Regional Credit Environment Evaluation Based on Analytic Hierarchy Process (AHP) Method and Fuzzy Comprehensive Evaluation (FCE)

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Abstract. Taking the data of the sixteen prefecture-level cities in Shandong Province as an example, this paper attempts to construct regional credit environment indicators and quantify these indicators. The Analytic Hierarchy Process (AHP) method and Fuzzy Comprehensive Evaluation (FCE) have been used to empower the indicators. Meanwhile, this paper has obtained the AHP score through calculation. The corresponding credit ranking has been given using the factor analysis. The research result shows that the credit environment evaluation scores of Shandong eastern coastal cities centered on Qingdao and neighboring cities centered on provincial capital Jinan are often higher than those of inland cities such as southwestern Shandong and northwestern Shandong. The construction of regional credit environment should be based on economy, culture and government. Three aspects go hand in hand. On this basis, this paper puts forward the feasible countermeasures and suggestions for constructing regional credit environment from the perspective of policy.

Keywords: Credit indicator system; Fuzzy comprehensive evaluation; AHP-Factor analysis.

1. Introduction
With the rapid development of today's society, "credit", as a bridge between people's daily communication, is becoming prominent. In recent years, the CPC Central Committee has proposed to strengthen the construction of government, business, and social integrity, as well as the construction of judicial credibility; and the Third Plenary Session of the 18th CPC Central Committee has proposed to establish and improve the social credit system, encourage and reward the credibility principle, and warn and punish dishonesty. To this end, the State Council issued the Notice of the State Council on the Outline of the Plan for the Construction of the Social Credit System(2014-2020) on June 27, 2014. The Notice proposed that by the end of the second decade of the 21st century, we will basically establish the basic laws and regulations of social credit and the standard system of social credit supervision, the credit system based on the sharing of credit information resources and covering the whole society. Moreover, we will perfect and improve the credit supervision system, the credit service market system. We will endeavor to make the integrity incentive and dishonesty punishment system take effect. Thus, the establishment of social credit system is the inevitable requirement of national development and progress. And the perfection of regional credit environment as the foundation of social credit environment should not be ignored. This paper discusses the establishment of the regional credit environment evaluation index system and uses the relevant mathematical and statistical models to evaluate the regional credit environment in all directions.
2. Build a Regional Credit Environment Evaluation Index System

The social credit system covers a wide range, and the regional credit environment as the basis of social credit, it should include individuals, enterprises and governments. From the economic environment perspective, all three are the creators of benefits. So this paper is intended to take the three as a starting point to build a regional credit environment index system covering personal credit indicators, enterprise credit indicators and government credit indicators.

Through a large number of literature research, and arguments of the credit department of People's Bank of China, credit department of commercial bank and university professors and other relevant experts and scholars, Table 1 is designed to show the regional credit environmental evaluation indicators:

Table 1. Credit environmental evaluation indicators and Determining weigh in Shandong Province.

| Destination layer | Standard layer | Index layer                                                                 | The direction of the indicator | Determining weigh |
|-------------------|----------------|-----------------------------------------------------------------------------|--------------------------------|------------------|
|                   |                | Average wage / GDP per capital                                               | Positive                       | 0.08             |
|                   |                | Consumer consumption / GDP per capital                                       | Positive                       | 0.08             |
|                   |                | Number of / regional motor vehicles / number of resident population (cars / 10,000 people) | Positive                       | 0.03             |
|                   |                | Number of civil litigation agents / resident population (pieces / 10,000 / people) | Negative                       | 0.04             |
|                   |                | Regional Crime Cases / Resident Population (pieces / 10,000 / people)        | Negative                       | 0.08             |
|                   |                | Number of local listed companies(A shares) /total number of listed companies | Positive                       | 0.03             |
|                   |                | The value-added ratio of total annual fixed asset investment in the region    | Positive                       | 0.09             |
|                   |                | The value-added ratio of output of industrial enterprises of annual scale in the region | Positive                       | 0.09             |
|                   |                | Average asset-liability ratio of locally listed companies                    | Negative                       | 0.09             |
|                   |                | Number of registered trademarks / total number of enterprises of industrial enterprises of regional scale | Positive                       | 0.05             |
|                   |                | Local Government Liabilities / Local Government Revenue                     | Negative                       | 0.10             |
|                   |                | Engel’s coefficient                                                         | Negative                       | 0.06             |
|                   |                | Number of university students / total resident population                    | Positive                       | 0.03             |
|                   |                | Crimes committed by government officials/total number of cases of law-breaking | Negative                       | 0.10             |
|                   |                | Total number of motor vehicles/number of public transport operations         | Positive                       | 0.04             |
| SUM               |                |                                                                             |                                | 1                |

