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Regional Leading Industry Selection Based on an Extended Fuzzy VIKOR Approach

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ABSTRACT

To improve the deployment and optimization of the industrial structure, researchers and practitioners have performed a variety of researches in terms of regional leading industry selection based on AO Hirschman, Rostow, and Miyohei's principles. The criteria and methods employed in previous studies are mainly based on the mass industrial development data, leading to the limitation of study on the application in new high-tech district and underdeveloped regions. Due to lack of industrial data and detail industry information, it is difficult to employ the deterministic regional industry selection model. Therefore, an extended fuzzy-VIKOR approach that the expert-based and trapezoidal fuzzy number decision-making techniques embedded into the VIKOR steps is proposed. It is developed to solve the regional leading industry selection problems concerning industrial, economic, social, and environmental dimensions. Finally, a case study for the industrial planning of a high-tech zone is applied to verify the proposed decision-making approach.

KEYWORDS

Extended Fuzzy Extended VIKOR, Information Entropy, Multi-Criteria Decision-Making (MCDM), Regional Leading Industry, Selection Benchmark

INTRODUCTION

Leading industry, with the characteristics of a broad market prospect, large development scale, high industrial relevance and high technical precision, is the most crucial sector that plays a significant role in regional economic development in a certain period. Regarding as the foundation of national economic development and the core of promoting the steady growth of the regional economy, the leading industry is of great significance on regional strategy achievement (Yaochen & Lijun, 2008). Scientific leading industrial establishment contributes to the regional coordination development with

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other industrial sectors, can also assist to upgrade transformation of regional industry-structure (Chen & Xiong, 2015; Sifeng et al., 1998). Besides, the leading industry identification and its coordination with other industrial sectors will also play an exemplary role on regional development.

The leading industry identification involves in research area of spatial geography and industrial economics. Under the atmosphere of increasing global economic and supply chain management, the dynamic benchmark and higher requirement make it difficult to establish a leading industry (Yaochen & Lijun, 2008). Due to the characteristics of spatial heterogeneity, the selection criteria of regional leading industry must focus on advantageous industry and characteristic economy. The selection benchmarks of regional leading industry mainly include the Hirschman benchmark, the Rostow benchmark and the Miyohei benchmark (income elasticity coefficient and productivity increase benchmark). Zejing & Huijun (2017), who has studied the leading industry upgrade and reconstruction path of Jiangsu Province from the perspective of industrial upgrading and global value chains, regards that the leading industry is significant source of regional competitiveness improvement as well as industrial value chain upgrading and reconstruction. According to the demand characteristics of different regional industry, academic circle's benchmarks, theoretical and empirical studies on the choice of leading industry vary from each other, but mostly based on the Hirschman benchmark, the Rostow benchmark and the Miyohei benchmark (Lam et al., 2017; Y.-q. Liu et al., 2006; XIA Qing & Min, 2013; Zhenyuan et al., 2016). However, research methods in literature need to be supported by quantities of industrial data, which means there are certain limitations in the management practice application of the new area of strategic level and the underdeveloped regions of the central and western. In addition, there are rarely environmentally friendly and sustainability requirements in the course of industrial selection in literature. Since the 18th National Congress of the Communist Party of China, the Party Central Committee, with General Secretary Xi Jinping as the core, has repeatedly put forward the requirement that "green water and green mountains are golden mountains and silver mountains". Therefore, the choice of regional leading industry under new background must take the principle of ecological sustainability into consideration and accomplish "not only need gold and silver mountains, but also green water and green mountains" eventually. Based on the benchmarks and principles of industry, economy, society and environmental sustainability, this paper constructs a comprehensive evaluation index system. In order to deal with fuzzy uncertainty of qualitative indexes, trapezoidal fuzzy number characterization judgment information is introduced, and through the fuzzy extended VIKOR method, the selection of regional leading industry can be achieved.

