

Optimization of the Digital Business Environment in Shanxi Province under the Background of the Rise Strategy of Central China

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Abstract: Against the strategic background of the Rise of Central China, optimizing the digital business environment has become a core driving force for Shanxi Province to transform its resource-based economy, promote high-quality sustainable development, and integrate into regional coordinated development. This paper aims to clarify the current situation, dilemmas and optimization paths of Shanxi's digital business environment, so as to provide empirical reference for resource-based provinces in Central China to improve digital governance capabilities. Adopting the research methods of entropy weight-TOPSIS empirical evaluation and comparative analysis, this paper constructs a digital business environment evaluation system covering four dimensions: digital infrastructure environment, digital innovation environment, digital market environment, and digital legal governance environment. It measures the development level of digital business environment in Shanxi from three aspects: the provincial level, regional level and urban level. The results find that Shanxi has made initial progress in the construction of digital business environment, but regional and urban level exist huge differences. From the perspective of sustainable development, this paper puts forward targeted optimization paths from four aspects: the construction of digital infrastructure, the development of digital talent teams, the digital transformation of enterprises, and the improvement of government environment, so as to help Shanxi break through development bottlenecks and boost the high-quality growth of the Central China. This study enriches the theoretical research on the coupling of national regional strategies and digital business environments, and has practical guiding significance for the sustainable development of resource-based regions.

Keywords: Digital business environment; Rise of Central China Strategy; Shanxi Province; resource-based economy transformation; sustainable regional development; digital governance.

1. Introduction

Against the backdrop of the rapid development of the global digital economy, the optimization and construction of the digital business environment have become one of the core engines driving high-quality regional economic development. It plays an irreplaceable and crucial role in integrating resource factors, stimulating innovation vitality, promoting the coordinated development of market entities, and profoundly influencing the position and developmental trajectory of regional economies within the global competitive landscape, which is highly consistent with the core requirements of the United Nations Sustainable Development Goals (SDGs), especially SDG 8 (Decent Work and Economic Growth) and SDG 9 (Industry, Innovation and Infrastructure).

In July 2024, the Third Plenary Session of the 20th Central Committee of the Communist Party of China explicitly proposed to improve institutions for the in-depth integration of the real economy and the digital economy [1]. Earlier, in November 2020, at the 27th APEC Economic Leaders' Meeting, President Xi Jinping particularly emphasized the need to optimize the digital business environment to stimulate the vitality of market entities and unleash the potential of the digital economy [2]. In China, the strategy for the Rise of Central China, as a major national regional development strategy, aims to bridge the development gap between eastern and western regions, promote industrial transformation and upgrading, and build a coordinated regional development

pattern, providing a rare strategic opportunity for the high-quality development of six central provinces including Shanxi. The central region, encompassing six provinces—Henan, Shanxi, Hunan, Hubei, Jiangxi, and Anhui—serves as a critical national base for grain production, energy and raw materials, modern equipment manufacturing, high-tech industries, and a comprehensive transportation hub, holding a pivotal position in China. In March 2024, during an inspection in Changsha, Hunan Province, President Xi Jinping specifically convened a symposium on promoting the rise of the central region, stressing the need to solidly advance the region's development from a higher starting point, strengthen the construction of a market-oriented, rule-of-law-based, and internationalized business environment, and enhance its attractiveness to domestic and international factor resources [3]. In October 2025, the "Proposal of the Central Committee of the Communist Party of China on Formulating the 15th Five-Year Plan for National Economic and Social Development" emphasized the construction of a "Digital China." The rise of the central region has been endowed with new connotations, with technological innovation and the digital economy serving as the core driving forces to lead coordinated regional development. The construction of a digital business environment is a key measure for implementing the major decisions of the Party Central Committee and the State Council, as well as an inherent requirement for driving high-quality regional economic development and accelerating the development of new quality productive forces.

As a typical resource-based province in central China, Shanxi has long been dominated by coal and heavy industry, facing prominent problems such as single industrial structure, low resource utilization efficiency, and urgent pressure of economic transformation and green development. In recent years, relying on the strategic dividend of the Rise of Central China, Shanxi has accelerated the layout of the digital economy and the construction of the digital government, and has achieved phased results in the optimization of the business environment: the coverage rate of 5G infrastructure has been continuously improved, the "one-stop online service" of government services has been fully promoted, and a series of digital governance policies have been issued to support the development of market entities. However, compared with developed eastern provinces and other central provinces with strong digital economy foundations, Shanxi's digital business environment construction still has obvious shortcomings: the fragmentation of digital policies is prominent, inter-departmental and inter-regional data barriers are difficult to break in the short term, the digital service capacity for small, medium and micro enterprises is insufficient, the digital supervision system is not perfect, and the degree of integration with the coordinated development of the central region is low. These problems have become important constraints restricting Shanxi's economic transformation, the release of market vitality and the sustainable development of the regional economy, and it is urgent to carry out targeted research and optimization.

At present, academic circles have carried out extensive research on the digital business environment and regional development strategies. Existing studies have explored the concept and connotation of the digital business environment, the path to optimize the digital business environment, the Rise Strategy of Central China, and the impact effect of digital business environment on national regions, providing a solid theoretical foundation for this study. However, there are still obvious research gaps in the existing literature: first, most studies focus on the national level or developed eastern regions, and there is a lack of targeted research on resource-based provinces in central China, especially the combination of the Rise of Central China strategy and the digital business environment of Shanxi; Second, the existing research rarely links the optimization of the digital business environment with the sustainable transformation of resource-based regions, and the empirical evaluation and path exploration for the specific situation of Shanxi are insufficient; Third, few studies analyze the coordinated development of the digital business environment between Shanxi and other central provinces from the perspective of regional integration, which cannot fully meet the needs of Shanxi to integrate into the Rise of Central China strategy.

In view of this, this study takes Shanxi Province as the research object, and takes the strategy of the Rise of Central China as the research background, aiming to systematically sort out the current situation and dilemmas of Shanxi's digital business environment construction, construct a scientific and targeted evaluation index system through empirical methods, and explore feasible optimization paths to promote the sustainable development of Shanxi's economy and the coordinated development of the central region. The marginal contributions of this study are mainly reflected in three aspects: first, it integrates the national regional development strategy with the micro-level digital business environment research, enriches the theoretical research on the coupling

mechanism between regional strategies and digital governance; Second, it constructs a digital business environment evaluation system suitable for resource-based provinces in central China, and conducts horizontal and vertical comparative analysis through entropy weight-TOPSIS method, which makes the research conclusions more objective and credible; Third, it puts forward targeted optimization paths from the dimensions of strategic integration, system improvement, infrastructure upgrading, data sharing and ecological empowerment, providing practical decision-making reference for Shanxi to break through the bottleneck of digital business environment construction and realize economic transformation, and also providing experience reference for other resource-based regions in central China to optimize the digital business environment.

The rest of this paper is arranged as follows: the second part is the literature review; The third part explains the materials and research methods applied; The fourth part constructs the evaluation index system and carries out empirical analysis and result discussion; The fifth part draws on the advanced experience of domestic and foreign regions to put forward specific optimization paths; the sixth part summarizes the research conclusions, points out the research limitations and future research prospects.

