

An approach to the influence of industrial structure on urban ecological environment

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Abstract— Industrial structure is key link of man's action to ecological environmental system. Its combination type and intensity determine, to a great extent, economic benefit, resources utilization efficiency and stress on environment. So the assessment to the rationality of industrial structure is of great importance. In present paper, the research theories and ways on relationship between industrial structure and ecological environmental systems were put forward. Environmental carrying capacity (ECC) was adopted to describe quantitatively the relationship between man's social economic activity and environmental resources. At the end of this paper, analysis was made with Benxi City as an example.

Keywords, industrial structure; ecological environmental system; environmental carrying capacity; Benxi City.

1 Introduction

The research of environmental sciences to industrial structure is based on its great influences to ecological environment. The rationality of industrial structure determines the degree and rationality of the utilization of the area's natural resources, and then affects the survival and development of mankind. It can be considered as "the controller of quality of pollutants produced".

As a component part of economic system, industrial structure affect ecological environment through a series of production process by man's economic activity. It is an essential factor controlling the influence degree (demand and stress) of economic system on ecological environmental system, while environmental system provides the support and hold to economic system. The relationship between them can be showed by environment carrying capacity (ECC)—the action interface between the behavior of man's economic development and ecological environment.

In this paper, we try to following the above to analyze the influence of urban industrial structure as a whole on ecological environment, and to use the research results of EEC to adjust urban industrial structure, finally to provide the basis of improving ecological environment and coordinating the relationship between environmental and economical development.

2 Theories and method

2.1 The research principles of the coordination of urban economy and ecological environment

The goal of constructing reasonable industrial structure is to give full play to social, economical and environmental benefits, to productive, living and environmental quality with overall consideration, and to guarantee the sustainable development of economy and ecological environment. So the general goal of selecting industrial structure type must be comprehensive improvement of the three benefits and sustainable utilization of environmental resource. These are major basis to assess the reasonable degree of industrial structure.

The principle of whole and the systematic method should be emphasized in the research on urban system. The whole principle is displayed in synthesization of structural sub-system and environmental subsystem, and also in the whole analysis of the interior of subsystems. So economic structure type is treated as whole to study its influences on ecological environment, and the supporting capacity of ecological environment to economic development will also reflect all-direction function of synthesis.

2.2 The system of environmental carrying capacity (ECC)

The intention of ECC has been systematically discussed in some reference. As an interface between social economic developmental behavior of mankind and ecological environment, ECC is a quantitative expression of the connection effect between both. ECC adds artificial action to its natural property. Therefore, the aim of ECC's research is to find out the way to higher ECC, or to regulate the economic behavior of mankind to maximize an area's ECC with positive "supporting" rather than passive "bearing". This is one of environmental sciences' contribution to the economic development of human being.

ECC includes both environmental quality carrying capacity and resources carrying capacity. Its research content includes following parts (Fig. 1)

For these reasons, ECC can be used to quantitatively assess the rationable degree of industrial structure and to assess the direction and intensity of man's interferences. Of course, the index system of ECC is far from satisfaction at present, but we can believe it will continuously tend to be perfect as the development and expansion of the research work. The influence of industrial structure to ecological environment is displayed in Fig. 2.

Table 1 Parameters of the industrial structure and the environmental resources (ER) system

