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Research on dynamic evaluation for sustainable development of resource-based cities with innovation element difference

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ABSTRACT

Features of innovation elements will be different on different lifecycle stages of resource-based cities, and comprehensive differences will affect sustainable development conditions. This paper constructs background evaluation indexes with technological innovation elements and institutional innovation elements, and proposes the idea for dynamic evaluation of sustainable development of resource-based cities based on differences of innovation elements. The adjusted evaluation results can effectively reduce non-comparative issue of evaluation results, improve fairness of evaluation, and provide reasonable basis for research on sustainable development of resource-based cities.

KEYWORDS

Innovation elements; Resource-based cities; Sustainable development; Dynamic evaluation; Lifecycle.

INTRODUCTION

Sustainable development system of resource-based cities is a dynamically evolving system, in which the state variable x (t) is the function of the time t, namely with time shift, the system structure, state and behavior will continuously change. It is significant for development of resource-based cities to regard development change of resource-based cities from dynamic view, reasonably assess sustainable development conditions, propose countermeasures, and adjust strategic direction in time.

Now research on sustainable development evaluation of resource-based cities mainly focuses on indexes and models. (1) Select evaluation indexes: the early sustainable development evaluation indexes include the economy welfare index, weak sustainable development index and ecology trace index[1-3]. In addition, Dijk and Zhang(2005) divide the sustainable development evaluation of cities into economy, society, environment and institution[5]. Tang Wanjin (1999) and Yao Pin (2008) have conducted systematic research on sustainable development evaluation index system of the mining area[6-7]. Most of research on the evaluation index recognizes that sustainable development of cities depends on reasonable structure and coordination role of sub-systems. (2) Applications of models: Chen Yu and Zhang Youdi (2002) have constructed measurement system and evaluation model for sustainable development elements of mining areas[8]. Xu Jun (2005) proposed the state trend evaluation model based on APH and mathematical statistics method[9]. Yin Zongchen (2007) established the evaluation model based on the rough set and information entropy[10]. Liu Xue (2012) combined cloud model, rough set and entry weight theory to establish the evaluation model[11]. Most of research is conducted by researchers in China and achievements are mainly applied to measure sustainable development conditions of resource-based cities and compare sustainable development conditions among cities or of single city on different stages.

To analyze existing research work, the basic idea of sustainable development evaluation is described as follows: based on construction of index system, compute evaluation results by weighting and averaging index values, which is scientific to some extent. However, the resource-based cities are particular and are affected by resource industry, so their development feature obvious stage feature and the development conditions of innovation elements affect sustainability development trace of cities[12]. From dynamic evolving view, based on the lifecycle feature of resource-based cities, this paper incorporates comprehensive development conditions of technological innovation elements and institutional innovation elements into dynamic evaluation system and adjusts comprehensive evaluation results via innovation evaluation value. This method considers significant influences of time factor on evaluation and important adjustment role of innovation elements in sustainable development, so it is significant for research on sustainable development evaluation system of resource-based cities.

ANALYSIS ON INNOVATION ELEMENT DIFFERENCES

The resource reserve dominates development of cities and the development history of resource-based cities is divided into construction period, maturity period and recession period (transition period) and regeneration period due to restriction of the resource industry lifecycle features. When the sustainable development conditions are assessed, if the value of sustainable development is specified, the comprehensive value of innovation elements will affect actual sustainable development conditions.

Lifecycle differences of innovation elements

The kernel elements include technological innovation element and institutional innovation element in innovation elements affecting sustainable development of resource-based cities. The characteristic performance of technological and institutional elements will relate to reasonability and optimization of the industry structure of resource-based cities and further affect general development conditions of cities (shown as the TABLE 1).

