THE EVALUATION INDEX SYSTEM OF GREEN PROCESS INNOVATION NICHE OF CHINESE HOME APPLIANCE MANUFACTURING INDUSTRY

Hongna TIAN [1] and Bo SHI [2]

ABSTRACT: On the basis of analyzing the status and problems of green process innovation of Chinese home appliances manufacturing, the paper uses expert scoring method to select the evaluation targets and construction principles for green process innovation niche. According to niche ecostate-ecorole theory, the paper builds the evaluation index system of green process innovation niche of home appliances manufacturing from the ecostate level and ecorole level which consist of eight criterion level indexes and twenty indicator level indexes. Then, it analyzes each evaluation index. This evaluation index system comprehensively reflects the condition of green process innovation niche of home appliances manufacturing, it provides the gist for carrying out green process innovation activity of home appliances manufacturing.

KEY WORDS: home appliance manufacturing industry, green process innovation, niche ecostate-ecorole, evaluation index system

1 THE STATUS OF CHINESE HOME APPLIANCE MANUFACTURING

The home appliance manufacturing is an emerging industry after China's reforming and opening. It is the important industry of national economy. With more than 30 years development, the production scale of Chinese home appliance manufacturing expends continually. Its industry competitiveness is still growing. Chinese home appliance manufacturing has become one of the industries with strong international competitiveness. Its gross industrial output value has reached 1500 billion in 2014, which increased by 54.51% than 682.3 billion in 2008. It achieves the stable growth in 7 years (As shown in figure 1). It has important meaning for putting the sustain development of economy, society, and environment.

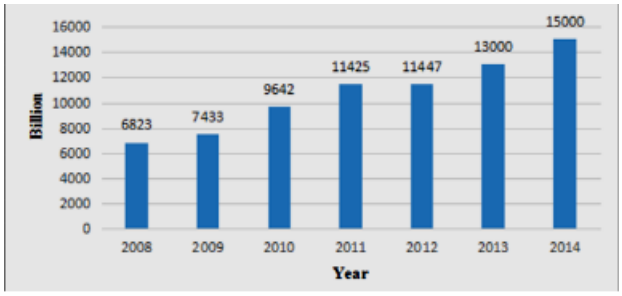

Fig 1. The gross industrial output value of Chinese home appliance manufacturing from 2008 to 2014

Home appliances are important consumer durable goods which take on the important tasks of prospering market and increasing output.

According to "the durable goods ownership of average per hundred urban households at the end of the year from 1995 to 2013" in China Statistical Yearbook (2014), the ownership of home appliances of the Chinese urban households, except the washing machine, increased more than 50% year by year from 1995 to 2013. The air conditioning increased fastest among them which reached 99.73% and every one hundred families had almost 126.81 units, as shown in Table 1. Obviously, Chinese home appliance manufacturing plays the important role in the industrial production and consumption.

Table 1. The durable goods ownership of average per hundred urban households at the end of the year (1995-2013)

Indicator \ Year	1995	2000	2005	2010	2011	2012	2013	Rise(%)
Washing machine (unit)	78.4	88.97	90.50	95.51	96.92	97.05	98.02	20.00
Refrigerator (unit)	42.33	66.22	80.10	90.72	96.61	97.23	98.48	570.2
TV (unit)	59.04	89.79	116.60	134.80	137.43	135.15	136.07	56.61
Stereo (unit)	---	10.52	22.20	28.79	28.08	23.97	23.63	55.48
Air conditioning (unit)	0.34	8.09	30.80	80.67	112.07	122.00	126.81	99.73
Water heater (unit)	---	30.05	49.10	72.65	84.82	89.14	91.02	66.99
Microwave oven (unit)	---	---	17.60	47.61	59.00	60.65	62.24	71.72

The overall economy of Chinese home appliance manufacturing grows steadily in recent years. But it must speed up the construction of ecological civilization and pay more attention to green design, cleaner production, energy conservation, emissions reduction and recycling etc, if it wants to become "created in China" instead of "made in China" during the transformation period for the china's economy. In addition, it must work on developing environmental and healthy home appliances and

[1] Harbin University of science and technology in China
[2] Harbin University of science and technology in China
E-mail: tianhongna@hrbust.edu.cn;

attach greater importance to green process innovation activities of home appliance manufacturing (Sun et al, 2014)[1].