2. Literature Review

2.1. The Concept and Connotation of the Digital Business Environment

Scholars have two viewpoints on the understanding of the digital business environment: "digital business + environment" and "digital + business environment" [4, 5]. The former believes that the digital business environment refers to the sum of new institutional factors and various conditions involved by market entities in their economic activities under the new situation of rapid development of the digital economy [6, 7]. The latter believes that it is the digital transformation and upgrading based on the traditional business environment, presenting characteristics such as intelligent infrastructure, online government services, unbounded data operation, and interactive platform information, which promotes the continuous optimization and improvement of the business environment [8]. At the same time, some scholars have integrated these two viewpoints.

2.2. The Path to Optimize the Digital Business Environment

Most scholars generally believe that by strengthening the enabling role of digital technology in the three aspects of digital government, digital economy, and digital society, and optimizing the construction of the digital business environment, the empowerment effect can be enhanced. Wang and Hou (2024) based on the data of 280 prefecture-level and above cities in China from 2018 to 2022, conducted theoretical analysis and empirical tests on the impact and mechanism of digital government construction on the optimization of the business environment. The study found that digital government construction significantly promoted the optimization of the urban business environment [9]. Liu and Xia (2024) proposed that in the era of digital economy, the overall situation of the business environment should be analyzed and evaluated through the principle of fair

competition, and the digital business environment should be optimized to create a fair competitive business environment where the online and offline markets are unified and orderly [10]. Ding and Bai (2025) based on the panel data of prefecture-level cities in China from 2007 to 2021, using the difference-in-differences model, systematically studied and found that the public data openness significantly promoted the optimization of regional business environment [11].

2.3. The Rise Strategy of Central China

Since the implementation of the Rise Strategy of Central China, Chinese scholars have conducted extensive research on the implementation effect of the strategy, the new problems and characteristics it faces, as well as the new directions and paths for further promoting the rise of the central region. Wen (2024) believes that the central region should continuously maintain its strategic positioning as a "three bases and one hub", prioritize food security, and use innovation power, opening opportunities, new systems, and the reshaping and optimization of the development advantages of the central region to strive for a new situation of the rise of the central region [12]. Cheng Bizhi et al. (2024) propose that on the path of achieving the rise of the central region, the key lies in accelerating the improvement of the scientific and technological innovation capabilities of the central region, the supporting capacity of infrastructure as a "hub", and the attractiveness and competitiveness of inland opening up, etc. [13].

2.4. The Impact Effect of Digital Business Environment on Regions

Liu and Li (2024) explored the influence and mechanism of digital business environment on common prosperity, finding that the digital business environment can indirectly promote common prosperity through industrial agglomeration and regional innovation and entrepreneurship [14]. Lei and Li (2024) discovered that the digital business

environment can promote the concentration of innovative talents and innovative capital, significantly enhancing the efficiency of the circulation industry [15]. Wang and Wen (2024) conducted an empirical analysis from the dual perspectives of "quantity" and "quality", finding that the optimization of the digital business environment helps achieve a "simultaneous improvement in quantity and quality" of manufacturing export competitiveness [16].

2.5. Research Gap

In summary, the current academic community has conducted beneficial explorations on optimizing the digital business environment to promote regional development. However, from the perspective of research objects, there is still a lack of specialized studies on optimizing the digital business environment to facilitate the Rise of the Central China. Compared with other regions in China, the actual foundation and key bottlenecks of development in the central region have regional particularities. Based on this, Shanxi Province, as a comprehensive reform pilot zone for the transformation of the country's resource-based economy, has recently taken optimizing the digital business environment as a breakthrough and actively explored the transformation path of "digital empowerment", providing an important local practice sample for the Rise of the Central China. The selection of Shanxi Province as the research object in this study is of typical significance. Figures 1 is the location map of the six provinces in central China and Figures 2 is the location map of Shanxi Province. As an important energy base of China, Shanxi Province is implementing the "Smart Shanxi" strategy through the "Shanxi Province Digital Government Construction Plan (2023-2025)", focusing on promoting smart city pilot projects, big data demonstration projects, and other measures. These practices have not only laid a solid foundation for the construction of the digital business environment but also exposed the special challenges of the transformation of resource-based regions.

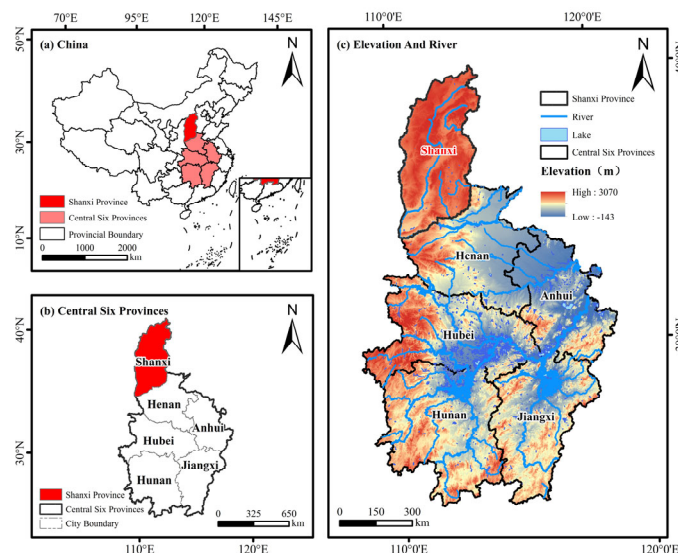


Figure 1. Location Map of Six Provinces in Central China

This study constructs an evaluation index system for the digital business environment in Shanxi Province from four dimensions: digital infrastructure environment, digital innovation environment, digital market environment, and digital legal governance environment. It measures the development level of the digital business environment in 11

prefecture-level cities of Shanxi Province and deeply analyzes the problems existing in the digital business environment of Shanxi Province, and then proposes corresponding solutions. The aim is to provide a reference for continuously optimizing the digital business environment in Shanxi Province, not only providing decision-making

references for regional development, but also offering paradigmic inspiration for the digital transformation and sustainable development of similar resource-based regions. Figure 1 and Figure 2 respectively show the location maps of

the six provinces in central China and the location map of Shanxi Province. The map was created using the Arcgis software.

