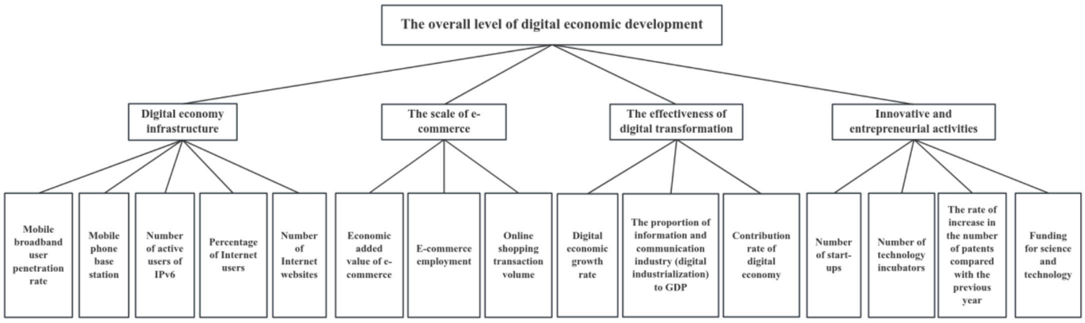

Figure 1 Hierarchical Structure Diagram

3.2.2 Establishing a Hierarchical Analysis Model

This study constructs four secondary indicators: digital economy infrastructure, e-commerce scale, digital transformation outcomes, and innovation and entrepreneurial activities. Additionally, fifteen tertiary indicators are established, as illustrated in Figure 1 below:

Table 2: Scaling Methods for Judgment Matrices

Scale	Meaning
1	ndicates that two elements are equally important.
3	Indicates that one element is slightly more important than the other.
5	Indicates that one element is significantly more important than the other.
7	Indicates that one element is strongly more important than the other.
9	Indicates that one element is extremely more important than the other.
2, 4, 6, 8	Represents the median value between two adjacent judgments.
Reciprocal	If the judgment of element i compared to j is Bij, then the judgment of j compared to i is Bji = 1/Bij.

3.2.3 Hierarchical Single Sorting and Consistency Test

To ensure the credibility of hierarchical single sorting, it is necessary to test the consistency of the judgment matrices, which involves calculating the Consistency Ratio (CR).

The formula for the Consistency Index (CI) is:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \tag{1}$$

The formula includes $\lambda_{\max}$, which represents the maximum eigenvalue of matrix A.

Random Consistency Index as shown in Table 3 below:

Table 3: Random Consistency Index

Order of the Judgment Matrix	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

The formula for the Consistency Ratio (CR) is:

$$CR = \frac{CI}{RI} = \frac{\lambda_{\max} - n}{RI(n - 1)} \tag{2}$$

Only when CR < 0.1, the results of the single ranking in the hierarchy are considered satisfactory; otherwise, it is necessary to adjust the values of the judgment matrix elements.

Calculations reveal that for the digital economy infrastructure, the maximum eigenvalue λmax is 5.056, the Consistency Ratio (CR) is 0.012, and the Consistency Index (CI) is 0.014. For e-commerce scale: the maximum eigenvalue λmax is 3, with a CR of 0 and a CI of 0. For digital transformation outcomes, the maximum eigenvalue λmax is 3, with a CR of 0 and a CI of 0. For innovation and entrepreneurship activities, the maximum eigenvalue λmax is 4, with a CR of 0 and a CI of 0, indicating that the hierarchy's single sorting is consistent.

3.2.4 Overall Hierarchical Ranking and Its Consistency Test

$$CR^{(p)} = CR^{(p-1)} + \frac{CI^{(p)}}{RI^{(p)}}, p = 3, 4, \cdots, s \tag{3}$$

Only when the Consistency Ratio (CR) is less than 0.1, the results of the overall hierarchical ranking are considered to have satisfactory consistency; otherwise, it is necessary to readjust the values of the elements in the judgment matrix.

The calculations yield that the maximum eigenvalue λ_{max} for the overall level of digital economy development is 4, with the Consistency Ratio (CR) and the Consistency Index (CI) both being 0. This indicates that the overall hierarchical ranking is consistent.