2 THE STATUS AND EXISTING PROBLEMS OF GREEN PROCESS INNOVATION OF CHINESE HOME APPLIANCE MANUFACTURING

In recent years, China has issued some policies and regulations on energy conservation and emission reduction for home appliance manufacturing. The government focuses on the key technologies of energy conservation, noise reduction, recycling, modular and removable material. It carries out green process innovation widely and has strong production capacity. Many home appliance manufacturing enterprises in China innovate and upgrade their technologies continually and have the capacity of independent innovation. However, compared to the international fist-class home appliances manufacturing enterprises, the investment in green process innovation is inadequate and the awareness for green innovation is still insufficient. Due to industry particularity, there are some society problems induced by the poor ability of green process innovation. For example, unscientific recycling of obsolete home appliances can damage environment, faultiness green process technology can threaten safe and health of consumers. Nowadays, Chinese home appliance manufacturing enterprises still have some problems in improving quality, energy conservation and emission reduction, which exist in manufacturing and production schedule.

2.1 The insufficient humanized and personalized design of green process

Chinese home appliance manufacturing enterprises pay more attention to the production cost. In order to control the cost, they are lack of attention to the green process innovation which needs higher investment. Their key green process technologies and equipment almost entirely depend on import. For instance, the patent of cfc-free refrigerants R410a is held by the foreign companies like Dupont and Honeywell (Yan, 2010)[2]. There are few Chinese home appliance manufacturing enterprises realize the material substitution of R0HS directive harmful ingredients. However, the multinational companies in European and American began to research the replacement for the material substitution technology years ago. They monopolized the green process technology and forced Chinese home appliance manufacturing enterprises to introduce the foreign mature green technologies and green material with high patent fees.

2.2 The low ability of independent innovation of green process technology

Today the personalized design of green process is very popular. The consumers' demands become wide varieties, high performance, individuation, humanization and functional diversification. These market demands require the home appliance manufacturing enterprises to eliminate the old production mode and use one production line which can make a large number of different types green productions. Most of the green processes designed by the home appliance manufacturing enterprises in China are crude. They lack the humanized, personalized and green design concept. Mean while, some green processes designed by the home appliance enterprises in abroad embody the humanized design idea not only from exterior shape but also from internal function.

2.3 The imperfection of energy conservation and environmental protection laws and regulations, and the technical standards

Although China issued national standards, laws and regulations of energy conservation and environmental protection for home appliance manufacturing. But they are not strict on the whole. It makes cost of breaking the law is too low. Moreover, Chinese home appliance manufacturing doesn't strictly carry out the revising process of standards, which leads to quality problems happen frequently. For instance, there is a tableware typed ZTD100K-S2 made by Zhejiang Sacon Electric Co., Ltd. is found unqualified, which is unqualified, having radiation, toxicity and risk. And a tableware sterilizer typed ZTD90A-292 produced by Shanghai Sakura Electric Co., Ltd. also has the same problems of radiation, toxicity and similar hazards. There is no exception for Shanghai Yingqi brand tableware disinfection cabinet which models of ZTD90A-292 (Zhao, 2014)[3]. A series of undemanding green process innovation lead to problems of safety and quality in home appliances. These reflect the energy-saving environmental regulations and quality standards are not perfect.

3 THE CONSTRUCTION OF EVALUATION INDEX SYSTEM OF GREEN PROCESS INNOVATION NICHE ECOSTATE-ECOROLE

3.1 The construction targets of the evaluation indexes

According to the systems theory, it is necessary to pay attention to study whether the system operates efficiently, coordinately and continuously when we evaluate a system. In other words, the construction targets of evaluation index system of green process innovation niche ecostate-ecorole are overall efficiency, structural compatibility and dynamic sustainability. The specific construction target is complete, comprehensive, systematical and multidisciplinary to reflect the actual situation of green process innovation niche of home appliance manufacturing.