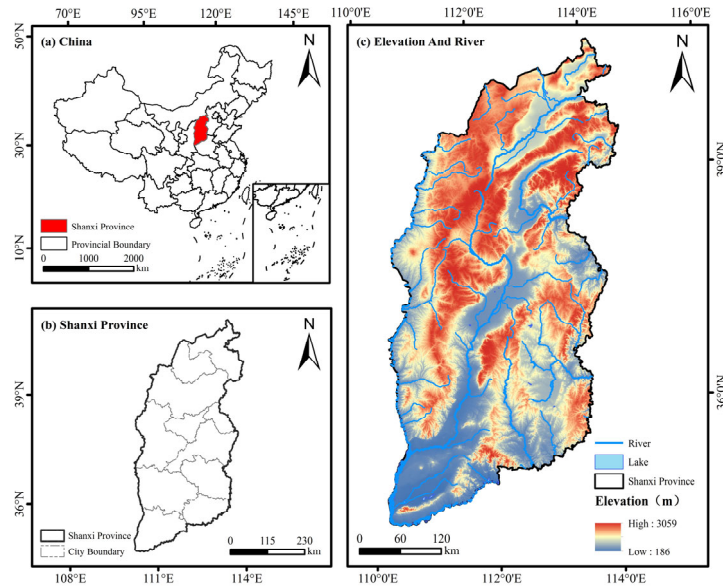


Figure 2. Location Map of Shanxi Province, China

3. Materials and Methods

3.1. Indicator Construction

This paper refers to relevant studies [17, 18] and takes into account the availability of data to construct a numerical evaluation index system for the digital business environment, which consists of 4 primary indicators and 18 secondary indicators, as shown in Table 1. Eleven prefecture-level cities

in Shanxi Province were selected as the research objects. The entropy weight-TOPSIS method was used to measure and analyze the current development level of the digital business environment in Shanxi Province. The original data involved in the model were respectively derived from the "China City Statistical Yearbook" from 2013 to 2024, the statistical yearbooks and statistical bulletins of Shanxi Province and each municipal level, and the China Court Decision Database.

Table 1. Evaluation System for Digital Business Environment in Shanxi Province

First-level Indicator	Second-level Indicator	Measurement Indicator	Attribute
Digital Infrastructure Environment	Internet Application	Internet broadband access ports per 100 people	Positive
	Mobile Phone Penetration	Mobile phone users per 100 people	Positive
Digital Innovation Environment	Financial Innovation Input	Scientific expenditure / General public budget expenditure	Positive
	Innovation Talent Input	Employees in scientific research and technical services / Total employment	Positive
	Human Capital Level	Population with junior college degree or above / Permanent resident population	Positive
	Digital Human Resources	Employees in information transmission, software and IT services / Total employment	Positive
	R&D Output Capacity	Authorized patent applications	Positive
Digital Market Environment	Number of New Enterprises	Number of industrial enterprises above designated size	Positive
	Enterprise Tax Burden	Taxes and surcharges on core business of industrial enterprises / Core business income of industrial enterprises	Negative
	Foreign Investment Level	Actual use of foreign capital / GDP	Positive
	Financing Efficiency	Year-end loan balance of financial institutions / GDP	Positive
	Digital Financial Development	Digital inclusive finance index	Positive
	Digital Industrialization	Per capita telecom business volume	Positive
Digital Legal Governance Environment	Economic Development Level	Per capita regional GDP	Positive
	Government Financial Support	General public budget expenditure	Positive
	Government-Enterprise Relations	Marketization level	Positive
	Government Intervention Degree	(Current government budget expenditure – Current government budget revenue) / Current government budget expenditure	Negative
	Social Security	Number of criminal cases	Negative

3.2. Measurement Methods

This research selects various data from 11 cities in Shanxi Province from 2013 to 2024 as the research sample. Due to the absence of data for some years, in order to ensure the comparability and accuracy of the data, drawing on the research methods of scholars such as Tu [19], the linear interpolation method is adopted to fill in the missing values.

Firstly, the data is standardized, using the extreme value method. Then, the entropy method is used to calculate the weight of each secondary indicator, and finally, the weighted comprehensive method is used to obtain the digital business environment score of each city. The specific calculation process is as follows:

In the first step, in order to reduce the influence of numerical values on the results, the extreme value method was used to standardize the original data and obtain the positive index:

$$x'_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)}, \quad (1)$$

Negative indicators:

$$x'_{ij} = \frac{\max(x_j) - x_{ij}}{\max(x_j) - \min(x_j)}, \quad (2)$$

Here, x_{ij} represents the original value of the j th indicator for the city in the i -th year, where $i = 1, 2, 3, \dots, n$ and $j = 1, 2, 3, \dots, m$. $\min(x_j)$ represents the minimum value of the j th indicator, $\max(x_j)$ represents the maximum value of the j -th indicator, and x'_{ij} represents the standardized indicator value after processing.

In the second step, calculate the proportion P of index j in year i :

$$p_{ij} = \frac{x'_{ij}}{\sum_{i=1}^n x'_{ij}}, \quad (3)$$

In the third step, calculate the j information entropy indicators:

$$e_j = -k \sum_{i=1}^n p_{ij} \ln p_{ij}, \text{ here } k = \frac{1}{\ln(mn)}, \quad (4)$$

and $k > 0$, such that $e_j \geq 0$

In the fourth step, calculate the information entropy difference j index of the coefficient of:

$$d_j = 1 - e_j, \quad (5)$$

In the fifth step, calculate the weight of the j -th indicator:

$$w_j = \frac{d_j}{\sum_{j=1}^m d_j}, \quad (6)$$

In the sixth step, calculate the weighting matrix:

$$Z_{ij} = x'_{ij} \cdot w_j, \quad (7)$$

In the seventh step, calculate the Euclidean distance, and determine the maximum value of each indicator as the positive ideal solution Z_j^+ , and the minimum value of each indicator as the negative ideal Z_j^- .

The distance to the positive ideal solution:

$$D_i^+ = \sqrt{\sum_{j=1}^m (Z_{ij} - Z_j^+)^2}, \quad (8)$$

The distance to the negative ideal solution:

$$D_i^- = \sqrt{\sum_{j=1}^m (Z_{ij} - Z_j^-)^2}, \quad (9)$$

In the eighth step, calculate the degree of closeness:

$$C_i = \frac{D_i^+}{D_i^+ + D_i^-}, \quad (10)$$

The larger the C_i , the better the evaluation object.

3.3. Calculation Results of Evaluation Indicators

Table 2 presents the entropy values, weights, and coefficient of variation of each dimension indicator of the digital business environment in Shanxi Province. From the calculation results of entropy TOPSIS, it can be seen that the digital construction of the four environmental dimensions has had varying degrees of influence on the development level of the digital business environment in Shanxi Province. Among them, the digital innovation environment and the digital market environment have a greater impact on the overall development level of the digital business environment in Shanxi Province, both exceeding 40%; the impact of digital infrastructure calculation is 5.95%; and the impact of the digital legal governance environment is 10.91%. Based on the weight calculation results of the secondary indicators, the "digital industrialization" of the digital market environment and the "research and development output capacity" of the digital innovation environment have relatively higher weights, 14.51% and 13.62% respectively; followed by "human capital

level", "foreign investment level", and "fiscal innovation investment", with weight percentages all exceeding 9%. This result indicates that the digital construction in these four

directions plays an important role in promoting the development of the digital business environment across the province.

