

Article

Developing an Evaluation Index System for Enterprise Niche

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Abstract: With the progress of globalization, the environment for enterprises' survival and development has become increasingly complex. More and more enterprises realize that their sustainable competitive advantage is closely related to the development of enterprise niche. Based on the ecostate-ecorole theory, an evaluation index system for enterprise niche is developed in this paper. The study selects indicators based on literature research and frequency analysis, adopts factors including market environment, industrial environment, human resources, and technical resources to evaluate ecostate of enterprise niche, and establishes an evaluation model for ecostate; the research uses factors including policy environment, innovation decision-making ability, resource accessibility, and technical management capability to evaluate ecorole of enterprise niche, and sets up an evaluation model for ecorole by catastrophe progression method. The results of the reliability and validity test showed that the evaluation index system is both reliable and effective. The paper provides implications for the evaluation of enterprise niche.

Keywords: enterprise niche; evaluation index system; ecostate; ecorole; catastrophe progression model



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1. Introduction

In recent years, the basic laws and principles of ecology have gone beyond the field of biology and have been widely introduced into many aspects of society, especially the research of social sciences. As an enterprise and an industrial system are very similar to natural ecological systems, studies on enterprises and industrial ecosystems from the perspective of ecology are becoming increasingly popular, and gradually turning into the mainstream of economics and business management studies [1].

The niche refers to a relationship between an enterprise and an environment, in which a balanced state is achieved after the interaction between the enterprise and the environment. It is influenced by the internal capabilities of the enterprise and is manifested through the material exchange interface between the enterprise and the environment resources and demand [2,3]. With globalization, the environment for enterprises' survival and development has become growingly complicated. More and more enterprises realize that their competitive advantage is closely related to the development of enterprise niche [4–6]. Therefore, to ensure the sustainable development of enterprises, it is important to set up an evaluation index system for enterprise niches to scientifically evaluate the development level of enterprise niches of enterprise, find their own suitable enterprise niche, and ultimately establish an ecological relationship of harmonious symbiosis with the ecological environment and related organizations. However, not much research has been completed on the following questions: Can enterprise niches be evaluated simply like the evaluation of the vitality of living organisms in natural ecosystems? How is an evaluation model for an enterprise

niche constructed? What are the major factors affecting enterprise niche? A framework is needed to develop the outcomes.

This paper, aiming to develop an evaluation index system for enterprise niche, consists of seven sections. The remainder of this paper is organized as follows, Section 2 presents a literature review and theory; Section 3 develops an evaluation index system for enterprise niche; in Section 4, the reliability and validity are tested for the evaluation index system; Section 5 constructs evaluation models for both ecostate and ecorole of enterprise niche; empirical research is shown in Section 6; Section 7 concludes by offering some insights into the development of enterprise niche.

2. Literature Review and Theory

2.1. Enterprise Niche

In recent decades, enterprise niche theory has attracted considerable interest in the study of economics and business management.

There are two major viewpoints in terms of enterprise niche.

From the view of the enterprise population, Hannan and Freeman [7] put forward the concept of species niche in their works and believed that niche is a multi-dimensional resource space occupied by enterprises in strategic environments. An enterprise population can be considered as an enterprise cluster occupying a specific resource space, which is a fundamental niche. Each enterprise in the cluster actually occupies part of or the entire fundamental niche, which is realized niche. On the basis of this, two theoretical viewpoints have been developed [8]: the resource separation of niche [9] and the niche breadth [10,11]. The concept of resource separation of niche focuses on the competitiveness of enterprises, so it emphasizes their operational efficiency; while the niche breadth centers on the ability to stave off the competition of enterprises, thus stressing their wide adaptability.

From the view of the individual enterprises, Baum et al. [12] considered enterprise niche as the characteristics of an enterprise in terms of resource demand and production capacity. An enterprise has its own niche, and an enterprise population is a collection of niches, that is, a group of similar enterprises or a cluster of similar niches constitutes an enterprise population. The possibility of direct competition between enterprises with two niches depends on the degree of similarity—the degree of overlapping in their niches [2].

These two views on enterprise niche can also be interpreted as macro niche and micro niche, respectively [13]. The studies on macro enterprise niche regard enterprise population as the basic unit of niche and focus on how the enterprise group under the same environmental mechanism adapts to the changes in the environment, and how the environment chooses the enterprise population, thus find out the reasons for the diversity and difference of enterprise population. The studies on micro enterprise niche are based on the individual enterprises. They center on the difference between the individual enterprises in the enterprise population and find out the characteristics of the interaction between those enterprises and the niche they occupied. Integrating the above two viewpoints, Liang et al. [14] considered that niche is a clear position of an enterprise and even an industry in the enterprise ecosystem. The niche of enterprises in the industry is an indicator of their competitiveness in the industry. Guo et al. [15] found that the proposal of the concept of enterprise niche reveals the fact that researchers are starting to accept enterprises as non-isolated individuals and pay more attention to the coordination and symbiosis between enterprises and the surrounding environment.

2.2. Ecostate and Ecorole Theory

In 1997, the niche ecostate-ecorole theory and niche expansion hypothesis were developed by Zhu [16]. Zhu suggested that any organism constantly interacts with other organisms and inevitably affects the physical and chemical environment in which it lives. Its status and role must also be reflected in comparison with other organisms under certain environmental conditions.

The niche should include two aspects. The first is the state of the biological unit (energy, biomass, number of individuals, possession of resources, adaptability, intelligence level, economic development level, level of scientific and technological development, etc.), which is the accumulated result of growth and development, learning, socioeconomic development and interacting with surroundings in the past. The second is the biological unit's current influence on or dominance over the environment, such as the rate of exchange of energy and matter, productivity, biological growth rate, economic growth rate, and expanding rate for new niches, etc. The former can be considered as the ecostate of the biological unit, while the latter can be regarded as the ecorole of the biological unit. These two aspects together reveal the relative position and role of specific biological units in the ecosystem.

According to the niche principle in biology, Wan described enterprise niche as "in a certain socioeconomic environment, an enterprise, supported by core technical capabilities and manufacturing capabilities, acquires the ability to survive, develop and compete through the interaction of its sub-processes such as organizational internal strategic management, organizational interface management, marketing management and learning innovation management" [17].

Based on Zhu's niche ecostate-ecorole theory, Yan [18] held that the enterprise niche includes ecostate and ecorole. The ecostate refers to the current state of an enterprise, which is the sum of resource control and other influences accumulated during the interaction of an enterprise with the environment along with the establishment and development of the enterprise; the ecorole refers to the existing and potential impacts of an enterprise on the environment, which determines the future direction of the enterprise and can be equated with the indicators of an enterprise's core competitiveness in corporate strategic research.

