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Retraction

Retracted: Evaluation of High-Quality Development of Shaanxi's Economy Based on Digital Economy Based on Machine Learning Algorithm

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] L. Wang, "Evaluation of High-Quality Development of Shaanxi's Economy Based on Digital Economy Based on Machine Learning Algorithm," *International Transactions on Electrical Energy Systems*, vol. 2022, Article ID 6327347, 9 pages, 2022.

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Research Article

Evaluation of High-quality Development of Shaanxi's Economy Based on Digital Economy Based on Machine Learning Algorithm

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With the strong development of industrial transformation, the digital economy, as the most dynamic, innovative, and widely radiated economic form at present, has become an important force driving the development of the global economy. Shaanxi Province has accelerated the development of the digital economy, and the development of the province's digital economy has shown a good trend. However, the current digital economy development measurement is still unable to accurately observe the development law of the digital economy industry, which makes it difficult to measure the control standards for the digital economy industry. Therefore, this study has evaluated the development of digital economy in Shaanxi Province based on machine learning algorithms. This study first puts forward the dimensions of digital economy monitoring and evaluation and then combines the characteristics of digital economy development in Shaanxi Province to determine the quality evaluation indicators of digital economy development. Finally, according to the machine learning algorithm, a quality evaluation model of digital economy development was established, and through the evaluation results, suggestions were put forward for the development plan of digital economy in Shaanxi Province. The experimental results showed that, after re-planning the digital economy in Shaanxi Province according to the evaluation results, the development of the digital economy in Shaanxi Province has increased by 9.82%, indicating that the evaluation model plays a good reference role in the formulation of the digital economy development plan.

1. Introduction

Shaanxi Province has made great progress in the fields of digital economy such as online shopping, online entertainment, mobile communication, and online education, which has played the dual function of promoting epidemic prevention and control and economic and social development. In the process of promoting the scale of the digital economy, the main tasks of Shaanxi Province are as follows. The first is information infrastructure construction. Shaanxi has implemented communications' infrastructure construction actions for four consecutive years, which comprehensively enhances the supporting capacity of information infrastructure. The second is to innovate and promote the pilot demonstration of the digital economy, accelerating the implementation of special actions such as "Internet +" and "Intelligence +." The third is to implement the "five major projects" for poverty alleviation through the Internet, and the e-commerce poverty alleviation and consumption poverty alleviation have achieved remarkable results. The fourth is to carry out international exchanges and cooperation in information infrastructure construction and digital economy development. However, there is currently no method to accurately assess the development level of the digital economy, which is an important issue that remains to be resolved.

Many scholars have conducted research on the digital economy. Han and Ding studied the impact of the digital economy on total factor carbon productivity [1]. In the context of COVID-19, Li and Liang examined the impact of the digital economy on the integration of China's cultural tourism industry [2]. Wang et al. discussed the role of the digital economy in green innovation and put forward relevant suggestions for improving geographic information capabilities [3]. Chizhikov et al. considered a theoretical approach that made it possible to formulate rational choices for the construction of distributed systems and telecommunications in the digital economy under the influence of external special software and hardware [4]. On the basis of measuring the level of data economy at the city level, combined with pm2.5 data of haze pollution and related economic statistics, Huang discussed the relationship between the development level of digital economy and urban haze pollution from both theoretical and empirical levels [5]. Although there are many studies on the digital economy, further research is needed on the digital economy to promote the high-quality development of Shaanxi's economy.

Machine learning algorithms are widely used in evaluation. Frolov et al. used machine learning to assess changes in cerebral cortical synchrony under long-term cognitive load [6]. Beswick et al. evaluated the improvement of sinus computed tomography with CFTR modulator treatment by machine learning [7]. Hung used machine learning to evaluate the performance and predicted outcomes of robotic-assisted radical prostatectomy [8]. Guimaraes et al. evaluated whether the use of a machine learning software program can accurately define the use of a standardized reporting template and language for non-compliance with a human review performed by a machine learning software program [9]. Trentzsch and Schumann used a machine learning algorithm to identify gait parameters suitable for assessing subtle changes in gait in patients with multiple sclerosis [10]. Although machine learning algorithms are often used for evaluation, there is little research on machine learning algorithms in the evaluation of high-quality economic development.

