

The Research on the Coordinated Development Evolution of Technology Innovation in New Energy High-tech Industry

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Abstract

Based on improving the Entropy Evaluation Method and Er'xiang Dual Theory, this paper firstly divides new energy high-tech industry system into two subsystems: one is status subsystem, based on the representation of innovation ability and another is process subsystem, based on the measurement of innovation efficiency, then makes a further statement on Er'xiang characteristics of new energy high-tech industry according to the subsystems. Finally, this paper carries out a demonstration measurement through the development level of Er'xiang subsystem, the comprehensive development level of whole system, and the coordinated development level of these two subsystems, of the new energy resources systems in Heilongjiang Province of China from 2005 to 2012. The final evidence shows that the comprehensive developments of new energy high-tech industry system and its Er'xiang subsystems of Heilongjiang Province are on an overall fluctuated climbing condition and the degree of coordinated developments of Er'xiang subsystems is also on an overall rising condition.

Keywords: *New energy high-tech industry; technology innovation system; coordinated development; Er'xiang Dual Theory*

1. Introduction

The economy development of China is facing serious restrains of resources and energy, especially the restrain of fossil energy control, which has brought about a series of energy safety and ecological and environmental problems. So striving to develop the new energy high-tech industry combined with the modern cutting-edge technology, the key step on breaking through the energy restrains during the economy development process of China, which will gradually make the industry become the most active industry on technology innovation of knowledge-based economy activities, will make a real difference on national industrial structure optimization and the transformation of economic development mode. Innovation is an essential for new energy high-tech industry development. However, the industry innovation is not a simple achievement of one single innovation element. Taking the innovated system, composed by various kinds of correlative innovation elements, as platform and condition are more important. As a dynamic system, the new energy resource system embraces two characteristics on describing the “status” of static state and the “process” of dynamic state. “Status” refers to the innovation ability of industry innovation system; “process” refers to innovation efficiency. The coordinated condition of “status” and “process” will embody the evolution state of new energy high-tech industry, and will make a real difference on the stability and optimization of the whole system.

Therefore, based on improving the entropy evaluation method and Er'xiang dual theory, this paper has integrated the “status” of static state, which takes the innovation ability of new resource and high-tech industry as representation, with the dynamic

“process”, which takes innovation efficiency as measurement tools, and sets the new energy high-tech industry system’s development of Heilongjiang province as an example to estimate the development trend of new energy high-tech industry in China.

2. Basic Concept

2.1. Er’xiang Dual Theory

Suppose following 5 characteristics and 2 parts constitute system S , and make a statement according the 2 parts, then we can call systems as Er’xiang system, write down as $S=(X, X^*)$. 1. X is a real Xiang, (X) is a virtual Xiang, and they have a mutual compatibility; 2. There is an essential difference between (X) and (X^*) on spatial dimension, and they will not appear in a coordinate system at the same time; 3. There is no one-to-one correspondence relationship between (X) and (X^*) , and all the $x^* \in X^*$ belong to the overall mapping of X ; 4. There is a internal check between (X) and (X^*) ; 5. There is proportional relation between (X) and (X^*) , and proportional values are in a certain reasonable range[1]. Besides, (X) and (X^*) have a dual relation in a system, which is a system inherent operation mechanism, and they are only a static structure of system [2].

The input indexes of new energy resources and high-tech technology industry system include six indexes: R&D staff (X1), the R&D staff proportion of the industry’s whole personnel(X2), the R&D annual input expenditure(X3), technology improvement expenditure(X4), technology introducing expenditure(X5), assimilating cost (X6); The output indexes of new energy resources and high-tech technology industry system include six indexes: the number of invention patents owned by the industry (Y7), the total number of patent application(Y8), the product annual added rate of the industry(Y9), the new product annual output(Y10), product annual sales profits(Y11) and the sales profits of new products.

2.2. Data Collection

All of the relevant data of this paper are selected from *China Statistic Yearbook* (from 2005 to 2013), *China High-tech Technology Industry Statistic Yearbook* (from 2005 to 2013) and *China High-tech Technology Industry Development Statistic Yearbook*(from 2015 to 2013). Besides, this paper also selected time series data (from 2005 to 2012) from the above papers.

3. New Energy High-tech Technology Innovation System Coordinated Development Demonstration Measure

3.1. The Definition of Index Balance

This paper determines the index balance according to the entropy evaluation method improvement. The steps for determining index balance by entropy evaluation method are as follows[9]:

Firstly, convert the original index to integrated index, the formula is as follows:

$$x'_{ij} = \frac{x_{ij} - x_j}{\sigma_j} \quad (1)$$

In the above formula, x'_{ij} is a number after quantification without link. x_{ij} is the original data of index j for the evaluation object i, x_j is the mean value of evaluation index j, and σ_j is the standard deviation of index j.

Besides, in order to eliminate the influence of minus after quantification without link, the formula makes a following translation,

$$x''_{ij} = x'_{ij} + D \quad (2)$$

In the formula (2), x''_{ij} is the index after translation, D is the range of translation.