The reminder of this research is organized as follows. Section 2 presents literature review. In Section 3, the main criteria for selecting the leading industry are collected. Subsequently, an extended fuzzy VIKOR method is developed to determine the regional leading industry. An example is performed to prove the feasibility of the proposed decision-making steps in Section 5, which provides a novel perspective for selecting regional leading industry. Finally, the paper is ended with some conclusions.

LITERATURE REVIEW

With variable demands of regional development and characteristics of regional heterogeneity, the benchmark of leading industry selection shows a dynamic tendency due to upgrades of economics, culture and industrial development of a region (Wan et al., 2010). Representative benchmarks for leading industry selection mainly include: the Hirschman benchmark, the Rostow benchmark and the Miyohei benchmark (income elasticity benchmark and productivity increase benchmark) in foreign economic circles. Geographers regard regional leading industry as growth poles from a qualitative perspective. Due to the established characteristics of regional leading industry, the selection of regional leading industry is supposed to follow the principles of resource advantages, market supply and demand, economic benefits and correlation effects (H. Liu & Li, 2004). Martynovich & Lundquist (2016) analyzed the role of leading industries basing on the technological change and geographical

reallocation of labor from a dynamic perspective. Under the new background of "Internet plus modern agriculture", Qin et al. (2016) constructed an evaluation index system from the aspects of industrial competitive advantage and industrialization level. Through the hierarchical fuzzy comprehensive evaluation method, he identified the leading industry in modern agriculture area and promoted the optimization of the primary industry in Yunnan Province. Most researchers have studied the leading industry selection from the Hirschman benchmark, the Rostow benchmark and the Miyohei benchmark, but few consider the principles of environmental sustainability.

The selection benchmarks of leading industry from different perspectives are various. Researches on the selection methods of regional leading industry also emerge in, mainly about two categories (qualitative and quantitative), including comprehensive evaluation methods such as Analytical Hierarchy Process (AHP), Information Entropy (IE), Principal Component Analysis (PCA), Shift-Share-Analysis Method (SSM), Grey System (GS) and Fuzzy Reasoning (FR)(Chao et al., 2016; Lacerda et al., 2021; Y.-q. Liu et al., 2006; Webster, 2013; Zhou, Wang, & Goh, 2018; Zhou, Wang, et al., 2019). Y.-q. Liu et al. (2006) put forward a leading industry selection model based on the diamond theory, and realized the management practice of leading industry selection by linear weighting based on the theory of comparative advantage and competitive advantage. Taking Hefei as an example, Chunshui et al. (2019) constructed the evaluation system from the four dimensions of technological innovation, regional influence, industry growth and regional comparative advantages using weighted sum method to determine the leading industries of the urban service industry. To select the leading industries of Kashgar urban agglomeration, Bai et al. (2020) combined index system with grey incidence degree method and built multi-attribute weighted intelligent grey target decision-making evaluation model. About the uncertainty of indicators in the selection of leading industry, grey system theory is widely applied in the determination of regional leading industry. Fang et al. (2013) employed grey system theory and the input-output method, which can assist people to select the leading industry under uncertain information. Fu & Xu (2016) employed multiple attribute decision analysis which achieves high solution reliability to explore the selection of leading industries. Due to the methods above require the quantity of industry data as support, there are certain limitations on the selection of the leading industry in the central and western regions as well as newly established high-tech zones. Therefore, it is necessary to introduce expert evaluation methods and fuzzy set theory to enrich the research of leading industry selection methods.

CRITERIA CONSTRUCTION

Regional leading industry is the core power to adjust the industrial structure and promote economic growth. To achieve the purpose, governments determine the leading industries and the order of industrial development in a certain period according to the overall scale of the local industrial structure.

Regional Industry Selection Benchmark

Scholars have different interpretations of the connotation of the region in different historical periods, and the criteria for selecting regional leading industries are also different under different social backgrounds and production organization patterns. With the development of economic society, the research on the selection of regional leading industries has also changed significantly, from the research on regional differences caused by geographic location to regional differences in social activities and the resulting spatial interactions, from the study of geographical distance to regional environment. Therefore, in the new era, the selection of pillar industries in regional economics also involves comprehensive and complex factors such as economy, society, environment and sustainability. From the 1980s, the selection of regional leading industries is studied in China based on foreign regional economics research, which is mainly summarized in Table 1.

