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Empirical Study on Innovation Environment of Technology Innovation System of Chinese New Energy Industry

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Abstract: In order to improve innovation environment, the paper adopts SEM to study infrastructure, economics, resources, service, legal and politics and industrial technology innovation ability in the new energy industry. The results show that infrastructure has a positive effect on industrial technology innovation ability, but not significant. Meanwhile, economics, resources, service, law and politics have a remarkable positive effect. The study not only offers policy guidance for the new energy industry to create a sound innovation environment but also has significance for our industrial development.

Keywords: technology innovation, innovation environment, new energy industry, SEM

1 Presentation of Questions

Compared to developed countries, China's new energy industry is backward in technological innovation ability, science and technology talents as well as research achievements commercialization rates; it means the suppo rt from government is essential to innovation. Since the Special Fund of Renewable Energy was launched in 2011, the new energy industry has experienced fast growth and the industry-university-research cooperation has made remarkable achievements. Meanwhile, a more prominent challenge before China is to improve the innovation environment.

Franco Malerba (2002) upgraded the industrial innovation theory amid the industry life cycle theory, the connection of industry boundary and innovation system theory. Malerva and Porter (2006) made research on industrial innovation system respectively; their studies show the relations between formal industry and informal industry as well as market and non-market. Hu Mingming (2009) pointed out that industrial innovation system is a network, and the performance of main-body's innovation and the interaction between enterprises and non-business organizations are essential to the network. Cheng Yu (2010) raised the concept of innovative economy that explain the "cycling" system and operating mechanism of innovative economy; she considered innovative system as an inner economic system, which is unified in demand and supply. From the law of technological innovation of new energy, Su Jun (2012) developed R&D to R&3D (research, development, demonstration and deploy) and explained the theoretical and policy basis under the perspective of technology life cycle and technological innovation input. Wang Qunwei (2013) analyzed constrains of new energy enterprises and their interaction relations from four dimensions of technology innovation: input, management, demonstration and deploy. Wang Hanxin (2014) studied the technologic al innovation of new energy from the view of public policy. Guo Shufen (2015) exploited RENB to figure out the policy impact on new energy technological innovation, which is based on the patent data from 2000 to 2013.

According to the studies mentioned above, there is insufficient study on the innovation environment of new energy industry technological innovation system both at home and abroad. The innovation environment can be divided into two parts: hard environment and soft environment. The former refers to infrastructure and natural environment; while the later refers to economic environment, resources that include venture capital and financial system, service environment that covers intermediary agencies and commercial services, and the legal and political environment that embrace laws and rules. This paper elaborates on the interactive relations between the innovation ability of China's new energy industry and those influencing factors, utilizing SEM and the regression analysis. The results show the environmental factors' contribution made to the technological innovation of China's new energy industry; it is instructional on China's headway to developing the new energy industry.

2 Presentation of Relevant Concepts and Research Hypotheses

In order to explore the influence that infrastructure,

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economic environment, resources environment, service environment and legal and political environment bring to China's new energy industrial innovation system and innovation activities, this paper investigates the method of Structural Equation Model (SEM). This paper studies the interaction between these influencing factors and industrial innovation system, and tests the impact on China's new energy industrial innovation system and its operation.

This study assumes natural environment is the invariant parameter and is not involved in the empirical analysis of influence that environmental factors have brought to China's industrial innovation system.

Any technological innovation activities needs certain places to be carried out, implemented and feed back. The infrastructure requirements in this research are mainly provided by the government, which can be summarized as public goods service, the introduced R&D equipment by universities and research institutions. Owing to the particular nature of these work places, infrastructure are mostly funded or purchased by government; the large equipment or experimental sites that enterprises prepared for production operation can also win government support since they can bring substantive development to China's new energy industry. The government supported public goods service providing to the universities, research institutions and enterprises bring convenience to technological innovation activities, thus the differences of infrastructures have direc t relationship to its success. The direct influence of economic environment to the new energy industry reflects on whether it can create a sound, stable and opportunity-f illed market economy. The influence of resources environment reflects on whether financing supports, such as capital, are timely provided so as to guarantee the successful development of innovation activities. The service environment is supposed to provide service assurance for the commercialization of technological innovation achievements. The legal and p olitical environment is the essential guarantee for a sound and fast-developing market economy. Therefore, thi s paper makes following relevant hypotheses:

H1：Infrastructure has significant positive impact on the technological innovation ability of China's new energy industry.