Industrial output value	Parameters of economic assessment, E	Output ability of ER, P	Satisfied Demand to ER, s_m	degree to ER (s) Support ability of ER, d_m
n=13	1. Per capita national income, 10000 Yuan per capita	1. Output land resources, 10000 Yuan per km ²	1. Demanded quantity of industrial land, m ²	1. Urban available land, m ²
	2. Per capita profit and tax revenue 10000 Yuan per capita	2. Output of water resources, 10000 Yuan per ton	2. Demand to water resources, m ³ /a	2. Exploitable quantity of water resources, m ³ /a
	3. Realized profit and tax revenue of original value of fixed assets per 10000 Yuan	3. Output of water environment, 10000 Yuan per ton pollutant, m ² /a	3. Demand to water environment, ton pollutant/a	3. Capacity of water environment, ton pollutant /a
		4. Output of atmospheric environment, 10000 Yuan per ton pollutant	4. Demand to atmospheric environment, ton pollutant/a	4. Capacity of atmospheric environment, ton pollutant /a
		5. Output of energy resources 10000 Yuan per ton standard coal	5. Stacked area of solid wastes, m ² /a	5. Available area to stack solid waste, m ² /a
		6. Output of technical labor force 10000 Yuan per capita	6. Demand to technical labor force, person/a	6. Potential growth ability of technical labor forces, person/a
			7. Demand to energy resources, ton Standard coal per year	7. Available quantity of urban energy resources ton standard coal per year
			8. Mined quantity of minerals, ton/a	8. Exploitable quantity of minerals, ton/a
			9. Living space of residents, m ²	9. Potential expand ability of living space, m ²
			10. Urban green land, m ²	10. Urban potential afforesting ability, m ²

* The 9th and 10th are independent calculated, because of having no relation to output value

** Environmental demand and environmental capacity are expressed by the standard quantity of pollutant which transformed by national environmental standard value; water pollutant are expressed by BOD₅, and atmospheric pollutant are expressed by SO₂

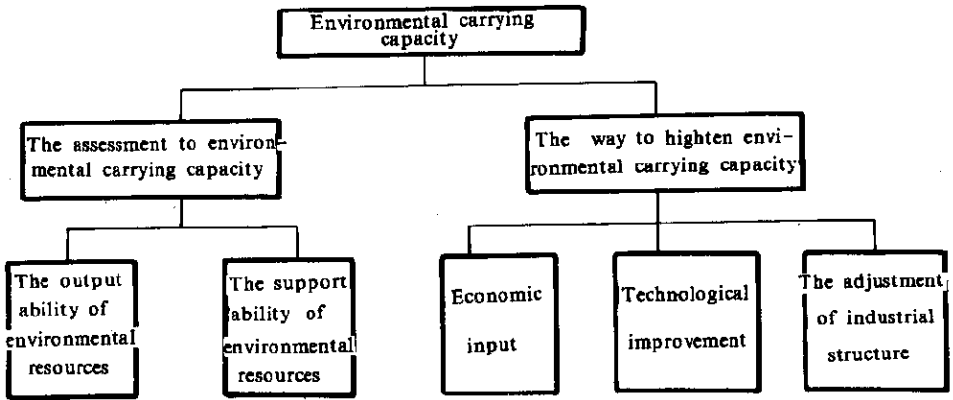


Fig. 1 The research content of ECC

2.3 Parameter selection

On the basis of above-mentioned principles and views, we selected 13 types of output value (according to the classification of industries) as state variables of the system. The classification of these parameters is listed in Table 1.

2.4 Research method

2.4.1 The quantitative expression of industrial structure

The industrial combination property of industry are determined by "Wilford Thomas" approaching method (see 3.1.1).

2.4.2 The structural form of industrial structure and matrix operation

Two vector matrix (matrix A—the demand matrix of environmental resources, satisfied degree) are constructed to describe constitutional type of industrial structure, and assess the influence of industrial structure to ecological environment by operation.

The reciprocal matrix of the demand of industrial structure to environmental ecosystem multiplied by the matrix of support ability of environmental resources is satisfied degree to environmental resources of the industrial structure.

2.4.3 Rationality assessment to industrial structure

The assessment method of factor weight indexes is adopted. Here, three types of factor sets are selected from Table 1; economic profit of industrial structure (E), output ability of environmental resources (P), and satisfied degree to environmental resources (S). Total goal is unity of three profits and perpetual utilization to resources.