Explanation of regional credit environment indicators.
2.1. Personal Credit

As an individual in society, the individual is closely related to the society, and the individual's credit status will directly affect the regional credit environment. At the same time, economic conditions, cultural level, the overall quality of residents and so on have become important factors affecting personal credit. To evaluate personal credit more comprehensively, this paper builds the following five indicators: (a) Average wage / GDP per capital. Wage levels directly reflect the income status of the population, and the per capital GDP of a region reflects the level of economic development in the region, which is directly related to the level of personal credit. The higher the ratio, the higher the personal credit; and conversely, the lower the credit level. (b) Household consumption / GDP per capital. The level of consumption of residents in a fixed region is a true reflection of their life quality, economic development and the creation of GDP cannot be separated from personal consumption. The higher the ratio, the higher the quality of residents, the better the personal credit, and otherwise, the worse the personal credit. (c) Number of motor vehicles / number of residents in the area. The level of development of a region cannot be separated from the transportation equipment around, and personal travel relies more on the cars. Automobile as a typical daily consumer goods, also reflects the level of people's consumption, the more individuals own cars on average, the higher the level of personal consumption, and then the higher the credit, and otherwise, the lower the credit. (d) Number of civil litigation agents / resident population. The civil litigation cases in a region represent whether the region's people is harmony. The more the civil litigation cases means more disputes among people, which further reflects the poor personal credit status; otherwise, people will have higher credit level. (e) Number of crime cases / resident population in the region . The security status in a region is directly reflected by the number of criminal cases. And the level of personal credit is negatively related to it - if the number of cases is greater, personal credit level is lower.

2.2. Corporate Credit

In the regional credit environment evaluation, the corporate credit occupies the irreplaceable position. It is a platform for people to engage in production activities, and the corporate is credit reflected in its financial situation, culture, credibility and other aspects, for this reason we selected the following indicators to its credit evaluation. (a) Number of listed companies in a region (A-shares ) / total number of listed companies . The stock market is a barometer of the market economy. If a company can list on the exchange, that means all its aspects have reached a high standard; Generally speaking, the number of listed companies is positively related to the regional credit level - the more the number of listed companies, the higher the credit level of a region, and otherwise the lower. (b) The value-added ratio of total fixed asset investment. Fixed asset investment is a more comprehensive indicator, which is performed in the form of money. It is the amount of work that an enterprise builds and buys fixed assets over a period of time, and the related cost changes, including immobility, buildings, machinery, means of transport, and other fixed asset investment that the enterprises use in capital construction, renovation, and major repairs. It can be seen that the indicator reflects the production and operation status of enterprises in a certain period of time, from which we can see the credit status of enterprises. In general, the higher the value-added ratio of the enterprise's annual fixed asset investment, the better the credit status of enterprises, and otherwise, the worse. (c) The value-added ratio of output of large-scale industrial enterprises. The level of enterprise's production capacity is closely related to the enterprise's operation, the value added of the enterprise's output directly represents the business situation of the enterprise. And the business condition of the enterprise is directly related to the enterprise's credit. The better the business condition of the enterprise, the better its credit status, and otherwise the worse. (d) Average asset-liability ratio of listed companies. It is also an important index directly reflected in the business situation of enterprises. The higher asset-liability ratio indicates that the more debt a company has, the lower its credit level will be, and otherwise it will be higher. (e) Number of registered trademarks / total number of enterprises of industrial enterprises of regional scale. In terms of industrial enterprises in regional unit scale, the more the registered trademarks, the higher the enterprises’ popularity, which will have a positive impact on credit. The higher the value of the indicator, the higher the credit level of the enterprise, and the two changes are in the same direction.
2.3. Government Credit
Government credit is a comprehensive evaluation of the ability and behavior of the public to keep the "promise" of the government, it is a kind of agency-commissioned relationship in some kind of environment, in which the government is the subject, while the corresponding people become the object. People's evaluation of government credit depends on the decisions made by the government organs and functional departments as the main body in the management of the social economy, and whether the government's actions are beneficial to improve people's living standards and social economy. When evaluating the regional credit environment, we must attach importance to government credit, and the evaluation index of government credit in this paper is constructed as follows: (a) Local government liabilities / fiscal revenue. As an indicator of the evaluation of the local economy, in addition to GDP, the government's debt and income is also a side reflection. The ratio is inversely proportional to the credit level of the local government. (b) Engel’s coefficient. To evaluate the wealth status of a region, the Engel’s coefficient is the most convincing and direct manifestation. The richer the regional population, the lower the Engel’s coefficient, the higher the government credit, and otherwise the lower the government credit. (c) Number of university students / total resident population. Government credit is also reflected in the cultural environment. The government’s culture construction cannot be separated from higher education. The more college students in the unit residents, the higher the proportion of residents in higher education, which to some extent reflects the higher the government credit, otherwise the lower the government credit. (d) Crimes committed by government officials/total number of cases of law-breaking. Irregularities and corruption of public officials are the most direct reflection of the government's ability to keep faith. The more such cases, the lower the level of government credit, and otherwise the higher the level of government credit. (e) Total number of motor vehicles/number of public transport operations. The transportation facilities in a region can reflect the government's investment in urban infrastructure, and the status of infrastructure in a city also reflects the government's competence. So the more the public transport, the higher the credibility of the government, and otherwise the lower.

