Study on Sustainable Development of Shaanxi Economy Based on Evaluation Function

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Abstract: How to handle the relationship of environment and industrial coordination development and promote sustainable social and economic development is a hot topic in present social studies. This paper constructs sustainable development evaluation index system and establishes function of sustainable coordinated development degree through designing the indicator system of environment subsystem and industrial subsystem. Take the economic development of Shaanxi Province for example, the empirical analysis has shown that economic development of Shaanxi is good on the whole, but sustainable coordinated development degree still has a certain gap with the perfectly coordinated. Therefore, it is necessary to further strengthen industrial restructuring efforts, and meanwhile, increase environmental management and equipment replacement, improve the technological level of environmental protection and realize that the development of economy and society moves in a more sustainable coordinated direction.

Introduction of evaluation function.

Development of evaluation function. Evaluation function is a systematic quantitative description of the evaluation objects' quantitative characteristics from different aspects and expressed by using a series of mathematics, statistics and other quantitative methods based on; and it can obtain relatively real evaluation values which can reflect the evaluation objects and evaluate certain things. In 1888, British statistician Edgeworth published a paper "The Statistics of Examinations", in which he raised the question of how to make weighted comparison on different courses in examinations [1]. In 1913, Spearman published a paper "correlation between sum and difference", in which the functions of different weightings were discussed and in fact the related content of multivariate analysis was applied to the problem of evaluation function [2]. The researches on fuzzy mathematics which began to appear in 1960s have played a great role in promoting the development of evaluation function. The evaluation function in modern science sprang up and developed in depth and breadth in China from 1970s to 1990s; and various and fruitful studies on thetheories, methods and applications of evaluation function have been conducted. Evaluation function as a new discipline has matured.

Evaluation function can be divided into dozens of types such as expert meeting law, Delphi method, analytic hierarchy process, principal component analysis, factor analysis and fuzzy comprehensive evaluation method according to evaluation methods. According to the difference of theoretical bases of various evaluation methods, evaluation function can be roughly divided into two categories: weight evaluation method and unweighted evaluation method; qualitative and quantitative evaluation methods are integrated in evaluation methods [3].

Dimensionless method of evaluation indicator. The assumptions that ideal dimensionless method should meet are mainly monotonicity, invariability of diversity ratio, translational independence, scaling independence, interval stability and constancy of amounts. The more above properties are satisfied, the better the method is. By comparison, standardized processing method, extreme value processing method and efficacy coefficient method have met the most properties and thus are much better relative to other methods.

Dimensionless method of evaluation indicator is also called the standardization and normalization of indicator data, a way to eliminate the effects of dimension of quantity of original indicators by mathematical manipulation. It is necessary to apply dimensionless methods to evaluation indicators in order to reflect the acctual situation as far as possible, to eliminate the influence brought about by the differences of dimension of quantity of various indexes and the disparities in order of magnitudes of their numerical values and to avoid the occurrence of unreasonable phenomenon. The following indicator considered $x_j\,(j=1,2,...,\ m)$ is an indicator of maximum type and its observation value is $\{x_{ij} \mid i=1,2,...,n;\ \mathrm{j}=1,2,...,m\}$:

1. Standardized processing method: (1)

$$x_{ij}^{*}=\frac{x_{ij}-\overline{x_j}}{s_j} \quad . \qquad (1).$$

In formula (1):

$\overline{x_j}$ and $s_j\,(j=1,2,...,m)$ are (sample) average value and (sample) standard deviation of observations of indicators of item j respectively, while x_{ij} is standard observation value. The characteristic is that sample average value is 0 and variance is 1; the interval is uncertain, the maximum and minimum values of various indicators after processing are different; this is not applicable for the case with indicator values constant and also not applicable for the evaluation methods (such as weighted geometric method) requiring index values $x_{ij}^{*}>0$.

2. Extreme value processing method:

$$x_{ij}^{*}=\frac{x_{ij}-m_j}{M_j-m_j} \quad . \qquad (2)$$

In formula (2):

$M_j=\max\limits_i\{x_{ij}\}, m_j=\min\limits_i\{x_{ij}\}$. The characteristic is $x_{ij}^{*}\in[0,1]$ with maximum value 1 and minimum value 0; this is not applicable for the case with indicator values constant (denominator is 0).

Determining weight coefficients of evaluation indicators. When many common evaluation functions are evaluated comprehensively, the weights in various function indicator models must be determined. The size of a weight in effect reflects the function of a certain index in the whole evaluation. But the determination of a weight is in effect a difficulty in an evaluation function. Up to now, there is no uniform and general accepted method. But in the practice of comprehensive evaluation, the methods often used for determining weights are equal weight method, Delphi method, different weighting method, optimal weighting method and AHP etc.