Table 2. Entropy value, weight and coefficient of variation of evaluation indicators for digital business environment in Shanxi Province

First-level Indicator	Second-level Indicator	Weight of primary indicators	Weight of secondary indicators	Entropy value	Coefficient of variation
Digital Infrastructure Environment	Internet Application	5.95%	2.60%	0.9695	0.0305
	Mobile Phone Penetration		3.36%	0.9606	0.0394
	Financial Innovation Input		9.12%	0.8930	0.1070
Digital Innovation Environment	Innovation Talent Input	41.55%	4.79%	0.9438	0.0562
	Human Capital Level		10.69%	0.8745	0.1255
	Digital Human Resources		3.34%	0.9608	0.0392
	R&D Output Capacity		13.62%	0.8401	0.1599
	Number of New Enterprises		3.57%	0.9580	0.0420
	Enterprise Tax Burden		1.36%	0.9840	0.0160
Digital Market Environment	Foreign Investment Level	41.59%	9.50%	0.8885	0.1115
	Financing Efficiency		5.31%	0.9377	0.0623
	Digital Financial Development		2.76%	0.9677	0.0323
	Digital Industrialization		14.51%	0.8297	0.1703
	Economic Development Level		4.58%	0.9463	0.0537
	Government Financial Support		3.24%	0.9620	0.0380
Digital Legal Governance Environment	Government-Enterprise Relations	10.91%	2.70%	0.9683	0.0317
	Government Intervention Degree		2.97%	0.9652	0.0348
	Social Security		2.01%	0.9764	0.0236

4. Results and Discussion

4.1. Provincial Level

Table 3 and Figure 1 present the TOPSIS score data and overall trend of the four dimensions of digital business environment in Shanxi Province from 2013 to 2024. Through a systematic analysis of their evolution patterns, it is found that the development of digital infrastructure environment, digital innovation environment, digital market environment and digital legal governance environment shows significant imbalance and phased characteristics.

First, the digital infrastructure environment shows a continuous and rapid upward trend. The score increased from 0.1499 in 2013 to 0.4981 in 2024, with a cumulative increase of 232%, indicating that Shanxi Province has achieved remarkable results in the construction of hard facilities such as broadband networks, mobile phones and data centers, especially after 2017, the growth rate accelerated. This trend is closely related to Shanxi Province's strategic layout of vigorously promoting the construction of shared digital infrastructure in recent years: On the one hand, Shanxi's comprehensive computing power index has ranked 7th in China, completing the "14th Five-Year Plan" 5G construction tasks ahead of schedule, providing a basic support for the stable operation of computing infrastructure; On the other hand, the provincial government cloud has achieved interconnection among five industry clouds and 11 municipal government clouds, building a basic framework of "one cloud" throughout the province, and the electronic government extranet has been horizontally connected with 114 provincial units and vertically covered from provincial, city to county and town levels. At the same time, the intelligent coal mine construction has been continuously advanced, and 400 intelligent coal mines have been built

across the province, reflecting the gradual improvement of the layout of new infrastructure.

Second, the overall level of the digital innovation environment is relatively low and shows a stable and gradual fluctuation. The score has been hovering within the range of 0.14 to 0.21 for a long time, reaching a peak of 0.2098 in 2020 and then slightly declining. This indicates that the construction of soft environments such as the aggregation of innovation elements and technology transformation is relatively lagging behind; On the other hand, the deeper reason lies in the large gap between the investment and output of scientific and technological innovation in Shanxi Province. The research and experimentation funding intensity in the province in 2024 was only 1.22%, far lower than the national average of 2.69%. In addition, the information technology innovation industry is facing structural challenges such as reliance on foreign technologies for core chips, operating systems, and supply chain disruptions, as well as shortages of high-end R&D talents and versatile application talents. In the digital transformation of manufacturing, the phenomenon of enterprises "not wanting to transform, not daring to transform, and not knowing how to transform" is widespread. The accuracy of provincial policies' coverage is insufficient, the internal driving force for enterprise transformation is limited, and the supply gap of digital talents is big enough. Problems still remain prominent.

Third, the digital market environment has experienced the most dramatic fluctuations: between 2013 and 2017, it remained within the range of 0.17 to 0.21; from 2018 onwards, it rose sharply, reaching a historic high of 0.4837 in 2020, but subsequently plummeted to 0.1954, before gradually recovering to 0.2154. This sharp rise and fall is closely linked to specific factors: in June 2018, Shanxi Province launched full-process electronic tendering, completing 2,067 full-

process online tenders that year, placing it at the forefront nationally; this figure further increased to 6,017 in 2019. During the 2020 pandemic, Shanxi Province took the lead nationwide in issuing the “Guidelines for Conducting Remote and Off-site Bid Opening and Evaluation During the Pandemic Prevention and Control Period”. Third-party trading platforms utilised technologies such as remote bid opening and off-site evaluation to complete a cumulative total of 1,086 remote bid openings, providing critical support for procurement and supply during the pandemic, which directly boosted the market environment score for that year. However, the normalisation of market activities following the pandemic, alongside innovative models such as the application of electronic performance bonds which reduced the capital tied up by enterprises, may have led to a subsequent decline in scores and a slow recovery. Such fluctuations reflect the market environment’s susceptibility to short-term factors such as policy stimuli and unforeseen events, indicating that its stability requires further enhancement.

Fourth, the legal environment for digital governance has remained at a relatively high level for a long time. In 2013, it was 0.4673, then experienced a brief decline, and has steadily recovered since 2016, reaching over 0.55 in 2021-2022. In recent years, it has remained above 0.51. The sustained high performance of this dimension in Shanxi Province directly reflects the continuous deepening of digital government construction: At the provincial level, a management and operation framework of "one bureau, one company, one

center" has been established, ensuring the seamless connection and integrated operation of digital government construction throughout the province from the institutional perspective. The "one-network-for-all-services" for government services has become the norm, and the "one-event" for enterprises and the public throughout the entire life cycle has achieved "one acceptance, integrated processing". 28 industries have completed the "one-business-one-license" reform. The integrated online government service platform across the province has achieved full coverage at the provincial, municipal, county, township, and village levels, with the online availability rate of provincial government services items reaching 91%. The "thousand data resource sharing project" has been carried out to enhance data sharing and support. The aim is to utilize government data to improve the user experience of government services. In multiple fields such as urban management, financial services, and medical health, the government data resources have achieved remarkable effects in enhancing governance efficiency and driving industrial innovation. These reform measures have effectively optimized the legal environment for government affairs, significantly improved the government's service efficiency and responsibility fulfillment capabilities, facilitated the convenience of basic public services, and have increasingly demonstrated the effectiveness in optimizing the business environment. However, a slight decline in the score in recent years also indicates the need to pay attention to the sustainability of policy effectiveness.