TABLE 1 : Comparison of technological and institutional element of different lifecycles

Stage	Features of technical elements	Features of institutional elements	Features of industry structure	Development conditions of cities
Construction period	Mining industry and preliminary processing technology dominated Low resource utilization rate and big loss Small overflowing degree of kernel technology	Lack of institution preparation and adjustment mechanism related to resource industry Unfair allocation of resource benefits Unsound social security	Flourishing resource industry Development of resource support industry Development blockage of other industries	High guarantee resources Continuous decreasing mining cost Stable growth of economy High institutional support strength insignificant social and environmental issues
Maturity period	Improved technology capability of resource industry Preliminary development of replacement industry technologies and environmental protection technology	Gradual establish of institutions on resource industry Adjustment of resource benefit allocation Gradual implementation of social security Gradual implementation of environmental compensation	Stable development of resource industry and significant pillar position Initial growth and slow development of non-resource industry	Gradual reduction of guaranteed resources Stable output High-speed economy growth Significant single industry feature Social and environmental issues focused
Recession period (transition period)	High technical requirements for resource industry Increased investment on R&D on substitution industry and environmental protection technology	Further perfection of institutions on resource industry Implementation of industry assistance and investment guidance Gradual improvement of social security Gradual perfection of environmental institutions	Slow-down of resource industry development and gradual transition from extensive type to intensive type Quick growth of non-resource industry	Gradual exhaustion of resources and reduction of output Growth of mining cost Low economy development Significant adjustment and control based on institutions Quick development of substitution industry Critical governance of society and pollution issues
Regeneration period	Stable improvement of R&D capability of industries Enhanced competition capability	Comprehensive planning of diversified industries Perfection of market management institution Gradual perfect of social security Stable implementation of environment protection institutions	Resource industry eliminated from pillar industries Gradual reasonable industry layout	Diversified development of industries Gradual substitution of resource industries by non-resource industries Stable economy growth Gradual institution perfection Alleviation and gradual solution of social and environmental issues

The technological innovation element is one important driver for driving resource economy growth. On the one hand, the technological innovation can drive deep resource processing and comprehensive utilization, extends the industry chain and improves the resource utilization rate. On the other hand, development of new technologies also reduces resource dependency, further promotes formation of the substitution industry, and promotes sustainable development of cities. Therefore, when the evaluation value of sustainable development is specified, a bigger comprehensive development value of technological innovation element is better. The institutional innovation element is an important adjustment driver for transformation and development strategy change of resource-based cities and plays a critical role in city development. Better institutional environment, effective resource development and cultivation of substitution industry can also fully exert potential of different economy elements, drive industry evolution, and ensure sustainable development of cities. Therefore, when the evaluation value of sustainable development is specified, a bigger comprehensive development value of the institutional innovation element is better. The technological and institutional innovation element can drive gradual reasonability of the industry structure, gradual reduction of resource dependency and gradual solution of ecology and society issues and further improve sustainable development capability of cities.

Research assumptions

Most of research on comprehensive evaluation of sustainable development of resource-based cities does not consider if the innovation element background of the evaluation cities is at same or similar development level. Resource-based cities have significant lifecycle stage features and the innovation elements are very different, so the evaluation results obtained according to the traditional comprehensive evaluation method are potentially incomparable.

This paper assumes that resource-based cities have different background information on innovation element on different development stages.

(1) Assume that $x_{ij}(t_k)$ is the value of the index $x_j(j=1,\ldots m)$ *for the assessed city* $c_i(i=1,\ldots N)$ at the time $t_k(k=1,\ldots,n)$ and reflects different influence factors of sustainable development conditions of the assessed cities;

(2) Assume that $a_l(l=1,\ldots,w)$ is the innovation sub-element and its value of the assessed city c_i at time t_k is $a_{il}(t_k)$.

Assume that the values of $x_{ij}(t_k)$ and $a_{il}(t_k)$ are standardized via index type consistence and nondimensionalization

DIFFERENCE INDEX AND COMPREHENSIVE DEVELOPMENT CONDITION OF INNOVATION ELEMENTS

Evaluation of comprehensive development conditions of innovation elements includes construction of innovation element index and selection of evaluation model.