It can be seen from Table 1 that the selection criteria of regional leading industries have different considerations and changes over time and regions. The selection benchmark and process of leading

Table 1. Benchmark of regional leading industry selection

Period	Research focus	Research paradigm	Research genre	Determinant factors	Theoretical foundation	Connotation of benchmarks
1980-1990	Econometrics; Urban regional planning; Space structure	Regional developmentalism	Positivism	Discrepancy of technology and element density	Industrial policy; Regional development theory;	Comparative advantage; Diffusion effect; Resource endowment; Industry coordination; Demand elasticity
1990-2000	Regional economy	Regional developmentalism; New regionalism	Structuralism	Economics intensity; Substitutability of alternative products; Market scale	New trade theory	Bottleneck benchmark; Market share benchmark
2000-now	Industrial cluster, Innovation environment of new industrial zone	New regionalism	Postmodernism; Humanism	Economics intensity; Substitutability of alternative products; Trade cost	New trade theory; New economic geography theory	DEA efficiency; Economic value added; Employment function; Ecological economy benchmark

industries have changed significantly in the new era, which are mainly reflected in the following points: 1. Theoretically, sector-leading industries are shifting to regional leading industrial clusters or leading industrial chains, with more emphasis on the influence of regional characteristics and industrial organization production patterns on leading industries.2. The selection of regional leading industries has expanded from a single industrial sector to various comprehensive sectors, involving all levels of economy, society and environment; 3. The understanding of region is more innovative and in-depth, not only on geographical distance, but also on space distance; 4. The environment of industry transforms from closed to open, and the impact of regional economic integration and globalization are paid more attention to, while the coordinated development with other industries and regions are taken into consideration; 5. The impact of ecological environment and sustainability are paid more attention to in the selection process of regional leading industries.

Therefore, it is too general to use only one of static or dynamic advantage theory as the leading industry selection criterion. Therefore, when it comes to specific standards such as the broad market prospect, high industrial relevance, technological progress and high productivity growth rate, social benefit and environmental sustainability should be considered as well while chasing economic benefits.

Criteria Index System Construction Based on IESE Dimensions

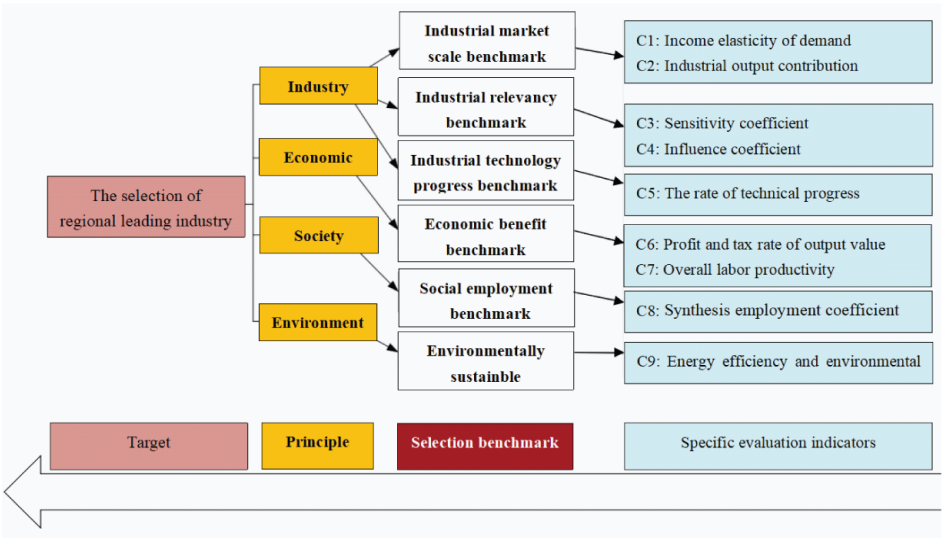
Through the previous analysis of theoretical benchmarks and principles of leading industry selection, combined with a literature review, the evaluation index system which affects the selection of leading industries in Zone I, II, III is determined as showed in Figure 1. The four indicators are taken into account to perform the leading industry selection, namely, industry (D1), Economics (D2), Society (D3) and Environment (D4).