In this paper, the data of regional credit environment evaluation index are taken from the Statistical Yearbook of Shandong Province, The Financial Yearbook of Shandong Province, the Traffic Yearbook of Shandong Province, the Yearbook of The Prosecutor of Shandong Province, and the report of the government of various cities in Shandong Province and the statistical yearbook. In view of some regional changes and the continuity of the data, this paper selects data for 2014-2016 in Shandong Province and 16 cities in Shandong Province. We chose the expert rating method for weighing AHP credit indicator.

The data selected in this paper is not convenient to compare because of the different degrees, so in order to eliminate the effect of scale, this paper adopts the $X_i$ efficacy factor method:

For a negative indicator (it’s better when the corresponding value of the indicator is smaller):

$$Y_i = \frac{X_{i}^i - X_i}{X_{max}^i - X_{min}^i}$$  \hspace{1cm} (1)

For a positive indicator (it’s better when the corresponding value of the indicator is bigger):

$$Y_i = \frac{X_i - X_{i}^i}{X_{max}^i - X_{min}^i}$$  \hspace{1cm} (2)

3. Model and Analysis

3.1. Analytic Hierarchy Process (AHP) and Credit Score
Analytic Hierarchy Process (AHP) is a method proposed by Saaty, an American operations researcher, in the 1970s to evaluate an issue using weight decision analysis. He decomposes elements or factors related to participation in decision-making, i.e. layers like the destination layer, the criterion (standard) layer, the indicator layer (alternatives), and provides quantitative and qualitative analysis of the
various layers on this basis. This method is simpler and more flexible and is now widely used in systems engineering theory and multi-objective evaluation models. The basic principle of this approach is to break down the problem into different grouping factors according to the basic attributes of the problem and the goals to be achieved, and at the same time, to develop a differentiated clustering combination based on the mutual influence and affiliation of different factors, and to form a multi-layered analytical structure model that ultimately complicates. The problem boils down to determining the relatively important weights, that is, determining the relatively important weights of the lowest levels, such as scenarios, measures, or arranging the relatively good or bad order relative to the target at the highest level.

It includes the following steps:

(a) Build a hierarchical model.

The first step in hierarchical analysis is to sort out the problem and build a hierarchical model that follows the relationship between the two. The three layers are: the highest level, the middle layer, the bottom layer, that is, the corresponding target layer, the criterion layer, and the indicator (alternatives) layer. Usually we don't limit the number of levels, but each layer contains preferably fewer than or equal to nine elements.

(b) Construct a judgment matrix.

In determining the weighting between the sub-factors (indicators), Saaty et al. used the case of a consistency matrix to replace all factors together to comparison. Hierarchical analysis requires the construction of a judgment matrix, where the scale of the judgment matrix is defined as Table 2 (general scale is 1-9).