3.2 The construction principles of the evaluation indexes

First, the objective and overall principle. The basic concepts and logical structures of evaluation index system should be rigorous and reasonable. They should reflect comprehensively and objectively the main work of green process innovation of home appliance manufacturing, and avoid evaluating just based on only a small number of indicators. In order to seize the most representative indicator, the evaluation indexes must be the objective descriptive indicators.

Second, the acquisition and operational principle. The evaluation index system must determine whether the index can be obtained, whether be obtained index concept clear and defined clearly. The indicators to be operable, it can fairly reflect the green process innovation niche status of home appliance manufacturing. It must conforms to the practical level, content is simplified and straightforward, easy to quantify, data collected to are true and reliable.

Third, the scientific and practical principle. The construction of index system should be established on the basis of scientific and practical theory. This refers to the relevant domestic and foreign scholars research results. It must reflect the actual situation of home appliance manufacturing comprehensively and systematically. This paper uses the niche ecostate-ecorole theory, it makes the theory deep into the construction of index system, so as to guarantee its scientific and practical.

Fourth, the dynamic and guiding principle. The green process innovation of home appliance manufacturing is a procedure of continuous develop and dynamic change. The evaluation index system should properly adjust with the development of ecology, economy and social benefit. It should be clear, provide reference for the associated policy, and it reflects the goals of the green process innovation of Chinese home appliance manufacturing.

3.3 The selection method of the evaluation indexes

Based on the construction targets and principles, this study carries out theoretical analysis by making the relevant research results at home and abroad as the reference (Feng, 2013)[4]. Combining the niche's ecostate and ecorole attributes of green process innovation in home appliance manufacturing, this paper selects 56 indicators, constructs the primary evaluation index system of the green process innovation's niche ecostate-ecorole of home appliance manufacturing.

The evaluation index system has greater subjectivity and requires expert investigation, correlation analysis and other methods to empirically select the evaluation index. There are 20 experts' opinions are asked for in the form of mail and direct interviews. These experts consist of the college teachers and senior managers of home appliance enterprises. They engaged in technological innovation, green innovation, and the environmental performance management of home appliance manufacturing. They have the relevant professional knowledge and practical experience. Their opinions can enhance the scientificity and objectivity of evaluation indexes. Our study makes the consultation table of evaluation influencing factors of green process innovation in home appliance manufacturing and let the experts to fill in the consultation tables through e-mail and interviews. We require the experts to rate the importance of each indicator based on their professional knowledge and practical experience. The select items are divided into 5 points depending on the degree of strength (1: very weak; 2: weak; 3 general; 4: strong; 5: very strong). There are 18 consultation tables are recovered, of which 15 are valid.

We calculate the mean and variance of each evaluation index in the effective consultation tables completed by the experts. Then the results are fed back to the experts. The experts carry out the second round evaluation according to the reflection

of the overall opinion trend and degree of dispersion of the index scores. We do the same to the second round evaluation of the effective recycling questionnaire, and make a significant test of x^2 to the mean of two rounds expert scoring and variance. The specific formula is:

$$x^2 = (n-1)\frac{seoond\ round\ of\ expert\ scoring\ variance}{the\ first\ round\ of\ expert\ scoring\ variance}$$

Among the formula, n is the number of experts, x^2 is the significance of two rounds variance.

The research constructs the statistical tests. When the $x^2 < x^2 0.95$, it shows the two rounds variance has no significant difference and the variance of this round is smaller. We use SPSS21.0 software to calculate and test these indexes and find that each index has a $x^2 < x^2 0.95$. This result indicates that the variance of the two rounds of expert scoring has significant regularity and there's no need to carry out the third round of expert scoring. Based on the statistical results of the second round expert scoring, our research deletes the indexes which scores are less than or equal to 3 points. Thus we consists of 8 criterion level and 20 Indicator level of "The evaluation index system of green process innovation niche ecostate-ecorole of home appliance manufacturing", as shown in table 2.