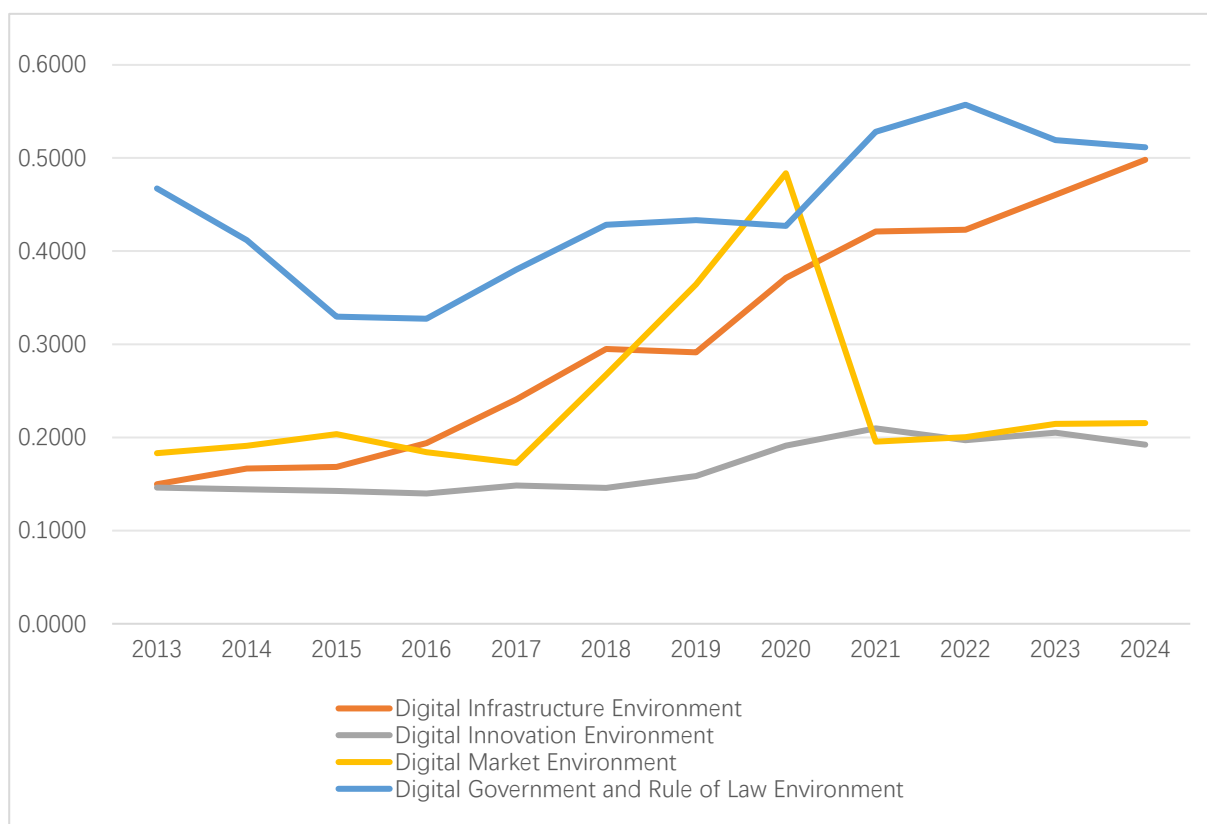


Figure 3. Trend of TOPSIS Scores for the Four Dimensions of Digital Business Environment in Shanxi Province from 2013 to 2024

Table 3. TOPSIS scores of the four dimensions of digital business environment in Shanxi Province from 2013 to 2024

Dimension	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Digital Infrastructure Environment	0.1499	0.1667	0.1684	0.1939	0.2409	0.2949	0.2913	0.3713	0.4210	0.4229	0.4604	0.4981
Digital Innovation Environment	0.1462	0.1443	0.1427	0.1399	0.1484	0.1458	0.1585	0.1912	0.2098	0.1970	0.2051	0.1921
Digital Market Environment	0.1831	0.1909	0.2036	0.1841	0.1727	0.2673	0.3643	0.4837	0.1954	0.2004	0.2145	0.2154
Digital Legal Governance Environment	0.4673	0.4118	0.3297	0.3275	0.3802	0.4282	0.4333	0.4270	0.5281	0.5572	0.5192	0.5113

4.2. Regional Level

Table 4 presents the measurement results of the digital business environment in each region of Shanxi Province in 2024. The average comprehensive score of the digital business environment in Shanxi Province is 0.2233. There is a significant gradient difference among the regions: Central Shanxi region leads with a score of 0.3045, followed by Southern Shanxi and Southeastern Shanxi regions respectively, with local scores of 0.2179 and 0.1923, and Northern Shanxi region with a score of 0.1784, lagging behind slightly.

From the perspective of individual dimensions, the digital infrastructure environment in Central Shanxi is significantly higher than other regions. Southern Shanxi and Southeastern Shanxi regions are close to the average score of 0.4891, while Northern Shanxi region has the lowest score of 0.4534. As the core area of the provincial capital Taiyuan and its surrounding core regions, Central Shanxi enjoys priority layout in new infrastructure construction, with higher coverage densities of computing power centers and 5G networks; while Northern Shanxi region is constrained by terrain and economic volume, and its infrastructure level is relatively weak. In terms of digital innovation environment, Central Shanxi has the highest score of 0.3322, followed by Southern Shanxi with 0.1224, which is lower than the provincial average of 0.1676, and Northern Shanxi and Southeastern Shanxi have significantly lower scores. This is due to the imbalance of innovation factor concentration, with Central Shanxi gathering major universities, research institutions and high-tech enterprises, having a strong intensity of R&D investment and technology transfer capabilities, while Northern Shanxi and Southeastern Shanxi have a relatively high proportion of

traditional industries and have not yet formed a digital innovation ecosystem. The scores of the digital market environment in each region are relatively close, with Central Shanxi and Southeastern Shanxi slightly higher, and Northern Shanxi and Southern Shanxi slightly lower. The overall market environment is at a relatively low level and there is little regional difference, indicating that soft indicators such as digital transaction activity and the willingness of market entities to digitalize have not yet achieved breakthroughs, and still require policy guidance and market cultivation. In terms of digital government legal environment, Central Shanxi performs the best, exceeding the provincial average. Southern Shanxi comes second, followed by Northern Shanxi and Southeastern Shanxi. The legal environment of digital governance is generally high, reflecting that the reform measures such as "one seal manages approval" and digital government construction in Shanxi Province have been well implemented in each region.

The digital business environment levels in the four regions are closely related to the economic development levels, industrial foundations, and policy resource endowments of each region. Overall, the digital business environment in Shanxi Province presents a spatial pattern of "core leading and gradient development": Central Shanxi region, relying on the resources of the provincial capital, has formed obvious advantages in infrastructure and innovation environment; Southeastern Shanxi performs relatively well in the legal and administrative environment of government affairs, but there are still shortcomings in innovation; Northern Shanxi and Southeastern Shanxi need to increase investment in infrastructure and innovation factors.

Table 4. Measurement results of digital business environment in all regions of Shanxi Province in 2024

Region	Digital Infrastructure Environment	Digital Innovation Environment	Digital Market Environment	Digital Legal Governance Environment	Overall score
Central Shanxi	0.5568	0.3322	0.2379	0.5609	0.3045
Southeastern Shanxi	0.477	0.119	0.2364	0.5578	0.2179
Southern Shanxi	0.4692	0.1224	0.1975	0.4532	0.1923
Northern Shanxi	0.4534	0.1007	0.1834	0.453	0.1784
Shanxi Province	0.4891	0.1686	0.2138	0.5062	0.2233