Through a literature review, it is found that niche is the relative position and role of an enterprise's interaction with environment in a certain ecosystem. The enterprise niche includes both ecostate and ecorole. Ecostate refers to the result of the coexistence and balance in the interaction between enterprise and market environment, industrial environment, human resources environment, and technical resources environment, whereas ecorole refers to the result of the coexistence and balance in the interaction between enterprise and policy environment, innovation decision-making ability environment, resource accessibility environment, and technical management capability environment. The former reveals the existing influence of an enterprise, while the latter, the future influence.

2.3. Evaluation Index System for Enterprise Niche

In the study of enterprise niche theory, a key issue is the evaluation and measurement of enterprise niche. In order to evaluate and measure enterprise niches, Gao et al. [19] established an evaluation index system for enterprise niches with four factors, i.e., demand, resource, technology, and institution, with each factor requiring a series of sub-factors to reflect the status of enterprise niche. Qian and Zhang [20] set up an enterprise niche match model with six factors consisting of internal resources, culture, external resources, demand, technology, and institution.

Based on enterprise niche ecostate-ecorole theory, Wan [17] established an evaluation index system for enterprise niche. He illustrated enterprise niche as a combination of six types of capabilities (six dimensions), namely, enterprise manufacturing capacity, core technology competence, interface management ability, strategic management ability, core marketing competency, and learning creativity. In each dimension, sub-indicators and weights are designed for the calculation of indicators of enterprise niche. Yan [18] designed an evaluation index system for ecostate with enterprise scale, social influence, and human resources, and designed an evaluation index system for ecorole with four factors, including management ability, marketing ability, technological innovation ability, and organizational management ability. Zhao et al. [21] constructed an evaluation system for Chinese Wind Turbine Manufacturers with resources, technology, and institution. Hillman et al. [22] suggested that policies, legislation, and supervision have a significant impact on the

development of the enterprise niche. Zhang and Gao [23] build a platform enterprise niche factors theoretical model with the characteristics of the platform enterprises. They point out that the user scale, the value transfer ability, and the technological innovation ability are more important for the platform enterprise development.

Based on the literature review, two major limitations are found in the existing research on the evaluation of enterprise niches. Firstly, despite the fact that some factors are of great importance to the development of enterprise niche, the existing evaluation index systems did not include those factors, namely, policy environment, market environment, industrial environment, and technical management capability. Secondly, the reliability and validity of the evaluation index system for enterprise niches were not tested on the basis of large-scale investigations.

3. An Evaluation Index System for Enterprise Niche

3.1. Design Principles of Index System

This research has led to the design and establishment of an evaluation index system for enterprise niche according to the following principles:

(1) Systematic: Relationships between the indicators should be logical. The indicators should reveal not only the historical accumulation of an enterprise at the ecostate level, but also the existing and potential impacts of an enterprise on the environment at the ecorole level. The indicators should be constructed at different levels, from macro to micro, forming an inseparable evaluation system.

(2) Scientific: The design of indicator systems and the selection of evaluation indicators should be scientific, that is, they can objectively and effectively reveal the level of development of the enterprise niche and can objectively and comprehensively reflect the real relationship between indicators.

(3) Representative and non-correlative: The evaluation indicators should be representative and can reveal the characteristics of the enterprise niche as accurately as possible. The correlation and overlapping between indicators should be minimized or avoided. Different and non-correlative indicators should be selected in order to prevent distorted evaluation caused by overlapping indicators.

(4) Feasible and workable: In the selection of indicators, overall consistency should be taken into consideration. The index system serves measurement of enterprise niche. Therefore, the calculation metrics and calculation methods must be consistent and unified. Indicators should be as simple and clear as possible and should have strong feasibility and comparability. Moreover, whether indicators can be processed quantitatively should be considered for the purposes of calculation and analysis.

3.2. Selection of Indicators

Based on the above design principles, an evaluation index system for enterprise niche is constructed as shown in Table 1. The evaluation index system for enterprise niche in this paper includes two dimensions: ecostate and ecorole. The ecostate dimension includes four ecological factors, namely, market environment factor, industrial environment factor, human resources factor, and technical resources factor; the ecorole dimension includes four ecological factors, i.e., policy environment factor, innovation decision-making ability factor, resource accessibility factor, and technical management capability factor.

Table 1. Evaluation index system for enterprise niche.

Dimension	Ecological Factors	Evaluation Index
1. Ecostate	1.1 Market environment factor	1.1.1 Stability of consumer group 1.1.2 Market credit 1.1.3 Fairness, justice, and openness of market supervision
	1.2 Industrial environment factor	1.2.1 Scale of industrial technology association 1.2.2 Integration of industrial chain 1.2.3 Perfection of industrial technology platform constructed by enterprises 1.2.4 Perfection of industrial technology platform constructed by government
	1.3 Human resources factor	1.3.1 Capability of R&D team 1.3.2 Proportion of R&D personnel 1.3.3 Proportion of managers with R&D background 1.3.4 Frequency of R&D personnel training
	1.4 Technical resources factor	1.4.1 Numbers of patents and know-how 1.4.2 Per capita patent ownership rate 1.4.3 R&D success rate
2. Ecorole	2.1 Policy environment factor	2.1.1 Impact of financial policy 2.1.2 Impact of tax policy 2.1.3 Impact of IPR policy 2.1.4 Impact of technology incentives
	2.2 Innovation decision-making ability factor	2.2.1 Senior decision makers' consciousness of technical innovation 2.2.2 Senior decision makers' tolerance for risk and failure 2.2.3 Senior decision makers' ability to predict and evaluate technological innovation
	2.3 Resource accessibility factor	2.3.1 Cooperation with government departments 2.3.2 Cooperation with research institutes 2.3.3 Cooperation with venture capital institutions 2.3.4 Cooperation with entrepreneurial support organizations
	2.4 Technical Management Capability Factor	2.4.1 Incentive of corporate compensation system for technological innovation 2.4.2 Incentive of corporate promotion system for technological innovation 2.4.3 Technical cooperation in R&D, manufacturing, and marketing 2.4.4 Technical cooperation with other enterprises

3.2.1. Selection of Ecostate Dimension Indicators

(1) Market environment factor

The market environment mainly includes market concentration and market system, which are the two major factors affecting the development level of enterprise niche [24–27]. Wan [17] held that the corporate marketing level is an important indicator affecting the development of a niche. Yan [18] believed that market status is an important factor affecting the ecostate level of enterprise niche. Zhao et al. [21] used the capability to control the market and marketing capacity to describe market factors. Huang et al. [28] believed that a fair market environment is conducive to the development of enterprise niches. Based on the above literature, this paper selects stability of consumer group, market credit, fairness, justice, and openness of market supervision to describe the market environment of an enterprise, which is simple and workable.