Table 2. The evaluation index system of green process innovation's niche ecostate-ecorole of home appliance manufacturing)

Object level	Criterion level	Indicator level	Unit
The level of ecostate	Financial strength	Fixed assets C1	Ten thousand yuan
		Current assets C2	Ten thousand yuan
	R&D resource	R&D personnel C3	Person
		R&D funds C4	Ten thousand yuan
		Production personnel C5	Person
	Science and technology policy	Technical transformation funds C6	Ten thousand yuan
		Scientific and technological innovation award C7	Ten thousand yuan
		Government research and development subsidy C8	Ten thousand yuan
	Environmental management	Environmental management investment C9	Ten thousand yuan
		Energy conservation and emission reduction investment C10	Ten thousand yuan
	Risk management	Inventory turnover days C11	Day
		Asset liability ratio C12	%
The level of ecorole	R&D output	The proportion of invention patents C13	%
		the proportion of new products output value C14	%
		labor productivity C15	%
	Green operation	Carbon dioxide emission reductions C16	Ton
		Waste emission reductions C17	Ton
		Waste water emission reductionsC18	Ton
	Green performance	the annual comprehensive energy saving rate C19	%
		the recovery rate of waste household appliances C20	%

4 THE ANALYSIS AND EXPLANATION OF THE EVALUATION INDEXES OF THE NICHE ECOSTATE-ECOROLE OF

Chinese scholar Zhu Chunquan (1997) first put forward the theory of niche ecostate-ecorole. He believes that any biological unit has two characteristics which are ecostate and ecorole [5]. We think that appliance manufacturing. It provides support and investment for green process innovation.

The ecorole attribute of green process innovation of home appliance manufacturing is a real influence on the environment when the home appliance manufacturing carries on the green process

innovation activity. It is not only a dominator of sustainable green process innovation, but also a communication and transformation between the industry and the material, energy and information from environment. A good achievement transformation of green technology innovation will be conducive to the development of green process innovation and provide support for the home appliance manufacturing to obtain sustainable competitive advantage.

The green process innovation niche of home appliance manufacturing is the combination of ecostate attribute and ecorole attribute. The evaluation index system of green process innovation of home appliance manufacturing is a relative measure of the level of green process innovation in home appliance manufacturing, which comprehensively reflects the status of the green process innovation niche of home appliance manufacturing.

4.1 The level of ecostate in niche ecostate-ecorole evaluation system

According to the niche ecostate-ecorole theory, the ecostate level of green process innovation niche mainly reflects the true status of green process innovation of home appliance manufacturing. This paper divides the ecostate attribute into four components, which are financial strength, R&D resource, science and technology policy and environmental management. These four elements reflect the status of resource accumulation of green process innovation of home appliance manufacturing.

The financial strength is mainly composed of fixed assets and current assets. The fixed assets and current assets are the basic components of the financial situation of home appliance manufacturing, and they are the basic guarantee for the green process innovation (Wu and Zhao, 2011) [6]. Fixed assets express the construction and acquisition of the fixed assets purchased by the whole society in the form of money and the related costs and the cost of acquisition of fixed assets costs in a certain period. The index is an integrated indicator and mainly reflects the investment scale, structure and development of the fixed assets in a certain area. It embodies the device resource belonged by green process innovation of home appliance manufacturing. Current assets refer to the assets that can be realized or applied in one year or one operating cycle longer than one year (Guo, 2013) [7]. It is an essential part of business assets. This index is conducive to maintaining the flow of assets structure of home appliance manufacturing. It also improves the debt paying ability of home appliance manufacturing so as to guarantee the production and operation activities of the green process innovation of home appliance manufacturing smoothly.