Table 2. AHP judgement matrix scale and the connotation.

| Scale | Connotation |
|-------|-------------|
| 1     | The two indicators (factors) are of the same importance when compared to each other. |
| 3     | When two indicators (factors) are compared, one indicator is slightly more important than the other. |
| 5     | When two indicators (factors) are compared, one indicator is more important than the other. |
| 7     | When two indicators (factors) are compared, one indicator is more important than the other. |
| 9     | When two indicators (factors) are compared, one indicator is more important than the other. |
| 2 4 6 8 | Represents the important degree of the two indicators is between the adjacent median values of the above judgment. |

The indicator here, indicators \( i \) and \( j \) are compared, and a judgment matrix is formed, \( a_{ij} = \frac{1}{a_{ji}} \).

(c) Hierarchical single ordering and consistency testing.

The so-called hierarchical single ordering refers to the column vector \( W \) formed by the maximum feature value of the judging matrix \( \lambda_{\text{max}} \) corresponding to normalization, and the normalized value represents the sort weight of the hierarchy relative to the importance of the indicator at the next level. In determining whether the judgment matrix is a consistency matrix, the judgment matrix needs to be tested, and the indicators of consistency are:

\[
CI = \frac{\lambda_{\text{max}} - n}{n - 1}
\]

The standard values for the average random consistency indicator are shown in Table 3.
Table 3. Average standard values for random consistency indicators.

| n | RI | 1   | 2   | 3   | 5   | 6   | 7   | 8   | 9   | 10  |
|---|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|   |    | 0   | 0   | 0.58| 1.12| 1.24| 1.32| 1.41| 1.45| 1.49|

Finally, the consistency ratio is calculated: 

\[ CR = \frac{CI}{RI} \]

When \( CR \) is less than 0.1, the judgment matrix is considered to be consistent, otherwise there is no consistency.

(d) Total hierarchy ordering and consistency testing.

A weight value represents a general order of layers, and this weight value measures the relative importance of all metrics at a level to the highest level (total goal). This process is carried out from the highest to the lowest levels.

In this article, the metric weights obtained from the AHP method are listed in Table 4. Excel calculates that the consistency ratio of the above judgment matrix \( CR \) is less than 0.1, which indicates that the consistency test of the judgment matrix passed.

After reviewing the data related to the calculation, the AHP score for 16 cities in Shandong Province is concluded as shown in Table 5 below.

Table 4. AHP score and ranking of the credit environment of 16 cities in Shandong Province.

| City serial No. | Name   | AHP score |
|-----------------|--------|-----------|
| 1               | Weihai | 0.77      |
| 2               | Yantai | 0.70      |
| 3               | Qingdao| 0.52      |
| 4               | Jinan  | 0.52      |
| 5               | Jining | 0.50      |
| 6               | Weifang| 0.50      |
| 7               | Rizhao | 0.49      |
| 8               | Linyi  | 0.49      |
| 9               | Taian  | 0.48      |
| 10              | Dongying| 0.47     |
| 11              | Dezhou | 0.46      |
| 12              | Zibo   | 0.45      |
| 13              | Binzhou| 0.44      |
| 14              | Zaozhuang| 0.41    |
| 15              | Heze   | 0.40      |
| 16              | Liaocheng| 0.39    |

3.2. Factor Analysis and Credit Score

Factor analysis refers to the use of a few factors or variables to describe the interrelation among multiple variables or indicators. Specifically, factor analysis classifies several variables with higher correlations into the same categories, and each class of variables becomes a common factor; finally, a small number of common factors reflect a large amount of information in the original event. Its core idea is to reduce the dimensionality in order to solve the problem of collinearity in complex primitive events.

3.2.1. The main process of factor analysis.

(a) Evaluation of the effectiveness of the indicator data.

The premise of factor analysis is that the indicator data can be analyzed by factor analysis. In view of this, we first have to test the data, and the following data analysis and processing all take SPSS 22.0. First, we conducted correlation analysis of multi-dimensional data. As can be seen, from the KMO and
Bartlett’s test results (Table 6), the KMO index reaches 0.569 and the P value does not exceed 0.01, rejecting the original assumption that there is no correlation between variables, indicating a strong correlation between variables. Therefore, the indicator data meets the conditions of using factor analysis to reduce the dimensional processing of variables.