(2) Industrial environment factors

From an ecological point of view, the development of an enterprise requires an appropriate industrial environment, and a good industrial environment contributes to the

development of the enterprise niche [29]. The existing studies discussed the importance of the industrial environment to corporate development [30–32] but did not introduce industrial environment factors into the evaluation of enterprise niche. In view of the important role of the industrial environment in the development of enterprise niche, this paper selects four factors, i.e., the scale of industrial technology association, integration of industrial chain, perfection of industrial technology platform constructed by enterprises, and perfection of industrial technology platform constructed by the government to describe the industrial environment.

(3) Human resources factor

As the most important resource for corporate development, human resources have drawn universal attention and become an important strategic resource for the core competitiveness of enterprises [18,33]. Yan [18] introduced the human resources factor into the evaluation index system for enterprise niche and adopted educational structure and level, senior management index, and training expense rate as specific evaluation indicators. Hu and Zhang [34] introduced the human resources factor into the technology niche evaluation index system of high-tech enterprises and used a proportion of R&D personnel and a proportion of R&D managers with technical backgrounds as specific evaluation indicators. The human resources factor, an important influencing factor for enterprise innovation, can effectively spur the development of the enterprise niche. This study selects the capacity of the R&D team, the proportion of R&D personnel, the proportion of managers with an R&D technical background, and the frequency of R&D personnel training to describe the human resources factor of an enterprise.

(4) Technical resources factor

Technical resources, the key to enterprise innovation [17,35–37], can effectively promote the development of the corporate niche. Wan's research shows that the core technical capability of an enterprise is an important influencing factor for enterprise niche, and core technological level, development of new products, the input of technological development, and technological output are selected as evaluation indicators [17]. Yan [18] believed that technological innovation ability is an important influencing factor for enterprise niche, and used the input of scientific research funds, level of per capita technical equipment, and success rate of new product development as evaluation indicators. Zhao et al. [21] introduced technical factors into the evaluation index system for enterprise niche for China's wind power generation enterprises and used wind turbine capacity, technology maturity, and technological innovation capability to describe technology factors. Based on the above literature, this paper selects the numbers of patents and know-how, per capita patent ownership rate, and R&D success rate to describe technical resource factors.

3.2.2. Selection of Ecorole Dimension Indicators

Based on prior research this paper selects four factors, namely, policy environment, innovation decision-making ability, resource accessibility, and technical management capability as the secondary indicators.

In the quantitative study, the paper finds that these four indicators may have the characteristics of order parameters, which can be mathematically processed by mutation function. Therefore, it is convenient for us to establish models and apply them. To this end, the paper intends to analyze the systematic characteristics of the four indicators of ecorole based on their connotations in economics and management and analyze whether the evaluation index of ecorole has the characteristics of order parameters to determine whether the model can be constructed by mutation function.

The order parameter is a concept defined by H. Haken, the founder of synergy in describing a self-organizing system and is a state parameter that reflects the change in the degree of order of the system [38]. The evolution direction of the order parameter directly affects the future stability of the system and determines the degree of order of the system. The order parameters specified in synergy should have the following characteristics [16,39]:

① An order parameter is generated by cooperation and synergy between a large number of sub-systems within the system; ② An order parameter dominates subsystem movement; ③ An order parameter is a long-lived slow relaxing variable that exists in the system for a long time; ④ An order parameter is an extremely active and unstable transformation factor in the system; ⑤ An order parameter is a main parameter to measure the degree of order within the system. Four factors, i.e., policy environment, innovation decision-making ability, resource accessibility, and technical management capability are evaluated according to the above five characteristics of order parameters.

(1) Policy environment factor

The policy environment is one of the most important factors affecting corporate innovation and strategic choice [40] and is also the key to the development of enterprise niches. From the literature review, the study found that the existing literature discussed the importance of policy environment to the development of enterprises [2,41–43] but did not introduce policy environment factors into the evaluation of enterprise niche. In view of the important role of the policy environment in the development of enterprise niche, this paper selects the impact of financial policy, the impact of tax policy, the impact of intellectual property rights (IPR) policy, and the impact of technology incentives to describe the policy environment factor. The policy environment factor has the characteristics and conditions that order parameters should have [2]. From the perspective of the enterprise ecosystem, a policy is an important order parameter for maintaining enterprise order, and it reflects the will of a social central system in the enterprise ecology. Only by realizing the organic combination of the policy environment and production management can an enterprise ensure the orderliness of its system.

(2) Innovation decision-making ability factor

Simon believed that organizational behavior is a complex network of many decision-making processes, which shows the importance of innovative decision-making ability to the enterprise. Innovation decision-making ability affects the direction and speed of the development of enterprise technology, which in turn affects the development of enterprise niches [34]. Wan [17], when evaluating enterprise niche, selected four indicators to describe innovation decision-making ability. The indicators are senior corporate decision-makers' tolerance for risks and failures, senior corporate decision-makers' attention to new business areas, senior corporate decision-makers' accurate judgment of the dynamics of industrial competition, and senior corporate decision makers' ability to properly handle emergencies [43]. Based on the above-mentioned literature, this paper selects senior decision makers' consciousness of technical innovation, senior decision makers' tolerance for risk and failure, and senior decision makers' ability to predict and evaluate technological innovation to describe corporate innovation decision-making ability. Innovation decision-making ability is produced by cooperation and synergy among various departments within an enterprise. It is a product of cooperation between different departments and dominates the behaviors of those departments. It is the most important factor for the external evaluation of internal orderliness, and a long-lived variable. Therefore, the innovation decision-making ability factor is an order parameter of enterprise niche.

(3) Resource accessibility factor

An enterprise's ability to access resources directly determines the formulation and implementation of corporate strategies and affects the development of the enterprise niche. Qu [44] studied the effect of functional routes of resource accessibility cognition on enterprises' growth performance through entrepreneurial orientation. To describe resource accessibility, Zhao et al. [21] proposed three indicators, i.e., cooperation with universities and research institutes in R&D, the establishment of technical alliances with other enterprises, and government support. On the basis of the above-mentioned literature, this paper selects four indicators to evaluate resource accessibility, namely, cooperation with government departments, cooperation with research institutes, cooperation with venture

capital institutions, and cooperation with entrepreneurial support organizations such as law firms, taxation bureaus, management consulting firms, etc. These indicators are the concrete manifestation of an enterprise's ability to access resources, the result of interaction between an enterprise and its external environment, and the most important factor for evaluating the orderliness of an enterprise. An enterprise's ability to access resources directly affects its competitive advantage and orderly operation. It is a long-lived slow relaxation variable that exists in the system for a long time and plays a decisive role in the overall evolution of the system. Therefore, the resource accessibility factor is an order parameter of enterprise niche.