H2：Economic environment has significant positive impact on the technological innovation ability of China's new energy industry.

H3：Resources environment has significant positive impact on the technological innovation ability of China's new energy industry.

H4：Service environment has significant positive impact on the technological innovation ability of China's new energy industry.

H5：Legal and political environment has significant positive impact on the technological innovation ability of China's new energy industry.

The conceptual model is made according to these five hypotheses, as shown in Tab.1.

Tab.1 Hypotheses of Empirical Analysis on Innovation Environment of Technological Innovation System of China's New Energy Industry

Hypothesis dimension	Contents
Infrastructure	Infrastructure has significant positive impact on the technological innovation ability of China's new energy industry.
Economic environment	Economic environment has significant positive impact on the technological innovation ability of China's new energy industry.
Resources environment	Resources environment has significant positive impact on the technological innovation ability of China's new energy industry.
Service environment	Service environment has significant positive impact on the technological innovation ability of China's new energy industry.
Legal and political environment	Legal and political environment have significant positive impact on the technological innovation ability of China's new energy industry.

3 Research Methods

3.1 Questionnaire Design

In order to increase credibility and social value of this research, the author interviewed researchers' opinion about the status and dynamic of new energy industry. The researchers work for State Grid, China Datang Corporation, China Longyuan Power Group Corporation Limited, Power Construction Corporation of China, Guangzhou Institute of Energy Conversion of Chinese Academy of Sciences, Harbin Engineering University (HEU), Zhejiang University. The questionnaire focuses on infrastructure, economic, service, resources and legal and political environment of Chinese new energy industry and discusses their impact. Combined with references and relevant theoretical basis, this paper aims to target the influencing factors of Chinese new energy industrial innovation.

Then this paper chooses domestic universities, research institutes and enterprises related to new energy as samples; and it takes questionnaire as a way of data collection. Questionnaires mainly distributed to: (1) the government departments related to renewable energy and strategic emerging industry, (2) famous scholars among HEU in the field of new energy, (3) leaders and researchers in the State Grid, (4) managers and scientific personnel engaged in new energy technology in Harbin Electric Corporation. Respondents are middle-senior managers and researchers because the survey is specific to technological innovation activities of new energy. Meanwhile, the research centers on new energy industry are interviewed, such as Tsingtao, Zhejiang, Canton and Dalian.

The questionnaire adopts a seven-level LiKert scale, which is a refinement of five-level LiKert Scale. 1~7 represents “strongly disagree” to “strongly agree”. The lager the number is, the more satisfying the respondents are. The questionnaire requires respondents to compare the problem statement with technological innovation conditions of new energy in the department they are engaged in, which shows whether the statement fits reality or whether they agree with it. In order to improve the validity and credibility of this scale, the questionnaire adopts multi-items to verify the hypotheses.

3.2 Scale Design

The scale items of variable in this questionnaire use overseas relevant achievements as reference; and then combine with the reality of China’s new energy industry. The source of this questionnaire includes: (1) scale items in relevant researches both domestic and overseas, which has been verified as high credibility, (2) adjust scale items on the basis of existing documents to China’s reality, (3) increase or decrease scale items according to the interview with experts in new energy industry. The final scale is shown in Tab.2.