1. Subjective weighting method, Delphi method (expert method) ----in effect each expert can choose different methods according to their own understanding.
2. Equal weight method. This weight method is very simple; to some degree, this is in effect a non-weighting method. Its essence is that giving an equal weight to every indicator when comprehensively evaluating the indicator.

Establishing evaluation function for Shaanxi sustainable development.

Selection of evaluation function variables. Macro-control is essential to promote sustainable economic and social development, but its effect is mainly depend on whether the core objectives are grabbed accurately and whether a difference can be made on the core objectives. Short-term macroscopic regulation should be combined with long-term development program to adapt to the requirements of 'new normal' for the economy, further strength and improve micro-control and perfect macro-control target system according to the real situations of various areas. Considering the situation in Shaanxi province, put forward the evaluation function of sustainable economic development of Shaanxi and establish the sustainable development evaluation function for macro-control mainly from environmental system and industrial system.

The major variables included in the environmental system are resource variables and environment variables; resource variables are mainly natural resources, including mineral resources, land resources and water resources etc. variables used to reflect the relationship between resource utilization & economic development and resource& population are per capital water availability, energy consumption per GDP and water consumption per GDP etc. Environment variables include total emissions of various environmental pollutants and emissions per GDP.

Industrial system concerns whether economic development improves people’s materials and whether cultural life and industrial structure are reasonable etc., and mainly includes variables of economic structure and economic benefit; through reasonable and efficient configuration and utilization of resources, variables of economic structure adjust the industrial structure, promote economic growth and are also key contents of stabilizing growth, adjusting structure and guarantying for employment and are mainly the proportion of secondary and tertiary industrial output values in GDP and their growth rates, the proportion of output-value of industries with core competition in total output-value of above-scale industries, urban employment rate, energy consumption etc.. Variables of economic benefit mainly include gross domestic product, per capital gross domestic product, GDP growth rate, per capital GDP growth rate, urban per capital disposable income and rural per capital net income etc. Based on existing data, select major variables and establish the three class indicator system of sustainable development evaluation function, as shown in table1.

Table 1 indicator system of sustainable development evaluation function

First class indicator	Second class indicator	Third class indicator	Unit	Variable	Weight
environment	water environment	gross amount of water resources	billion cubic meters	x1	0.112
		per capital volume of water resources	cubic meter/person	x2	0.145
		waste-water discharge amount	Ten thousand tons	x3	0.072
		waste-water discharges per GDP	ton/thousand CNY	x4	0.042
	atmospheric environment	total emissions of sulfur dioxide	ton	x5	0.124
		sulfur dioxide emissions per GDP	ton/billion CNY	x6	0.098
		total emissions of nitrogen oxide	ton	x7	0.072
		nitrogen oxide emissions per GDP	ton/billion CNY	x8	0.046
		total emissions of soot	ton	x9	0.082
		soot emissions per GDP	ton/billion CNY	x10	0.046
	solid waste	total discharge volume of solid waste	ten thousand tons	x11	0.095
		solid waste discharges per GDP	ton/ten thousand CNY	x12	0.066
industry	economic structure	proportion of primary industry in GDP	%	y1	0.018
		growth rate of output value of primary industry	%	y2	0.017
		proportion of secondary industry in GDP	%	y3	0.126
		growth rate of output value of secondary industry	%	y4	0.039
		proportion of tertiary industry in GDP	%	y5	0.135
		growth rate of output value of tertiary industry	%	y6	0.041
		the proportion of output-value of industries with core competition in total output-value of above-scale industries (equipment and electronic output-value)	%	y7	0.042
		energy consumption per GDP	Mtce/ten thousand CNY	y8	0.111
		water consumption per GDP	cubic meter/ten thousand CNY	y9	0.026
	economic benefit	gross domestic product	billion CNY	y10	0.125
		per capital gross domestic product	ten thousand CNY /person	y11	0.062
		GDP growth rate	%	y12	0.035
		per capital GDP growth rate	%	y13	0.071
		urban per capital disposable income	CNY /person	y14	0.046
		rural per capital net income	CNY/person	y15	0.106

Determining the indicator system weights of evaluation function. Since the establishment of indicator system of sustainable development evaluation function, the establishment of related index weights become crucial and also determines the accuracy and feasibility of sustainability assessment. For Shaanxi, in terms of growth rate, to guarantee stabilizing growth requires the economic growth rate of Shaanxi faster than that of the country. In terms of structure, industrial structure is required to be more reasonable and diversified and cannot rely too much on energy and chemical industry, manufacturing services and the full process of industrial products etc.; in terms of employment, the structure is required to be more inclined to be reasonable and the public is encouraged to start businesses and to be innovative; in terms of sustainability, scientific and green development is required. The index weights of this paper mainly refer to national average and the proportion of data of economic development in eastern provinces; the index weights obtained according to subjective weight method and after processing are shown in table 1.

