Research on Harmony between Agricultural Modernization and Regional Economy Development in China

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Abstract The inharmonious development of agricultural modernization and regional economy is a major cause to the imbalanced development of regional economy in China. The evaluation index system of modern agriculture is established according to the relevant data from *Chinese Agricultural Yearbook* 2009, *China Rural Statistical Yearbook* and *China Statistical Yearbook*. By using the Grey Relation Analysis, the developmental level of agricultural modernization of 31 provinces and cities in China is ranked and compared by combining the overall regional economic strength. The results show that the developmental level of agricultural modernization in each area of China is different; the agricultural modernization level of each area in China is inharmonious with the total economic strength; inharmonious characteristic is presented between agricultural modernization development and regional overall economy development in China.

Key words Agricultural modernization, Regional economy, Inharmonious, Grey correlation analysis, China

Modernization of agriculture is the process of transforming agriculture from the traditional labor-based agriculture to technology-based modern agriculture. Accelerating the progress of agricultural modernization is a crucial measure for realizing high efficiency of agriculture, farmers' income increase and rural prosperity. Since reform and opening up, the progress of agricultural modernization has not only deeply changed the backward situation of Chinese rural areas, but also made great contribution to the rapid growth of Chinese economy and social progress. However, from the perspective of regional economy, the progress of agricultural modernization is inharmonious with the development of regional economy. The inharmonious relations are reflected on two aspects. The first one is the imbalance among various regions. Due to the different basic situation, economic environment, degree of reform and opening up and regional developmental opportunism, the east coastal area has the highest degree of agricultural modernization, but the central and west area, especially, the west areas, the progress of agricultural modernization is slow and backward. The second one is the incoordination in the inside of each region. The agricultural modernization degree of an area directly affects the structure of three industries , and then affect the overall industrial structure of the area. And the industrial structure relates to the healthy development of regional economy, so in some area, the backward development of agricultural modernization has restricted the local economic development. In the process of developing regional economy, one of the crucial problems is the unbalanced development among areas and the rapid expanding gap among areas. Agricultural economy is a major part of regional economy, so fully understanding the imbalance and inharmony of the progress of agricultural modernization is of great importance in further accelerating the development tempo of agricultural modernization; narrowing down the gap among various areas and promoting the harmonious development of agricultural modernization and regional economy. On the basis, by applying the grey correlation analysis and the using the rough rank of agricultural modernization situation of 31 provinces and cities in China, the paper analyzed the inharmonious relations in the process of agricultural modernization and regional economic development.

1 Data source and research method

1.1 Data source The original data of the research come from *Chinese Agricultural Yearbook*, *Agricultural Rural Statistical Yearbook* and *China Statistical Yearbook* in the year of 2009.

1.2 The establishment of evaluation index system of agricultural modernization The key to evaluating agricultural modernization is the scientific selection of index and establishment of index system. The domestic evaluation index of agricultural modernization can be classified into three kinds. The first one is the index system at national macro-economic level. the rural economy research center of Ministry of Agriculture divided the index system of agricultural modernization into ten evaluation items in three categories including agricultural external condition, internal condition and production effects; science and technology documentation and information center of the Chinese Academy of Agricultural Science divided the index system of agricultural modernization into 22 items in seven categories. The second one is the index system that reflects the local economic distinct. In 1999, the team worked for " Agricultural Modernization in Zhujiang Delta" in Guangdong Province put forward an evaluation index system, which was composed by 11 first-grade indexes and 19 second-grade indexes. In 2001, Zhejiang Statistical Bureau made an evaluation index system formed by 17 indexes in 8 categories. In 2003, institute of rural economy of Shandong Academy of Social Science determined

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an evaluation index system composed by 26 items in six categories. The third one is the index system put forward by domestic experts according to their understanding on agriculture modernization and demands on research. For example, according to the definition of agricultural modernization, LIU Xiaoyue established the evaluation index system contains 16 items in four categories[1]; JIANG He-ping *et al.* established an evaluation index system composed by 15 individual indexes and four standard indexes[2].