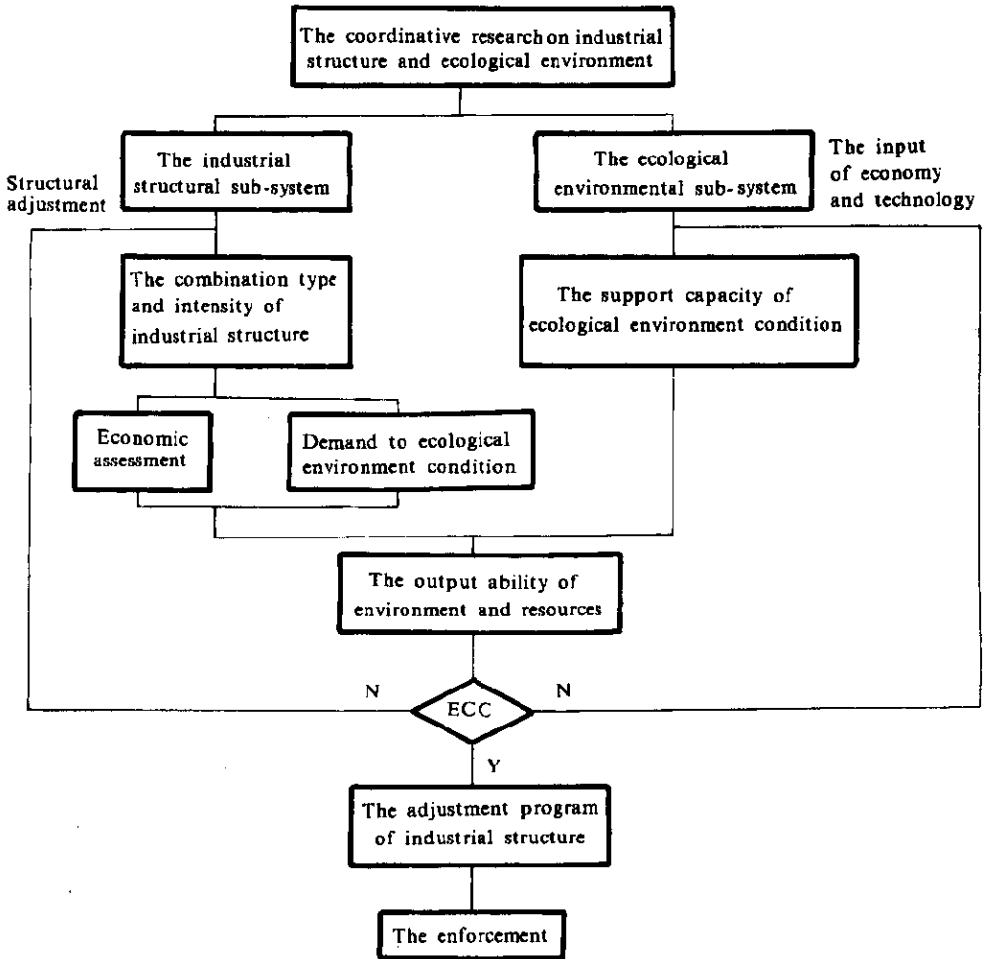


Fig. 2 The research frame diagram

Firstly, we adopt AHP to determine the weight of each key interior element of each factor (the constitution of each factor's key interior elements is in Table 1), and conduct the addition of parameters.

$$E = \sum E_i / E'_i \times W_i; i = 1, 2, 3; \sum W_i = 1;$$

$$P = \sum P_i / P'_i \times W_i; i = 1, 2, \dots, 6; \sum W_i = 1;$$

$$S = \sum S_i \times W_i; i = 1, 2, \dots, 10; \sum W_i = 1.$$

In above formula, E is the economic assessment value; P is the output ratio of en-

vironmental resources; W is the weight coefficient; E'_1 and P'_1 is reference value to divide, here adopt native large and middle cities' average. Then, conduct the overall assessment to industrial structure.

$$SI = EW_E + PW_P + SW_s.$$

W_E , W_P and W_s are weight coefficients, the sum of them is 1. SI (structure index) is the index of structure, its classification index is:

$SI \leq 0.7$: the most unreasonable; $0.7 < SI \leq 0.9$: unreasonable; $0.9 < SI \leq 1.1$: reasonable; $1.1 < SI \leq 1.3$: good $SI > 1.3$: the best.