This study first describes the dimensions of digital economy monitoring and evaluation, including six parts: digital infrastructure, data resource elements, digital technology innovation, digital industry development, digital industry application, and digital social governance. Then, based on these six dimensions, the quality evaluation index of digital economy development is proposed. Then, Support Vector Machine (SVM), *K*-Nearest Neighbor Algorithm (KNN), *K*-Means Clustering, and Gaussian Mixture Model are selected as models for evaluating the quality of digital economy development. Finally, according to the evaluation results, suggestions are put forward for the development of the digital economy in Shaanxi Province, and the digital development of Shaanxi Province is re-evaluated after adjustment according to the suggestions.

2. Evaluation Model of High-Quality Development of Digital Economy Based on Machine Learning Algorithm

2.1. Dimensions of Digital Economy Monitoring and Evaluation Based on High-Quality Development. The role of digital technology in the economy and society is mainly reflected in two aspects. One is the diffusion process of digital infrastructure, and the other is the integration process of digital technology and social environment [11]. Based on the above framework, this study divides the evaluation dimension of the digital economy into two parts. The theoretical framework of digital economy monitoring is shown in Figure 1.

The base layer of the digital economy includes three parts: digital infrastructure, data resource elements, and digital technology innovation. The digital economy contribution layer includes three parts: digital industry development, digital industry application and digital social governance. The development and application of the digital industry reflect the economic benefits of the digital economy, and the governance of the digital society reflects the social benefits of the digital economy.

2.2. Selection of Quality Evaluation Indicators for Digital Economy Development. Combined with the construction goals and development characteristics of digital economy cities in Shaanxi Province, on the basis of six first-level dimensions, two-level dimensions and three-level indicators are determined [12]. The specific indicators are shown in Table 1.

2.3. Construction of the Evaluation Model. This research collected the analysis index data from 2015 to 2021 and selected *K*-Means clustering and Gaussian mixture model as the model to evaluate the quality of digital economy development.

2.3.1. Support Vector Machine Evaluation Model. In machine learning, SVM is a widely used supervised learning algorithm, which is commonly used for pattern recognition, classification, and regression analysis [13]. The SVM is shown in Figure 2.

SVM is used for classification in the research work of this study. The constraint of SVM is as follows:

$$x_i\left(w^T y_i + b\right) \geq 1. \quad (1)$$

When considering the problem of outliers, the constraints become formulas (2) and (3):

$$x_i\left(w^T y_i + b\right) \geq 1 - \xi_i, \quad (2)$$

$$\xi_i \geq 0. \quad (3)$$

If ξ_i satisfies formula (3), it is called a slack variable.

Constraints are added so that the sum of ξ_i is minimized:

$$\min \frac{1}{2} w^2 + C \sum_{i=1}^{n} \xi_i, \quad (4)$$

where C is a parameter.

For nonlinear problems, a nonlinear SVM optimization problem can be obtained by constructing a Lagrangian function and solving the derivative in some way:

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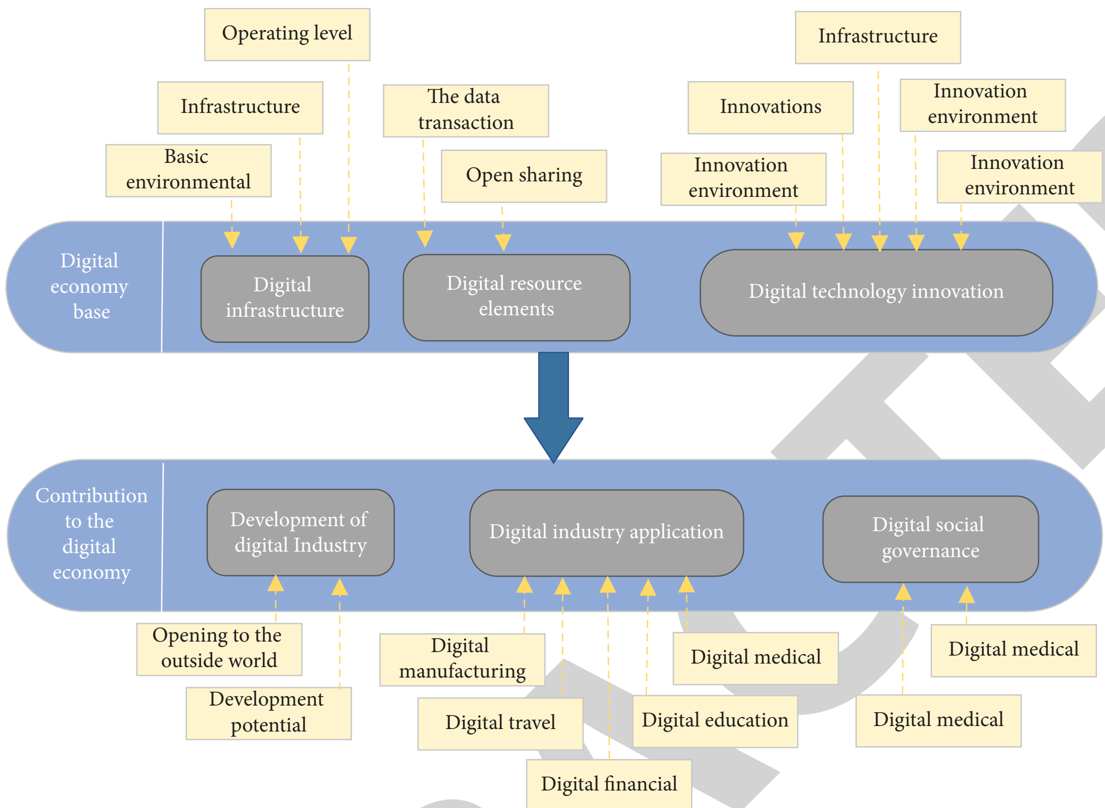

Figure 1: Theoretical framework of digital economy monitoring.

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$$\min \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N}\alpha_i\alpha_j\beta_i\beta_j H(y_i, y_j) - \sum_{i=1}^{N}\alpha_i,$$
$$\sum_{i=1}^{N}\alpha_i\beta_i = 0, \tag{5}$$
$$0 \leq \alpha_i \leq C.$$

When faced with data samples from low-level regions that cannot be divided, kernel functions can be used to map data samples from low-level regions to high-level regions to solve the problem. The commonly used kernel functions are as follows.

(a) Linear kernel function:

$$H(y_i, y_j) = y_i, y_j. \tag{6}$$

Linear kernel function classification results are good. Therefore, when processing data, the first attempt is to use the linear kernel function to classify.

(b) Polynomial kernel function:

$$H(y_i, y_j) = \left((y_i, y_j) + 1\right)^d. \tag{7}$$

The polynomial kernel function has many parameters. When the order is high, the computational complexity is too large to calculate.

(c) Gaussian radial basis kernel function:

$$H(y_i, y_j) = \exp\left(-\gamma y_i - y_j^2\right),$$
$$\gamma = \frac{1}{2\delta^2}. \tag{8}$$

The Gaussian radial basis function has better performance and less parameters.

(d) Sigmoid kernel function:

$$H(y_i, y_j) = \tanh\left(H(y_i, y_j) - \delta\right). \tag{9}$$

In this study, in order to select the best clustering result, the radial basis kernel function is used for training, and then, it is validated on the training dataset to find the best C and y parameters. Finding better C and y enables the classifier to correctly predict the test set data, while making the classification accuracy relatively high [14].

2.3.2. K-Nearest Neighbor Algorithm. The *K*-nearest neighbor algorithm is shown in Figure 3.

Figure 3 shows which group the test sample in the image, the yellow five-pointed star, should belong to. If the value of *K* is set to 3, which is the extent of the blue circle, then the yellow star is assigned to the green triangle group because there are two green triangles inside the circle and only one blue square. If the value of *K* is set to 5, which is the range of

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Table 1: Digital economy development quality indicators.