And then, work out the proportion of each index q_{ij} according to x''_{ij}

$$q_{ij} = \frac{x''_{ij}}{\sum_{i=1}^m x''_{ij}} \quad (3)$$

Finally, figure out the entropy e_j of index j according q_{ij}

$$e_j = -\frac{1}{\ln m} \sum_{i=1}^m q_{ij} \quad (4)$$

Therefore, we can get the index balance w_j of index j

$$w_j = \frac{1 - e_j}{\sum_{j=1}^n (1 - e_j)} \quad (5)$$

According to formula (1)~(5), we can finally get the index balance of each index, as table 1 shows:

Table 1. Index Balance

Input Index	Index Balance	Output Index	Index Balance
X1	0.081	Y7	0.083
X2	0.086	Y8	0.083
X3	0.084	Y9	0.084
X4	0.083	Y10	0.086
X5	0.079	Y11	0.090
X6	0.082	Y12	0.080

3.2. The Measure for New Energy High-tech Technology Innovation System's Coordinated Development Level

Owing to order magnitude varies from index to index, we standardize all the original data first, and provide the following formula for data standardization with consideration to all the indexes in this research are efficiency index[2].

$$X_{ij}^* = 0.1 + 0.9 \times \frac{X_{ij} - X_{j\min}}{X_{j\max} - X_{j\min}} \quad (6)$$

3.2.1. The Development Level of Status Subsystem: We obtained the 12 index balances by the entropy improving method, and do a weighting summation of the index for new energy resources and high-tech technology innovation system development level of Heilongqiang province from 2005 to 2012, then work out the development of subsystem

$$L(S_1) = \sum_{i=1}^{12} W_i X_{ij}^* \quad (7)$$

3.2.2. The Development Level of Process Subsystem: The process subsystem of new energy resources and high-tech technology innovation system can be obtained from the ratio between input index and output index. We can work out the development level of process subsystem from the following formula (formula 7)

$$L(S_2) = \sum_{i=7}^{12} W_i X_{ij}^* / \sum_{i=1}^6 W_i X_{ij}^* \quad (8)$$

3.2.3. System Comprehensive Development Level: New energy resources and high-tech technology innovation system's comprehensive development level includes development process and development status. So , in order to avoid the influence of Er'xiang subsystem's image on dispersion, we use formula(6) to standardize $L(S_1)$ and $L(S_2)$, which counted as $L'(S_1)$ and $L'(S_2)$ after standardization, and then figure out new energy resources and high-tech technology innovation system's comprehensive development level, as formula (8) shows.

$$L(S) = [L'(S_1) + L'(S_2)] / 2 \quad (9)$$

3.2.4. The Measure of System Coordinated Development: The system coordinated development level shows the coordination level between Er'xiang process subsystems of new energy resources and high-tech technology innovation system, and shows the new energy resources and high-tech technology innovation system has a trend to change from disorder to well-organized. In this research, the Er'xiang process subsystem's coordinated level between S_1 and S_2 which can be manifested as VC according to the relative dispersion of $L'(S_1)$ and $L'(S_2)$, then we can get the formula of VC, as formula (9) shows.

$$VC = 2 \frac{|L'(S_1) - L'(S_2)|}{[L'(S_1) + L'(S_2)]} = 2 \sqrt{1 - \frac{L'(S_1)L'(S_2)}{\left[\frac{L'(S_1) + L'(S_2)}{2}\right]^2}} \quad (10)$$

Because of the relative deviation is smaller, the coordination degree of the system is better, the VC will be smaller, and the coordinated level between S_1 and S_2 will be

higher. Besides, owing to $L'(S_1) > 0$, $L'(S_2) > 0$, the necessary and sufficient conditions for minimum value of VC is as follows :

$$\frac{L'(S_1)L'(S_2)}{\left[\frac{L'(S_1)+L'(S_2)}{2}\right]^2} \rightarrow Max$$

So, we can define the coordination degree between S_1 , S_2 , the Er'xiang subsystem of new energy resources and high-tech technology innovation system, is :

$$VC = \left\{ L'(S_1)L'(S_2) / \left[\frac{L'(S_1)+L'(S_2)}{2} \right]^2 \right\}^k \quad (11)$$

In the formula (10), K is distinguishing coefficient, and $k \geq 1$, so, it comes out that $0 \leq VC \leq 1$.

It can figure out the coordination degree of new energy resources and high-tech technology innovation system in Heilongjiang province through formula (6) to formula (10), as graph 2 shows:

Table 2. The Coordination Degree of New Energy Resources and High-tech Technology Innovation System in Heilongjiang Province

	Status subsystem	Process subsystem	Comprehensive development level	Coordination degree
2005	0.559	0.979	0.653	0.603
2006	0.164	0.525	0.100	0.100
2007	0.208	1.626	0.591	0.309
2008	0.288	1.421	0.582	0.474
2009	0.503	0.744	0.505	0.404
2010	0.437	1.017	0.555	0.550
2011	0.624	1.150	0.784	0.746
2012	0.647	1.450	0.928	0.922

Through the result of table 2, it can conclude that:

From the prospect of status subsystem's development level, we can learn that there is low point in the development of new energy high-tech technology in Heilongjiang province in 2006. But with China's accession to WTO and the future effort in reform and opening up, there are more and more advanced technology introduced from abroad and R&D investment, so it comes out a stable increase period in new energy resources and high-tech technology in Heilongjiang province from 2007 to 2012. What's more, restrained by the traditional factor's influence during the transformation process of energy equipment manufacturing industry in Heilongjiang province, the regional industry's massive structure and geographical location factors, it turns out that the overall development level of new energy resources and high-tech technology in Heilongjiang province is relatively slow.