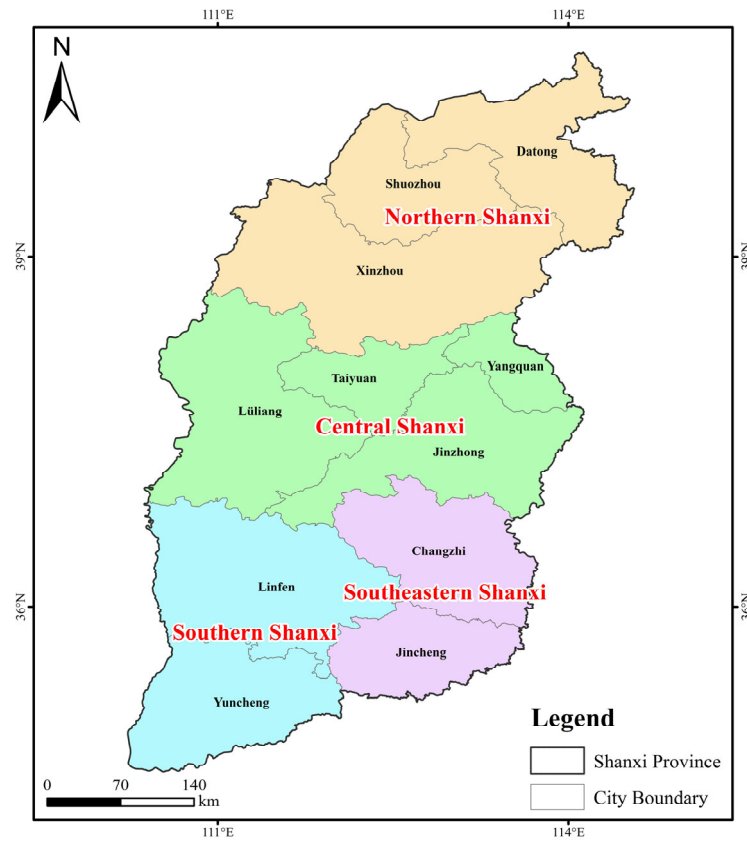


Figure 4. Map of the Regional Division Across Shanxi Province

4.3. Urban Level

4.3.1. Overall trend of digital business environment in Prefecture-level cities

Figure 5 shows the map of 11 prefecture-level cities in

Shanxi Province. Table 5 presents the TOPSIS scores of the digital business environment of these cities in Shanxi Province from 2013 to 2024.

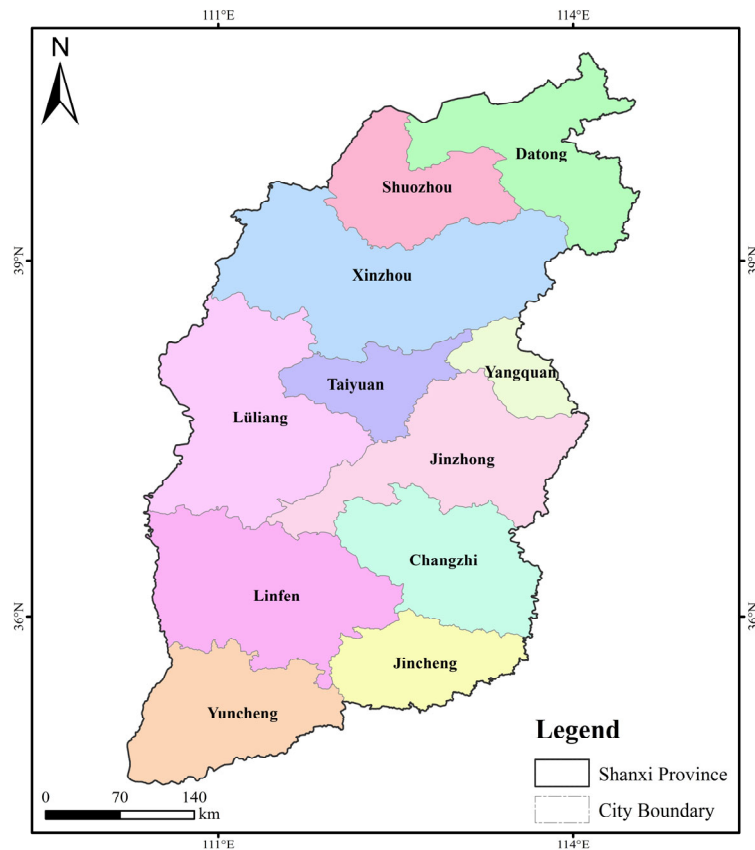


Figure 5. Map of 11 Prefecture-level Cities in Shanxi Province

From the perspective of temporal evolution, the average score of the entire province has steadily increased from 0.1914 in 2013 to 0.2340 in 2024, with a cumulative growth of 22.3%. From 2013 to 2017, the scores of each city were generally low and grew slowly, reflecting that the early policies mainly focused on framework construction. Since 2018, most cities have entered a rapid upward trend, benefiting from the implementation of the "Three-Year Action Plan for Communication Infrastructure Construction in Shanxi Province", with the deepening coverage of fiber broadband and 4G networks; in 2019, the People's Government of Shanxi Province issued the *Opinions on Accelerating the Development of Digital Economy in Shanxi Province*, systematically laying out in five major fields of

"network, intelligence, data, equipment, and core", further accelerating the improvement of the digital business environment in all regions. In 2020, it reached a generally high point, related to the surge in remote service demand during the pandemic and policy innovations such as electronic bidding; after 2021, it entered a period of adjustment and consolidation, with some cities' scores slightly falling back, reflecting that the construction of digital business environment has shifted from incremental expansion to quality improvement and efficiency enhancement, and localities have begun to focus on the implementation effectiveness of policies and the establishment of long-term mechanisms.

Table 5. TOPSIS scores of digital business environment in 11 Prefecture-level Cities in Shanxi Province from 2013 to 2024

Cities	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Taiyuan	0.4419	0.4703	0.4532	0.4094	0.465	0.5593	0.6287	0.6869	0.5586	0.5178	0.543	0.5073
Jinzhong	0.1432	0.1478	0.1628	0.1441	0.1439	0.1895	0.2558	0.3427	0.1685	0.1919	0.1831	0.1866
Jincheng	0.2391	0.2408	0.254	0.2515	0.162	0.1675	0.2389	0.2992	0.2015	0.1896	0.2025	0.2009
Changzhi	0.178	0.1727	0.2058	0.2155	0.1757	0.2023	0.2677	0.3426	0.2228	0.2149	0.2143	0.2101
Yangquan	0.1943	0.1843	0.1701	0.1382	0.1543	0.197	0.2705	0.3382	0.2177	0.2121	0.2504	0.2258
Yuncheng	0.1625	0.1557	0.1431	0.1346	0.1451	0.179	0.2392	0.3274	0.182	0.1911	0.185	0.1864
Lüliang	0.1921	0.2368	0.2503	0.2492	0.2542	0.2807	0.3251	0.388	0.3016	0.3015	0.2951	0.3179
Linfen	0.1234	0.1162	0.117	0.1093	0.1224	0.1534	0.2224	0.3064	0.1833	0.1848	0.1917	0.1938
Datong	0.122	0.1107	0.104	0.1004	0.1127	0.1503	0.2139	0.2987	0.1656	0.1622	0.1595	0.1622
Shuozhou	0.1337	0.1319	0.1309	0.1294	0.135	0.1655	0.2233	0.3158	0.1663	0.1765	0.1803	0.1908
Xinzhou	0.1754	0.1053	0.0906	0.0892	0.1085	0.3042	0.2341	0.3312	0.1672	0.191	0.191	0.1919
<i>Shanxi Province</i>	0.1914	0.1884	0.1892	0.1792	0.1799	0.2317	0.2836	0.3616	0.2305	0.2303	0.236	0.234

4.3.2. Measurement of digital business environment by dimensions

Table 6 presents the measurement results of the digital business environment of 11 prefecture-level cities in Shanxi Province in 2024. Through a systematic comparison and characteristic analysis of the development levels of the digital business environment in these 11 prefecture-level cities, the cities are divided into three tiers. Taiyuan, as the capital city of Shanxi Province, leads the way with a comprehensive score of 0.5073, ranking first in all dimensions and forming the first tier; Jinzhong, Jincheng, Changzhi, and Yangquan have comprehensive scores ranging from 0.21 to 0.32, constituting the second tier; the remaining six cities, namely, Shuozhou, Lüliang, Datong, Linfen, Yuncheng and Xinzhou have scores ranging from 0.1622 to 0.2009, with a relatively lower overall level and small differences, belonging to the third tier.