By mirroring the existing research results, the paper laid stress on the following problems when establishing index system. The first one is the systematic index system. The indexes should be mutually connected, mutually cooperated and with priority given to different aspects to form an organic integration and reflect the actual situation of agricultural modernization from different perspectives. The second one is the comprehensiveness of the index system. The determination of index should not only takes the typical index of agricultural modernization into consideration, but also pays attention to the related indexes of agricultural modernization and considers the major factors concern the agricultural modernization as more as possible. The third one is the feasibility of index system. The index system should be feasible. The system should make full use of the existing data; the economic connotation of index should be clarified and the calculation and integration method should be unified, so as to achieve dynamic comparability and ensure the rationality, objectivity and impartiality of results. Guided by the principles above, the paper determined an evaluation index system composed by 13 indexes in six categories. It can be seen on Table 1 and it is used to evaluate the developmental level of Chinese agricultural modernization.

Table 1 Evaluation index system of agricultural modernization

First-grade indexes	Second-grade indexes	Connotation of indexes
The quality of rural labor forces	The rate of labors with middle school education or above x_1	Reflecting the cultural quality of rural labor forces
Input of rural finance	Per capita agricultural capital input x_2	Reflecting input level of agricultural modernization
Agricultural production means	Per capita a gross agricultural machinery power x_3	Reflecting the machinery level of agricultural modernization
	Per capita electricity consumption x_4	Reflecting the popularization of electricity of agricultural modernization
	Harvest rate of drought and flood x_5	Reflecting the irrigation level of modern agricultural modernization
	The volume of fertilizers used by per unit of farmland x_6	Reflecting chemical level of agricultural modernization
	The volume of agricultural film used by per unit of farmland x_7	Reflecting the chemical level of agricultural modernization
	The volume of pesticides used by per unit farmland x_8	Reflecting the chemical level of agricultural modernization
Agricultural output	Labor productivity rate x_9	Reflecting the output level of per unit of labors of agricultural modernization
	Per capita net income x_{10}	Reflecting economic income of farmers
	Land productivity rate x_{11}	Reflecting the output level of per unit land of agricultural modernization
Agricultural production environment	Disasters rate suffered by agriculture x_{12}	Reflecting the level of tough agricultural production environment
Sustainable development of agriculture	Coverage of forest x_{13}	Reflecting the tough agricultural ecological environment

1.3 Research method China, as a big country, the agricultural system of it is not homogenous structure, but a complex social economic system. The agricultural economy varies hugely in different areas affected by varied natural situation, element structure, economic development, location and market distance, *etc.* Different provinces and cities have different features in the process of agricultural modernization[3]. Therefore, when studying the development level of agricultural modernization of each province and city, the paper regards the agricultural economic system as an incomplete information system with part of known information and part of unknown information, and selects grey correlation analysis. The basic principles of grey correlation analysis are as follows. Supposing the evaluation system S is composed by $S_i(i=1, 2, \cdots, m)$, the characteristic parameters (indexs) sequence of S_i is $X_{ij}(j=1, 2, \cdots, n)$, the system expressed by matrix is as follows:

$$X=\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

1.3.1 Determining the reference sequence. Supposing the sequence of reference parameters (indexes) X_0 is $\{x_{0j}\}$, $(j=1, 2, \cdots, n)$, and then:

$X_0=(x_{01}, x_{02}, \cdots, x_{0n})$.

In the sequence, as for the bigger and the better indexes, supposing $x_{0j}=\max(x_{ij})$; as for the smaller the better indexes,

supposing $x'_{0j} = \min(x_{ij})$.

1.3.2 Normalizing the original data by using the optimized indexes. The normalization of high-priority indexes: $z_{ij} = x_{ij} / x_{0j}$; the moralization of low-priority indexes: $z_{ij} = x'_{0j} / x_{ij}$.