**Table 5. KMO and Bartlett’s Test.**

|                          | Take the right number of samples for the Kaiser-Meyer-Olkin test. | .569 |
|--------------------------|------------------------------------------------------------------|------|
| Chi-Square               | 231.953                                                           |      |
| df                       | 105                                                              |      |
| Significance             | .000                                                              |      |

(b) Analysis of the main components of the raw data.
Second, we analyzed the main component of the original data, and the results showed in Table 7 that the cumulative variance contribution rate of the first four variables reached 80.03%, so we extracted the first four factors as common factors. After that, we rotate the resulting common factors and analyze them specifically.

**Table 6. Cumulative variance of raw data.**

| Indicators | Initial Eigenvalues | quadratic sum of the extract and load data | quadratic sum of the extract and rotation data |
|------------|---------------------|---------------------------------------------|-----------------------------------------------|
|            | Sum                | Variance percentage | CPV          | Sum            | Variance percentage | CPV          | Sum            | Variance percentage | CPV          |
| \(x_1\)    | 5.139              | 34.259                | 34.259 5.139 | 34.259 34.259  | 4.315 28.765 28.765 |
| \(x_2\)    | 3.081              | 20.540                | 54.799 3.081 | 20.540 54.799  | 3.442 22.944 51.709 |
| \(x_3\)    | 2.247              | 14.978                | 69.777 2.247 | 14.978 69.777  | 2.403 16.021 67.731 |
| \(x_4\)    | 1.538              | 10.256                | 80.033 1.538 | 10.256 80.033  | 1.845 12.302 80.033 |
| \(x_5\)    | .947               | 6.312                 | 86.345 .947 | 6.312 86.345  |
| \(x_6\)    | .741               | 4.940                 | 91.286 .741 | 4.940 91.286  |
| \(x_7\)    | .432               | 2.883                 | 94.169 .432 | 2.883 94.169  |
| \(x_8\)    | .387               | 2.580                 | 96.748 .387 | 2.580 96.748  |
| \(x_9\)    | .191               | 1.272                 | 98.020 .191 | 1.272 98.020  |
| \(x_{10}\) | .126               | .840                  | 98.861 .126 | .840 98.861  |
| \(x_{11}\) | .092               | .613                  | 99.474 .092 | .613 99.474  |
| \(x_{12}\) | .051               | .337                  | 99.811 .051 | .337 99.811  |
| \(x_{13}\) | .018               | .117                  | 99.928 .018 | .117 99.928  |
| \(x_{14}\) | .010               | .066                  | 99.993 .010 | .066 99.993  |
| \(x_{15}\) | .001               | .007                  | 100.000 .001 | .007 100.000 |

Extraction method: Analysis of the main components

(c) Factor rotation and factor naming.
With SPSS22.0, we get a factor rotation matrix shown in Table 8, and then we name the four selected common factors.
The first common $F_1$ includes 5 indicators $X_1, X_2, X_7, X_8, X_{11}$, and they are named economic and business environment indicators.

The second common factor $F_2$ includes 4 indicators $X_6, X_{10}, X_{11}, X_{14}$, and they are named cultural and educational environment and enterprise innovation indicators.

The third common factor $F_3$ includes 4 indicators $X_3, X_4, X_5, X_9$, and they are named personal credit and business indicators.

The fourth common factor $F_4$ includes 2 indicators $X_{12}, X_{15}$, and they are named the government governance capacity indicators.

| Indicators | Common factors |
|------------|----------------|
|            | 1   | 2   | 3   | 4   |
| $x_1$      | .919| -.090| -.096| .079 |
| $x_2$      | .890| -.147| -.164| .207 |
| $x_3$      | -.449| .077| .725| -.077 |
| $x_4$      | -.232| .235| .550| -.591 |
| $x_5$      | .093| .171| .889| -.076 |
| $x_6$      | -.417| .654| -.383| -.026 |
| $x_7$      | .461| .430| -.363| .111 |
| $x_8$      | .878| -.051| .001| -.298 |
| $x_9$      | .016| .349| -.643| -.158 |
| $x_{10}$   | -.153| .885| .137| .024 |
| $x_{11}$   | .867| -.409| .016| .060 |
| $x_{12}$   | .348| -.525| -.026| .634 |
| $x_{13}$   | -.256| .878| .123| .133 |
| $x_{14}$   | -.515| -.682| .138| .366 |
| $x_{15}$   | -.171| .350| .055| .866 |

Extraction method: Main component analysis method.
Rotation method: Kaiser Varimax Orthogonal Rotation
a. Rotation converges after 6 iterations.