Specifically, in the dimension of digital infrastructure environment, Taiyuan and Yangquan rank first and second respectively, significantly higher than other cities, reflecting their leading advantages in the layout of new infrastructure; Jincheng and Jinzhong follow closely; while Shuozhou, Lüliang, and Changzhi rank behind, related to regional economic volume, terrain conditions, and investment intensity. In terms of digital innovation environment, Taiyuan leads, Jincheng ranks second, but the gap with the leading

position is large; Yangquan, Yuncheng, and Changzhi are in the middle range; Xinzhou, Lüliang, and Jincheng are at the back. The innovation environment is highly concentrated in Taiyuan and its surrounding areas, reflecting that the innovation ecosystem of most resource-based cities has not been effectively formed. In the digital market environment, the overall level is low and the differences among cities are small, Taiyuan remains at the top, Jincheng, Lüliang, and Shuozhou rank second to fourth respectively; Yuncheng, Datong, and Xinzhou rank behind. The market environment is generally weak, indicating that soft indicators such as the activity of digital transactions and the willingness of enterprises to digitalize still need to be improved. A few cities such as Jincheng and Lüliang perform relatively well, benefiting the digital exploration of specific industries. In the digital legal governance environment, Taiyuan is absolutely leading, Changzhi, Jincheng, Lüliang, and Jinzhong rank second respectively; Yangquan, Xinzhou, and Yuncheng are relatively lagging behind. The digital legal governance environment is generally high, reflecting that the reforms and measures such as digital government construction in Shanxi Province have been well implemented in each city, but cities like Yangquan have low scores, suggesting that the services and legal guarantees of government need to be further optimized.

Table 6. TOPSIS scores of digital business environment in each dimension of 11 Prefecture-level Cities in Shanxi Province in 2024

City	Digital Infrastructure Environment		Digital Innovation Environment		Digital Market Environment		Digital Legal Governance Environment		Digital Business Environment		Category
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	
Taiyuan	0.6899	1	0.7108	1	0.3211	1	0.8077	1	0.5073	1	First tier
Jinzhong	0.5021	4	0.3695	2	0.2308	3	0.5377	3	0.3179	2	
Jincheng	0.505	3	0.1059	9	0.2614	2	0.5275	5	0.2258	3	Second tier
Changzhi	0.4489	9	0.1321	5	0.2113	5	0.5881	2	0.2101	4	
Yangquan	0.6051	2	0.1654	3	0.1879	9	0.362	11	0.2009	5	
Yuncheng	0.4592	8	0.1356	4	0.1976	6	0.4153	9	0.1938	6	
Lüliang	0.43	10	0.0829	10	0.212	4	0.5363	4	0.1919	7	Third tier
Linfen	0.4791	6	0.1093	8	0.1974	7	0.4912	6	0.1908	8	
Datong	0.4829	5	0.1239	6	0.1821	10	0.4765	7	0.1866	9	
Shuozhou	0.4092	11	0.1123	7	0.1958	8	0.476	8	0.1864	10	
Xinzhou	0.468	7	0.0658	11	0.1722	11	0.4065	10	0.1622	11	

5. Optimization Suggestions

5.1. Strengthen the construction of digital infrastructure

The digital infrastructure construction in Shanxi Province requires the joint efforts of the government and enterprises. It should be carried out in a coordinated manner from three dimensions: policy support, technological innovation, and ecosystem building. On the one hand, from the government's perspective, it is necessary to strengthen policy guidance and financial support: increase fiscal support, and suggest that the Shanxi Provincial Government establish a special fund for the digital transformation of small and medium-sized enterprises, giving priority to supporting 5G network coverage, edge computing node deployment, and the construction of industrial internet platforms. Optimize the use mechanism of special bonds, and focus on investing in digital transformation projects of industrial parks, such as the Digital Empowerment Center of Taiyuan Comprehensive Reform Demonstration Zone, to provide SaaS-based solutions like intelligent customer service and precise marketing for small and medium-sized enterprises. Innovate financial support models, implement data-based credit financing mechanisms, incorporate enterprise digital assets such as cloud service usage records and IoT device coverage rates into the credit assessment system, develop digital loan financial products, and lower the financing threshold for small and medium-sized enterprises. Encourage financial institutions to collaborate with technology enterprises, provide digital infrastructure leasing services, and reduce the initial investment costs for enterprises. On the other hand, from the enterprise perspective, optimize technological application and ecosystem collaboration: accelerate the deep integration of digital technologies, promote the cloud-based upgrade of ERP systems, build data centers, and improve the efficiency of utilizing production data. Introduce industrial internet technologies such as AI quality inspection and predictive maintenance, optimize production processes. Build a digital industrial ecosystem, implement the "Digital Partner Program", encourage provincial state-owned enterprises such as Jineng Holding and Taiyuan Iron and Steel Group to open their supply chain digital systems to upstream and downstream small and medium-sized enterprises, and promote the coordinated transformation of the industrial

chain. Support industry associations in building "Small and Medium-sized Enterprise Digital Sharing Platform", providing on-demand services for computing power, algorithms, data, etc., of resources.