First-level indicators	Two-level indicators	Three-level indicators
Digital infrastructure	Infrastructure	Number of 5 G base stations built
		The proportion of new infrastructure in the city
		City's per capital computing power
	Operational level	Number of mobile subscribers per 100 inhabitants
		5 G end user penetration rate
		Gigabit broadband household penetration
	Environmental basics	Ease of doing business
Data resource elements	Open sharing	Public data open index
	Data transaction	Big data transaction volume growth
Digital technology innovation	Innovation input	Research and development (R&D) investment intensity of digital economy enterprises
	Innovation environment	Global science and technology innovation center index
	Creativity	Growth rate and proportion of graduates majoring in digital economy
		The proportion of ICT employees in the city's employees
		R&D personnel account for the proportion of employees in the city
	Innovative achievements	Income and growth rate of enterprises in independent innovation demonstration zone
		The number of papers published in top journals in the field of computer science
		The number and proportion of digital economy invention patents authorized
Digital industry development	Scale structure	The added value of the core industries of the digital economy accounts for the proportion of the city
		The proportion of e-commerce transaction volume in the national e-commerce transaction volume
	Development potential	The proportion of the top 100 digital economy benchmarking companies in the world by market capitalization
		The number of digital economy unicorn companies accounts for the proportion of the world
		The scale of financing of digital economy public enterprises
	Open to the outside world	Digitizable trade in services
		The scale of investment in other countries in the digital economy
		The scale of capital utilization of other countries in the digital economy
Digital industry application	Digital manufacturing	Growth rate of total output value of digital manufacturing enterprises
		Technology contract turnover and growth rate of digital manufacturing enterprises
	Digital mobility	Number of intelligent and connected roads built
		Autonomous driving road miles
		Average daily service person-time of public transport mobile payment
		Dynamic data access rate of operating record parking lot
		Monthly active users of key internet travel platforms
	Digital health	Monthly active users of key internet medical platforms
		The coverage rate of personal health records for each citizen, one code
	Digital education	The number of people studying online on the internet education platform
	Digital finance	Growth rate of third-party mobile payment amount
		Operating income of key financial technology companies
		Online payment inter-bank clearing system business volume
Digital society governance	Digital government	The rate of online handling of government service matters
		The ratio of actual handling of government service matters
		Monthly active users of online government services
		Total applications of electronic business licenses
	Digital life	Digital life citizen satisfaction
		Intelligent rate of end systems of water, electricity, and gas systems

the red line circle, then the yellow five-pointed star is assigned to the blue square group.

In the field of pattern recognition technology, KNN algorithm is widely used for classification. In this study, the classification technique is mainly applied to the nearest neighbor algorithm.

When calculating the distance between objects in KNN, in order to avoid matching problems between objects, Euclidean distance or Manhattan distance is often used [15].

Euclidean distance:

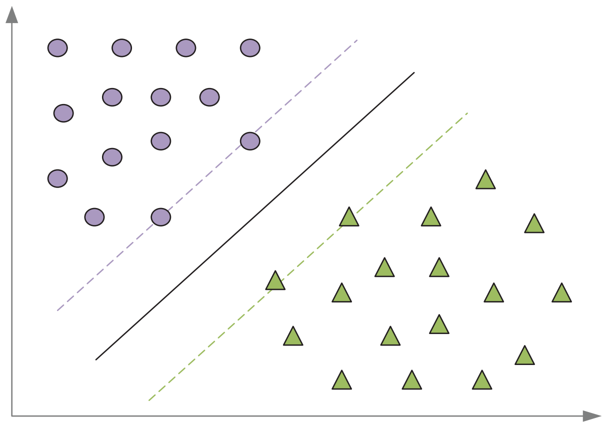

Figure 2: Support vector machine.