1. Data sources for quantitative indicators.

According to the evaluation index system of leading industrial selection, values are calculated separately using the relevant statistical data from the *Statistical Yearbook of Henan Province* (2011-2015) and *China Input-Output Table* based on various indicators. Due to the inconsistency between the industrial sector settings in *Henan Statistical Yearbook* and *China Input-Output Table*, relevant industrial sectors in *Henan Statistical Yearbook* were merged based on the industrial sector settings in *Input-Output Table*.

2. Acquisition of uncertain qualitative index data.

Figure 1. Generated criteria index system affecting regional leading industry selection



For qualitative indicators that are uncertain and difficult to quantify, linguistic variables and trapezoidal fuzzy number are employed to characterize them, adopting a method combined interview research and expert evaluation. In this paper, fuzzy numbers are used to express the fuzzy uncertainty of qualitative indicators, which can be specifically referred to the operation steps in the literature (Zhou, Lim, et al., 2019; Zhou, Wang, Lim, et al., 2018).

THE EXTENDED FUZZY VIKOR MODEL

According to the judgment information of multiple control indicators, fuzzy VIKOR method (Opricovic, 2007; Opricovic, 2011), a multi-attribute decision making method that deals with indicators containing mixed uncertainly, is employed to select a solution with better comprehensive performance (Ayouni et al., 2021; Kumar & Barman, 2021; Zhou, Wang, & Goh, 2018; Zhou, Wang, Lim, et al., 2018). And it develops based on L_p - $Metrix$:

$$L_{p,i} = \left\{ \sum_{j=1}^{n} \left[\frac{w_i (f_j^* - f_{ij})}{f_j^* - f_j^-} \right] \right\}^{1/p} , 1 \le p \le +\infty, i = 1, 2, \ldots, m \tag{1}$$

$L_{1i}(S_i)$ and $L_{\infty i}(R_i)$ are used for selection and sorting above.

The extended fuzzy VIKOR-based model is formulated to select the regional leading industry subjecting to multiple criteria. The developed extended VIKOR model in our study is oriented to qualitative and quantitative mixed data. In addition, the qualitative information is described by the trapezoidal fuzzy number. Through the defuzzification operation, the crisp decision making is generated, whose criteria weights are obtained by the information entropy. To establish the leading industry, the VIKOR-steps are then employed to prioritize the best alternative candidate industry. The extended fuzzy VIKOR-based model consists of two sub-sections, including criteria weight and VIKOR-based steps.

Table 2. Notation and description of established criteria

Benchmark	Criteria	Description	Calculation
Industrial market scale benchmark	Income elasticity of demand	The ratio of the growth rate of a certain industry's demand to the growth rate of per capita national income	$E_i = (\Delta Q / Q) / (\Delta Y / Y)$
	Industrial output contribution	The proportion of the total output value of a certain industry in the total output value of all industries	$MC_i = C_i / \sum_{i=1}^{n} C_i$
Industrial relevancy benchmark	Sensitivity coefficient	The degree of demand sensitivity received by a certain industrial sector when each industrial sector of the national economy all increases one unit in final use,	$G_i = \sum_{j=1}^{n} \overline{b_{ij}} / \frac{1}{n} \sum_{i=1}^{n} \sum_{j=1}^{n} \overline{b_{ij}}$
	Influence coefficient	The affected degree of production demand generated by each industrial sectors of the national economy when a certain industrial sector increases a unit in final use,	$Y_j = \sum_{i=1}^{n} \overline{b_{ij}} / \frac{1}{n} \sum_{j=1}^{n} \sum_{i=1}^{n} \overline{b_{ij}}$
Industrial technology progress benchmark	The rate of technical progress	The contribution degree of technological progress to capital growth	$T_i = \frac{dQ}{Q} - \alpha \frac{dL}{L} - \beta \frac{dK}{K}$
Economic benefit benchmark	Profit and tax rate of output value	The ratio of the total profit and tax realized by a certain industry to the total output value of the industry	$XC_i = M_i / C_i$
	Overall labor productivity	The ratio of the added value of a certain industry to the average number of employees in the industry	$XL_i = J_i / L_i$
Social employment benchmark	Synthesis employment coefficient	The total number of jobs created directly or indirectly within the industry and in other industries by adding a unit of production in a certain industry	$\mathrm{H}_i = U_i (E - A)^{-1}$
Environmentally sustainable benchmark	Energy efficiency and environmental protection	Resource and energy consumption of a certain industry while achieving economic benefits, which mainly reflects sustainability and environmental friendliness of industries	Qualitative indicator (linguistic variable & trapezoidal fuzzy number theory) (Dombi and Jónás, 2020; Zhou, Wang, and Lim, 2018)

