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Research on the Evaluation of the New Energy Auto Industry Innovation System

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Abstract
The evaluation of the new energy automotive industry innovation system is due to improve the comprehensive evaluation of system operation ability. It helps the new energy automotive industry to know, grasp and analyze the regular of innovative activities. It is an important tool to systematize, scientificly demonstrate and analyze the implementation of the industry innovation of various system components.

Key words: New energy automotive; Industry innovation system; System evaluation

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New energy automotive industry refers to the enterprise sets that product the new energy vehicles (including Hybrid Car, Electric Vehicle, Fuel Cell Electric Vehicles and Hydrogen Vehicle, and other new energy vehicles). The basic connotation of the new energy automotive industry innovation system can be interpreted as: on the basis of enterprises innovation, developing with the direction of low carbon, taking new energy automotive market demand as motive force, regarding new energy manufacturing enterprise, university, scientific research institution, governments at all levels as main parts of innovation system; Each part respectively realize technological innovation by means of interaction of the system structure and environment. These innovations include organizational innovation, management innovation, and policy system innovation. Thus the whole the new energy automotive industry innovation can be realized; by the fusion between self-operation of the new energy automotive industry innovation and low-carbon economy development environment, the competitiveness of organic system for new energy automotive industry can be promoted.

1. THE CONSTRUCTION OF EVALUATION INDEX OF NEW ENERGY AUTOMOTIVE INDUSTRY INNOVATION SYSTEM

1.1 The Design Principle of Evaluation Index System
The first step of evaluation of new energy automotive industry innovation system is selecting evaluation index. We should take into consideration system characteristics when selecting index system of new energy industry innovation. The index system can comprehensively reflect operation ability of the innovation system. Index selection would abide by the following principles: 1)the scientific principles. 2) comprehensive and systematic principles. 3) comparability principles. 4) practical and operational principles. 5) goal-oriented principles.

1.2 The Evaluative Index System of New Energy Automotive Industry
According to the general rules, features, the important aspects and the key link of the new energy automotive industry innovative activities, as well as component elements and interactions of new energy automotive industry innovation system, this paper raises the evaluative index of the new energy automotive innovation system which mainly consists of five primary indexes and 30 secondary indexes. As shown in table 1.

Among them, the five primary indexes include industry policy environment, industry supply and demand market

level, industry participants level, industry intermediary agency level, knowledge and technology level in industry. Specific content as follows:

1.2.1 Industry Policy Environment

Industry policy environment is the condition of policy environment in the process of operation. It mainly evaluates operation situation of industry innovative system through the government's support and strength of implementation. It includes seven secondary indexes: subsidies and its implementation, the intensity of carbon emission's regulation and its implementation, the investment's policy of industry R&D, the rule of R&D standard and its implementation, government procurement's policies and its implementation, government revenue, the factors of the government's policies.

1.2.2 Industry Supply and Demand Market Level

The operation's ability of industry innovation system depends on status market demand. The operation of innovation system will be smooth and more quickly to improve industry competitiveness if there is a big market demand. So this paper selected four secondary indexes: auto possession, consumer purchasing power, the proportion of private car, purchases of government policy.

1.2.3 Industry Intermediary Agency Level

Due to its high-input and high-risk characteristics, intermediary agencies become a part of the new energy automotive industry innovation system for their survival. Intermediary agencies level in development and service information will impact the ability of operation to new energy automotive industry innovation system. Including four secondary indexes: the automobile consumption credit, bank credit capacity, agency service factors, the number of bank assistant agency.

1.2.4 Industry Participants Level

It evaluates the ability of the innovation and operation through the participants 'level in the industry innovation system. So we choose the seven indexes, which include the enterprise number of new energy vehicles, the number of industrial colleges and universities, the number of industry R & D personnel, the number of industry research institutions, the number of research projects, industry output value of new products, industry enterprise profits.

1.2.5 Knowledge and Technology Level

The core of new energy automotive industry innovation system is innovation of knowledge and technology, so its level is the key role to the industry innovation system of ability of the operation. This paper selected eight secondary indexes: the number of graduates, industry R & D expenditure, industrial R & D staff, the number of possess in patents, the number of applications for patents, the number of industrial technology papers, the amount of technical market transactions, the quantity of knowledge achievements.

