Comprehensive Evaluation on the Regional Economy of Commodity Grain Base in Heilongjiang Province Based on Factor Analysis Method

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Abstract Taking a total of 13 areas in Heilongjiang commodity grain base as the research objects, 9 indices are selected, which are regional GDP (X_1), per capita GDP (X_2), total value of tertiary industry (X_3), financial revenue (X_4), urban fixed assets investment (X_5), average salary (X_6), gross industrial output value (X_7), total output value of farming, forestry, husbandry and fishing (X_8), and retail sales of social consumer goods (X_9). Based on this, evaluation index system of regional economy is established. According to the 2006 -2008 *Heilongjiang Statistical Yearbook*, average values within 3 years are used as analytical data. Factor Analysis Method is adopted to establish regression model and to carry out comprehensive analysis. Result shows that Heilongjiang commodity grain base has extremely uneven regional economic development in different areas. According to the score order and actual situation, the 13 areas are divided into 4 types. The first and second types are Harbin and Daqing, respectively. The third type is Qiqihaer, Suihua, Mudanjiang and Jiamusi. And the forth type is Jixi, Shuangyashan, Heihe, Yichun, Qitaihe, Hegang and Daxinganling. Suggestions for the development of these areas are put forward.

Key words Heilongjiang commodity grain base, Factor Analysis Method, Regional economy, Comprehensive evaluation, China

Heilongjiang Province is one of the biggest commodity grain bases in China with grain commodity quantity and commodity rate ranking the first in the whole country. Heilongjiang Province has been long reputed as "North Warehouse" and has made great contribution to the grain security of China. Scholars have done a lot of researches on the construction of commodity grain base in Heilongjiang Province. However, most researches are focused on the layout, location selection, base construction, base operation and other related aspects, but neglect the regional economic development of commodity grain bases[1]. A total of 9 indices reflecting the economic development degree are selected. Factor Analysis Method is adopted to carry out comprehensive analysis on the economic situation of commodity grain bases in 13 areas of Heilongjiang Province. After comparing the 13 areas, economic strength is sorted and suggestions are put forward according to the actual situation.

1 Index selection, data source and research method

1.1 Index selection When evaluating the regional economy of Heilongjiang commodity grain base, we select 14 areas as the research objects. Based on the related literature and the consultation with the relevant experts, 9 indices are selected according to the commeasurable, prominent and easy operational principles, which are regional GDP (X_1), per capita GDP (X_2), total value of tertiary industry (X_3), financial revenue (X_4), urban fixed assets investment (X_5), average salary (X_6), gross industrial output value (X_7), total output value of farming, forestry, husbandry and fishing (X_8), and retail sales of social consumer goods (X_9)[3].

1.2 Data source Data are from the 2006 - 2008 *Heilongjiang Statistical Yearbook*[4-6]. In order to improve the reliability of data, the average values within 3 years are used as analytical data (Table 1).

1.3 Research method Factor Analysis Method is selected to carry out the comprehensive analysis on the regional economy of Heilongjiang commodity grain base.

1.3.1 Mathematical model. Assuming that there are N samples and P indices, $X=(X_1, X_2, \cdots, X_p)^T$ is a random vector, and the common factor we search for is $F=(F_1, F_2, \cdots, F_m)^T$. Hence, we have the factor model[2]:

$$\begin{aligned} X_1 &= a_{11}F_1 + a_{12}F_2 + \cdots + a_{1m}F_m + \varepsilon_1 \\ X_2 &= a_{21}F_1 + a_{22}F_2 + \cdots + a_{2m}F_m + \varepsilon_2 \\ &\vdots \\ X_p &= a_{p1}F_1 + a_{p2}F_2 + \cdots + a_{pm}F_m + \varepsilon_p \end{aligned} \quad (1)$$

where a_{ij} is factor load, the statistical significance of which is the correlation coefficient of common factor F_i and factor variable X_j, ε_p is specific factor, which represents all the influencing factors, expect common factor, and can be ignored when analyzing.

1.3.2 Calculation step.

(1) Obtain data and carry out standardized treatment in order to eliminate the impacts of dimension and magnitude. The equation is

$$y_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j}, \quad (2)$$

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where $i=1, 2, \cdots, n$; $j=1, 2, \cdots, p$, $\bar{x}_j$ is the mean value of the jth index and s_j is standard deviation.