Criteria Weight Calculation

To realize the quantification of qualitative indicators, fuzzy attribute value of decision groups is calculated through expert evaluation information and trapezoidal fuzzy number $\tilde{x}_{ij} = (x_{ij}^{L}, x_{ij}^{M1}, x_{ij}^{M2}, x_{ij}^{U})$. Among them, x_{kij} is the fuzzy evaluation value of decision-making expert *k* for subordinate decision attribute C_j of industry A_i. The expert group evaluation information is integrated as following:

$$x_{ij}^{L} = \min_{k}\left\{x_{kij}^{L}\right\}, x_{ij}^{M1} = \frac{1}{k}\sum_{k=1}^{K} x_{kij}^{M}, x_{kij}^{M2} = \frac{1}{k}\sum_{k=1}^{K} x_{kij}^{M2}, x_{ij}^{U} = \max\left\{x_{kij}^{U}\right\} \tag{2}$$

Realize the conversion of group evaluation value by defuzzification operation (formula 3):

$$defuzzy(\tilde{x}_{ij}) = \frac{\int \mu(x)xdx}{\int \mu(x)dx} = \frac{(x_{ij}^{U} + x_{ij}^{M2})^2 - (x_{ij}^{M1} + x_{ij}^{L})^2 + x_{ij}^{L}x_{ij}^{M1} - x_{ij}^{M2}x_{ij}^{U}}{3\left[(x_{ij}^{U} + x_{ij}^{M2}) - (x_{ij}^{M1} + x_{ij}^{L})\right]} \tag{3}$$

Determine the weight of the hybrid index combined with information entropy. The process is as follows:

Normalization of decision matrix: $p_{ij} = \dfrac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}$ (4)

Entropy calculation of indicators: $e_j = -k\sum_{i=1}^{m} p_{ij} \ln p_{ij} = -\dfrac{1}{\ln m}\sum_{i=1}^{m} p_{ij} \ln p_{ij}$ (5)

Index weight: $w_j = \dfrac{1 - e_j}{\sum_{j=1}^{n}(1 - e_j)}$ (6)

The VIKOR-Based Implementation Steps

Step 1: Determine the positive ideal solution f_j^* and negative ideal solution f_j^- under each index:

$$f_j^* = \begin{cases} \max\limits_{i} x_{ij}, \text{interest-based index, the bigger the better} \\ \min\limits_{i} x_{ij}, \text{cost-based index, the smaller the better} \end{cases} \tag{7}$$

$$f_j^- = \begin{cases} \min\limits_{i} x_{ij}, \text{interest-based index, the smaller the worse} \\ \max\limits_{i} x_{ij}, \text{cost-based index, the bigger the worse} \end{cases}$$

Step 2: Calculate the maximum group utility S_i and the minimum regret value R_i of each candidate industry:

$$S_i = \sum_{j=1}^{n} w_j \left[\frac{f_j^* - f_{ij}}{f_j^* - f_j^-} \right], R_i = Max_j \left[w_j \frac{f_j^* - f_{ij}}{f_j^* - f_j^-} \right] \tag{8}$$

Step 3: Calculate the comprehensive utility value Q_i of each target component:

$$Q_i = v \frac{S_i - S^*}{S^- - S^*} + (1-v) \frac{R_i - R^*}{R^- - R^*} \tag{9}$$

Among them, $S^- = \max_i S_i, S^* = \min_i S_i, R^- = \max_i R_i, R^- = \min_i R_i, v \in (0,1)$ represents the weight of the maximum group utility of decision makers and (1-v) represents the weight of individual regret.