The data matrix after being normalized is:

$$Z = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1n} \\ z_{21} & z_{22} & \cdots & z_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ z_{m+1,1} & z_{m+1,2} & \cdots & z_{m+1,n} \end{bmatrix} = \begin{bmatrix} Z_1 \\ Z_2 \\ \vdots \\ Z_{m+1} \end{bmatrix}$$

1.3.3 Calculating associated matrix. Taking Z_1, Z_2, $\cdots$, Z_{m+1} respectively as reference sequence; $m+1$ sequences as the comparable sequence and then calculating the associated matrix R by using the grey correlation analysis.

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1,m+1} \\ r_{21} & r_{22} & \cdots & r_{2,m+1} \\ \vdots & \vdots & \cdots & \vdots \\ r_{m+1,1} & r_{m+1,2} & \cdots & r_{m+1,m+1} \end{bmatrix}$$

In the matrix, $r_{ij}(1 \leqslant i \leqslant m+1, 1 \leqslant j \leqslant m+1)$ takes the index sequence of the i evaluation subject as reference sequence, the index sequence of the j evaluation subject is the correlation degree of comparable sequence.

Supposing the evaluation subject is Z_j and its index sequence is $Z_j = (z_{j1}, z_{j,2}, \cdots, z_{jn})$; reference sequence is Z_i and its index sequence is $Z_i = (z_{i1}, z_{i2}, \cdots, z_{in})$ and then the actual number is:

$$\xi_{ij}(k) = \frac{\min_j \min_k |z_i(k) - z_j(k)| + \delta \max_j \max_k |z_i(k) - z_j(k)|}{|z_i(k) - z_j(k)| + \delta \max_j \max_k |z_i(k) - z_j(k)|} \quad (1)$$

In the equation, the actual number is the correlation coefficient of Z_j to Z_i in the k point; δ is the resolution ratio and it is used to adjust the comparable environment, the value is between 0 and 1. The smaller the δ, the larger the resolving capability is. Under the principles of least information, when $\delta = 0.5$, the resolution ratio achieves the highest value[4]. The equation of the correlation degree of Z_j to Z_i is as follows:

$$r_{ij} = \frac{1}{n} \Sigma \xi_{ij}(k) \quad (2)$$

The bigger the value of r_{ij}, the closer Z_j and Z_i is; the smaller the value of r_{ij}, the further relations between Z_j and Z_i.

1.3.4 Establishing grey similarity matrix G.

$$G = \begin{bmatrix} g_{11} & g_{12} & \cdots & g_{1,m+1} \\ g_{21} & g_{22} & \cdots & g_{2,m+1} \\ \vdots & \vdots & \cdots & \vdots \\ g_{m1} & g_{m2} & \cdots & g_{m,m+1} \\ g_{m+1,1} & g_{m+1,2} & \cdots & g_{m+1,m+1} \end{bmatrix}$$

In the matrix, $g_{ij} = (r_{ij} + r_{ji})/2$, so $g_{ij} = g_{ji}$.

1.3.5 Ranking and evaluating. In the grey matrix G, the X_0 is taken as the correlation ranks worked out by reference sequence. According to the value of the correlation ranks, the evaluation subjects are ranked and the advantages and disadvantaged of each evaluation subjects are obtained.

2 Results and analysis

2.1 Normalizing the original data The matrix Z can be obtained from Table 2. Taking matrix Z as the basis, Z_1, Z_2, $\cdots$, Z_{31}, Z_{32} as the reference sequence, and then the correlation matrix R can be calculated by using grey correlation analysis (due to the matrix R is the step matrix of 31 ×31 and it is incontinent to list so it is omitted). Then by using equation (1) and (2), the grey similarity matrix G can be worked out (the method is same to the calculation of matrix R so it is omitted). The line 32 in the matrix G is the correlation order obtained by taking the X_0 as reference sequence. The advantages and disadvantages of each evaluation subject can be obtained according to the value and ranks of the evaluation subjects (line two of Table 3).

