

Research on Evacuation and Warning Model of Circular Economy

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Abstract. Circular economy is destined to be the choice for keeping on developing as an advanced development mode for harmonizing the problems among resource, environment and economy. How to choose the evaluation index system and correctly evaluation the development trace of circular economy is treated as a decision problem. In this paper, a hybrid warning model using matter-element model, combination weight method and place value method for evaluating the development trace of circular economy is proposed. Finally a case study demonstrates the application of the proposed model.

Keywords: Circular economy; Evaluation and warning model; Combination weight; Place value method

1 Introduction

Circular economy focuses on resource productivity and eco-efficiency improvement in a comprehensive way [1]. It is a new concept of sustainable development model of economic development with the objective of making the most effective use of resources and protecting the environment. However, a series of barriers to the implementation of circular economy was existed [2]. Joseph Sarkis focused on the developing circular economy policy and provided the framework about circular economy [3]. Qian Liu created a new understanding of public awareness and performance in the promotion of circular economy to increase positive attitude towards circular economy [4]. Jiuping Xu constructed a multi-objective programming model using the theory of SD for analyzing the risk of circular economy [5]. Liu Hai Tao determined the evaluation index system and established the fuzzy model to evaluate the production effect of the circular economy in coal enterprise [6]. Shao-lun Zeng applied the DEA and benchmarking procedure model to ranking the circular economy efficiency in electric power industry [7]. Hongzhe Sun applied a new algorithm in fuzzy evaluation on the circular economy [8].

This paper chooses the statistical index thinking about the effect of regional difference and characteristics, constructs the comprehensive evaluation and warning model for monitoring the development state of circular economy.

2. Establishment on warning model of circular economy

2.1 Matter-element model on statistics measure and index choice of circular economy

2.1.1. Confirmation of matter-element to be evaluated. It makes evaluation on characteristics value of unit N_i of target level and gets structure of matter-element to be evaluated. It is indicated as follows:

$$R_i = (N_i, C_i, V_i) = \begin{bmatrix} N_i & , & c_1 & , & v_{i1} \\ & & c_2 & , & v_{i2} \\ & & \dots & & \dots \\ & & c_n & , & v_{in} \end{bmatrix}$$

N_i is the index to be evaluated of target level on evaluation index system of circular economy, v_i is value of detailed evaluation of index c_i .

2.1.2. Correlation function. The matter-element correlation function use by this paper is as follows:

$$R_i = f(c_i, v_i) = \frac{f_{v_i}}{\frac{\sum_{i=1}^n v_i \cdot f_{v_i}}{\sum_{i=1}^n f_{v_i}}}, \quad i = 1, 2, \dots, n$$

$R_i = f(c_i, v_i)$ is matter-element correlation function, f_{v_i} is the appearance time of index c_i , $\sum_{i=1}^n v_i \cdot f_{v_i}$ is the total of statistics frequency of index, $\sum_{i=1}^n f_{v_i}$ is total of evaluation index of evaluation set N_i .

If $R_i > 1$, then keep this index. If $R_i < 1$, then delete this index.

2.2 Standard procession of data

$$X_{ij} = \begin{cases} X_{ij} = \frac{a_{ij} - \min a_{ij}}{\max a_{ij} - \min a_{ij}}, & a_{ij} \text{ as positive indicators} \\ X_{ij} = \frac{\max a_{ij} - a_{ij}}{\max a_{ij} - \min a_{ij}}, & a_{ij} \text{ as negative indicators} \end{cases}$$

a_{ij} ---original data of index, X_{ij} ---data of index after standardization.

2.3 Determination of combination weight

$$w_j = \frac{w_j^1 \cdot w_j^2}{\sum_{j=1}^n w_j^1 \cdot w_j^2}$$

w_j is combination weight, w_j^1 is weight obtained by deviation weight method, w_j^2 is weight from AHP.