The Research and development (R&D) resource includes R&D personnel and funds, production personnel, technical renovation funds. R&D resource is an important source of green process innovation. R&D staff reflects the situation of the persons who involved in the basic research, applied research and experimental studies of green process innovation of home appliance manufacturing. R&D funds are the actual expenditure on research and development. The number of R&D personnel and R&D funds directly affects the procedure and results of green process innovation (Cleff and Rennings 1999) [8]. Therefore, the number of R&D personnel and R&D internal funds is the indicator that green process innovation must consider. It is the driving force of the innovation of manufacturing industry. The production personnel are the personnel take part in production and manufacturing activities of home appliance manufacturing. The higher production personnel of home appliance industry suggest more human resource for manufacturing activities and the production manufacturing capacity is higher. It guarantees the home appliance manufacturing has sufficient human resource for green process innovation activities (Green et al, 1994) [9]. The expenditure on technical transformation refers to the purchase cost of the home appliance manufacturing to carry out technical transformation. The technological transformation will be applied to all areas of scientific and technological achievements. It uses the advanced technology to achieve the expansion and reproduction.

The science and technology policy includes scientific and technological innovation award and government research and development subsidy. The amount of science and technology innovation award is the spending amount that home appliance enterprises carry out a series of thematic activities through rewarding the employee's scientific and technological innovation. This science and technology policy can continue to create a cultural atmosphere for enterprises to encourage innovation, respect for science and technology, respect for talent. It can motivate staff to contribute their own a scientific and technological strength for the green process innovation of home appliance manufacturing (Rennings et al, 2006) [10]. The government R&D subsidy refers to the policy

support of the Chinese central government or local government technology research and development. The government R&D subsidy includes the human engineering energy subsidy, waste electrical appliances dismantling subsidy, science and technology development fund, etc (Jin, 2013) [11]. The government R&D subsidy specified technical research direction for home appliance industry. In a certain extent, it alleviates the problem of shortage of funds of home appliance manufacturing enterprises. It can encourage them to actively participate in R&D and innovation activities, which are conducive to home appliance manufacturing enterprises smooth green process innovation activities.

The environmental management includes the environmental management investment and the energy conservation and emission reduction investment. The home appliance manufacturing has been the global brand power and responsibility to practice green, low-carbon commitments. It insists green and low-carbon concept on each process from the design to the manufacture and sales of products, recycling, treatment and utilization of waste electrical. To realize the value of its green, continue to promote sustainable, low carbon and harmonious development of the society. The environmental management investment is mainly used for detection training, participation in the environmental training of the external organization and environmental advocacy (Annette, 2012) [12]. The energy conservation and emission reduction investment is mainly used for saving energy and reducing consumption and pollution prevention (prevention of air pollution, prevention of water pollution). It is trying to improve the technology in energy saving equipment, increasing productivity, reducing energy and material consumption, effective use of energy and reduce the production of waste and pollutants emission. These indicators are the guarantee of successful green process innovation of manufacturing.

4.2 The level of ecorole in niche ecostate-ecorole evaluation system

The level of ecorole of green process innovation niche of home appliance manufacturing is mainly reflected the trend of the development of green process innovation of home appliance manufacturing. It is the influence of the future process innovation of home appliance manufacturing, or it maybe the ability of a dominant power to maintain a sustainable and effective process innovation. In this paper, the level of the green process innovation niche ecorole of home appliance manufacturing is also divided into four measure factors, which are risk management, R&D output, green operation and green performance. Four elements of the home appliance manufacturing to reflect the development trend of green process innovation.

The risk management mainly consists of two parts: the inventory turnover days and the asset liability ratio. The inventory turnover days are the number of days that an enterprise has experienced from the beginning of the inventory to consumption and sales. This index reflects the level of inventory management of home appliance industry, but also to measure the speed of new process product realization capacity. This value is lower, the faster the inventory turnover rate, the more the new process products to meet the market demand, so that it will greatly reduce the risk of inventory. To the home appliance industry has a certain role in promoting green process innovation activities. The asset liability ratio is the percentage of the total assets of indebted amount. It reflects how much proportion in the total assets is raised by borrowing. The index is the comprehensive evaluation index of enterprise debt level. If corporate debt is large, beyond the psychological level of creditors, then the enterprise will borrow less than money. If the corporate debt ratio is very small, so that enterprise quail, lack of confidence for the future, the use of creditor capital for green process innovation ability will be very poor. These indicators reflect the development trend of the green process innovation economic risk control of home appliance manufacturing, whether it can be continue to provide a suitable economic environment for the process innovation.