Table 2 Normalized results of original data

Area	z_{i1}	z_{i2}	z_{i3}	z_{i4}	z_{i5}	z_{i6}	z_{i7}	z_{i8}	z_{i9}	z_{i10}	z_{i11}	z_{i12}	z_{i13}
Beijing	1.000	0.367	0.087	0.129	0.877	0.658	0.703	0.375	0.160	0.932	1.000	0.289	0.583
Tianjin	0.857	0.525	0.455	0.323	0.553	0.658	0.293	0.194	0.330	0.691	0.721	0.254	0.283
Hebei	0.865	0.430	1.000	0.407	0.585	0.554	0.211	0.302	0.595	0.419	0.508	0.236	0.409
Shanxi	0.840	0.256	0.608	0.177	0.186	0.286	0.102	0.133	0.233	0.358	0.247	0.125	0.283
Inner Mongolia	0.699	0.631	0.966	0.118	0.219	0.242	0.079	0.060	0.857	0.407	0.263	0.169	0.315
Liaoning	0.851	0.756	0.373	0.476	0.272	0.353	0.308	0.288	0.731	0.487	0.607	0.425	0.583
Jilin	0.744	0.713	0.603	0.108	0.192	0.332	0.104	0.164	0.875	0.431	0.377	0.706	0.709
Heilongjiang	0.797	1.000	0.693	0.094	0.157	0.171	0.064	0.118	0.788	0.424	0.238	0.274	0.740
Shanghai	0.900	0.159	0.041	0.706	1.000	0.657	1.000	0.745	0.194	1.000	0.894	0.950	0.283
Jiangsu	0.793	0.327	0.318	1.000	0.663	0.802	0.205	0.442	0.507	0.643	0.585	0.539	0.315
Zhejiang	0.698	0.601	0.243	0.650	0.589	0.543	0.311	0.769	0.299	0.809	0.824	0.115	0.961
Anhui	0.722	0.311	0.513	0.089	0.469	0.601	0.143	0.437	0.422	0.367	0.336	0.287	0.441
Fujian	0.700	0.296	0.205	0.358	0.532	1.000	0.533	0.970	0.585	0.542	0.864	0.505	1.000
Jiangxi	0.691	0.315	0.508	0.093	0.545	0.527	0.169	0.767	0.468	0.411	0.327	0.077	0.945
Shandong	0.850	0.493	0.741	0.265	0.491	0.710	0.490	0.518	0.650	0.493	0.677	1.000	0.346
Henan	0.841	0.329	0.620	0.138	0.524	0.851	0.189	0.337	0.496	0.389	0.455	0.378	0.331
Hubei	0.769	0.331	0.373	0.121	0.397	0.787	0.145	0.666	0.633	0.407	0.478	0.055	0.504
Hunan	0.741	0.292	0.405	0.076	0.603	0.661	0.210	0.668	0.541	0.394	0.485	0.042	0.882
Guangdong	0.788	0.288	0.147	0.617	0.518	0.897	0.144	0.797	0.373	0.559	0.846	0.111	0.899
Guangxi	0.807	0.333	0.324	0.056	0.288	0.591	0.081	0.330	0.528	0.323	0.489	0.116	0.866
Hainan	0.802	0.291	0.347	0.044	0.219	0.702	0.306	1.000	1.000	0.384	0.850	0.132	0.929
Chongqing	0.611	0.192	0.189	0.107	0.154	0.442	0.159	0.211	0.294	0.361	0.364	0.174	0.551

Continued (Table 2)