From the prospect of process subsystem's development level and the comprehensive development level of the whole system, we can learn that the innovation efficiency of new energy resources and high-tech technology industry had gone through a big fluctuation, reflected as two lows and highs in general. From 2005 to 2006, the innovation efficiency of new energy resources and high-tech technology industry of the province was in a

decline phase. However, with the implementation of industry improvement policies for new energy resources and high-tech technology industry, there was another improvement of innovation efficiency accomplished with a short-term rapid growth in 2007. From 2008-2009, the industry was in the second low point, which arose from the impact of global economic crisis on industry development in northeast China region. After 2009, the development of new energy resources and high-tech technology industry gradually began to recover, and climbed fast for years, which reflected that the implement of series policies from central and local government, for supporting the industry has brought a good result. Driven by the development of subsystem, the evolution trend of new energy resources and high-tech technology comprehensive development level is similar to development law of the process subsystem. At the same time, because the influence of status subsystem, the low point and high point of innovation system's comprehensive development level is gentler.

From the point of Er'xiang 's coordinated development level, the coordination degree was in a low point in 2006, which was mainly caused by the simultaneous abnormal performance of status and process subsystem ,and the development of Er'xiang's subsystems were also in a low level in 2006. With the carrying out of incentive policies by the government, after 2007, the situation of Er'xiang systems' coordination started to become better and better. During the period from 2007 to 2012, the Er'xiang's coordinated development was in a overall fast growing state. At the meantime, it's inevitable to appear a deviated time sequence of some exceptional years, such as the light imbalanced recession of Er'xiang's coordinated development of 2009, and the main reason is the inconsistent development of process and status systems. So the coordinated development of regional new energy resources and high-tech technology should have a harmonious coordination to avoid shortness of some subsystems.

4. Conclusion

Based on the improved entropy method and Er'xiang dual theory and from the new energy resources and high-tech technology developing evolution point of time series, this paper divided new energy resources and high-tech technology innovation system into status and process subsystems, and made the system become the Er'xiang dynamic system filled with time meaning. Then, this paper carried out a demonstration measurement through the development level of Er'xiang's subsystems, the system's comprehensive development level and Er'xiang's coordinated development level. The final results show that the status subsystem of new energy resources and high-tech technology innovation system keeps a stable and slow growth after the low point in 2006; the process subsystem has big fluctuations, two high points and two low points, and its evolving curve likes "S"; the whole system also had two fluctuations, but because of the buffering influence of status subsystem, the fluctuations are more gentler. The low point of Er'xiang coordinated development also appeared in 2006, but in the following few years, subsystems gradually started to recover and keep an overall rising trend.

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References

- [1] G. Longchang and X. Fei, "First exploration on systematics' Er'xiang theory: A theory framework", *System Engineering Theory and Practice*, vol. 5 (2007), pp. 95-96
- [2] G. Longchang and L. Wei, "The first exploration on management of Er'xiang dual theory", *Management Journal*, vol. 6, no. 6, (2009), pp. 718-721

- [3] C. Wei, F. Zhijun, K. Xing, T. Shihai, "The research on the measurement and evaluation of regional innovation system's coordination development—Based on the view of Er'xiang dual theory", *Science of sciences research*, vol. 1-2, no. 14, (2005), pp. 63-82.
- [4] S. Yunfei and T. Jinsong, "The formation mechanism of regional technology innovation ability", *Management science journal*, vol. 2, (2006), pp. 36-39.
- [5] H. Lucheng and Z. Caihong, "The research on the technology innovation coordination and manufacturing industry competitiveness in Beijing", *Scientific Research Management*, vol. 28, (2007), pp. 14-19
- [6] X. Qiang, "The development research and evaluation of knowledge-intensive industry", *Fudan University*, (2007), pp. 45-47
- [7] J.C. Guan and K. Chen, "Measuring the innovation production process: a cross-region empirical study of China's high-tech innovations", *Technovation*, vol. 30, (2010).
- [8] H. Jing, "The research on the innovation efficiency of China high-tech technology industry - Based on the empirical analysis of SFA", vol. 5, no. 31, (2014), pp. 348-358
- [9] M. Fansheng and L. Meiyong, "The research on evaluation of China energy consumption influence factor –Based on the research of Mutation series method and entropy improving method", *Systems Engineering*, vol. 8, no. 30, (2012), pp. 79-89.

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