(4) Technical management capability factor

The main task of enterprise technology management is to promote scientific and technological progress and the development of niche, and constantly improve the labor productivity and economic benefits of an enterprise. Enterprises should make long-term investments in technology management capability, and continuously improve technology management capability [45]. The improvement of technical management capability mainly includes technology scanning capability, evaluation technique, optimization of organization, enrichment of technological sources, enhancement of absorptive capacity, protection of intellectual property rights, and monitoring of technological status [46]. Wan [17] described the technical management capability by selecting the frequency of information exchange between technical researchers and product developers within an enterprise, and the effectiveness of information exchange between technical researchers and product developers within an enterprise. On the basis of the above-mentioned literature, to describe the technical management capability factor, this paper selects four indicators, namely, the incentive of the corporate compensation system for technological innovation, the incentive of corporate promotion system for technological innovation, technical cooperation in R&D, manufacturing and marketing, and technical cooperation with other enterprises. Technical management capability factor has typical characteristics of an order parameter [2]. Schumpeter held that technological innovation is an endogenous process of economic activities, that is, the inherent strength from economic activities drives technological development; technical management capability optimizes the whole organization and improves its overall efficiency; technical management capability is a "revolutionary" factor that breaks the old balance of the system and upgrades to a new higher structure; it is also the main parameter to measure the degree of order of the evolution of a corporate system.

4. Reliability and Validity Test

4.1. Data and Sample

In this study, the status quo of the enterprise niche was obtained through a questionnaire survey by the administrative committee of the Guangzhou development zone. Taking the enterprises which involving the manufacturing, bioindustry, new materials, new energy, electronic information, and other industries in China as respondents, 218 copies of questionnaires were sent out, and 200 questionnaires were taken back. Among them, 190 were valid and 10 were deemed invalid for they were incompletely filled, so the effective response rate was 87.16%, as shown in Table 2.

Table 2. Statistics of sample enterprises.

Background Information of Sample Enterprise		Frequency	Frequency Ratio (%)
Industry involved	Electronic information	55	28.57
	Bioindustry	48	25.71
	New material	16	8.42
	New energy	16	8.42
	Manufacturing	26	13.68
	High-tech service industry	20	10.5
	other	9	4.7

4.2. Reliability Test

In this study, the Cronbach α reliability coefficient is adopted to analyze the internal consistency of the project, and the SPSS statistical software is used for reliability analysis. The reliability coefficients of each variable are shown in Table 3. The total reliability of the questionnaire is $0.908 \geq 0.800$, so the internal consistency test of the reliability of the sample is passed to ensure the reliability of the questionnaire.

Table 3. Reliability coefficient.

Variable Name	α Reliability Coefficient	Reference Values
Market environment factor	0.747	$\alpha \geq 0.650$
Industrial environment factor	0.884	
Human resources factor	0.784	
Technical resources factor	0.746	
Policy environment factor	0.747	
Innovation decision-making ability factor	0.820	
Resource accessibility factor	0.751	
Technical management capability factor	0.867	
Total reliability	0.908	$\alpha \geq 0.800$

4.3. Validity Test

The validity analysis of this study mainly examines the Kaiser–Meyer–Olkin (KMO) Measure of Sampling Adequacy and Bartlett’s Test of Sphericity. The SPSS statistical software is used for validity analysis. The KMO value of each variable satisfies the requirement of not less than 0.6 as can be seen in Table 4, and the total validity of the questionnaire is $0.856 \geq 0.800$, so the validity of the sample is verified to ensure the validity of the questionnaire.

Table 4. Validity coefficient.

Variable Name	KMO Values	Sig	Reference Values
Market environment factor	0.613	0.000	KMO Value ≥ 0.6
Industrial environment factor	0.817	0.000	
Human resources factor	0.67	0.000	
Technical resources factor	0.684	0.000	
Policy environment factor	0.709	0.000	
Innovation decision-making ability factor	0.713	0.000	
Resource accessibility factor	0.673	0.000	
Technical management capability factor	0.730	0.000	
Total Validity	0.856	0.000	

5. Evaluation Model

5.1. Evaluation Model for Ecostate

5.1.1. Index Weight

According to the analysis of the indicators in Section 3.2, the ecostate factors of enterprise niche mainly includes market environment factor, industrial environment factor, human resources factor, and technical resources factor. According to the characteristics of the indicators of ecostate factors, the weight is calculated by the analytic hierarchy process, as shown in Table 5.

Table 5. Weights for the indicators of ecostate factors.

Dimension	Ecological Factors	Weight r_i	Evaluation Index	Weight r_{ij}
1. Ecostate (ES)	1.1 Market environment factor (ES ₁)	$r_1 = 0.154$	1.1.1 Stability of consumer group (ES ₁₁)	$r_{11} = 0.429$
			1.1.2 Market credit (ES ₁₂)	$r_{12} = 0.142$
			1.1.3 Fairness, justice, and openness of market supervision (ES ₁₃)	$r_{13} = 0.429$
	1.2 Industrial environment factor (ES ₂)	$r_2 = 0.069$	1.2.1 Scale of industrial technology association (ES ₂₁)	$r_{21} = 0.375$
			1.2.2 Integration of industrial chain (ES ₂₂)	$r_{22} = 0.125$
			1.2.3 Perfection of industrial technology platform constructed by enterprises (ES ₂₃)	$r_{23} = 0.125$
			1.2.4 Perfection of industrial technology platform constructed by government (ES ₂₄)	$r_{24} = 0.375$
	1.3 Human resources factor (ES ₃)	$r_3 = 0.389$	1.3.1 Capability of R&D team (ES ₃₁)	$r_{31} = 0.195$
			1.3.2 Proportion of R&D personnel (ES ₃₂)	$r_{32} = 0.504$
			1.3.3 Proportion of managers with R&D background (ES ₃₃)	$r_{33} = 0.195$
			1.3.4 Frequency of R&D personnel training (ES ₃₄)	$r_{34} = 0.106$
	1.4 Technical resources factor (ES ₄)	$r_4 = 0.389$	1.4.1 Numbers of patents and know-how (ES ₄₁)	$r_{41} = 0.142$
			1.4.2 Per capita patent ownership rate (ES ₄₂)	$r_{42} = 0.429$
			1.4.3 R&D success rate (ES ₄₃)	$r_{43} = 0.429$

5.1.2. Model Building

According to the evaluation index system (see Table 1) and the corresponding weights, the evaluation model for the ecostate factor of enterprise niche is established.