(d) Factor scores.
Finally, through the table 9 factor score coefficient matrix, we can get the final mathematical expression of the factor scores.

\[
\begin{align*}
F_1 &= 0.23X_1 + 0.213X_2 + \ldots + (-0.175)X_{14} + 0.001X_{15} \\
F_2 &= 0.047X_1 + 0.32X_2 + \ldots + (-0.231)X_{14} + 0.16X_{15} \\
F_3 &= 0.04X_1 + 0.014X_2 + \ldots + 0.015X_{14} + 0.098X_{15} \\
F_4 &= 0.044X_1 + 0.107X_2 + \ldots + 0.166X_{14} + 0.518X_{15}
\end{align*}
\]

The factor composite score is calculated as follows:
The score factor matrix is shown in Table 9 below.

### Table 8. Factor Scores coefficient Matrix

| Indicators | Common factor |
|------------|---------------|
|            | 1  | 2  | 3  | 4  |
| x1         | .230| .047| .040| .044|
| x2         | .213| .032| .014| .107|
| x3         | -.050| .018| .289| .015|
| x4         | -.003| .043| .193| -.278|
| x5         | .116| .101| .416| .043|
| x6         | -.091| .157| -.182| -.008|
| x7         | .127| .167| -.095| .069|
| x8         | .225| .035| .051| -.160|
| x9         | -.026| .073| -.289| -.119|
| x10        | .044| .282| .093| .083|
| x11        | .199| -.056| .069| .020|
| x12        | .056| -.099| .046| .328|
| x13        | .017| .278| .087| .141|
| x14        | -.175| -.231| .015| .166|
| x15        | .001| .160| .098| .518|

Extraction Method: Main Ingredient Analysis.
Rotation method: Kaiser Varimax Orthogonal Rotation

By calculating the factor composite score and the cities’ ranking according the common factors $F_1$, $F_2$, $F_3$, $F_4$ is shown in Table 10: From the score ranking of the first common factor $F_1$, we can see that Jinan and Qingdao are in the top two, with obvious advantages. It is further confirmed that the two major cities, which are the pillars of Shandong’s economy, play a benchmark role in the economic and enterprise environment. Jinan, Qingdao, as the capital of the province and Shandong’s largest port city, has a unique position advantage in the economic and corporate credit environment. The relatively backward cities are located in the northwest and southwest regions of Shandong province, and the main reason for this result is that social consumption and per capita income account for a large proportion in the economic environment, which in turn becomes the key to affect the economic credit environment score. Inland areas are inferior in income levels and consumption capacity than provincial capitals and coastal cities, so stimulating consumption capacity and expanding local domestic demand are top priorities. In the enterprise environment, increasing fixed asset investment and improving the output capacity of enterprises, also cannot be ignored. Especially at this stage, the state and many departments increase support for small and medium-sized enterprises and promote private economy. How to scientifically and effectively put the preferential treatment of small and medium-sized enterprises into practice to solve its financing difficulties in its development, is a major challenge facing the government.

In the second common factor $F_2$ score ranking, the top two are still Jinan and Qingdao. As far as the cultural environment, Jinan, as the capital city of Shandong Province, has the largest number of colleges and universities in the province, and Qingdao is closely followed, which is the most direct
embodiment of the cultural environment. While the southwestern cities such as Heze, Zaozhuang, etc. with large population base are much inferior in this respect. Therefore, improving the cultural level of the resident population, increasing the talent introduction will be a focus of government work. In addition, the government needs to optimize the allocation of educational resources and increase investment in educational assets.