Construction of innovation element index

(1) Technological innovation: the technology is the important drive for resource economy growth and is also the kernel force to drive growth of the substitution industry economy. The following representative indexes are selected according to the features of technological innovation, extensiveness of technological innovation element contents, data obtainability, and foundational conditions, investment conditions and output conditions of technological elements: 1) number of graduates from colleges per 10000 persons: it indicates the percent of the persons with junior college degree and higher degree in total population of a city and is used to measure talent reserve foundation of resource-based cities; 2) Percent of technological innovation talents in all employees. The scientists include the persons who directly engage technological innovation activities and persons who directly provide the service for technological innovation activities, e.g. experimental assisted persons and technology management persons; 3) Percent of new product development projects in total technology projects. It indicates the percent of R&D development of new products in total technology projects and is used to measure R&D degree of the new products such as deep resource processing products and substitution products; 4) percent of R&D fund in total GDP. R&D fund includes the labor fee, routine expense, fund paid to the trusted organization and land use and construction expense in R&D activities; 5) Contribution rate of technology advance: it indicates the contribution share of the technology advance to economy growth; 6) Percent of high-new technology output in total industry output. It is used to measure reduction degree of

resource dependency and formation conditions of substitution industry and relaying industry (shown as the TABLE 2).

TABLE 2 : Innovation element indexes

Target layer	Rule layer	Index layer	Computing equation
Resource background Comprehensive development conditions	Technological innovation elements	number of graduates from colleges per 10000 persons	Total graduates from colleges/total population (10000 persons)
		Percent of technological innovation talents in all employees	Number of technology talents /total employees
		percent of new product development projects in total technology projects	Number of new product development projects /number of technology projects
		percent of R&D fund in total GDP.	R&D fund /GDP
		Contribution rate of technology advance:	Local statistical and published number
		Percent of high-new technology output in total industry output	High-new technology output/total industry output
	Institutional innovation elements	Percent of education fund in financial outlay	Education fund / local financial outlay
		Percent of governmental investment in science and research in GDP	Science and research outlay invested by government /GDP
		Implementation strength of resource property right innovation institutions	Institution implementation class(within 1-0)
		Implementation strength of resource environment compensation innovation institution	Institution implementation class (within 1-0)
		Implementation strength of resource benefit allocation innovation institution	Institution implementation class (within 1-0)
		Implementation condition of industry layout innovation policy	Industry layout reasonability class (within 1-0)
		Implementation conditions of social security innovation policies	Implementation class of security policy (within 1-0)

(2) Institutional innovation elements: the institution is the critical factor to decide the long-term performance and ensure sustainable development and is the governmental policy and economy system to compose the economy foundation. It can provide an inspiration structure and enables people to be engaged in the economy activities. The resource economy is mainly caused due to institution lack. A perfect institution system can fully exert its guidance, restriction and support function, inspire innovation vigor, expand human capitals, induce economy elements to flow among resource industry and other industries, and promote sustainable development capability of the resource-based cities. The institutional innovation elements affecting sustainable development of resource-based cities include: 1) percent of education fund in financial outlay. Investment on education outlay is the foundation for innovative talent security and culture ambience and is one of significant indexes to affect innovation development of cities. 2) Percent of science and research fund from governments in GDP: governmental support for science and research activities can effectively drive technological innovation of the resource industries and substitution industries, drive optimization of the industry structure, and improve sustainable development capability; 3) Implementation condition of innovation institutions for sustainable development of cities: The innovation institutions for development of resource-based cities mainly include the resource property right innovation institution, resource environment compensation innovation institution, resource benefit allocation innovation institution, industry layout innovation policy and social security innovation policy. It is difficult to quantify the obtained indexes for these

institution indexes, so this paper measures these indexes via the class and classifies perfection and implementation conditions of corresponding institutions in city development via expert score. The class range is from 1 to 0. 1 indicates top perfection and implementation degree. The lower number indicates less perfection and implementation degree. Institution perfection and implementation of resource-based cities drives transformation of cities and change of city development strategy and ensures sustainable development of sub-systems such as population, resources, economy and environment (shown as the TABLE 2).