3.3. Indicator Weight Table

For the construction of the Analytic Hierarchy Process (AHP) described above, the weight score table obtained in this study is shown in Table 4 below:

Table 4: Indicator Weights for Measuring the Level of Digital Economy Development

Primary Indicator	Secondary Indicator	Tertiary Indicators	Weight
Digital Economy Development Overall Level	Digital Economy Infrastructure	Mobile broadband user penetration rate	0.0244
		Mobile phone base stations	0.0092
		Active IPv6 users	0.0092
		Internet users ratio	0.0579
		Number of internet websites	0.0244
	E-commerce Scale	E-commerce economic value added	0.0179
		E-commerce employment	0.0536
		Online shopping transaction volume	0.0536
	Digital Transformation Outcomes	Digital economy growth rate	0.2250
		Proportion of ICT industry (digital industrialization) in GDP	0.0750
		Digital economy contribution rate	0.0750
	Innovation and Entrepreneurship	Number of start-ups	0.1406
		Number of technology incubators	0.0469
		Patent number growth rate over previous year	0.1406
		Science and technology relationship funds	0.0469

4. Fuzzy Comprehensive Evaluation Method

Fuzzy comprehensive evaluation is a method that utilizes concepts from fuzzy mathematics for assessment purposes. Based on fuzzy mathematics, this method employs fuzzy sets to manage imprecise and incomplete information, quantifying factors that are otherwise vague and difficult to measure. By integrating various factors, it conducts a comprehensive evaluation of the membership level status of the entity being assessed. This approach effectively combines qualitative and quantitative analysis, facilitating more nuanced decision-making in scenarios where traditional methods may fall short.

4.1. Introduction to Determining the Factor Domain

The factor domain for the evaluation object is defined as:

$$F = \{f_1, f_2, ..., f_p\} \tag{4}$$

This means that there are p evaluation indicators, which indicate from which aspects the evaluated object is to be judged and described.

4.2. Determining the Appraisal Level Domain

The set of appraisals, represented as C, consists of the various overall evaluation outcomes that evaluators may assign to the evaluated object. This set encapsulates all possible general assessments, structured to provide a comprehensive judgment of the object's performance or status based on the evaluation criteria established.

$$C = \{c_1, c_2, ..., c_q\} \tag{5}$$

Indeed, it essentially represents a division of the range of variation for the evaluated object. Here, c_i denotes the i-th appraisal outcome, and q is the total number of possible appraisal results. This partitioning helps in categorizing the evaluated object into different levels based on its performance or characteristics.

4.3. Conducting a Single-Factor Evaluation

Single-Factor Fuzzy Evaluation refers to evaluating based on a single factor to determine the evaluated object's degree of membership in the evaluation set V. After constructing the level fuzzy subsets, it is necessary to quantify the evaluated object from each factor $f_i(i=1,2,...,p)$ individually. This means determining the degree of membership of the evaluated object in each level fuzzy subset from the perspective of that single factor. This process results in the creation of a fuzzy relation matrix:

$$Z = \begin{Bmatrix} z_{11} & z_{12} & \cdots & z_{1q} \\ z_{21} & z_{22} & \cdots & z_{2q} \\ \vdots & \vdots & \ddots & \vdots \\ z_{p1} & z_{p2} & \cdots & z_{pq} \end{Bmatrix} \tag{6}$$

4.4. Determining the Fuzzy Weight Vector of Evaluation Factors

These weights then form a fuzzy set U, which is the weight set. Based on the model constructed using the Analytic Hierarchy Process (AHP) mentioned earlier, we have already determined the weights for each indicator.

4.5. Multi-Factor Fuzzy Evaluation

The model for fuzzy comprehensive evaluation is:

$$Y = U \circ Z = (u_1, u_2, \cdots, u_p)\begin{Bmatrix} z_{11} & z_{12} & \cdots & z_{1q} \\ z_{21} & z_{22} & \cdots & z_{2q} \\ \vdots & \vdots & \ddots & \vdots \\ z_{p1} & z_{p2} & \cdots & z_{pq} \end{Bmatrix} = (y_1, y_2, \cdots, y_q) \tag{7}$$

Based on the principles described above, the datapplied in this paper are as follows:

$$Y = U \circ Z = (0.0244, 0.0092, \cdots, 0.0469)\begin{Bmatrix} 1 & 0.9872 & \cdots & 0.6845 \\ 1 & 0.9451 & \cdots & 0.0126 \\ \vdots & \vdots & \ddots & \vdots \\ 0.6301 & 1 & \cdots & 0.0052 \end{Bmatrix} = (0.6912, 0.5847, \cdots, 0.4580) \tag{8}$$

Based on the fuzzy comprehensive evaluation method, the scores for various regions in China and Japan have been calculated and multiplied by 10^2 to obtain the final results. The evaluation scores for the level of digital economy development are shown in Table 5 below:

Table 5: Digital Economy Development Level Score Table

Region	Score	Rank
Zhejiang Province	69.12	2
Jiangsu Province	58.47	3
Shanghai	74.96	1
Anhui Province	51.73	4
Fukuoka Prefecture	38.68	7
Saga Prefecture	30.58	9
Nagasaki Prefecture	44.01	5
Kumamoto Prefecture	29.68	10
Oita Prefecture	39.04	6
Miyazaki Prefecture	23.96	11
Kagoshima Prefecture	32.02	8

5. Conclusion

(1) The highest scores were achieved by Shanghai and Zhejiang Province, with scores of 74.96 and 69.12, respectively.