The R&D output consists of the proportion of invention patents, the proportion of new products output value, and the labor productivity. The proportion of invention patents mainly reflects the technological achievements output quality of green process innovation of home appliance manufacturing. The invention patent high will enter the barrier to the competitor, increase the production cost. This can maintain the sustainable competitive advantage of the manufacturing industry. The quality of patent output depends on the optimal allocation of a variety of resource, different resource allocation will also form a different path of green process innovation (Puccini et al, 2014) [13]. The proportion of new product output value refers to the proportion of the output value of new products. It is used to reflect the direct contribution to the process innovation output and economic growth, the output value increased shows

that the production process of the new product is adapted to the market demand (Yue et al, 2009) [14]. The labor productivity refers to the use value or efficiency of the specific labor production. It is an important indicator for monitoring and measuring the process of green process innovation of home appliance manufacturing, this is also an important indicator to assess the R&D output of home appliance manufacturing (Ayhan, et al, 2013) [15]. The efficiency of labor productivity increases, which indicates that the ability of workers to adapt to the new technological process is improved, the ability of labor productivity has a direct impact on whether the home appliance manufacturing can have sufficient power to realize the evolution of traditional process innovation to green process innovation.

The green operation contains the carbon dioxide emission reductions, the waste emission reductions and waste water emission reductions. The Carbon dioxide gas is a kind of greenhouse gas, it can absorb and release infrared radiation and exist in the atmosphere. Then it pollutes the air. The home appliance manufacturing through the continuous improvement of energy saving system, reduce carbon dioxide emissions per unit of output value, it through technical improvements and the use of new energy, to make an effort to achieve the maximum amount of carbon dioxide in the process of production activities. The waste emission reduction mainly refers to the enterprise solid waste reduction of emissions over the last year (Chen, 2006) [16]. The home appliance manufacturing is committed to improving the rate of finished products in the production process to control the amount of waste generated, at the same time it through the further improvement of the amount of waste to achieve the final disposal of the ultimate disposal of nearly zero emissions of the plant waste target. The waste water emission reduction mainly refers to the reduction of the liquid waste in the enterprise over the last year (Bi et al, 2002) [17]. The large amount of waste water, waste residue and waste gas produced in the process of production are not adapted to the requirements of clean production, they are contrary to the effect of the implementation of green process innovation activities. Therefore, the green process innovation is particularly important.

The green performance includes the annual comprehensive energy saving rate and the recovery rate of waste household appliances. The annual comprehensive energy saving rate refers to the proportion of home appliance manufacturing using innovative energy-saving products save power ratio of total power consumption. The home appliance manufacturing has been pushing green design and manufacturing, building energy management system, regulating energy reasonable, to achieve the scientific use of energy. The recovery rate of waste home appliances refers to the measures for the recycling of waste home appliances (Wang, 2014) [18]. The home appliance manufacturing implements the recycling of products and packaging. At the same time it sets up waste recycling center, and arrange for the commissioner to classify all the wastes.

Waste recovery units recycle the waste with the value of reuse, waste and municipal solid waste with no recycling value is transported to the designated waste landfill site by the qualification unit. The above indicators can promote the conversion of the traditional process to the green process, they promoting the development and implementation of green process innovation activities. These indicators comprehensively reflect the trend of the development and change of green environmental performance in green process innovation niche of home appliance manufacturing.

5 CONCLUDING REMARKS

The green process innovation is an important way to realize the traditional home appliance manufacturing turn into modern home appliance manufacturing. This paper constructs the evaluation index system of niche ecostate-ecorole of green process innovation of home appliance manufacturing based on niche ecostate-ecorole theory. It affects the green process innovation actively.

Through exploring and clearing the evaluation index of niche esostate-ecorole of green process innovation, Chinese home appliance manufacturing can pointedly promote the development of green process innovation, realize a virtuous cycle between green economic growth of home appliance enterprises and ecological environmental protection, and improve the ability of green process innovation in home appliance manufacturing. All of these will be of great meaning for improving the green process innovation of Chinese home appliance manufacturing and sustainable development of society.

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