Comprehensive development value

Development conditions of the innovation elements of resource-based cities in different lifecycle are described with comprehensive development value of innovation elements. The innovation element a_l of resource-based cities continuously changes within $[t_1,t_n]$, so the comprehensive development value of innovation element should consider the time factor. This paper calculates comprehensive development value of the innovation element of assessed cities by using two weighting and averaging comprehensive sorting index method[13].

If the assessed city c_i takes the value $a_{il}(t_k)$ of the innovation sub-element a_l at time t_k, then:

$$h_{il} = \sum_{k=1}^{n} e^{\lambda_{t_k}} a_{il}(t_k),\ i=1,\ldots,N;\ l=1,\ldots,w \qquad \textbf{(1)}$$

It is the comprehensive development value of the innovation sub-element a_l within $[t_1,t_n]$ for the assessed city c_i.

In the equation (1), $\exp\{\lambda_{t_k}\}$ is the time weight function, λ is the time cashing factor, $\lambda \in (0,1)$ and can be given (e.g. Let $\lambda = (2n)^{-1}$). With the planning model (2), we can calculate:

$$\max \sum_{1}^{N} (h_{il} - \overline{h_l})^2 \quad s.t.\ 0 < \lambda \le 1 \qquad \textbf{(2)}$$

Where in $\overline{h_l} = (\frac{1}{N})\sum_{i=1}^{N} h_{il}$. The equation (2) can expand differences of the comprehensive development value $h_{1l}, h_{2l}, \ldots h_{Nl}$ of the innovation element for assessed city by using the parameter λ .

DYNAMIC EVALUATION MODEL OF SUSTAINABLE DEVELOPMENT

The basic idea of dynamic evaluation model for the sustainable development of resource-based cities is to consider differences of innovation elements. based on evaluation of comprehensive development value of the innovation element and comprehensive feature value of assessed cities, this model constructs adjustment coefficient of the evaluation value and finally calculates the adjusted comprehensive evaluation value to make final evaluation result better comply with current conditions of sustainable development.

Initial comprehensive evaluation value

Sustainable development of resource-based cities aims to realize comprehensive and harmonious development of population, resource, economy and environment, drive economy growth, and improve living quality of residents. The projection pursuit model (PP) is selected in initial evaluation of sustainable development, which can best project high-dimension data to low-dimension sub-space, get the projection direction of population sub-system, resource sub-system, economy sub-system and environmental sub-system and general comprehensive projection direction parameters of cities, and facilitate analysis on general and classified results.

First standardize data by using PP method and next construct the projection feature value Z_j of eigenvalue j.

$$Z_j = \sum_{i=1}^{m} X_{ij} \cdot a_i \quad (i=1.2,\ldots.m;j=1,2,\ldots n \tag{3}$$

Wherein, Xij is the standardized data of the index i of the sample j and a_i is the component of the projection direction vector a. To identify the comprehensive feature value Z_j, the key is to find component a_i reflecting he best projection direction of the high-dimension data feature structure, so the projection index function $Q(a)$ is constructed as follows:

$$Q(a) = s(a) \cdot d(a) \tag{4}$$

Wherein $d(a) = \sum_{j=1}^{n}\sum_{k=1}^{n}(R - r_{jk}) \cdot f(R - r_{jk})$ is the density inside a class, $s(a) = [\sum_{j=1}^{n}\left(Z_j = \overline{Z}\right)^2 / n]^{1/2}$ indicates the gap between classes, a is the projection direction, $\overline{Z}$ is the mean of comprehensive project feature value Z_j of n samples, r_{jk} is the gap between the comprehensive feature value Z_j and Z_k for the sample j and k. The range of R is $r_{\max} + m/2 \le R \le 2m$,m is the number of indexes and generally $R=m$.