Establishing evaluation function. Establish subfunctions of evaluation targets respectively from environmental and industrial system perspective. Standardize all the data to eliminate the effect of the difference of dimension of quantity and order of magnitudes. Set the vector quantities of different indicators for describing environment and industrial systems as $x_{ij} = (x_{i1}, x_{i2}, ..., x_{in})$ and standardize them to get:

$$x_{xj}^{*} = \frac{x_{ij} - x_{j,\min}}{x_{i,\max} - x_{i,\min}} \quad . \tag{3}$$

After standardizing processing, the values of x_{ij}^{*} are all between [0, 1]. From this, subfunction of environmental evaluation and subfunction of industry evaluation can be established:

Subfunction of environmental evaluation:

$$f(x) = \sum_{i=1}^{n} a_i x_i \quad . \tag{4}$$

Subfunction of industry evaluation:

$$g(y) = \sum_{j=1}^{m} b_j x_j \tag{5}$$

Then the sustainable development evaluation function for environment and industry can be defined as:

$$C = \left(\frac{f(x)g(y)}{\left(\frac{f(x)+g(y)}{2} \right)^2} \right)^2 \tag{6}$$

To avoid the situation that the evaluation function values of environmental system and industrial system are lower and the cost function value of sustainable development is higher, sustainable coordinated development degree is introduced, indicated by DC, and defined as:

$$DC = \sqrt{f^{a}(x) g^{b}(y)} \tag{7}$$

In formula (7), a、b are undetermined coefficients; if environment and industry are thought to be at equally important status, then $a = b = 0.5$ could be set. The development types of environmental and industrial systems can be divided into seven types, as shown in table 2.

Table 2 types of sustainable coordinated development

Sustainable coordinated development degree	0-0.29	0.30-0.49	0.50-0.59	0.60-0.69
Type	extremely uncoordinated	uncoordinated	relatively uncoordinated	weakly coordinated
Sustainable coordinated development degree	0.70-0.79	0.80-0.89	0.90-1.0	
Type	relatively coordinated	coordinated	perfectly coordinated	

Analysis of simulation result. According to the Shaanxi statistics yearbook in recent years, data from environmental system and industrial system of Shaanxi Province are organized and data utilization GM (1, 1) from 2014 to 2015 are predicted and optimized; and standardized data of evaluation function for Shaanxi Province from 2006 to 2015 are obtained by using extreme value dimensionless method to standardize the data, see table 3.

Table 3standardized data of evaluation function for Shaanxi Province from 2006 to 2015

Variable	2006	2007	2008	2009	2010	2011	2012	2013	Predicted in 2014	Predicted in 2015
x1	0	0.323	0.1093	0.4429	0.7126	1	0.3659	0.257	0.5726	0.603
x2	0	0.3206	0.1016	0.447	0.7151	1	0.3615	0.2497	0.5687	0.5985
x3	0	0.2089	0.2907	0.4193	0.5332	0.5779	0.6918	0.748	0.8874	1
x4	1	0.9097	0.6387	0.5908	0.4128	0.2304	0.1554	0.0949	0.0515	0
x5	0.8727	1	0.7453	0.1734	0	0.9302	0.4383	0.1851	0.1689	0.0907
x6	1	0.8009	0.5428	0.3915	0.2506	0.2268	0.1293	0.0761	0.0376	0
x7	0	0.0642	0.1284	0.1925	0.2577	0.6443	0.6138	0.5505	0.8294	1
x8	1	0.8397	0.5159	0.5141	0.2304	0.8617	0.3871	0	0.295	0.3031
x9	0.28	0.2426	0.1153	0	0.3122	0.5279	0.525	0.678	0.8228	1
x10	1	0.663	0.227	0	0.2226	0.2606	0.1529	0.1856	0.1882	0.1954
x11	0	0.1837	0.3605	0.2016	0.589	0.6386	0.6506	0.7249	0.8822	1
x12	1	0.901	0.7114	0.443	0.4614	0.2651	0.1409	0.0872	0.052	0
y1	0.92	0.92	1	0.48	0.52	0.52	0.4	0.4	0.112	0
y2	0.5849	0.1321	0.6226	0.1132	0.283	0.3019	0.3208	0.0755	0	1
y3	0.4884	0.5814	1	0	0.4651	0.8372	0.9302	0.8605	0.886	0.8791
y4	0.339	0.8305	1	0.2034	0.9153	0.6441	0.3729	0	0.078	0.1
y5	0.4286	0.3571	0	1	0.625	0.3393	0.3214	0.375	0.4839	0.5375
y6	0.7576	1	0.8939	0.8182	0.3333	0.3939	0.2576	0	0.7727	0.6515
y7	0.6981	0.9434	0.6981	1	0.9245	0.3585	0	0.2075	0.0189	0.4528
y8	1	0.8231	0.5723	0.5277	0.3615	0.2123	0.1431	0.1031	0.0246	0
y9	1	0.7456	0.5685	0.4713	0.3223	0.2349	0.1689	0.131	0.0479	0
y10	0	0.0643	0.163	0.2172	0.341	0.4925	0.6155	0.7164	0.8479	1
y11	0	0.0556	0.1422	0.1876	0.2947	0.4266	0.5317	0.6162	0.8085	1
y12	0.5536	0.8929	1	0.5	0.6786	0.5536	0.375	0.0357	0.0714	0
y13	0.5797	0.9124	1	0.5096	0.7023	0.5797	0.387	0.0368	0.1016	0
y14	0	0.074	0.1778	0.2407	0.3183	0.4446	0.5678	0.673	0.8317	1
y15	0	0.0577	0.1314	0.1766	0.2767	0.4151	0.5253	0.6362	0.8108	1