In previous research, according to the study "Measurement and Influencing Factors of Digital Economy Development Level in the Yangtze River Economic Belt," factors such as economic development level, digital infrastructure, regional education level, advanced industrial structure, and resident wage levels all have a significant positive impact on the digital economy development of Shanghai and Zhejiang Province [19]. This paper further analyzes and finds that indicators such as the internet user ratio, number of internet sites, and digital economy contribution rate also play an important role in enhancing the digital economy development level of Shanghai, enabling it to lead other regions in the country; whereas Zhejiang Province has clear advantages in mobile phone base stations, e-commerce employment, digital economy growth rate, and the proportion of the information and communication industry (digital industrialization) in GDP. Additionally, the development level in other indicators is also relatively high in these two regions.

(2) Following Shanghai and Zhejiang Province, the regions ranked next are Jiangsu Province, Anhui Province, and Nagasaki Prefecture, with scores of 58.47, 51.73, and 44.01, respectively.

Jiangsu Province holds a leading position in indicators such as the number of active IPv6 users, online shopping transaction volume, number of startups, number of technology incubators, and funding for science and technology relations. Anhui Province, on the other hand, has relative advantages in mobile phone base stations, internet user ratio, number of internet sites, e-commerce economic added value, patent growth rate over the previous year, and funding for science and technology relations. Nagasaki Prefecture is significantly ahead in terms of the growth rate of patents compared to the previous year.

(3) The regions with medium rankings are Oita Prefecture, Fukuoka Prefecture, Kagoshima Prefecture, and Saga Prefecture, with scores of 39.04, 38.68, 32.02, and 30.58, respectively.

Oita Prefecture generally performs at a moderate level across various indicators. Fukuoka Prefecture has slight advantages in internet user ratio, number of internet sites, e-commerce economic added value, online shopping transaction volume, e-commerce employment, and number of technology incubators, but it is average or even behind in other indicators such as patent growth rate over the previous year. Kagoshima Prefecture ranks slightly higher in e-commerce economic added value, online shopping transaction volume, digital economy growth rate, and number of technology incubators, while its performance in other indicators is relatively ordinary. Saga Prefecture, on the other hand, is relatively behind in mobile phone base stations, e-commerce economic added value, e-commerce employment, online shopping transaction volume, number of startups, and number of technology incubators, indicating weaknesses in e-commerce scale and innovation and entrepreneurship activities.

(4) The two regions with the lowest scores are Kumamoto Prefecture and Miyazaki Prefecture, with scores of 29.68 and 23.96, respectively.

The article "P2M Theory for Reproducing and Expanding the Results of DX Projects for Regional Problem Solving" suggests that factors limiting the development of the digital economy in various regions of Japan include demographic challenges such as a declining birthrate and aging population, which lead to a shortage of human resources, as well as reductions in the number of local public organization staff due to administrative reforms [20]. In this study, it was found that in Kumamoto Prefecture and Miyazaki Prefecture, the factors limiting the development of the digital economy include the digital economy contribution rate, the growth rate of patent numbers compared to the previous year, and funding for science and technology relations. This indicates that the negative impacts of innovation and entrepreneurial activities are quite significant in these regions.

(5) The rankings show that the level of digital economy development in Kyushu, Japan, is generally lagging, but factors such as the size of the region and population numbers cannot be ignored either.

After comparative analysis, it is evident that Kyushu, Japan, is overall behind the Yangtze River Delta region in China in terms of the number of mobile phone base stations, active IPv6 users, internet websites, e-commerce employment, and funding for science and technology relations. From both the supply side and demand side, a shortage of personnel in the information and communication technology sector and resistance to change among employees are key factors behind the lag in Japan's digital transformation. It is worth noting that the total population of the Yangtze River Delta region is more than ten times that of Kyushu, and its total area is about eight times larger than that of Kyushu. It is apparent that the Yangtze River Delta region leverages its vast economic scale and rich talent resources to display significant competitive advantages in the digital economy. Therefore, factors such as the size of the region and the number of people have a considerable impact on the measurement of the level of digital economy development.