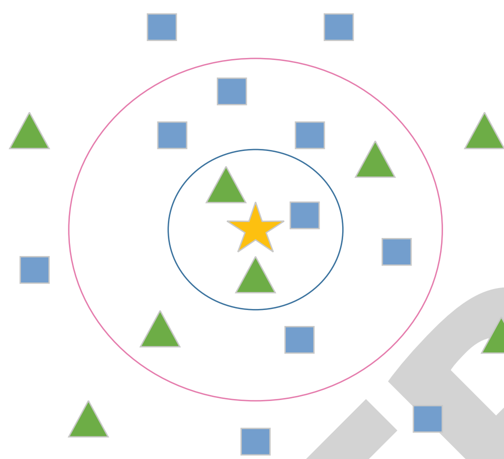

Figure 3: *K*-nearest neighbor algorithm.

$$d(x, y) = \sqrt{\sum_{k=1}^{n} (x_k - y_k)^2}. \quad (10)$$

Manhattan distance:

$$d(x, y) = \sum_{k=1}^{n} |x_k - y_k|. \quad (11)$$

In the nearest neighbor, the value of K affects the clustering results. If the K value is relatively small, overfitting easily occurs. If the K value is relatively large, it increases the training error, so the optimal K value can be selected by the method of cross-validation [16].

The training process of the K-nearest neighbor prediction model is as follows.

Input data: M is the dataset.

Training process: M is divided into two parts, training set and test set. New validation data are added to the training dataset circularly. The distance between the new data and each training sample is calculated. The K samples closest to the new data are found. The number of occurrences of each class in the K samples is counted. The class with the highest frequency is selected as the class of the new data.

Output: it is the accuracy of the K-nearest neighbor prediction model on the test set.

2.3.3. K-Means Clustering. The K-Means has good measurement performance in a large number of samples and is widely used in many different fields [17].

Given a set of observations, $x = \{x, x_2 ... x.\}$, the goal of K-Means is to obtain

$$\arg\min \sum_{i=1}^{k} \sum_{x \in s_i} x - \mu_i^2, \quad (12)$$

where μ_i is the mean of the midpoints of s_i.

The training process of the K-Means clustering prediction model is as follows [18].

Input data: tThe raw dataset $M\{X_1, X_2, \ldots, X_n\}$ that is unlabeled is input.

Training process K cluster centroid points are randomly selected. The variance of the remaining data at the K centroids is calculated separately, and these data are input into the cluster with the smallest variance. The different centers of the K groups are recalculated based on the clustering results by taking the arithmetic mean of the different measurements of all elements in the group. All points in M are regrouped according to the new center. The fourth step is repeated until the clustering results no longer change.

Output: iIt is the prediction accuracy of the K-Means clustering model.

2.3.4. Gaussian Mixture Model. The Gaussian mixture model algorithm process is as follows [19].

The number M of Gaussian distributions in the Gaussian mixture model is set, and the parameter θ in the Gaussian mixture model is initialized.

θ is the set of mean function μ, covariance matrix Σ, and prior probability a_j for each model scale.

$P(j|x;\theta)$ is calculated:

$$P(j|x;\theta) = \frac{a_j N_j(x_i;\theta)}{\sum_{l^M} a_l N_l(x_i;\theta)},$$
$$N_i(x) = \frac{1}{\sqrt{(2\pi)^d |\Sigma_i|}} \exp\left[-\frac{1}{2}(x - \mu_i)^t \sum_i^{-1} (x - \mu_i)\right]. \quad (13)$$

The weights are updated:

$$a_j = \frac{\Sigma i = 1^n P_{ij}}{N}. \quad (14)$$

The mean is undated:

$$\mu = \frac{\Sigma i = 1^n P_{ij} x_j}{\Sigma i = 1^n P_{ij}}. \quad (15)$$

The covariance matrix is updated:

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$$\sum_j = \frac{\Sigma i = 1^n P_{ij}\left(x_i - \mu_j\right)\left(x_i - \mu_j\right)^T}{\Sigma i = 1^n P_{ij}}. \quad (16)$$

The above steps are repeated until the convergence condition is satisfied [20].

The training process for a Gaussian mixture model is as follows.

Input data: the raw dataset 1 without labels is input.

Training process: for each Gaussian distribution, its mean and random variance are given. For each data sample, its probability in a Gaussian distribution is calculated. For each Gaussian distribution, the contribution of the Gaussian distribution for each data sample based on the probability is calculated [21, 22]. If the probability is large, the contribution is large, and if the probability is small, the contribution is small. Therefore, the contribution of the data samples to the Gaussian distribution is used as the weight to calculate the weighted mean and variance. The steps are repeated until both the mean and variance of the Gaussian distribution converge.