The objective function is:

$$ES = \sum_{i=1}^4 r_i \times ES_i, \tag{1}$$

The constraints are:

$$\left\{ \begin{array}{l} ES_1 = \sum_{j=1}^3 r_{1j} \times ES_{1j} \\ ES_2 = \sum_{j=1}^4 r_{2j} \times ES_{2j} \\ ES_3 = \sum_{j=1}^4 r_{3j} \times ES_{3j} \\ ES_4 = \sum_{j=1}^3 r_{4j} \times ES_{4j} \end{array} \right. , \tag{2}$$

where ES is the ecostate of enterprise niche, ES_{ij} is the evaluation index, and r_i, r_{ij} is index weight.

5.2. Evaluation Model for Ecorole

Because the policy environment factor, innovation decision-making ability factor, resource accessibility factor, and technical management capability factor are consistent with the characteristics of order parameters, this paper uses the catastrophe progression model to evaluate the ecorole of enterprise niche.

The catastrophe progression method is a method that divides the evaluation object into multiple levels, then combines the bifurcation set equation derived from the catastrophe theory with the membership function of fuzzy evaluation, constructs the multi-dimensional catastrophe fuzzy membership function, deduces the normalization formula, and then

gradually induces the total target score from the normalization formula, and finally obtains the objective evaluation ranking method. As shown in Formula (3)–(6), there are four common normalization formulas [47].

(1) Folded

$$x_a = \sqrt{a}, \tag{3}$$

(2) Spire

$$x_a = \sqrt{a}, x_b = \sqrt[3]{b}, \tag{4}$$

(3) Coattail

$$x_a = \sqrt{a}, x_b = \sqrt[3]{b}, x_c = \sqrt[4]{c}, \tag{5}$$

(4) Butterfly

$$x_a = \sqrt{a}, x_b = \sqrt[3]{b}, x_c = \sqrt[4]{c}, x_d = \sqrt[5]{d}, \tag{6}$$

According to the characteristics of the relevant parameters, the evaluation model is shown in Figure 1.

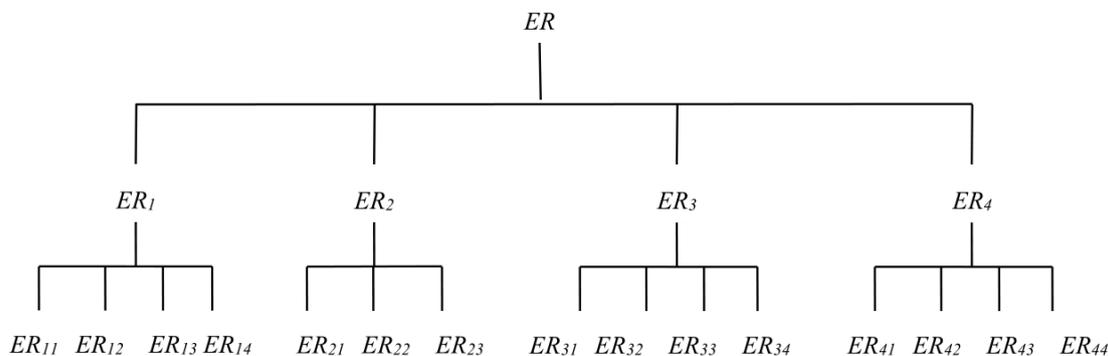


Figure 1. Model for ecorole of enterprise niche.

5.3. Evaluation Model for Enterprise Niche

In this study, the evaluation model for enterprise niche proposed by Yan is adopted [18].

$$EN = w_1 \times ES + w_2 \times ER, \tag{7}$$

In the formula, *EN* is enterprise niche; *ER* is the ecostate of enterprise niche; is the ecorole of enterprise niche, $w_1 = 1$ is the weight of ecostate factor, and $w_2 = 2$ is the weight of ecorole factor [18].

The weight coefficients of ecostate and ecorole in the model represent the contribution of the two to the enterprise niche; the weight coefficient of the ecostate factor essentially reflects the contribution of the index of each dimension to ecostate, and the weight coefficient of the corresponding evaluation index of each dimension reflects the contribution of the evaluation indicators to each dimension. The ecorole factor is not weighted because the mutation evaluation method used in the calculation of niche values below does not require a weighting factor.

6. Empirical Research

6.1. Selection of a Sample

In this study, from 190 valid questionnaires 30 enterprises was selected for the empirical research based on their representativeness in terms of their nature, scales, and their positions in the whole industry.

6.2. Measure of Ecostate

Based on the evaluation model for ecostate, the raw data of the enterprises E1, E2, ..., E30 are substituted into the Formula (1)–(2), and the ecostate values of the niche of

30 enterprises can be obtained (See Table 6). Take the enterprise E1 as an example, its calculation process is as follows:

$$\begin{aligned}
 ES &= \sum_{i=1}^4 r_i \times ES_i = r_1 \times ES_1 + r_2 \times ES_2 + r_3 \times ES_3 + r_4 \times ES_4 \\
 &= r_1 \left(\sum_{j=1}^3 r_{1j} \times ES_{1j} \right) + r_2 \left(\sum_{j=1}^4 r_{2j} \times ES_{2j} \right) + r_3 \left(\sum_{j=1}^4 r_{3j} \times ES_{3j} \right) + r_4 \left(\sum_{j=1}^3 r_{4j} \times ES_{4j} \right) \\
 &= 0.154 \times 1 + 0.069 \times 0.625 + 0.389 \times 0.728 + 0.389 \times 0.893 \\
 &= 0.827
 \end{aligned}$$

Table 6. Ecostate values of enterprise niche of 30 enterprises.

Name	ES ₁	ES ₂	ES ₃	ES ₄	Ecostate	Name	ES ₁	ES ₂	ES ₃	ES ₄	Ecostate
E1	1	0.625	0.728	0.893	0.827	E16	0.750	0.656	0.925	0.715	0.798
E2	0.607	0.500	0.777	0.607	0.666	E17	1.000	0.656	0.571	0.465	0.602
E3	0.500	0.438	0.549	0.500	0.515	E18	0.750	0.281	0.522	0.357	0.477
E4	0.678	0.500	0.774	0.893	0.787	E19	0.786	0.500	0.925	0.607	0.751
E5	0.750	0.344	0.598	0.786	0.677	E20	0.571	0.844	0.598	0.643	0.629
E6	0.857	0.844	0.947	0.643	0.809	E21	0.500	0.500	0.752	0.715	0.682
E7	0.536	0.656	0.898	0.357	0.616	E22	0.536	0.500	0.474	0.500	0.496
E8	0.500	0.594	0.445	0.465	0.472	E23	0.643	0.563	0.646	0.500	0.584
E9	0.643	0.281	0.575	0.393	0.495	E24	0.750	0.750	0.825	0.715	0.766
E10	0.857	0.719	0.598	0.715	0.692	E25	0.536	0.250	0.451	0.357	0.414
E11	0.607	0.563	1.000	0.465	0.702	E26	0.536	0.594	0.750	0.822	0.735
E12	0.893	0.906	0.695	0.893	0.828	E27	0.428	0.500	0.746	0.250	0.488
E13	0.965	0.500	0.679	0.571	0.669	E28	0.428	0.750	0.701	0.571	0.613
E14	0.643	0.406	0.376	0.500	0.468	E29	0.643	0.531	0.527	0.465	0.521
E15	0.750	0.250	0.728	0.715	0.694	E30	0.500	0.281	0.701	0.786	0.675