3. Research on a living example—analysis on the influences of industrial structure on the urban ecological environment in Benxi City

3.1 The characters of Benxi industrial structure

Benxi City is located among the middle cities group of Liaoning Province of China. It is an old industrial city with 50 years history, which developed with the exploitation

Table 2 The industrial output value of each department

Unit: 10000 RMB Yuan, 1990

No.	Industrial department	Output value	Proportion, %
1	Metallurgical industry	405309	62.7
2	Engineering, electronic & electric industry	45810	7.1
3	Chemical industry	43663	6.75
4	Building material industry	32798	5.1
5	Textile industry	32696	5.1
6	Food & drink industry	22844	3.53
7	Metal product industry	16954	2.6
8	Medical industry	13102	2.0
9	Chemical fiber, rubber and plastic industry	11633	1.8
10	Power industry	4201	0.65
11	Coal industry	3146	0.5
12	Excavation industry	2619	0.4
13	Paper-making & paper- made products industry	2431	0.38
14	Other industries	8551	1.32
Total		646834	100

and utilization of plenty coal and iron resources, and had played a major role in native economic development. However, because of the more abnormal industrial structure, the unreasonable industrial distribution and the disadvantageous topographical conditions (a basin surrounded all side by mountains), Benxi urban environment has been seriously polluted, and is named as "invisible city from manmade satellite".

The industrial output value of Benxi accounted for 89% of the whole social total output value (1990). It means that Benxi is a typical industrial city. The output value of each industrial department is listed in Table 2.

Table 3 The calculated values of the type of Benxi City's industrial structure by Thomas method

Industrial type	1	2	3	4	5	6	7	8	9	10	11	12	13	Di
Real distribution	62.7	7.1	6.75	5.2	3.53	2.6	1.8	2.0	1.8	0.65	0.5	0.4	0.38	
S_{0j} , %														
Supposed distribution (I) S_{1j} , %	100	0	0	0	0	0	0	0	0	0	0	0	0	1541
Supposed distribution (II) S_{2j} , %	50	50	0	0	0	0	0	0	0	0	0	0	0	2101
Supposed distribution (III) S_{3j} , %	33.3	33.3	33.3	0	0	0	0	0	0	0	0	0	0	2340

$$d_1 = \sum_{j=1}^{13} (S_{0j} - S_{1j})^2; d_2 = \sum_{j=1}^{13} (S_{0j} - S_{2j})^2; d_3, \dots; j=1, 2, 3, \dots, 13$$

where, S_0 is real value; S_j is supposed distribution value; D_j is minimum value, expressing the type of industrial structure.

Thus we can believe that metallurgical industry (iron and steel) is the principal part of Benxi industry. Meanwhile, Benxi is one of three big chemical industrial cities of Liaoning Province, and the developing potential of building materials industry (cement) is great, so we can conclude that the property of Benxi City is a heavy industry city (mainly with iron and steel, chemical and building materials industry), i. e., a typical raw material industrial city.

3.2 The analysis to environmental carrying capacity (ECC)

According to the method raised in 2.2—2.4, we collect and operate the index of economy, the index of the output ability of environmental resources, the index of the satisfied degree of environmental resources. At the same time, determine its weight by AHP, finally list the results in Table 4.