Output: it is the prediction accuracy of the Gaussian mixture model.

3. Experiment Results and Discussion of Digital Economy Assessment

The experiment collected data on digital economy indicators in Shaanxi Province from 2015 to 2021. The evaluation of digital economy development was carried out from six aspects: digital infrastructure, digital resource elements, digital technology innovation, digital industry development, digital industry application, and digital social governance [22, 23]. According to the evaluation results, suggestions have been put forward for the development plan of the digital economy in Shaanxi Province, and the development status of the digital economy in Shaanxi Province was re-evaluated according to the data after the plan [24].

3.1. Digital Infrastructure. The digital infrastructure index value of Shaanxi Province in 2015 is set to 100, and the evaluation results of digital infrastructure from 2015 to 2021 are shown in Figure 4.

The evaluation results of digital infrastructure in Shaanxi Province in 2016 and 2017 were relatively close to those in 2015, and the development of digital infrastructure in these two years has not changed much. Since 2018, Shaanxi Province has increased its investment in digital infrastructure, and the evaluation results of digital infrastructure have improved year by year. Especially in 2020 and 2021, the evaluation results of digital infrastructure have increased significantly. The evaluation result in 2019 was 117.83, which was raised to 132.58 in 2020 and 146.69 in 2021. It can be seen that the development of digital infrastructure in Shaanxi Province has made great progress in the past two years. In order to further improve the construction of digital infrastructure, it is necessary to integrate the network equipment of the four major operators, including Telecom,

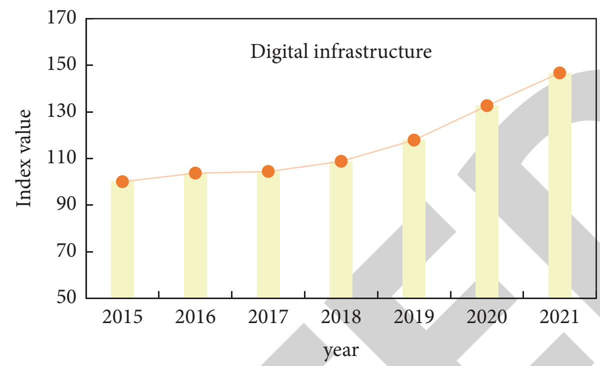

Figure 4: Digital infrastructure evaluation results.

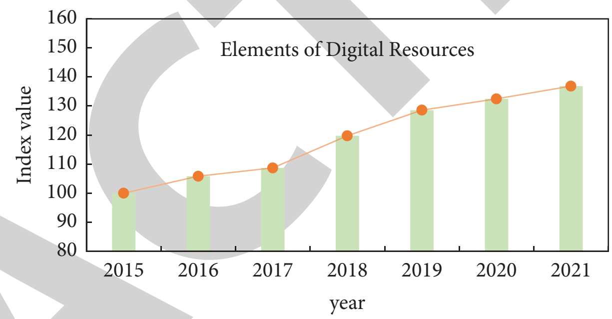

Figure 5: Evaluation results of digital resource elements.

China Mobile, China Unicom, and Radio and Television, increasing investment in various fields of "new infrastructure" and accelerating the pace of construction of new infrastructure such as data centers and 5 G networks, to improve network equipment and implement speed-up and fee reduction.

3.2. Elements of Digital Resources. Setting the index value of digital resource elements in Shaanxi Province in 2015 to 100, the evaluation results of digital resource elements from 2015 to 2021 are shown in Figure 5.

The development of digital resource elements in Shaanxi Province was relatively slow in 2016 and 2017, but has been greatly improved in 2018. It increased from 108.69 in 2017 to 119.74 and then maintained a relatively fast growth rate year after year. In 2021, the evaluation result of digital resource elements was improved to 136.84. To further enhance the construction of digital resource elements, it is necessary to accelerate the construction of an intelligent society, with the interconnection of different operating systems as the main line, and to promote the co-construction, sharing of software and hardware facilities.

3.3. Digital Technology Innovation. The digital technology innovation index value of Shaanxi Province in 2015 was set to 100, and the evaluation results of digital technology innovation from 2015 to 2021 are shown in Figure 6.