When the projection index function $Q(a)$ takes the maximum in the equation (3), the corresponding direction a is the best projection direction vector,

$$\max Q(a) = s(a) \cdot d(a) = [\sum_{j=1}^{n}(Z_j - \overline{Z})^2 / n]^{1/2} \cdot \sum_{j=1}^{n}\sum_{k=1}^{n}(R - r_{jk}) \cdot f(R - r_{jk}) \tag{5}$$

Wherein $\|a\|$=1, solve $\max Q(a)$ under the constraint condition and find the best projection direction a.

Coefficient adjustment based on innovation element difference

Considering development stage features of resource-based cities, the innovation element at different times will have different influences on sustainable development conditions, so this model will adjust the initial evaluation results of the assessed resource-based cities via the comprehensive development value of the innovation elements by referring to existing research[14]. The comprehensive development value h_{il} of technological innovation element and institutional innovation element of resource-based cities has forward change relation with the comprehensive feature value Z_j of sustainable development of cities, namely when the comprehensive feature value is specified, a bigger comprehensive development of the innovation element is better.

For the comprehensive feature value Z_j of the assessed cities $c_i(i=1,\ldots N)$ and comprehensive development value of l $(l=1,\ldots,w)$ innovation element, we construct the contribution coefficient d_{il} and comprehensive contribution coefficient g_i of the innovation element for evaluation value adjustment as follows:

$$d_{il} = h_{il} / Z_j \tag{6}$$

$$g_i = \sum_{l=1}^{w} k_l d_{il} \text{ ,i=1,...N} \quad \textbf{(7)}$$

Wherein k_l is the adjustment factor, $k_l \geq 0, \sum_{l=1}^{w} k_l = 1, k_l$ can be given in advance (let k_l =1/2,*l=1,…,w*), it can also be identified via the planning model:

$$\max \frac{1}{n} \sum_{i=1}^{N} (g_i - \overline{g})^2 \quad s.t. \ k_l \geq 0, \sum_{l=1}^{w} k_l = 1 \quad \textbf{(8)}$$

Wherein $\overline{g} = 1/n \sum_{i=1}^{N} g_i$, the final evaluation value adjustment coefficient is identified as follows:

$$\delta_i = g_i / \sum_{i=1}^{N} g_i \text{ ,i=1,...N} \quad \textbf{(9)}$$

Final comprehensive evaluation value

For the assessed resource-based cities $c_i(i=1,\ldots N)$, the final evaluation value p_i based on the innovation element difference is defined as follows:

$$p_i = \alpha_1 Z_j + \alpha_2 Z_j \delta_i \text{ ,i=1,...N;j=1,2,...n} \quad \textbf{(10)}$$

Wherein α_1 and α_2 are the preference coefficient of the evaluation value and its adjustment value. $\alpha_1, \alpha_2 \in (0,1)$ and $\alpha_1 + \alpha_2 = 1$. It can be given in advance or be computed via the model (8).

Based on the above model, the dynamic evaluation of the resource-based cities based on innovation elements is performed as follows:

Step 1 : calculate the comprehensive development value of the innovation sub-element a_l within $[t_1,t_n]$ for the assessed city c_i according to the model (1);

Step 2 : calculate the comprehensive feature value Z_j of the assessed city c_i according to the model (3);

Step 3 : calculate the evaluation value adjustment coefficient of the assessed city c_i according to the model (6), (7) and (9);

Step 4 : calculate the final evaluation value of the assessed city c_i based on the innovation element differences according to the model (10).

CONCLUSIONS

The sustainable development system of resource-based cities is a complex system involving population, resource, economy and environment. Different sub-systems coordinate with and restrict each other. For fair and scientific evaluation of sustainable development conditions, based on the existing research on sustainable development evaluation, the innovation element differences of the assessed cities at different times should be considered to reduce potential incomparability of evaluation results and provide more reasonable data support for sustainable development strategies of cities.