Table 9. Factors Composite Score and Ranking.

| City   | Public Factor 1 \( F_1 \) Score | Ranking | City   | Public Factor 2 \( F_2 \) Score | Ranking | City   | Public Factor 3 \( F_3 \) Score | Ranking |
|--------|-----------------------------------|---------|--------|-----------------------------------|---------|--------|-----------------------------------|---------|
| Jinan  | 0.249                             | 1       | Jinan  | 3.414                             | 1       | Jinan  | 1.093                             | 1       |
| Qingdao| 0.112                             | 2       | Qingdao| 1.196                             | 2       | Weihai | 0.400                             | 2       |
| Weihai | 0.103                             | 3       | Zibo   | 0.879                             | 3       | Zibo   | 0.396                             | 3       |
| Rizhao | 0.102                             | 4       | Yantai | 0.847                             | 4       | Binzhou| 0.364                             | 4       |
| Yantai | 0.098                             | 5       | Weihai | 0.846                             | 5       | Laiwu  | 0.339                             | 5       |
| Zibo   | 0.094                             | 6       | Rizhao | 0.738                             | 6       | Yantai | 0.328                             | 6       |
| Taian  | 0.085                             | 7       | Weifang| 0.611                             | 7       | Taian  | 0.202                             | 7       |
| Weifang| 0.083                             | 8       | Binzhou| 0.498                             | 8       | Zaozhuang| 0.182                            | 8       |
| Heze   | 0.083                             | 9       | Liaoche ng| 0.470                        | 9       | Dongying| 0.181                            | 9       |
| Binzhou| 0.081                             | 10      | Dongying| 0.468                           | 10      | Binzhou| 0.156                             | 10      |
| Liaoche ng| 0.079                        | 11      | Jining | 0.446                             | 11      | Weifang| 0.134                             | 11      |
| Zaozhuang| 0.075                        | 12      | Dezhou | 0.388                             | 12      | Linyi  | 0.095                             | 12      |
| Dezhou | 0.075                             | 13      | Laiwu  | 0.370                             | 13      | Liaoche ng| 0.087                          | 13      |
| Linyi  | 0.073                             | 14      | Zaozhuang| 0.292                        | 14      | Dezhou | 0.079                             | 14      |
| Jining | 0.072                             | 15      | Linyi  | 0.284                             | 15      | Heze   | 0.064                             | 15      |
| Dongying| 0.063                           | 16      | Heze   | 0.240                             | 16      | Jining | 0.040                             | 16      |

In the environment of enterprise innovation, the city of southwest of Shandong is relatively backward and needs to be promoted from the aspects of consciousness and action: Improving the awareness of enterprise innovation, so as to actively seek innovation by increasing the guidance of "mass entrepreneurship and innovation". Optimize the internal structure of enterprises, promote technological innovation, strengthen the combination of industry, science and research, so that the slogan of innovation and creation will be in practice.

In the third common factor \( F_3 \) score ranking, Jinan, Weihai, Qingdao rank the top three, from the point of scores, in addition to the provincial capital Jinan, other cities have less differences. This reflects the province's personal credit and business environment are in a more balanced development. However, the relevant departments also need to pay attention to the cities with more backward ranking such as Liaocheng, Dezhou, Heze. As far as personal credit environment, civil disputes and criminal cases are still prominent, and they are also an intuitive embodiment of regional governance and security. To improve personal credit, it is necessary for relevant departments to improve the capacity of civil mediation and build a harmonious social ecological environment; At the same time, it is
necessary for the government to strengthen the supervision of illegal and criminal incidents, keep "zero tolerance" for violations of the law, and to improve social equity and justice. In the business environment, the asset-liability ratio is the most direct embodiment of enterprise management. Therefore, the government should pay attention to improving the profitability of enterprises and maximizing the benefits of enterprises.

In the ranking of the fourth common factor $F_4$, the top three cities are Jinan, Zibo and Qingdao, and the score is significantly better than other cities. There is not necessarily a strong relationship between government governance ability and geographical location, economic development and cultural environment.

Improving the government's ability to govern and transparency, strengthening the training and education of Party and government cadres, adopting strict supervision over corruption and increasing penalties are the top priorities of every local government. Similarly, in the process of development, we should attach importance to infrastructure construction and ecological environment construction, give full play to the "multiplier effect" of infrastructure on the long-term and stable development of the economy, and protect the beautiful ecology.