6.3. Measure of Ecorole

Based on the general formulae as shown in Formula (3)–(6), the evaluation parameter of the ecorole can be obtained by calculating from the bottom of the inverse tree hierarchy. Since there are some complementary influences between the middle and bottom indexes in the model, the value of ER can be obtained by calculating their average. Based on the evaluation model for ecorole, the raw data of the enterprises E1, E2, . . . , E30 are substituted into the Formula (3)–(6), and the ecorole values of the niche of 30 enterprises can be obtained (See Table 7). Take the enterprise E1 as an example, its mutation model is shown as Figure 2. The bottom of the model is the dimensionless values of the initial data to niche indexes, then the values of ER₁, ER₂, ER₃, ER₄ can be calculated upwards based on the general formulae until the evaluation parameter ER of the ecorole of enterprise niche is finally obtained.

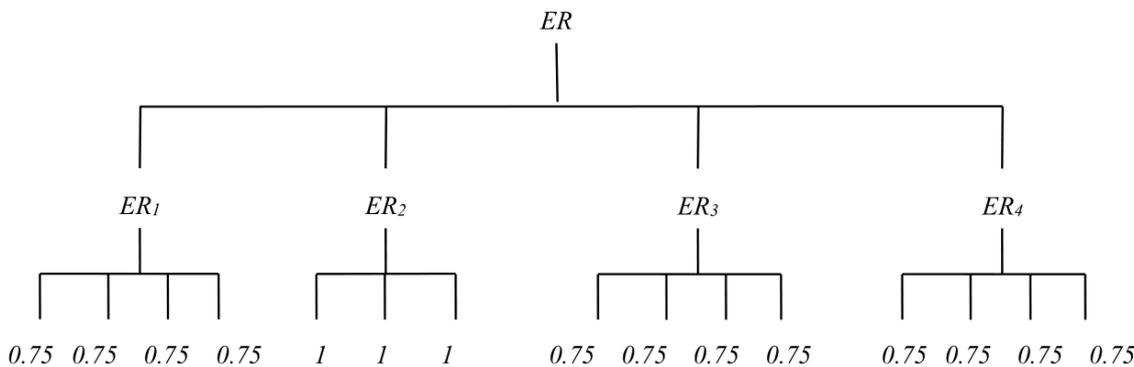


Figure 2. Model for ecorole of enterprise niche of E1.

Table 7. Ecorole values of enterprise niche of 30 enterprises.

Name	ER ₁	ER ₂	ER ₃	ES ₄	Ecorole	Name	ER ₁	ER ₂	ER ₃	ES ₄	Ecorole
E1	0.918	1	0.918	0.918	0.958	E16	0.700	1.000	0.798	0.912	0.837
E2	0.893	0.834	0.695	0.912	0.913	E17	0.967	0.946	0.927	0.917	0.981
E3	0.729	0.946	0.901	0.803	0.854	E18	0.832	0.834	0.375	0.844	0.783
E4	0.901	0.878	0.946	0.835	0.949	E19	0.949	0.946	0.890	0.912	0.971
E5	0.844	0.946	0.803	0.873	0.919	E20	0.750	0.902	0.928	0.843	0.866
E6	0.898	0.946	0.904	0.944	0.947	E21	0.729	0.781	0.500	0.825	0.841
E7	0.803	0.902	0.890	0.844	0.896	E22	0.930	0.834	0.873	0.803	0.941
E8	0.775	0.946	0.227	0.751	0.690	E23	0.913	0.779	0.930	0.861	0.920
E9	0.821	0.902	0.741	0.825	0.966	E24	0.912	0.834	0.917	0.930	0.941
E10	0.873	1.000	0.838	0.912	0.934	E25	0.736	0.834	0.541	0.844	0.858
E11	0.969	0.946	0.838	0.912	0.957	E26	0.944	0.849	0.854	0.803	0.947
E12	1.000	0.946	0.950	0.986	0.982	E27	0.912	0.834	0.817	0.825	0.941
E13	0.649	1.000	0.927	0.930	0.805	E28	0.935	0.946	0.912	0.944	0.967
E14	0.835	0.946	0.524	0.884	0.851	E29	0.854	0.834	0.850	0.821	0.924
E15	0.912	0.834	0.872	0.821	0.941	E30	0.854	0.902	0.828	0.821	0.924

ER₁ is a butterfly form mutation function, and according to the general Formula (6), we can get that $ER_{11} = \sqrt{0.75} = 0.886$, $ER_{12} = \sqrt[3]{0.75} = 0.909$, $ER_{13} = \sqrt[4]{0.75} = 0.931$, $ER_{14} = \sqrt[5]{0.75} = 0.944$. Then calculate the average value according to the principle of the mutual complementarities:

$$ER_1 = \frac{(ER_{11} + ER_{12} + ER_{13} + ER_{14})}{4} = 0.918.$$

ER₂ is a coattail form mutation function, and according to the general Formula (5), we can get that $ER_{21} = \sqrt{1} = 1$, $ER_{22} = \sqrt[3]{1} = 1$, $ER_{23} = \sqrt[4]{1} = 1$. Then calculate the average value according to the principle of the mutual complementarities:

$$ER_2 = \frac{(ER_{21} + ER_{22} + ER_{23})}{3} = 1.$$

ER₃ is a butterfly form mutation function, and according to the general Formula (6), we can get that $ER_{31} = \sqrt{0.75} = 0.886$, $ER_{32} = \sqrt[3]{0.75} = 0.909$, $ER_{33} = \sqrt[4]{0.75} = 0.931$, $ER_{34} = \sqrt[5]{0.75} = 0.944$. Then calculate the average value according to the principle of the mutual complementarities:

$$ER_3 = \frac{ER_{31} + ER_{32} + ER_{33} + ER_{34}}{4} = 0.918.$$

ER₄ is a butterfly form mutation function, and according to the general Formula (6), we can get that $ER_{41} = \sqrt{0.75} = 0.886$, $ER_{42} = \sqrt[3]{0.75} = 0.909$, $ER_{43} = \sqrt[4]{0.75} = 0.931$, $ER_{44} = \sqrt[5]{0.75} = 0.944$. Then calculate the average value according to the principle of the mutual complementarities:

$$ER_4 = \frac{ER_{41} + ER_{42} + ER_{43} + ER_{44}}{4} = 0.918.$$

ER is a butterfly form mutation function, and according to the general Formula (6), we can get that $ER_a = \sqrt{0.918} = 0.958$, $ER_b = \sqrt[3]{1} = 1$, $ER_c = \sqrt[4]{0.918} = 0.979$, $ER_d = \sqrt[5]{0.918} = 0.983$.