Table 1
The Evaluation Indexes System of the New Energy Auto Industry Innovation System

Destination Layer	Primary Index	Secondary Index
The evaluation indexes system of the new energy auto industry innovation system	industry policy environment $\mathbf{u_1}$	subsidies and its implementation $\mathbf{u_{11}}$ the intensity of carbon emission's regulation and its implementation $\mathbf{u_{12}}$ the investment's policy of industry R&D $\mathbf{u_{13}}$ the rule of R&D standard and its implementation $\mathbf{u_{14}}$ government procurement's policies and its implementation, $\mathbf{u_{15}}$ government revenue $\mathbf{u_{16}}$ the factor of the government's policies $\mathbf{u_{17}}$
	industry supply and demand market level $\mathbf{u_2}$	auto possession $\mathbf{u_{21}}$ consumer purchasing power $\mathbf{u_{22}}$ the proportion of private car $\mathbf{u_{23}}$ The purchases of government policy $\mathbf{u_{24}}$
	industry intermediary agency level $\mathbf{u_3}$	The automobile consumption credit $\mathbf{u_{31}}$ bank credit capacity $\mathbf{u_{32}}$ agency service factors $\mathbf{u_{33}}$ the number of bank assistant agency $\mathbf{u_{34}}$
	Industry participants Level $\mathbf{u_4}$	the enterprise number of new energy vehicles $\mathbf{u_{41}}$ the number of industrial colleges and universities $\mathbf{u_{42}}$ the number of industry R & D personnel $\mathbf{u_{43}}$ the number of industry research institutions $\mathbf{u_{44}}$ the number of research projects $\mathbf{u_{45}}$ industry output value of new products $\mathbf{u_{46}}$ industry enterprise profits $\mathbf{u_{47}}$
	Knowledge and technology level $\mathbf{u_5}$	the number of graduates $\mathbf{u_{51}}$ industry R & D expenditure $\mathbf{u_{52}}$ industrial R & D staff $\mathbf{u_{53}}$ the number of possess in patents $\mathbf{u_{54}}$ the number of applications for patents $\mathbf{u_{55}}$ the number of industry technology papers u56 the amount of technical market transactions u57 the quantity of knowledge achievements u58

2. RESEARCH ON THE EVALUATION MODEL OF THE NEW ENERGY AUTOMOTIVE INDUSTRY INNOVATION SYSTEM

2.1 Introduction of Evaluation Method

Analytic Hierarchy Process is a multiplecriteria evaluation method to quantitative analysis for qualitative problem, which is raised by the United States professor T.L. Saaty at the University of Pittsburgh in the mid 1970s. Its principle is that a complex problem is decomposed step by step according to logical attributes. It may form the hierarchical structure.

Fuzzy comprehensive evaluation method is using a fuzzy mathematical theory to establishment of matrix, which is founded by American scientists Professor Zadeh in the 1960s. It is achieved to the degree of each index by clustering analysis program. This method has not the strictly quantitative characterization, but the subjectively qualitative description to fuzzy phenomena of quantitative analysis. It close combines the qualitative description and quantitative analysis.

2.2 Application on Evaluation Method

This paper will combine the two for applications. Firstly, it used AHP to determine the weight of evaluation index in the new energy automotive industry innovation system; and then it calculated the value of comprehensive evaluation by the method of fuzzy comprehensive evaluation. The specific procedure is as follows:

2.2.1 Build Hierarchical Analysis Structure Model

The basic elements of the innovation system in the relationship will be analyzed, and relevant factors will be divided from top to down. The upper factors will be impacted by the lower ones, but within each factor is essentially independent. According to the table 1 evaluation index system, set five primary index for $U=\{u_1, u_2, u_3, u_4, u_5\}$, and $u_1=\{u_{11}, u_{12}, u_{13}, u_{14}, u_{15}, u_{16}, u_{17}\}$, $u_2=\{u_{21}, u_{22}, u_{23}, u_{24}\}$, $u_3=\{u_{31}, u_{32}, u_{33}, u_{34}\}$, $u_4=\{u_{41}, u_{42}, u_{43}, u_{44}, u_{45}, u_{46}, u_{47}\}$, $u_5=\{u_{51}, u_{52}, u_{53}, u_{54}, u_{55}, u_{56}, u_{57}, u_{58}\}$, among u_{ij} is the j secondary evaluation index which related to the i primary index. We set up the structure model as shown in figure 1 shows.

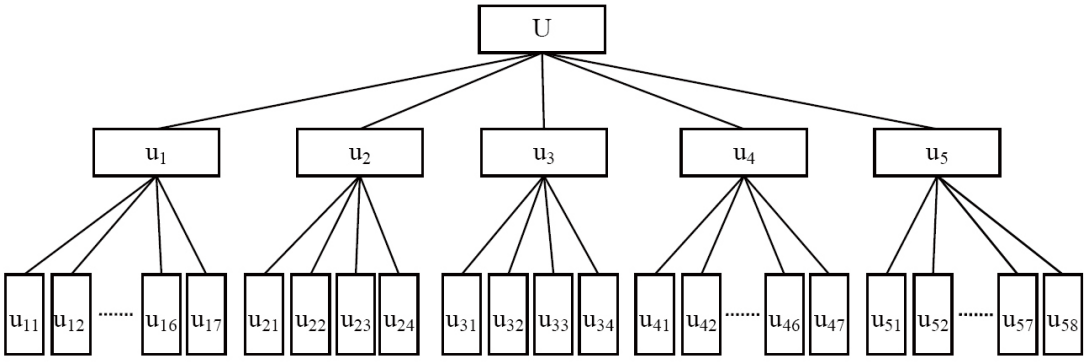

Figure 1
The Hierarchical Structure Model

2.2.2 Structure Judgment Matrixes

According to the affiliation between the upper and lower ones in the evaluation index system, it may construct to the judgment matrix. That is to say, according to a certain factors as standard, it will be given a certain score, through the comparison of the relative importance between two factors.