(2) Calculate the correlation coefficient matrix of sample $R=(r_{ij})_{p\times p}$, and determine whether it is appropriate to conduct the factor analysis by KMO and other indices. The equation is

$$r_{ij}=\frac{\sum_{k=1}^{n}(x_{ki}-\bar{x}_i)(x_{kj}-\bar{x}_j)}{\sqrt{i\sum_{k=1}^{n}(x_{ki}-x_i)^2(x_{kj}-x_j)^2}}, \quad (3)$$

where $i=1, 2, \cdots, n$; $j=1, 2, \cdots, p$.

(3) Calculate the characteristic root λ_i and eigenvector, determine the number of common factors by using the accumulative variance contribution rate, and obtain the factor analysis model. This research uses Principal Component Analysis to extract common factor.

(4) Calculate the score of common factor and construct the comprehensive score of regression model.

Table 1 Analytical data of indices of 13 areas in Heilongjiang commodity grain base

Area	X_1 ×10⁸ Yuan	X_2 Yuan	X_3 ×10⁸ Yuan	X_4 ×10⁸ Yuan	X_5 ×10⁸ Yuan	X_6 Yuan	X_7 ×10⁸ Yuan	X_8 ×10⁸ Yuan	X_9 ×10⁸ Yuan
Harbin	2 466.37	25 051	1 199	254.71	947.78	21 790	1 459.82	569.85	1 264
Qiqihaer	567.85	10 478	249	38.74	163.14	17 848	468.52	292.03	257
Jixi	272.25	14 253	111	22.03	60.54	17 446	133.63	78.86	86
Hegang	156.1	14 266	53	13.61	56.95	19 115	119.52	26.17	51
Shuangyashan	211.91	14 092	59	14.71	101.27	18 823	152.14	81.07	48
Daqing	1 887.66	69 436	221	170.85	489.32	30 272	2 861.88	143.15	372
Yichun	154.17	12 062	57	6.70	52.56	9 739	87.08	75.99	40
Jiamusi	337.96	13 559	163	13.65	84.63	15 597	133.68	160.97	148
Qitaihe	145.52	16 278	51	19.03	69.71	17 822	161.54	25.91	36
Mudanjiang	421.72	15 267	207	44.88	152.49	16 989	203.81	137.49	197
Heihe City	169.21	9 723	72	9.72	41.64	16 685	31.61	93.48	40
Suihua City	459.57	8 036	193	25.50	101.57	13 304	147.67	332.39	186
Daxinganling	5.98	11 248	26	3.33	18.03	14 502	9.50	42.00	26

2 Result and analysis

2.1 Operation and result of factor analysis

(1) Data test. After the standardized processing of data, factor analysis is conducted by SPSS software. Bartlett spherical detection value is 272.746 and probability value is $p=0.000$, indicating that the correlation matrix is not unit matrix. KMO detection value is 0.769. According to the judging criteria of KMO detection value, it is better to conduct factor analysis when the value is bigger than 0.7[7]. Therefore, observation variable is suitable for factor analysis.

(2) Extraction of common factor. Principal Component Analysis Method is used to extract common factor. Number of common factors is determined by the accumulative contribution rate of eigenvalue greater than 85%. Table 2 reports the eigenvalue, variance contribution rate and accumulative contribution rate. It can be concluded that variance of factor 1 accounts for 75.219% of the variance of total factor. Overall variance contribution rate of the first two factors reaches as high as 96.238%. Thus, the first two factors can describe the overall level of economic development in different areas.

Table 2 Eigenvalue of initial factor

Code of factor	Eigenvalue	Percentage %	Accumulative percentage //%
1	6.770	75.219	75.219
2	1.892	21.020	96.238
3	0.186	2.066	98.305
4	0.140	1.560	99.864
5	0.005	0.056	99.920
6	0.003	0.039	99.959
7	0.002	0.025	99.984
8	0.001	0.014	99.998
9	0.000	0.002	100.000