6. Suggestions

6.1. Focus on Patent Growth Rate

The Japanese government has a responsibility to actively encourage businesses and institutions to increase the number of patent applications, particularly in regions such as Kumamoto Prefecture and Miyazaki Prefecture, where such measures are crucial for promoting innovation and economic growth. To achieve this goal, several measures can be taken:

Firstly, incentives for R&D personnel and innovative enterprises should be strengthened by providing R&D funding, tax incentives, and rewards to encourage more substantial investment in patent applications.

Secondly, the patent application and approval processes need to be simplified to reduce the lengthy waiting times and increase the efficiency and convenience of applications.

Additionally, more patent training and consulting services should be offered to help businesses and institutions understand the patent application process and requirements, thus improving their capabilities and standards in patent applications.

Lastly, to protect intellectual property, the government should also enhance the protection of intellectual property rights by establishing comprehensive laws, regulations, and enforcement mechanisms to combat infringement and protect the legal rights of innovative outcomes.

6.2. Strengthening the Innovation and Entrepreneurship Ecosystem

To foster innovation and development in the digital economy, the Kyushu region of Japan must establish more technology incubators and support the growth of startups. This initiative not only provides entrepreneurs with the necessary resources and support but also promotes technological innovation and industrial upgrading. To achieve this, it is essential to create a comprehensive ecosystem conducive to innovation and entrepreneurship, attracting support and participation from various sectors such as government, industry, academia, investment institutions, and social organizations.

Policy Flexibility and Openness: More flexible and open policies and regulations need to be formulated to provide more room for development and policy support for innovative enterprises.

Venture Capital and Entrepreneurial Financing: Establishing a venture capital and entrepreneurial financing system to provide funding support and investment channels for startups is crucial.

Talent Development and Technology Transfer: Strengthening talent cultivation and technology transfer is essential to nurture more innovative talents and technology experts, thereby facilitating the commercialization and application of scientific and technological achievements.

Industry-Academia-Research Cooperation: Actively promoting cooperation between industry, academia, and research institutions, and enhancing technology transfer can significantly boost industrial innovation and technological advancement.

By implementing these strategies, the Kyushu region can significantly enhance its capability to drive digital economic growth through a robust innovation and entrepreneurship ecosystem.

6.3. Enhancing the Scale of E-commerce

In response to the situations in Saga Prefecture and Kagoshima Prefecture in Japan, as well as Anhui Province and Jiangsu Province in China, both the Japanese and Chinese governments need to implement a series of measures to enhance their e-commerce economic added value and online shopping transaction volumes, thereby boosting the vitality and influence of the digital economy.

Improving E-commerce Environment and Infrastructure: First and foremost, governments should focus on improving the e-commerce ecosystem and infrastructure conditions to facilitate the scale and development of e-commerce. This includes building more convenient and secure online payment and logistics systems to enhance user experience and trust, which in turn encourages more consumers to opt for online shopping.

E-commerce Training and Support Services: Additionally, more e-commerce training and support services should be provided to help businesses and individuals master e-commerce operational skills and market strategies, thereby enhancing their competitiveness and influence in the digital economy.

Encouraging Traditional and Small Businesses to Transition: Encouraging traditional enterprises and small and micro businesses to actively transform and upgrade, strengthening their layout and innovation in the e-commerce field to adapt to the trends of the digital age is critical.

Expanding Cross-border E-commerce and International Markets: Furthermore, efforts should be made to expand cross-border e-commerce and international markets, strengthen connections and cooperation with external markets, thereby broadening the business scope and influence of enterprises, and enhancing their status and competitiveness in the global digital economy.

By implementing these strategies, the regions can significantly enhance their e-commerce capabilities, contributing to a more dynamic and influential digital economy.

6.4. Improving Security Mechanisms to Foster a Healthy Development Environment

The Yangtze River Delta region boasts significant advantages in talent resources within the digital economy industry, which has laid a solid foundation for the in-depth development of the digital economy. To consolidate and expand this advantage, the region needs to continuously optimize its digital talent ecosystem, striving to become a highland for digital talents and actively recruiting top-tier talents in highly specialized and in-demand fields. Additionally, it is crucial to encourage cooperation among enterprises, universities, and research institutes to cultivate technical and market-oriented talents that align with the needs of digital businesses. While promoting widespread internet usage, it is essential not to overlook the importance of cybersecurity and personal information protection. It is vital to ensure that users can enjoy the convenience of the internet while being in a safe and reliable network environment. By comprehensively advancing these measures, the Yangtze River Delta region will further expand the developmental space of the digital economy and inject new vitality into the sustainable and healthy development of the economy and society.

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