Area	z_{i1}	z_{i2}	z_{i3}	z_{i4}	z_{i5}	z_{i6}	z_{i7}	z_{i8}	z_{i9}	z_{i10}	z_{i11}	z_{i12}	z_{i13}
Sichuan	0.662	0.301	0.211	0.093	0.303	0.457	0.199	0.229	0.496	0.360	0.429	0.291	0.551
Guizhou	0.550	0.180	0.256	0.048	0.136	0.208	0.122	0.065	0.227	0.244	0.253	0.133	0.661
Yunnan	0.526	0.306	0.288	0.067	0.157	0.309	0.141	0.158	0.369	0.271	0.324	0.214	0.787
Tibet	0.051	0.089	0.838	0.013	0.043	0.143	0.017	0.074	0.341	0.278	0.469	0.313	0.189
Shaanxi	0.789	0.268	0.337	0.190	0.218	0.459	0.078	0.061	0.407	0.274	0.469	0.251	0.614
Gansu	0.612	0.230	0.465	0.099	0.223	0.196	0.223	0.176	0.360	0.238	0.345	0.172	0.220
Qinghai	0.404	0.231	0.492	0.047	0.290	0.167	0.023	0.081	0.342	0.268	0.289	0.231	0.085
Ningxia	0.540	0.480	0.830	0.127	0.346	0.352	0.097	0.048	0.463	0.322	0.272	0.122	0.173
Xinjiang	0.634	0.699	0.648	0.235	0.665	0.405	0.470	0.100	0.896	0.306	0.440	0.097	0.050
Benchmark	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

2.2 Analysis on the results From the ranks of agricultural modernization on Table 3, it can be seen that the development of agricultural modernization varies in different areas. In general, agricultural modernization develops well in east China, followed by central China and it is backward in west China. from the top ten provinces or cities, it can be seen that Zhejiang Province, Shandong Province, Jiangsu Province, Fujian Province, Shanghai and Guangdong Province all belong to east China; from the late eleven provinces or cities, it can be seen that Yunnan, Inner Mongolia, Gansu Province, Guangxi Zhuang Autonomous Region, Chongqing, Shannxi Province, Guizhou Province and Tibet belong to west China(Table 4).

Table 3 The rank of agricultural modernization development and per capital GDP of each area

Area	Correlation degree	Rank	GDP Per capital GDP	Rank	Gap of ranks	Area	Correlation degree	Rank	GDP Per capital GDP	Rank	Gap of ranks
Zhejiang	0.977 5	1	4196 7	4	−3	Tianjin	0.962 6	17	54 034	3	14
Xinjiang	0.975 2	2	19 725	16	−14	Jilin	0.962 2	18	23 497	11	7
Shandong	0.973 2	3	32 996	7	−4	Qinghai	0.960 7	19	17 356	22	−3
Jiangsu	0.971 2	4	39 485	5	−1	Sichuan	0.959 3	20	15 368	24	−4
Fujian	0.970 5	5	30 031	10	−5	Beijing	0.959 0	21	61 876	2	19
Hunan	0.969 8	6	17 487	21	−15	Yunnan	0.958 6	22	12 547	29	−7
Jiangxi	0.969 7	7	14 728	26	−19	Heilongjiang	0.958 5	23	21 725	13	10
Shanghai	0.969 5	8	72 554	1	7	Inner Mongolia	0.957 2	24	32 153	8	16
Guangdong	0.968 7	9	37 402	6	3	Gansu	0.956 7	25	12 086	30	−5
Hubei	0.968 0	10	19 840	15	−5	Guangxi	0.956 5	26	14 891	25	−1
Hebei	0.966 6	11	23 163	12	−1	Chongqing	0.954 1	27	17 952	19	8
Liaoning	0.965 4	12	31 197	9	3	Shaanxi	0.951 5	28	18 212	18	10
Anhui	0.964 8	13	14 465	27	−14	Shanxi	0.949 5	29	20 342	14	15
Henan	0.964 7	14	19 523	17	−3	Guizhou	0.948 9	30	8 788	31	−1
Hainan	0.963 0	15	17 087	23	−8	Tibet	0.878 3	31	13 795	28	3
Ningxia	0.963 0	16	17 775	20	−4						