The first two factors are selected as common factors. Hence, the factor analysis model is:

$$X_1=0.998F_1+0.016F_2+\varepsilon_1$$
$$X_2=0.667F_1+0.726F_2+\varepsilon_2$$
$$X_3=0.865F_1-0.485F_2+\varepsilon_3$$
$$X_4=0.995F_1-0.015F_2+\varepsilon_4$$
$$X_5=0.984F_1-0.149F_2+\varepsilon_5.$$
$$X_6=0.710F_1+0.613F_2+\varepsilon_6$$
$$X_7=0.846F_1+0.502F_2+\varepsilon_7$$
$$X_8=0.748F_1-0.581F_2+\varepsilon_8$$
$$X_9=0.922F_1-0.374F_2+\varepsilon_9$$

(3) Factor rotation. Calculate the factor loading matrix, which describes the load of common factor on variables. To better name and explain the variables, maximum variance orthogonal rotation is conducted for loading matrix of initial factor, so that the factor loads are differentiated into 0 –1. Table 3 reports the factor loading matrix after rotation.

Table 3 Factor loading matrix after rotation

Variable	Common factor 1	Common factor 2
X_9	0.981	0.148
X_8	0.958	0.270
X_5	0.947	0
X_4	0.866	0.484
X_1	0.794	0.599
X_2	0.778	0.625
X_6	0	0.983
X_7	0.184	0.920
X_3	0.360	0.916

Table 3 indicates that the common factor 1 has relatively great load values of regional GDP (X_1), total value of tertiary

industry (X_3), financial revenue (X_4), urban fixed assets investment (X_5), total output value of farming, forestry, husbandry and fishing (X_8), and retail sales of social consumer goods (X_9), which are all greater than 0.7. According to the economic meaning, common factor 1 is named as the comprehensive economic strength factor. Meanwhile, common factor 2 has great load values of per capita GDP (X_2), average salary (X_6), and gross industrial output value (X_7), which is named as comprehensive economic benefit factor. Thus, these 9 indices can be classified into two types of comprehensive economic benefit index and comprehensive economic strength index.

(4) Scores of common factors and their comprehensive scores. Multiple-multiple regression analysis is carried out in order to investigate the economic development status of each area and to conduct analysis and comprehensive evaluation. In other words, the least square method is used to estimate the score function of common factor:

$$F_1 = 0.111X_1 - 0.158X_2 + 0.258X_3 + 0.121X_4 + 0.163X_5 - 0.116X_6 - 0.064X_7 + 0.276X_8 + 0.229X_9;$$

$$F_2 = 0.097X_1 + 0.364X_2 - 0.124X_3 + 0.084X_4 + 0.027X_5 + 0.320X_6 + 0.286X_7 - 0.175X_8 - 0.073X_9.$$

Table 4 Factor scores of 13 areas in Heilongjiang commodity grain base

Area	F_1	F_2	Comprehensive score
Harbin	3.132 71	0.250 43	2.504
Qiqihaer	0.349 63	−0.346 49	0.198
Jixi	−0.398 11	−0.140 33	−0.342
Hegang	−0.637 25	0.031 90	−0.491
Shuangyashan	−0.492 82	−0.030 57	−0.392
Daqing	−0.317 56	3.168 36	0.442
Yichun	−0.315 28	−0.718 71	−0.403
Jiamusi	−0.103 47	−0.40433	−0.169
Qitaihe	−0.625 61	0.016 12	−0.486
Mudanjiang	−0.025 50	−0.197 42	−0.063
Heihe City	−0.413 16	−0.349 26	−0.399
Suihua City	0.408 48	−0.860 12	0.132
Daxinganling	−0.562 03	−0.419 57	−0.531

Table 4 reports the scores of the two common factors calculated by SPSS. The two common factors reflect the overall level of regional economic development status of Heilongjiang commodity grain base. Comprehensive statistics is calculated by taking the variance contribution rate of common factor as the weight. The equation is[8]:

$$F = \frac{\lambda_1}{\lambda_1 + \lambda_2}F_1 + \frac{\lambda_2}{\lambda_1 + \lambda_2}F_2. \quad (4)$$

Based on equation (4), Table 4 shows the comprehensive scores of different areas.

According to the comprehensive scores in Table 4, order of the comprehensive scores of 13 areas in Heilongjiang commodity grain base is obtained (Fig. 1).

2.2 Analysis Fig. 1 illustrates that Heilongjiang commodity grain base has extremely uneven regional economic development in different areas. In order to effectively analyze the different regions, the 13 areas are divided into 4 types according to the actual situation of the order of comprehensive scores.