Table 4 The assessment parameter of Benxi industrial structure

No.	E (i=3)		P (i=6)		S (i=10)	
	E_1/E'_1	W_1	P_1/P'_1	W_1	$d_1/\sum_{j=1}^{13} a_{ij}Y_j$	W_1
1	0.80	0.3	0.91	0.2	0.72	0.21
2	0.85	0.3	0.85	0.2	0.85	0.18
3	0.71	0.4	0.71	0.18	0.33	0.12
4			0.70	0.18	0.33	0.12
5			0.99	0.15	0.10	0.04
6			1.12	0.09	0.82	0.08
7					0.98	0.10
8					1.67	0.04
9					0.61	0.08
10					0.53	0.03
Total	$E=0.779$	$W_E=0.4$	$P=0.85$	$W_P=0.3$	$S=0.68$	$W_S=0.3$

Note: $j=1, 2, \dots, 13; i=1, 2, \dots, 10; SI=0.778$

On the basis of above-mentioned content, we can get following views: (1) The social and economic benefit which is conformed by Benxi industrial structure is low, especially the output value of fixed assets is lower, it means that the ratio of output to input is low; (2) the output ratio of environmental resources is low, especially the output value of environmental pollutants. All in all, the utilization ratio of Benxi environmental resources is on the low side; (3) judged by the satisfied degree of environmental resources, all is very low except the satisfied degree of energy resources and mineral resources. The satisfied degree on the side of environmental pollution (water, atmosphere and slag) is the lowest, it accords with the seriously polluted station of Benxi City; (4) judged by the results of SI (structure index), it is on the low side of unreasonable level, the whole level of ECC (environmental carrying capacity) is low. Therefore, it is very urgently needed to take some proper measures, including appropriate regulation to industrial structure and improvement of environmental resources carrying capacity, to meet the demand of economic development.

3.3 The coordination between structure evolution of industrial structure and ecological environment in Benxi City

The urban function of Benxi City has developed under the condition of regional geographical position and inborn resources. The certain rationality of formed of industrial structure is displayed from the points of resources economy.

But the unreasonability of Benxi industrial structure is clear see. Since raw material

industry has low technical content and high cost, the stress and demand to environmental ecosystem is much larger than other industry. It sharpens the contradictory between economy and environment. So we can say undoubtedly that the change from low technical to high technical industry, from high pollution to low pollution industry is a progress of society. Therefore, Benxi industrial structure should be appropriately adjusted.

How to adjust the structure is a complicated problem. Only the deep research work is done, the adjustment program with rationality, possibility and operability can be put forward. However, the structure adjustment must be step by step and appropriate. The regulation direction of Benxi industrial structure should be as follows: (1) The extension of industrial chain. It means to develop finishing and deeping machining, to raise the additional value of products, to foster following-up industries, to variegate products. For these reasons, Benxi needs to devote major efforts to adjusting industrial structure as well as continuously developing the basic industries, and the variegating of products, the precision of chemical products and the superior quality of building materials is the major direction; (2) the supplement of industrial chain. According to the thoughts of market economy, it is need to foster the raising industry and beneficial type industry, add technical content, and give aid to it as the supplemental type of leading industry, such as the development of medical industry and an integral whole of engineering and electronic industry; (3) the major effort should be devoted to develop the industries which can multistagely utilize energy and resources, and environmental protective industry, to develop green products and energy-economized materials, in order to heighten the maintenance ability of urban ecosystem.

References

- Benxi EPA. Benxi environmental statistical annual. 1980-1991
- Benxi Statistical Bureau. Benxi economic statistical annual, 1986-1991
- Cheng Huai. Introduction to department structure of industry. Beijing: Chinese People's University Press. 1990
- Chinese National Statistical Bureau. Chinese cities statistic annual, 1990-1991
- Editorial Board of Environmental Sciences Big Dictionary. Environmental sciences big dictionary. Beijing: Chinese Environmental Sciences Press. 1991
- Hasler AV. Strategies for the protection of the environment in urban areas. In: A modern approach to the protection of the environment (Ed. by G. B. Marini-Bettolo). Oxford, New York, Pergamon Publishing. 1989
- Zhu Mingchun. Industrial structure, mechanism, policy. Beijing: Chinese People's University Press. 1990

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