2.4 Comprehensive evaluation on circular economy

The data normalization using place value method is as follows:

$$v_{ij} = \begin{cases} 0.01 + 0.99 \times \frac{a_{ij} - \min a_{ij}}{\max a_{ij} - \min a_{ij}}, & a_{ij} \in v_{ij}^+ \text{ positive index} \\ 0.01 + 0.99 \times \frac{\max a_{ij} - a_{ij}}{\max a_{ij} - \min a_{ij}}, & a_{ij} \in v_{ij}^- \text{ negative index} \end{cases}$$

Comprehensive value of circular economy calculated by using contribution method and linear weight is as follows:

$$f_j = \sum_{j=1}^n w_j v_{ij}, i = 1, 2, \dots, m, j = 1, 2, \dots, n$$

f_j is comprehensive value of certain subsystem evaluation, v_{ij} is the target fractile of index, w_j is the index weight calculated by combination weight method.

$$f = \sum_{j=1}^n f_{ij} \cdot w_j, i = 1, 2, \dots, m$$

f is the value on comprehensive evaluation of circular economy, f_{ij} is the comprehensive value of subsystem evaluation, w_j is subsystem weight calculated by combination weight method.

2.5 Warning measure on development trend of circular economy

The paper divides development state warning of circular economy into five kinds such as huge warning, serious warning, medium warning, light warning and no warning [9-10]. The warning division is illustrated in the following Table 1.

Table 1. Warning of Circular Economy

| f | 0-0.2 | 0.2-0.4 | 0.4-0.5 | 0.5-0.8 | 0.8-1.0 |
|----------------|--------------|-----------------|----------------|---------------|------------|
| Warning degree | Huge warning | Serious warning | Medium warning | Light warning | No warning |

3 Numerical Analysis

This paper divides the statistical index system of circular economy into five parts subsystem: subsystem of resources consumption, subsystem of economic development, subsystem of environment pollution, subsystem of environmental protection, subsystem of resources reuse. And the weight of index calculated by combined weight method is shown in Figure 1.

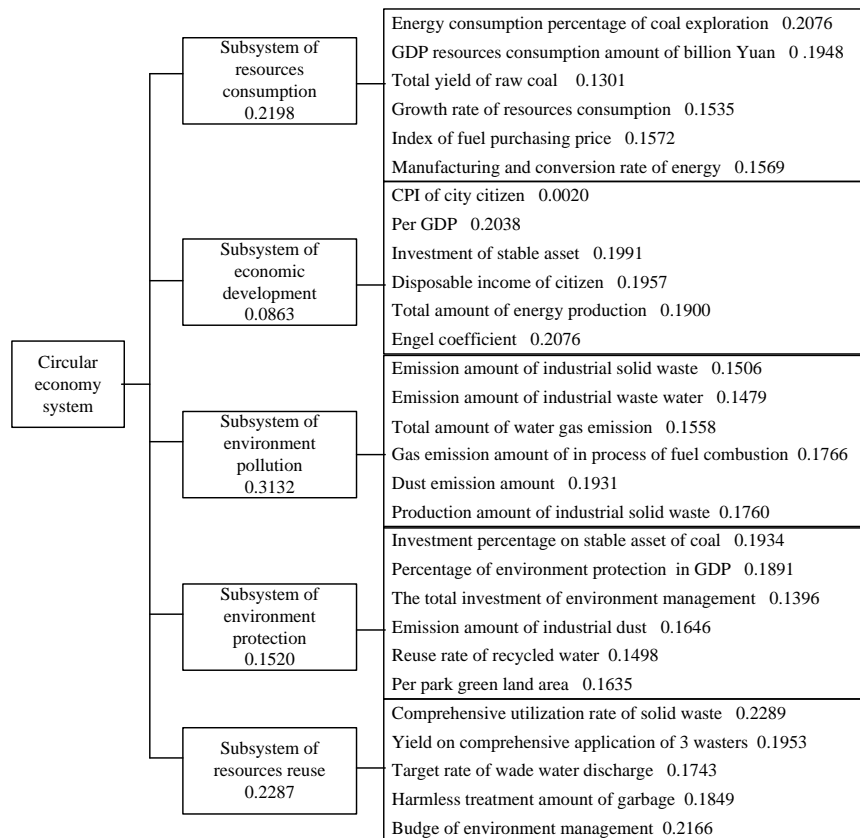


Fig. 1 Index system of circular economy

Table 2 is the warning on circular economy from 2004 to 2013 in Liaoning calculated by place value method and liner weight method and Figure 2 is the warning degree curve.