Calculating the data of Shaanxi Province after standardizing processing can get the sustainable development evaluation function and sustainable coordinated development degree, see fig.1.

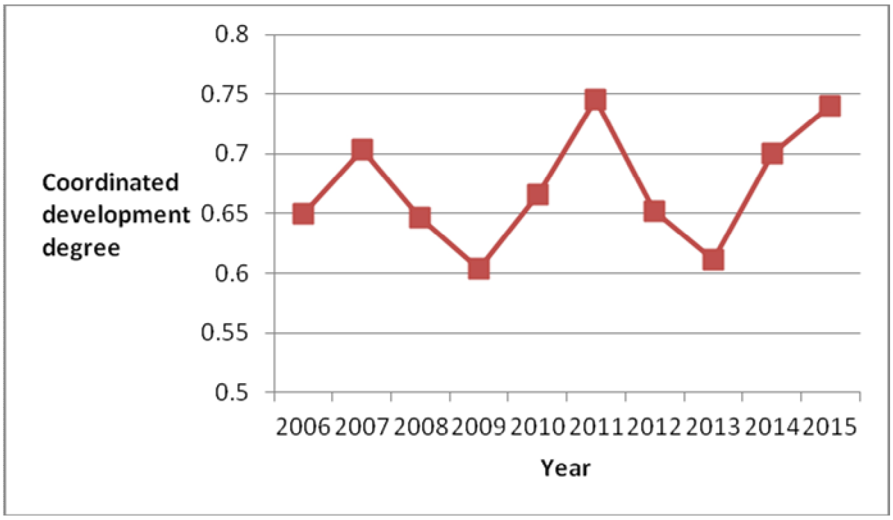

Fig.1 variation diagram for the sustainable coordinated development degree of Shaanxi Province

What we can get from Figure 1 analysis is that, the level of sustainable and coordinated development for the performance of the economy in Shaanxi is comparatively consistent; sometimes it's in a weak coordination situation, sometimes it's in a comparative coordinated situation. As a result of economic development slowdown in 2009, the economic growth quickly through macroeconomic regulation , and the coordination development level is also much increased, the economy has declined in 2013, through the optimization of economic structure from 2014 to 2015 , sustainable coordination development gradually became good and lay in a more coordinated stage, the numerical value is between [0.7-0.75], which shows that Shaanxi industrial structure also needs to be further optimized. Special attention should be paid to tertiary industry development. At the same time, increase the intensity of environmental protection, and reduce pollutant emissions with the aid of technology improvement so as to make the environment and industry to be more coordinated development.

Summary.

In this paper, we connect the two subsystems through three level evaluation indicator function model, including the environment subsystem and industrial subsystem and take the advantage of coordinated development level to estimate the sustainability of Shaanxi economic development, the result shows that Industry coordinated development level is improved after optimization, and the economic development is in a more harmonious range, which requires Shaanxi province go forward the industrial structure adjustment and optimization, meanwhile increasing the intensity of environmental management to realize the sustainable development of economy and society.

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Attached reference data (no need in the text): fig. 1 is produced by the following data.

Table 4 related data of sustainable development evaluation function for environment and industry

Year	Sustainable coordinated development degree
2006	0.6504
2007	0.7035
2008	0.6472
2009	0.6039
2010	0.6655
2011	0.7457
2012	0.6516
2013	0.6113
2014	0.7006
2015	0.7401