3.3. AHP-Factor Analysis Composite Ranking

In this paper, the following methods are used to rank the comprehensive credit environment scores of cities in Shandong Province:

$$ S = \alpha AHP + \beta F $$

(4)

Note: $\alpha = \beta = 0.5$

The final comprehensive ranking is shown in Table 11 below:

| Cities | Comprehensive score | Final ranking |
|--------|---------------------|--------------|
| Jinan  | 1.059               | 1            |
| Weihai | 0.583               | 2            |
| Qingdao| 0.559               | 3            |
| Yantai | 0.548               | 4            |
| Zibo   | 0.472               | 5            |
| Rizhao | 0.436               | 6            |
| Weifang| 0.397               | 7            |
| Taian  | 0.396               | 8            |
| Binzhou| 0.361               | 9            |
| Jining | 0.353               | 10           |
| Dongying| 0.347              | 11           |
| Dezhou | 0.342               | 12           |
| Linyi  | 0.332               | 13           |
| Liaocheng| 0.325              | 14           |
| Zaozhuang| 0.307              | 15           |
| Heze   | 0.267               | 16           |

4. Conclusion Analysis and Policy Recommendations

4.1. The Current Shortcomings of the Social Credit Environment in Shandong Province

(a) Development imbalance in East-West region. Looking at the credit environment ranking of Shandong Province, we can find that the gap between the eastern coastal cities and the cities of
southwest and northwest Shandong province is larger. Qingdao, Weihai and Yantai are at the first in terms of the credit environment of coastal cities and the credit environment of these three cities is better. Jinan is posited in the center place in inland cities, its surrounding cities endeavor to develop in pursuing the provincial capital city, but the cities like Heze, Zaozhuang, Dongying far away from the capital city are slightly backward. How to make backward cities to improve the level of credit environment is the issue that we need to pay attention to right now.

(b) There is room for improvement in social governance and local government governance. The fundamental measure of social development in a region lies in the governance ability of local governments. In all regions of Shandong Province, the government's governance has certain problems, and even some problems have not been exposed. How to make up for the shortcomings, find out the missing, will be a serious challenge for local governments, and this is related to the construction of the regional credit environment.

(c) Cultural construction cannot be ignored. Culture is the soul of a country and a nation, and cultural construction is related to the personal credit environment. The cultural construction gap in various regions of Shandong Province is large, taking Jinan and Qingdao as examples, they have good educational resource advantages and perfect personnel training measures, which makes their overall credit environment higher than other regions. Therefore, how to improve the cultural construction of the region in economic construction, this will be the local government in improving the level of credit environment, facing difficulties.

4.2. The Feasible Countermeasure to Optimize the Construction of Social Credit Environment in Shandong Province

(a) Integrated and coordinated economic development. Among many factors restricting the development of regional credit, economy is the basic factor. In view of this, the first step in improving regional credit is to create favorable conditions for economic development. By vigorously promoting science and technology, we will inject new impetus into economic development, improve the quality of economic development, and promote the economy to develop well and sound. Co-ordinate the development of the East-West region. For the relatively backward southwest and the northwest region of Shandong province, we can make full use of the development ideas of the eastern coastal and provincial capital cities, actively introduce high-tech and high-end equipment in the developed areas of the east, and give full play to our own advantages to provide labor force for the eastern region.

(b) Improve the level of local government governance. On the one hand, as far as the regional environment of various regions in Shandong Province, the western and northern regions are inland, and the information is more encapsulated. On the other hand, the layout of cities throughout the province can effectively make up for this problem. Take Jinan, the capital city as the center of Shandong province and it is located in the middle of Shandong Province, so, its government's ruling philosophy and ruling efficiency can affect the surrounding cities, and it will provide reference for surrounding cities. Take the coastal city Qingdao as the center, it is located in the east of Shandong Province, and its advanced development ideas can provide more ideas for the development of surrounding cities. At the same time, the cities’ support for local business development cannot be ignored.

(c) Develop regional cultural education vigorously. Education is the foundation of national revitalization and national development, and it is also the key to regional and individual development. The uneven distribution of educational resources leads to great cultural differences among different regions. The education in underdeveloped regions is poor, if the excellent educational resources of the developed regions can be passed on and shared to the underdeveloped regions, it can effectively make up for its short board. First of all, introduce excellent teachers, promote education in underdeveloped areas relying on the development of human resources; Secondly, we should ensure the scientific supply of educational infrastructure and improve the current situation of insufficient educational infrastructure in underdeveloped regions. Over time, the basic quality of the population in cities all over Shandong Province, especially in backward areas, will be greatly improved; Correspondingly, the social credit environment will be optimized and enhanced.
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