The value of the digital technology innovation index in Shaanxi Province showed a gradually increasing trend, and its growth rate was the fastest in 2019 and 2020. The index

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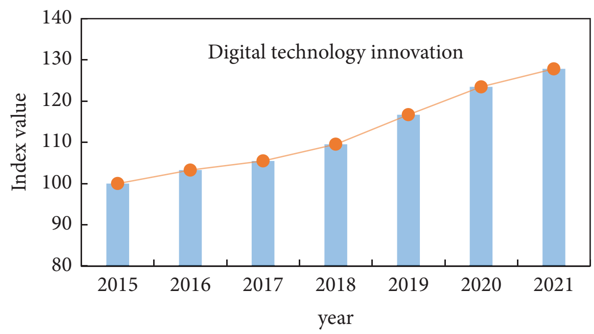

Figure 6: Digital technology innovation evaluation results.

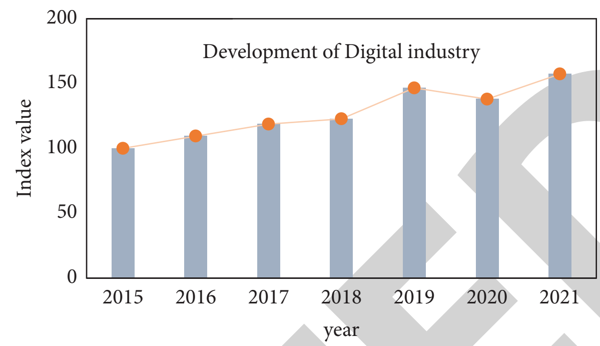

Figure 7: Digital industry development evaluation results.

value of digital technology innovation in 2019 was 116.69. The index value in 2020 was raised to 123.45, and it was 127.85 in 2021. To further enhance the construction of digital technology innovation, it is necessary to further increase the research and development investment intensity of digital economy enterprises and introduce digital economy professionals.

3.4. Development of Digital Industry. The digital industry development index value of Shaanxi Province in 2015 was set to 100, and the evaluation results of digital industry development from 2015 to 2021 are shown in Figure 7.

The development speed of the digital industry was relatively slow, showing a steady upward trend as a whole. In 2021, the development index value of the digital industry in Shaanxi Province was 157.36, and the development trend was good. To further enhance the construction of digital industry development, it is necessary to integrate good industries such as electronic information industry and software service industry to improve the effect of industrial integration. At the same time, relying on the existing industrial foundation and scientific and technological research and development advantages, the construction of digital industrial parks and bases needs to be continuously strengthened, and the radiation effect of the park should be enhanced.

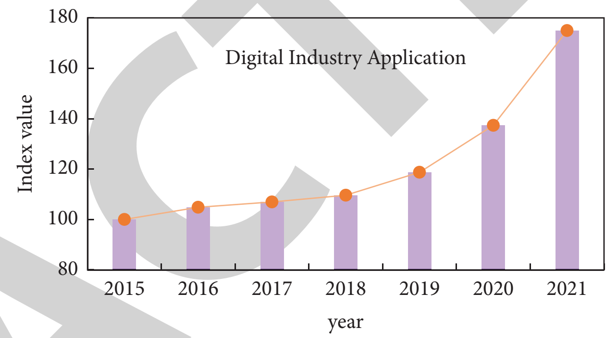

Figure 8: Digital industry application evaluation results.

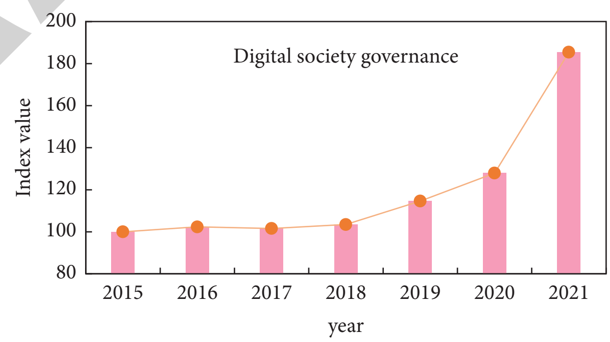

Figure 9: Digital society governance evaluation results.