5.2. Enhance the development of digital talent teams

The rapid development of the digital economy has led to an exponential increase in the demand for digital professionals. In the process of building a digital business environment in Shanxi Province, it is necessary to solve the problems of scarce talent, mismatched demands, and lagging training, and establish a collaborative mechanism involving education, enterprise recruitment, and government support. *First, improve the digital talent training system.* Strengthen the incubation of digital capabilities at the educational end: establish interdisciplinary digital subjects in universities in Shanxi Province, such as Taiyuan University of Technology, Shanxi University of Finance and Economics, and Shanxi University, and offer advanced courses such as blockchain and industrial big data. Refer to the digital craftsmanship training plan in Guangdong Province, implement the system of academic certificates and vocational skills certification certificates, and establish provincial digital teaching practice bases. *Second, optimize the mechanism for enterprise talent recruitment and retention.* Innovate digital talent incentive policies, offer personal income tax exemptions or provide relocation allowances to high-level, cutting-edge, and scarce digital talents recruited by enterprises, and open up promotion channels to improve their material rewards and spiritual incentives. *Third, build a government talent ecosystem service platform.* Establish a provincial digital talent database: integrate data from departments such as industry and information technology, human resources and social security, and education, create the Jincai Tong digital talent information platform, dynamically analyze the shortage positions in key industries such as coal, tourism, and vinegar in the province; use algorithm recommendation technology to intelligently match talent skills labels such as Python programming and ERP implementation experience with enterprise project needs; open a "special zone" for joint research and development results between schools and enterprises to promote technology transfer. *Fourth, deepen international talent cooperation:* establish an overseas workstation for digital talents in Shanxi Province to attract

overseas experts to participate in Shanxi projects; implement the Digital Star Program: select 100 young technical backbone every year to go to regions such as Silicon Valley and Shenzhen for exchanges and learning of cutting-edge applications such as industrial internet and AIGC. *Fifth, establish an evaluation mechanism for the effectiveness of talent policies.* Release the "Digital Talent Development Index of Shanxi Province" quarterly to monitor key indicators such as the rate of talent mobility and salary growth rate. Establish a digital talent development fund, with 30% funded by the provincial government and 70% raised by enterprises, specifically used for subsidies for the introduction of high-end digital talents.

5.3. Accelerate the digital transformation of enterprises

Under the background of high-quality economic development in the new era, the digital transformation of small and medium-sized enterprises in Shanxi Province has become a key factor for regional industrial upgrading and revitalizing market vitality. This transformation process requires the coordinated efforts of government guidance and enterprise entities. At the government level, a systematic policy support system should be established: Firstly, a "Special Plan for Digital Transformation of Small and Medium-sized Enterprises in Shanxi Province (2025-2030)" should be formulated, clearly defining the phased goals and implementation paths; Secondly, it is suggested to establish a provincial digital transformation service center, integrating resources from third-party service providers such as Alibaba Cloud and Huawei, to build a three-in-one support platform including technical diagnosis, talent training, and solution implementation. This institutional design can effectively reduce the trial-and-error costs of enterprises and alleviate the common anxiety of not daring or not knowing how to transform. At the enterprise level, transformation strategies should be promoted in multiple dimensions: *First, in the strategic dimension*, the management layer should establish a digital strategy committee and regularly conduct technical scans, focusing on technology fields such as industrial internet and AI quality inspection that are highly compatible with Shanxi's manufacturing industry; *Second, in the technical dimension*, it is recommended to implement ERP system transformation in stages and build a data middle platform based on cloud computing; *Third, in the organizational dimension*, a digital-specific training system should be designed, such as the digital craftsmanship certification system implemented by Taiyuan Iron and Steel Group, which significantly enhanced the human-machine collaboration capabilities of employees. *Fourth, in the adaptation dimension*, a performance evaluation system focused on enterprise profitability, exploring and balancing internal and external environmental relationships, should be established to build its own competitive advantages. It is particularly important to note that the unique resource-based economic background of Shanxi makes the digital transformation of enterprises exhibit differentiated characteristics. For advantageous industries such as coal mines, equipment, and manufacturing, vertical applications such as predictive maintenance can be prioritized; while for traditional industries such as vinegar and glass handicrafts, it is more suitable to start digital transformation from the e-commerce marketing end, and this classification promotion strategy has achieved remarkable results in the pilot projects

of industrial clusters in Jinzhong City.

5.4. Create a favorable government environment

In the process of striving to improve the quality and efficiency of government services and optimizing the digital business environment, the government must adhere to the principle of problem-oriented approach, restructure the government's service process, actively identify the most urgent and necessary problems faced by enterprises, and utilize modern technological tools such as big data and the internet to integrate online and offline service resources, making government services more convenient and transparent. *First*, the reconfiguration of the service process should be oriented towards the needs of enterprises. The government needs to conduct a systematic review of current government services, delete unreasonable approval steps and proof materials, simplify the process design, and achieve efficient approval. To further enhance the convenience of services for enterprises, reduce the number of documents submitted by enterprises, and follow the principle of "one-time completion", reduce the time for administrative approval, thereby effectively reducing the time cost of enterprise operations. *Secondly*, when setting market entry thresholds, a unified standard should be followed. The key to reconfiguring the government service process lies in ensuring fair treatment of all different types of market entities, eliminating various barriers and obstacles outside the market entry list. For enterprises from other provinces entering the market in Shanxi, the principle of equality should be adhered to, and no additional market entry conditions should be set. *Finally*, establishing a regular two-way communication mechanism between the government and enterprises is particularly crucial. The government should give enterprises more opportunities to express their needs, actively listen to the opinions of enterprises, and provide feedback at appropriate times. In addition, innovating government and enterprise communication platforms, expanding communication channels, and actively changing the traditional communication mode are necessary to improve the efficiency and quality of communication. Enterprises should also actively feedback the difficulties and demands they encounter in their operations to the government. At the same time, the service team of the government also needs to enhance communication skills with enterprises to ensure the simplicity, smoothness, and sustainability of the communication process.

6. Conclusions

The strategy of the Rise of Central China plays a crucial role in promoting high-quality development across the country and achieving Chinese-style modernization. "Digital reform" has become the core engine driving the high-quality development of Central China. Among these six provinces constituting Central China, Shanxi Province, as a comprehensive reform pilot zone for the transformation of the resource-based economy, has been exploring the transformation path of "digital empowerment" by taking digital business environment optimization as a breakthrough in recent years, providing an important local practice sample for the rise of the central region. This paper constructs an evaluation index system for the digital business environment of Shanxi Province from four dimensions: digital infrastructure environment, digital innovation environment,

digital market environment, and digital legal governance environment. It measures the development level of digital business environment in Shanxi Province from three aspects, that is, provincial level, regional level and urban level.

The results show that there is still considerable room for improvement in the overall digital business environment of Shanxi Province, with good digital infrastructure environment and digital legal governance environment, but poor digital innovation environment and digital market environment. There are significant regional differences in the digital business environment, with Central Shanxi having the best digital business environment, while the digital business environment construction in the Northern Shanxi is relatively lagging. The comprehensive level of digital business environment in Taiyuan ranks among the top in the province, while cities such as Shuozhou, Lüliang, Datong, Linfen, Yuncheng and Xinzhou still need to increase efforts in digital business environment construction. It is suggested to strengthen the construction of digital infrastructure environment, strengthen the construction of digital talent teams, accelerate enterprise digital transformation and create a favorable government environment, to provide good environmental support for Shanxi Province to strengthen, optimize and expand the digital economy.

This research enriches the regional perspective of digital business environment research in resource-based regions, expands the methodological system for evaluating digital business environment, and provides decision-making references and paradigm inspiration for Shanxi Province and similar regions to optimize the digital business environment. However, this research also has certain limitations: due to the limitation of data availability, the selection of some indicators may be limited; mainly based on descriptive analysis, the mechanism exploration of the impact effect of digital business environment is not deep enough. Future research can further explore the transmission mechanism and heterogeneity effect of digital business environment on regional economic growth and industrial transformation based on more complete data, and strengthen comparative research with other resource-based regions to provide more universal theoretical support and practical guidance for the Rise of Central China.

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