2.2.3 Calculating the Weight Vector

$$w_i = \frac{1}{n} \sum_{j=1}^{n} \frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}}$$

Firstly, the judgment matrix is determined; secondly, according to the formula, it calculates vector of the relative importance; finally, it obtained the weight vector that the lower strata is relative to the upper one's index.

2.2.4 Consistency Check of Judgment Matrix

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^{n} \frac{\sum_{j=1}^{n} a_{ij} w_j}{w_i}$$

$$C.I. = \frac{\lambda_{\max} - n}{n-1}$$

$$C.R. = \frac{C.I.}{R.I.}$$

Consistency check standards: if C.R. < 0.1, the judgment matrix passes the consistency check; otherwise, it does not pass the consistency check. We know that all of judgment matrix passes the consistency check. Judgment

matrix (ellipsis), weight results are as follows:

Rule layer u_1, u_2, u_3, u_4, u_5 to target layer U, the weight w = (0.082, 0.165, 0.046, 0.415, 0.292)

Industry policy environment u1 for each factors, the weight w_1 = (0.035, 0.023, 0.072, 0.084, 0.191, 0.187, 0.407);

Industry supply and demand's market level u2, the weight w_2= (0.059, 0.503, 0.305, 0.133);

Industry participants level u_3, the weight w_3= (0.326, 0.506, 0.114, 0.054);

Industry agency level u_4, the weight w_4= (0.047, 0.03, 0.05, 0.084, 0.135, 0.282, 0.373);

Knowledge and technology level u_5, the weight w_5= (0.208, 0.1, 0.147, 0.072, 0.032, 0.024, 0.067, 0.351);

2.2.5 Calculate Score of Comprehensive Evaluation

It is determined the weight by AHP in front of the article. Then it calculates score of comprehensive evaluation by using the fuzzy comprehensive evaluation method. First, it should be given a uniform criterion for judging level index in each one (Table 2).

Table 2
Evaluation Score Table

Grade	Optimal (v1)	Good (v2)	Medium (v3)	Qualified (v4)	Disqualification (v5)
Score	90~99	80~89	70~79	60~69	<60

Through investigation and statistical analysis methods, it gets the degree of membership for from i index to j comments grade. In table 1 of evaluation index system, its factors are divided into two layers: the u_i and u_{ij}, and the specific steps of the fuzzy comprehensive evaluation are as follows:

1) Conducting fuzzy comprehensive evaluation to the second layer u_{ij}, by using the evaluation factors set B_i and secondary factors weight factor w_i, It obtains a comprehensive evaluation of the two-level R_i,

$$R_i = w_i \cdot B_i = (r_{i1}, r_{i2}, r_{i3}, r_{i4}, r_{i5}), i = 1, 2, \cdots, 5$$

Where B_i is composited of the degree of membership b_{ijk} of single-factor evaluation matrix u_{ij} for evaluation factors u_i,

$$B_i = \begin{pmatrix} b_{i11} & b_{i12} & \cdots b_{i15} \\ b_{i21} & b_{i22} & \cdots b_{i25} \\ \cdots & \cdots & \cdots\cdots \\ b_{in1} & b_{in2} & \cdots b_{in5} \end{pmatrix}$$

Among them, matrix row n is the number of evaluation factors u_i.

2) Calculate comments set S of comprehensive evaluation index U

According to a comprehensive evaluation R and the first layer weights w, we can work out comprehensive evaluation set S. Judging by the maximum principle of degree of membership, we can do comprehensive evaluation.

$$S = w \cdot R = w \cdot \begin{pmatrix} R_1 \\ R_2 \\ \vdots \\ R_5 \end{pmatrix} = (s_1, s_2, s_3, s_4, s_5)$$