3.5. Digital Industry Applications. The digital industry application index value of Shaanxi Province in 2015 was set to 100, and the evaluation results of digital industry application in 2015–2021 are shown in Figure 8.

In terms of digital industry applications, the development of digital industry applications was relatively slow from 2015 to 2018. It improved in 2019 and significantly improved in 2020 and 2021. The value of the digital industry application index in 2020 was 137.35, and the index value in 2021 was 174.93. To further enhance the construction of digital industry development, it is necessary to break industrial boundaries to promote industrial integration and industrial model innovation, forming a new economic growth point and industrial development model. It is also necessary to seize the opportunity that enterprises from all walks of life have realized the urgency and importance of digital transformation to guide the industry and encourage enterprises, thereby flexibly implementing digital transformation strategies according to their own needs.

3.6. Digital Social Governance. The digital social governance index value of Shaanxi Province in 2015 was set to 100, and the evaluation results of digital social governance from 2015 to 2021 are shown in Figure 9.

The development of digital social governance in Shaanxi Province was relatively slow, and the index value did not change significantly from 2015 to 2018. In 2019 and 2020, the index value increased slightly, and in 2021, digital social governance developed rapidly. The digital social governance index value in 2020 was 127.93, and the index value in 2021 greatly increased to 185.44. To further enhance the

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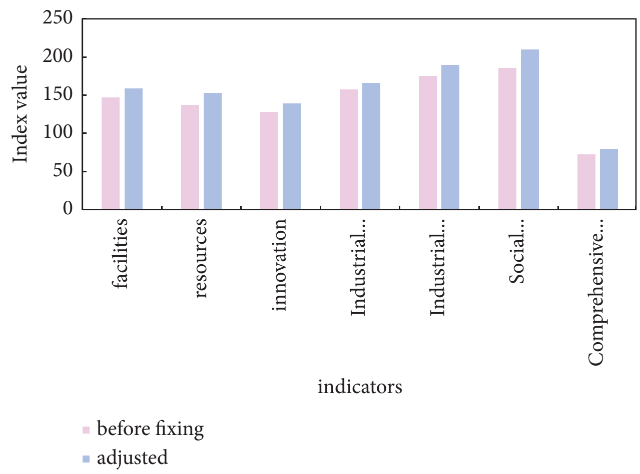

FIGURE 10: Digital economy development forecast.

construction of digital social governance, it is necessary to speed up the construction of digital government and improve the new system of data integration and sharing to vigorously develop e-government and facilitate the development and reuse of data value-added, which improve e-government-related laws and regulations and overall coordination mechanisms and improve the public data open system, thus ensuring the healthy development of e-government.

3.7. Development Forecast of Digital Economy. The digital economy development plan was adjusted according to the evaluation results of the digital economy development, and the development status of the digital economy in Shaanxi Province was evaluated according to the adjusted data, comparing it with the data in 2021. The results are shown in Figure 10.

After the adjustment, the index values of digital infrastructure, digital resource elements, digital technology innovation, digital industry development, digital industry application, and digital social governance have all improved. The comprehensive evaluation of the digital economy development in Shaanxi Province before the adjustment was 72.38, and the comprehensive evaluation after the adjustment was 79.49. The digital economy development in Shaanxi Province increased by 9.82%.

4. Conclusions

This study used machine learning algorithms to study the evaluation of the development of the digital economy, so as to grasp the law of the development of the digital economy for Shaanxi Province and build a digital economy monitoring and evaluation system according to local conditions, thereby effectively monitoring and evaluating the development of the digital economy and providing reference. This study first described the dimensions of digital economy monitoring and evaluation, including six parts: digital infrastructure, data resource elements, digital technology innovation, digital industry development, digital industry application, and digital social governance. Then, the digital economy evaluation index was established, and then, the digital economy evaluation model was established. Based on the evaluation results of the digital economy, this study also puts forward suggestions on the digital economy planning of Shaanxi Province. According to the adjusted plan, the development of digital economy in Shaanxi Province was reevaluated. The results showed that the evaluation model can grasp the development law of the digital economy and provide reference for the development of the digital economy.

Data Availability

No data were used to support this study.

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

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