Tab.2 Variable Measurement Scale

Variables		Code	Measurement Items
Hard Environment	Infrastructure A1	V1	High availability of market information
		V2	Perfect environment of international trade service
		V3	Convenient transportation
		V4	Increasing investment shares in infrastructure
		V5	Good livelihood of new energy industrial personnel
		V6	Sufficient public goods supply from government
Soft Environment	Economic Environment B1	V7	Less competition in relevant industry
		V8	Rich human resources within industry
		V9	Rational organization within industry
		V10	High cost of industrial capital
		V11	Favorable fiscal policy for industry development from government
		V12	Favorable monetary policy for industry development from government
	Resources Environment C1	V13	Easy to get loan from bank
		V14	High availability of civil financing
		V15	Perfect financial risk prevention and control system within industry
	Service Environment D1	V16	Large scale of third-party service enterprises in commercialization of research findings
		V17	Complete service facility in commercialization
		V18	Wide range of commercialization service system
		V19	High commercialization rate
		V20	High efficiency in industry-university-research cooperation
		V21	Mature technological trading market
	Legal and Political Environment E1	V22	Sound and standardized legal protection system
		V23	Favorable rules and policies to the development of new energy industry from government
		V24	Favorable regulations to the development of new energy industry from government
Technological Innovation Ability of China’s New Energy Industry F1		V25	Frequent technological innovation within intra-industry subjects
		V26	Frequent cooperation and communication within intra-industry subjects
		V27	Frequent process innovation within intra-industry subjects
		V28	New products and patents from independent innovation within industry

	V29	Promising commercial market scale of scientific innovation achievements within industry
	V30	Annual increase input of R&D

Note: Scale items in this table takes Gans.Joshua，Philip J. Vergrat and Liu Hongjuan’s articles as reference.

3.3 Data Analysis

There are 1000 questionnaires distributing to three main parts: around 20 research-oriented universities related to new energy (35%), around 15 marine energy institutes (35%) and around 15 new energy technology enterprises (30%). Universities includes Ocean University of China, Harbin Engineering University, Tsinghua University, Tongji University, East China University of Science and Technology, Zhejiang University, etc. Research institutes includes Guangzhou Institute of Energy Conversion of Chinese Academy of Sciences, Institute of Electrical Engineering Chinese Academy of Sciences, China Institute for Marine Affairs, National Center of Ocean Standards and Metrology, etc. Enterprises include China Huaneng Group, China Datang Corporation, China Power Investment Corporation, China Guodian Corporation, China Longyuan Power Group Corporation, China Electric Corporation, China Energy Conservation Investment Corporation, China State Shipbuilding Corporation, China Shipbuilding Industry Corporation, etc. There are 800 valid questionnaires, with 788 returned. After rejecting questionnaires with obvious rules, data missing and those did not finish by middle-senior managers, there are 768 pieces left, showing a questionnaire efficient of 96.0%. These questionnaires reflect the new energy industry’s familiarity to the influencing factors of technological innovation.

Data requirements. Sample test should be taken to test whether data are in accordance with requirements before operating SEM. This research adopts Maximum Likelihood Method (ML), recycling 768 valid questionnaires, which conforms to the operating requirements of SEM. Therefore, the software AMOS 17.0 can be adopted in data analyzing.

Data Reliability testing. This research does not require respondents and interviewees to take repetitive measure, so consistency is adopted when testing data credibility. First, this paper uses SPSS 17.0 to analyze the credibility of 30 items in 768 samples. As what is shown in Tab.3, the α parameter of service environment and technological innovation ability are all lager than 0.9, which means an excellent credibility. The α parameter of infrastructure, economic, resources and legal and political environment are all lager than 0.8, which represents a high credibility. Therefore, this combination of statistics possesses high credibility.

Validity Analysis. According to the result, all the measure values of KMO samples are lager than 0.70; meanwhile, all the Bartlett values are smaller than 0.0001 and the factor loaded value of 30 items are lager than 0.70. It can be seen from the analysis result that both infrastructure, economic, resources, service, legal and political environment and the scale of industrial technological innovation ability have strong reasonability logically. Hence, the corresponding scale has high credibility and validity.