As the factors of the ecorole of enterprise niche can affect the ecorole directly and independently, and their complementary relationship is relatively small, according to the Fuzzy Theory, the top index ER is the minimum amongst ER₁, ER₂, ER₃, ER₄. So, the parameter ER of E1 is $ER = \min(ER_a, ER_b, ER_c, ER_d) = 0.958$.

6.4. Measure of Enterprise Niche

Based on the calculation model for enterprise niche, the original data of the enterprises E1, E2, . . . , E30 are substituted into the Formula (7), and the enterprise niche can be obtained, as shown in Table 8. Take the enterprise E1 as an example, its calculation process is as follows:

$$EN = w_1 \times ES + w_2 \times ER = 1 \times 0.827 + 2 \times 0.958 = 2.743$$

Table 8. Values of enterprise niche of 30 enterprises.

Name	Ecostate	Ecorole	Enterprise Niche	Name	Ecostate	Ecorole	Enterprise Niche
E1	0.827	0.958	2.743	E16	0.798	0.837	2.472
E2	0.666	0.913	2.493	E17	0.602	0.981	2.564
E3	0.515	0.854	2.222	E18	0.477	0.783	2.042
E4	0.787	0.949	2.686	E19	0.751	0.971	2.694
E5	0.677	0.919	2.515	E20	0.629	0.866	2.361
E6	0.809	0.947	2.703	E21	0.682	0.841	2.364
E7	0.616	0.896	2.408	E22	0.496	0.941	2.378
E8	0.472	0.690	1.852	E23	0.584	0.920	2.424
E9	0.495	0.966	2.307	E24	0.766	0.941	2.648
E10	0.692	0.934	2.560	E25	0.414	0.858	2.130
E11	0.702	0.957	2.616	E26	0.735	0.947	2.629
E12	0.828	0.982	2.782	E27	0.488	0.941	2.370
E13	0.669	0.805	2.279	E28	0.613	0.967	2.547
E14	0.468	0.851	2.169	E29	0.521	0.924	2.370
E15	0.694	0.941	2.576	E30	0.675	0.924	2.523

The top six enterprises in the values of ecostate of enterprise niche are E12, E1, E6, E16, E4, and E24, with scores of 0.828, 0.827, 0.809, 0.798, 0.787, and 0.766, respectively. Based on the scores of the four ecological factors (market environment factor, industrial environment factor, human resources factor, and technical resources factor) of those six enterprises, the spider diagram is drawn, as shown in Figure 3. By comparing the scores of those four ecological factors, this study found that the market environment factor and human resources factor are the two most important factors affecting the ecostate value of the enterprise niche.

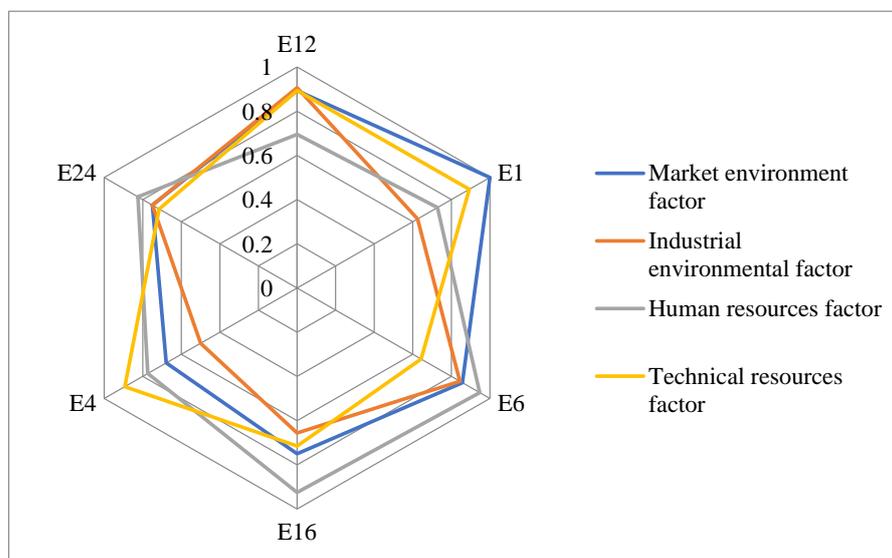


Figure 3. Spider diagrams of ecostate.

The top six enterprises in the values of ecorole of enterprise niche are E12, E17, E19, E28, E9, and E11 with scores of 0.982, 0.981, 0.971, 0.967, 0.966, and 0.957, respectively. Based on the scores of the four ecological factors (policy environment factor, innovation decision-making, resource accessibility factor, and technical management capability factor) of those six enterprises, the spider diagram is drawn, as shown in Figure 4. By comparing the scores of those four ecological factors, this study found that the policy environment factor and innovation decision-making ability factor are the two most important factors affecting the ecorole value of the enterprise niche.

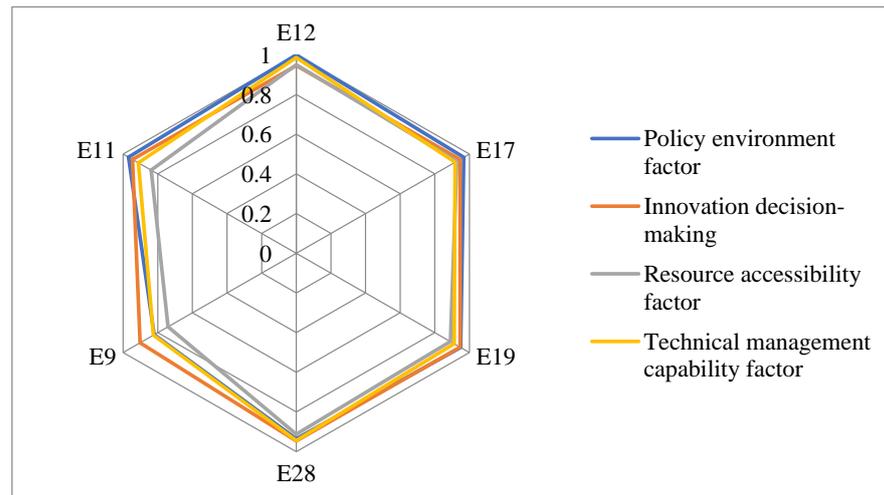


Figure 4. Spider diagrams of ecorole.