3. EMPIRICAL RESEARCHES ON THE EVALUATION OF THE CHINA NEW ENERGY AUTOMOTIVE INDUSTRY INNOVATION SYSTEM

3.1 The Evaluation of the New Energy Automotive Industry Innovation System in China

China is a larger automobile consumer. Due to the development of automobile industry relatively late, it lags behind other countries in traditional technology. The new energy automotive industry does not particularly attached to traditional technology, so it provides a good opportunity to the development of new energy automotive industry. Now the development of new energy vehicles in China has some achievements, whether or not is china to get competitive advantage, which depend on the ability of the new energy automotive industry innovation. We evaluate the new energy automotive industry innovation ability in a low carbon economy mode. First of all, we should investigate various indexes of new energy automotive industry innovation; then we analysis the results of the survey; finally we get comment score of each secondary indexes (table 3)

Table 3
The Comments Level of Each Secondary Indexes

	factor	Optimal(v1)	Good(v2)	Medium(v3)	Qualification(v4)	Disqualification(v5)
u_1	u_{11}	0.00	0.25	0.25	0.31	0.19
	u_{12}	0.00	0.06	0.25	0.38	0.31
	u_{13}	0.00	0.25	0.44	0.13	0.19
	u_{14}	0.00	0.06	0.38	0.38	0.19
	u_{15}	0.06	0.19	0.25	0.25	0.25
	u_{16}	0.19	0.38	0.38	0.00	0.06
	u_{17}	0.19	0.25	0.31	0.19	0.06
u_2	u_{21}	0.19	0.44	0.13	0.06	0.19
	u_{22}	0.06	0.25	0.44	0.13	0.13
	u_{23}	0.19	0.44	0.06	0.19	0.13
	u_{24}	0.06	0.25	0.44	0.06	0.19
u_3	u_{31}	0.19	0.38	0.31	0.13	0.00
	u_{32}	0.31	0.25	0.19	0.19	0.06
	u_{33}	0.06	0.19	0.44	0.13	0.19
	u_{34}	0.19	0.19	0.19	0.19	0.25
u_4	u_{41}	0.06	0.00	0.25	0.25	0.44
	u_{42}	0.00	0.13	0.19	0.50	0.19
	u_{43}	0.00	0.13	0.50	0.19	0.19
	u_{44}	0.00	0.13	0.44	0.25	0.19
	u_{45}	0.00	0.13	0.25	0.44	0.19
	u_{46}	0.06	0.13	0.31	0.31	0.19
	u_{47}	0.13	0.38	0.25	0.19	0.06
u_5	u_{51}	0.06	0.19	0.31	0.31	0.13
	u_{52}	0.06	0.06	0.56	0.25	0.06
	u_{53}	0.06	0.06	0.38	0.44	0.06
	u_{54}	0.00	0.06	0.38	0.13	0.44
	u_{55}	0.00	0.06	0.31	0.13	0.50
	u_{56}	0.00	0.31	0.06	0.38	0.25
	u_{57}	0.00	0.13	0.31	0.13	0.44
	u_{58}	0.00	0.13	0.31	0.38	0.19

The weight vector of each secondary index:

w_1=(0.035 0.023 0.072 0.084 0.191 0.187 0.407)

w_2=(0.059 0.503 0.305 0.133)

w_3=(0.326 0.506 0.114 0.054)

w_4=(0.047 0.030 0.050 0.084 0.135 0.282 0.373)

w_5=(0.208 0.100 0.147 0.072 0.032 0.024 0.067 0.351)

We can get corresponding single factor comments set through the fuzzy computation:

R_1=(0.123 0.241 0.323 0.184 0.128)

R_2=(0.108 0.318 0.305 0.132 0.137)

R_3=(0.237 0.280 0.257 0.160 0.067)

R_4=(0.067 0.213 0.294 0.274 0.153)

R_5=(0.028 0.121 0.346 0.316 0.190)

The weight vector of first class index w=(0.082 0.165 0.046 0.415 0.292)

We can get the comments sets of comprehensive evaluation index U, by using the fuzzy computation combining judgment matrix of first class index R.

S=(0.0750 0.2086 0.3115 0.2504 0.1551)

According to maximum principle of degree of membership, we can see that the maximum degree of membership is 0.3115, so the comprehensive assessment of new energy automotive innovation level is "medium".

CONCLUSIONS

According to the results of evaluation, we can see that the ability of the new energy automotive industry innovation belongs to medium level. We also know that the maximum membership degree R_1 is 0.323 from the single factor comments set R_i, that is to say, the evaluation of new energy auto industry policy environment is "Medium" in China; the maximum degree of membership R_2 is 0.318, that is to say, the evaluation of new energy automotive industry supply and demand market level is "Good" in China; the maximum degree of membership R_3 is 0.280, that is to say, the evaluation of new energy automotive industry agency level is "Good" in China; the maximum degree of membership R_4 is 0.294, that is to say, the evaluation of new energy automotive industry participant's level is "Medium"; the maximum degree of membership R5 is 0.346, that is to say, the evaluation of new energy automotive industry knowledge and technology level is "Medium" in China.

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