Tab.3 Reliability and validity of variables

Variables	Corresponding Item	Load Factor Value	$Cronbach's\ \alpha$ Parameter
Infrastructure A1	V1	0.801	0.833
	V2	0.822	
	V3	0.810	
	V4	0.815	
	V5	0.769	
	V6	0.788	
Economic Environment B1	V7	0.729	0.856
	V8	0.781	
	V9	0.802	

	V10	0.772	
	V11	0.805	
	V12	0.780	
Resources Environment C1	V13	0.860	0.832
	V14	0.848	
	V15	0.870	
Service Environment D1	V16	0.833	0.908
	V17	0.874	
	V18	0.899	
	V19	0.896	
	V20	0.866	
	V21	0.837	
Legal and Political Environment E1	V22	0.827	0.854
	V23	0.918	
	V24	0.902	
Technological Innovation Ability F1	V25	0.865	0.922
	V26	0.870	
	V27	0.865	
	V28	0.865	
	V29	0.824	
	V30	0.766	

4 Analysis on Model Results

4.1 Establish Roadmap

The analysis mentioned above shows that the model data have qualified reliability and validity. According to the marking method of SEM roadmap, this chapter transfers the conceptual model into SEM roadmap. The parameters can be found in Tab.1. The model includes: an exogenous latent variable, including technological innovation ability of new energy industry – F1; Inner variables, including infrastructure– A1, economic environment – B1, resources and environment – C1, service environment - D1 and legal and political environment – E1.

4.2 Model Evaluation

In AMOS17.0, after utilizing the estimation method of maximum likelihood parameter, model roadmap results are shown as follows in Tab.4.

Tab.4 Roadmap hypotheses Parameter and Hypotheses Testing

Counter Hypotheses	Relation between variables	P	Roadmap Parameter	Test Results
H1	Infrastructure → Technological Innovation Ability of New Energy Industry	0.014	0.160	Partial Support
H2	Economic Environment → Technological Innovation Ability of New Energy Industry	***	0.722	Support
H3	Resources and Environment → Technological Innovation Ability of New Energy Industry	***	0.401	Support
H4	Service Environment → Technological Innovation Ability of New Energy Industry	***	0.541	Support
H5	Legal and Political Environment → Technological Innovation Ability of New Energy Industry	***	0.375	Support

Note: ***means statistical significance when $p\langle 0.001$

Empirical Result shows that the model has good fitting goodness, the indexes are as follows：

χ^2/df =2.104

RMR=0.047,RMSEA=0.025,GFI=0.944

AGFI=0.911,NFI=0.920,CFI=0.904

To sum up, the SEM overall model has fine fitting goodness. Meanwhile, fitting indexes locate in an acceptable range that verifies the credibility of theoretical hypotheses proposed in this paper.

5 Conclusion

The analysis results of theoretical model's path coefficient are shown in Table 4.

Assume corresponding P value of H1 is 0.014, and then the path coefficient is not obvious, which means the infrastructure have a positive impact on the technological innovation ability of China's new energy industry. However, this hypothesis does not gain all the support. The results show that Chinese government is supposed to expand money input so as to improve the infrastructure in China's new energy industry. Assume the path coefficient of H2 is 0.722, and then it is statistical significance on the level of $p\langle 0.001$, which means the result is supportive to the theoretical hypothesis, that is economic environment has a positive impact on the technological innovation ability of China's new energy industry. Assume the path coefficient of H3 is 0.40, which means resources environment has a positive impact on the technological innovation ability of China's new energy industry. Assume the path coefficient of H4 is 0.541, which means service environment has a positive impact on the technological innovation ability of China's new energy industry. Assume the path coefficient of H5 is 0.375, which means legal and political environment has a positive impact on the technological innovation ability of China's new energy industry.

Based on the analysis mentioned above, it can be seen that economic, resources, service and legal and political environment all have positive impact on the technological innovation ability of China's new energy industry, but the degree is different. At present, the influence of economic environment occupies the first place, service environment comes the second, legal and political environment stands the third, meanwhile, resources environment contributes less than the others.

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