Table 4 Rank of agricultural modernization level of each area

Area	1st−10th	11th−20 th	21st−31st
East China	Zhejiang, Shandong, Jiangsu, Fujian, Shanghai, Guangdong	Hebei, Liaoning, Hainan, Tianjin	Beijing
Central China	Hunan, Jiangxi, Hubei	Anhui, Henan, Jilin	Heilongjiang, Shanxi
West China	Xinjiang	Ningxia, Qinghai, Sichuan	Yunnan, Inner Mongolia, Gansu, Guangxi, Chongqing, Shaanxi, Guizhou, Tibet

In order to make convenience for the process of agricultural modernization and the harmony of overall development level of regional economy, the paper uses the per capita GDP in 2008 as the index for weighing the overall economic power of regional economy and ranking the per capita GDP of 31 provinces and cities in China, and then calculating the grade gap of agricultural modernization of each area and regional economic power(Table 3). The gap of the grade is divided into three types. The first type is among −5 and 5, which indicates the agricultural modernization is inharmonious with regional economic development; the second type is the gap −5, which indicates the agricultural modernization is superior to the overall development of regional economy; the third type is the gap 5, which indicates that the agricultural modernization is inferior to overall development of regional economy. According to the principle, the results of Table 3 is concluded and listed on Table 5. The analysis results show that the agricultural modernization and regional economic development are harmonious in 13 provinces and cities of China. The level of agricultural modernization in Xinjiang, Fujian and some other seven areas have surpassed the regional economic development of these areas; in Shanghai, Fujian and some other seven areas, the develop-

mental level of agricultural modernization goes behind their regional economy. It can be seen that the level of agricultural modernization is inharmonious with the regional economic development.

Table 5 The harmony between agricultural modernization and regional economic development

Bad rank	Area	The number of areas
≤ -5	Xinjiang, Fujian, Hunan, Jiangxi, Hubei, Anhui, Hunan, Yunnan, Gansu	9
(-5,5)	Zhejiang, Shandong, Jiangsu, Guangdong, Hebei, Liaoning, Henan, Ningxia, Sichuan, Guangxi, Guizhou, Tibet	13
≥ 5	Shanghai, Tianjin, Jilin, Beijing, Heilongjiang, Inner Mongolia, Chongqing, Shaanxi, Shanxi	9

3 Conclusions

On the basis of factor analysis, the developmental level of agricultural modernization in each area is ranked and compared with the overall regional economic power. The results show that in China, the developmental level of agricultural modernization is inharmonious with the overall development of regional economy. The inharmonious relations are reflected on two aspects. The first one is the imbalance of the developmental level of agricultural modernization among various regions; the second one is the imbalance between the progress of agricultural modernization in the areas and regional economic power. Deepening the imbalance and inharmony of the developmental level of agricultural modernization; adopting effective measures to transfer the backward situation of agricultural modernization; pushing forward and realizing the harmonious development of agricultural modernization and regional economic development are not only conducive to the further prosperity of rural economy, but also of great significance in strengthening overall regional economic power and facilitating the national economic growth.

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increased, and the regional governments should integrate such optimization strategies into their economic and social development planning, as well as the new rural development initiatives. They should also coordinate urban and rural energy development to ensure the development of agricultural production energy is aligned with that of the national economy. Agricultural production energy should also be developed under the guidance of the country's overall energy development strategy in order to formulate locally adapted strategic objectives, principles, and supply and demand structure suitable for that region.

In the future, agricultural production energy should comply with the principle of "working out measures to suit local conditions, diversified development and combination of input-based external commodity energy and development of rural internal renewable energy". We should better coordinate urban and rural energy development systems, optimize energy structure, continuously improve the proportion of power in energy consumption in agricultural production, make use of local resources, and accelerate development and utilization of rural renewable energy to build the agricultural production energy system that is in line with the diversification and sustainability objectives for the rural regions.

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