(1) The selected innovation element indexes include technological innovation and institutional innovation indexes, which is the kernel force to drive industry transformation of resource-based cities and realize sustainable development. The technological innovation element indexes are selected from the foundational conditions, investment conditions and output conditions and the data can be easily

obtained. The institutional innovation elements are highly subjective and have significant influences on the results, so they should be selected by experts. The experts should fully know and understand implementation and perfection degree of the institutions for objective determination. The indexes can be quantified with other models and methods, which can be further discussed. The comprehensive evaluation model of innovation elements mainly considers the time factor. With the time cashing factor, the differences of the comprehensive development values of innovation elements of assessed cities can be expanded to ensure objectivity of evaluation results.

(2) The resource city system is a dynamic evolving system and depends on the resource industry, so it has significant city stage features. Cities are on different development phases, so they have innovation element difference. Generally the existing research on sustainable development evaluation assumes that the assessed cities are at same or similar development level and ignores influences of the innovation element difference on the sustainable development evaluation results. Based on the comprehensive development value of the innovation elements, the initial evaluation value of sustainable development of resource-based cities are adjusted to some extent to reduce incomparability of evaluation results and ensure objectivity and fairness of evaluation. The innovation elements can be adjusted to weaken false short-term flourishing development with higher values of economy and social indexes in evaluation to some extent, make evaluation results more fair and reasonable, and provide effective policies and recommendations for sustainable development of cities.

REFERENCES

[1] H.E.Daly, J.J.Cobb; For the Common Good: Redirecting the Economy Toward Community, the Environment and a Sustainable Future. Boston: Beacon Press **(1989)**.

[2] D.W.Pearce, G.D.Atkinson; Capital theory and the measurement of sustainable development: an index of ‘weak’ sustainability. *Ecol. Econ*., **8**, 103–108 **(1993)**.

[3] M.Wackernagel, W.E.Rees; *Our Ecological Footprint: Reducing Human Impact on the Earth*. Gabriola Island, BC and Philadelphia, PA: New Society Publishers **(1995)**.

[4] G.Haughton; Development sustainable urban development models, *Cities*, **14**, 189-195 **(1997)**.

[5] M.P.Dijk Van, M.Zhang; Sustainability indices as a tool for urban managers, evidence from four medium-sized Chinese cities, *Environmental Impact Evaluation Review*, **25**, 667-688 **(2005)**.

[6] Tang Wanjin, Gao Lin, Li Xiangyi; Research on Sustainable Development Index System and Evaluation Method in Mining Area, System Engineering Theory and Practics, **12**, 114-119 **(1999)**.

[7] Yao Ping; Measurement and Evaluation of Harmonious Development of Population, Resource and Environment System of Coal Cities. Planning and Management, **5**, 160-165 **(2008)**.

[8] Chen Yuhe, Zhang Youdi; Research on Objective Foundation on Selection of Sustainable Development Pattern for Mining Areas in China. Journal of China Mining University, **31(2)**, 151-157 **(2002)**.

[9] Xu Jun, Zeng Qi; Comprehensive Evaluation Model for Sustainable Development in Mining Area. System Engineering Theory and Practics, **25(1)**, 56-60 **(2005)**.

[10] Yin Zongchen, Ding Rijia, Zhao Zhenbao; Comprehensive Evaluation of Development Level of Coal Resource-based cities Based on Rough Set Theory, Coal Journal, **32(10)**, 1112-1116 **(2007)**.

[11] Liu Xue, Dong Chunyou, Cao Zhiguo, Yang Xiali; Evaluation Model for Sustainable Development of Coal Cities Based on Uncertainty Theory. China Coal Industry, **21(4)**, 37-40 **(2012)**.

[12] Liu Dan, Lu Yongheng; Research on Three-Dimensional System for Industry Transformation of Coal Cities---Collaborative Driving View Based on Technological innovation and Institutional innovation. Technology Advance and Countermeasure, **23**, 87-90 **(2011)**.

[13] Guo Yajun; Theory, Method and Aplication For Comprehensive Evaluation. Beijing: Science Press, **(2007)**.

[14] Guo Shanrui, Li Weiwei, Guo Yajun; Dynamic Comprehensive Evaluation Method for Resource Background Differences. Journal of Northeastern University (Natural Science Version), **2**, 296-299 **(2012)**.