Table 2. Warning on circular economy from 2004 to 2013 in Liaoning

| Year | 2004 | 2005 | 2006 | 2007 | 2008 |
|----------------|--------|--------|--------|--------|--------|
| Warning degree | 0.4924 | 0.4742 | 0.4361 | 0.3352 | 0.3960 |
| Year | 2009 | 2010 | 2011 | 2012 | 2013 |
| Warning degree | 0.4687 | 0.5514 | 0.5779 | 0.4796 | 0.6606 |

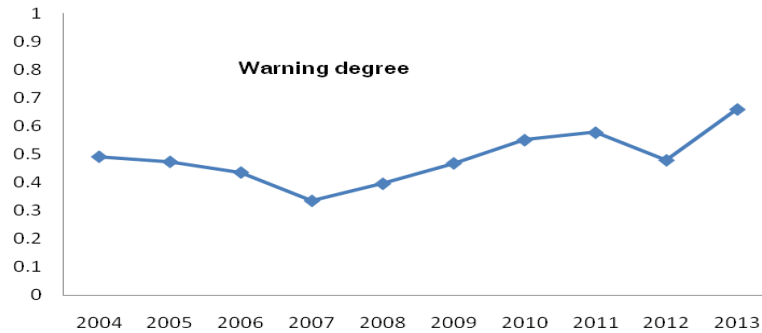


Fig. 2 Warning degree curve on circular economy from 2004 to 2013 in Liaoning

The overall development trend of circular economy in Liaoning is stable. From 2007 to 2009, the trend is serious warning, it is because the traditional economy was transforming to circular economy at this periods, two kinds of development models lack of effective connection and couples with imperfection in policy and regulation as well as insufficient strength of propaganda on circular economy idea. The warning on circular economy after 2009 was reduced and circular economy gradually was normal. The reason is that circular economy was greatly implemented in the whole province; meanwhile government strengthened monitoring on circular economy and promoted circular economy as strategic planning. The established warning model of circular economy by this paper is accord with real conditions and the choice method of statistical index is reasonable. The establishment on warning model is scientific and calculation method is reliable.

4 Conclusion

This paper designed the statistical index system according with real conditions and characteristics in Liaoning and established comprehensive warning model of circular economy through combination weight method and place value method. The numerical analysis result indicated that the development trance of circular economy in Liaoning from 2004 to 2013 was in the state of light warning and each subsystem of circular economy was in good operation, but stability of environment pollution subsystem was worse. On one hand, law system of circular economy should be improved. On the other hand, venous industry of circular economy should be greatly developed to reduce the effect of economic development on environment.

References

1. Zhang Guirong, Li Gengke, Zhao Zongjian, Mu Yuxin. Green transport management of logistics enterprises based on circular economy. International Conference on Information Management, Innovation Management and Industrial Engineering - ICIII (2010), November 26-28. Kunming, China. pp. 583-585.

2. Geng Y, Doberstein B. Developing the circular economy in China: Challenges and opportunities for achieving leapfrog development. *International Journal of Sustainable Development and World Ecology*.3,15 (2008),pp.231.
3. Joseph Sarkis, Hanmin Zhu. Information technology and systems in China's circular economy : Implications for sustainability. *Journal of Systems and Information Technology*.3,10(2008) pp. 202-217.
4. Qian Liu, Hui-ming Li, Xiao-li Zuo, Fei-fei Zhang, Lei Wang. A survey and analysis on public awareness and performance for promoting circular economy in China: A case study from Tianjin. *Journal of Cleaner Production* .2,17(2009), 265-270.
5. Jiuping Xu, Xiaofei Li, Desheng Dash Wu. Optimizing circular economy planning and risk analysis using system dynamics. *Human and Ecological Risk Assessment*.2,15(2009),pp. 316-331.
6. Liu Hai Tao, Hao Chuan Bo, Peng Yun Yan, Wang Xiao Ning . The fuzzy comprehensive evaluation based on the production mode effect of the circular economy in coal enterprise. *International Conference on Computational Intelligence and Software Engineering - CiSE*,(2010).December 10-12.Wuhan,China.pp.1-4.
7. Shao-lun Zeng, He-lan Zhang.Promoting low-carbon development of electric power industry in China: A circular economy efficiency perspective. *Energy Procedia*. 5(2011),pp. 2540-2548.
8. Hongzhe Sun. Fuzzy evaluation on circular economy development of coal mining based on improved Algorithm. *International Conference on E-Learning, E-Business, Enterprise Information Systems, and E-Government - EEEE*,(2009).December 5-6.Hong Kong,China.pp.192-195.
9. Zeng Yanfang, He Qingguang. Study on warning system of circular economy in Guangxi. *Contemporary Economy*.15(2013),pp.92-94.
10. Li Yuxin, Ren Feng. Study on difference warning on South and North of Xinjiang. *Resources and environment in Drought Area*. 8(2012), pp. 1-7.