The top six enterprises in the enterprise niche are E12, E1, E6, E19, E4, and E24 with scores of 2.782, 2.738, 2.703, 2.694, 2.686, and 2.648, respectively. Based on the scores of the eight ecological factors (market environment factor, industrial environment factor, human resources factor, technical resources factor, policy environment factor, innovation decision-making, resource accessibility factor, technical management capability factor) of those six enterprises, the spider diagram is drawn (see Figure 5). By comparing the scores of those eight ecological factors, this study found that the market environment factor, human resources factor, policy environment factor, and innovation decision-making are the four most important factors affecting enterprise niches.

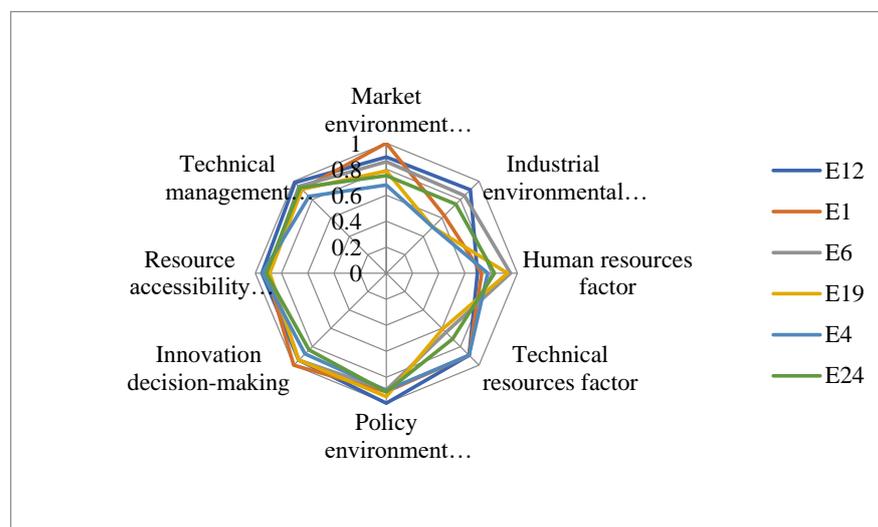


Figure 5. Spider diagrams of enterprise niche.

7. Discussion and Conclusions

This study attempts to bridge some of the many gaps in our understanding of the evaluation index system for enterprise niche. To this end, an evaluation framework has been developed based on ecostate-ecorole theory. Based on investigation, interview, and statistical data, the 190 local major Chinese enterprises were selected as a sample to test the reliability and validity of the evaluation index system for enterprise niches. The reliability and validity test show that the total reliability is $0.908 \geq 0.800$; thus, the evaluation index system is reliable, and the total validity is $0.856 \geq 0.800$; thus, the evaluation index system is effective. On the basis of establishing an evaluation database for enterprise niche, the evaluation index system proposed in this paper was applied to the self-evaluation of any enterprise to find out its weaknesses and make timely improvements, thus raising the development level of enterprise niche.

There are three main research findings in this paper. First, based on the ecostate-ecorole theory, the enterprise niche is composed of ecostate and ecorole. The ecostate of enterprise niche can be evaluated and measured from four dimensions, namely, market environment factor, industrial environment factor, human resources factor, and technical resources factor, which correspond to 14 specific evaluation indicators such as stability of consumer group, the scale of industrial technology association and capability of the R&D team. Secondly, the ecorole of enterprise niche can be evaluated and measured from four dimensions, namely, policy environment factor, innovation decision-making ability factor, resource accessibility factor, and technical management capability factor, which correspond to 15 specific evaluation indicators such as the impact of financial policy, senior decision makers' tolerance for risk and failure and technical cooperation with other enterprises. Third, on the basis of developing the evaluation index system for enterprise niche, an evaluation model for enterprise niche was established. Based on the investigation, interview, and statistical data, the 30 local Chinese major enterprises were selected as a sample to evaluate the development level of their enterprise niche. The empirical research shows that the market environment factor and human resources factor are the two most important factors affecting the ecostate value of an enterprise niche and that the policy environment factor and innovation decision-making ability factor are the two most important factors affecting the ecorole value of an enterprise niche.

The theoretical contributions of this study are mainly in the following two aspects. First, it expands the related research on the evaluation of enterprise niche, develops the evaluation index system, and makes an expansion of the existing literature. Wan [17], Yan [18], Gao et al. [19], Qian and Zhang [20], Zhao et al. [21], Hillman et al. [22], and Zhang and Gao [23] have discussed this issue in depth, and this has become an important theoretical basis for the study. However, some important indicators for the development of firm's ecological niche do not appear in the above literature, such as policy environment, market environment, industrial environment and technical management capability. Based on the literature [17–23], this study incorporates the above indicators into the study of enterprise niche evaluation based on the ecostate-ecorole theory and develops a more complete index system for enterprise niche evaluation, which provides theoretical support for the evaluation and measurement of enterprise niches. Second, this paper expands the scope of application of ecostate-ecorole theory. Ecostate-ecorole theory were developed by Zhu [16]. This paper extends the theory from the study of organisms or biological units to the study of enterprise niche, and the evaluation and measurement of enterprise niches, which further enriches and improves the theory of the enterprise niche. This, in turn, has expanded the scope of application of ecostate-ecorole theory.

The management insights of this study: first, the strategy of a firm must be adjusted or redesigned along with the changes in the enterprise niche of the firm. Currently, the competitive environment of enterprises has become more and more intricate and complex, showing ecological characteristics that challenge the traditional innovation theories and paradigms dominated by static, localized, and linear thinking [48]. Faced with the new competitive environment of complexity and uncertainty, the design difficulty of enterprise

innovation strategy grows exponentially, and the original meaning of ex ante decision making, proactive decision making and rational decision making must be shifted to the combination of ex ante decision making and ex post decision making, proactive decision making and reflective decision making, rational decision making and irrational decision making, and static decision making and dynamic decision making. How do we portray these complex situations? The enterprise niche is an ideal choice. Enterprise niche is an equilibrium state formed by the interaction of enterprise and enterprise, enterprise and environment. Therefore, enterprises should dynamically adjust or redesign their strategies according to the changes in the enterprise niche. Secondly, the empirical research suggests that improvement of the market environment and strengthening of human resources management can promote the development of ecostate of enterprise niche, that is, to enhance an enterprise's realistic impact on or dominance over the environment, and that optimization of the policy environment and enhancement of innovation decision-making ability can advance the development of ecostate of enterprise niche, that is, to increase an enterprise's future influence on or dominance over the environment.

Limitations of the study: This study also has some limitations. Similar to most studies of enterprise niches, this paper has a small sample size and adopts the usual international cross-sectional survey method, but for corporate ecological niches that need to be tested over a longer period of time, a multi-stage survey is more credible. In future studies, it is worthwhile to consider adopting a multi-stage survey method while reasonably increasing the sample size.

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