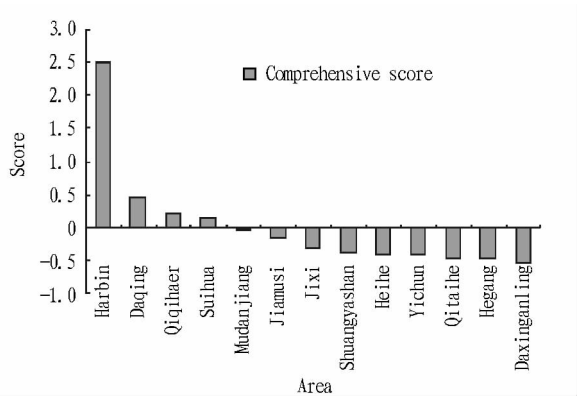

Fig. 1 Order of the comprehensive scores in different areas

(1) Harbin. As the capital city of Heilongjiang Province and an important heavy industry city, Harbin has absolute superiority in political, economic and geographical environment. According to the result of comprehensive evaluation, Harbin takes the first place in both the score of common factor and the comprehensive score, which are far greater than those of Daqing in the second place. This indicates that Harbin area has a strong industrial base with rapid urban construction and high living standard. Therefore, Harbin City should rely on its good economic base, continue to optimize the industry structure and layout, increase the construction input of regional commodity grain base, strengthen the regional division and cooperation with surrounding areas, and accelerate the economic development of surrounding areas and the whole Heilongjiang Province.

(2) Daqing. As the most famous oil city, Daqing is one of the important energy cities in China. It is a highly specialized resource city and is in an important strategic position in petroleum industry layout. According to the evaluation result, score of the common factor 2 in Daqing Area takes the first place; and its comprehensive score takes the second place, indicating that Daqing has relatively developed economy and the highest living standard. Therefore, Daqing Area should fully utilize its own resources and technical superiority to stabilize oil production, and develop the petrochemical industry, modern agriculture, equipment manufacturing, new material and new energy, and high-end service industry with the guidance of high technology. At the same time, Daqing should also promote the development of social undertakings in high quality, enhance the balanced progress of science, education, culture and sport, and improve the social security system in urban and rural areas.

(3) Qiqihaer, Suihua, Mudanjiang and Jiamusi. Comprehensive ranks of these areas are relatively close. Among them, Mudanjiang and Jiamusi Cities are important industrial cities of Heilongjiang Province, while Qiqihaer and Suihua also have certain industrial base with agricultural characteristics. Therefore, these 4 areas should be guided by the market, fully use the natural resources of commodity grain base, ensure the sustainable development of industry, vigorously devel-

op agricultural and grazing industry, cultivate new industry growth point, play their own unique strengths and potential, and form industries and regional brands with local characteristics[9].

(4) Jixi, Shuangyashan, Heihe, Yichun, Qitaihe, Hegang and Daxinganling. These areas are in a disadvantageous position in comprehensive evaluation, indicating that they are backward in economic development in Heilongjiang commodity grain base. Among them, Jixi, Shuangyashan, Qitaihe, and Hegang are coal cities, which are also important energy bases of China. Industrial structure of these cities is relatively single, and non-resource-based industry is relatively weak. Therefore, these cities should accelerate the system reform, pay attention to environmental protection and reasonable use of resources, increase investment and attract talents, vigorously develop the industry silicon, silicon carbide, magnesium alloy and so on, transform coal energy resources into economic advantage, and realize economic coordinated and sustainable development. However, Yichun, Heihe and Daxinganling are forestry cities with huge employment pressure and slow social economic development. Besides, these areas have immense woodland, broad snowland, and cold climate. Therefore, Yichun, Heihe and Daxinganling should fully use their superior resources, establish ice-snow tourism area and primeval forest park, vigorously develop sustainable industry, establish eco-tourism cities, accelerate the transfer of labor force, increase investment, broaden employment channels, and increase farmers' income[10].

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scientifically feed livestock and fowls.

4.2.4 Strengthening the support from government. The government should strengthen its support on agriculture and enact the policies implemented for benefiting farmers strictly; enforce the publicity; enhance farmers' awareness of scientific and reasonable planting and breeding, elevate farmers' activities in participating scientific farming. Furthermore, the government should increase farmers' income through solving the rural surplus labor.

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