Step 4: Determine the compromise and satisfactory solution. Rank the selected objects by S, R and Q values respectively and get three sets of ranking results. The order $A^{(1)}, A^{(2)}, \ldots, A^{(m)}$ is obtained according to the increasing value of Q_i. When the two conditions above are met at the same time, the evaluation object $A^{(1)}$ corresponding to the minimum objective comprehensive utility value $Q_i(Q^{(1)})$ will be the compromise and satisfactory solution.

CASE STUDY

In Zhengzhou, Henan, there is a High-tech Industrial Development Zone, which is the first development zone in Henan Province started in 1988. Located in the northwest of Zhengzhou City, it has more than 50,000 market entities, 823 high-tech enterprises within the validity period, 1399 national-level technology-based small and medium-sized enterprises, 563 national and provincial level technological innovation platforms. To verify the proposed extended fuzzy VIKOR decision-making steps, a case study of regional leading industry analysis in Zhengzhou is conducted to assist regional industry planning. There are three sub-regions (Zone I, Zone II, Zone III) in this high-tech zone in Zhengzhou, all of these three zones are divided by the geographical distance and fundamental facilities. For the further industry planning of high-tech zone, the proposed decision-making framework is used to determine the leading industry of each sub-region.

Background

Regional leading industries should be determined scientifically first in order to promote regional industrial linkage and coordinated development through the layout of new industries as well as the reform and integration of old industries. Therefore, as to adapt to the requirements and guidelines in the new background, the proposed fuzzy extended VIKOR model is used to validate the regional leading industry selection.

Results

The decision-making information of these objective three sub-regions are collected, and the extended fuzzy VIKOR steps are performed to derive the regional leading industry for each sub-region. The analysis results of the leading industries in the three major Zones (I, II, III) of a high-tech zone are shown in Table 3.

Table 3. Ranking results of three sub-regions

Product line	Alternative industries	D1	D2	D3	D4	Zone I				Zone II				Zone III			
		0.2	0.3	0.3	0.2	S	R	Q	Rank	S	R	Q	Rank	S	R	Q	Rank
Assembly manufacturing industry	Machine processing				L	0.01	0.18	0.09	4	0.10	0.13	0.12	4	0.35	0.49	0.42	10
	Equipment manufacturing				M	0.19	0.03	0.11	5	0.09	0.05	0.07	2	0.03	0.21	0.12	2
	Material processing				VL	0.71	0.63	0.67	18	0.44	0.68	0.56	15	0.86	1	0.93	19
	Electrical machinery				H	0.20	0.35	0.28	10	0.20	0.34	0.27	9	0.84	0.60	0.72	16
	Instrument and meter				M	0.14	0.18	0.16	6	0.05	0.41	0.23	5	0.51	0.41	0.46	11
Electronic information industry	Laptop industry				L	0.12	0.06	0.09	3	0.00	0.00	0.00	**1**	0.37	0.21	0.29	6
Automobile industry	Automobile accessories				L	0.26	0.14	0.20	9	0.12	0.36	0.25	8	0.51	0.33	0.42	9
Chemical industry	Paper industry				VL	0.81	0.75	0.78	19	0.43	0.78	0.61	16	1	1	1	20
	Furniture industry				M	0.41	0.17	0.29	11	0.41	0.20	0.31	10	0.35	0.27	0.31	7
	Leather products				L	0.47	0.51	0.49	17	0.67	0.45	0.56	14	0.52	0.65	0.59	13
	Home furnishing industry				L	0.23	0.11	0.17	8	0.17	0.32	0.25	7	0.46	0.30	0.38	8
	Metal products				VL	0.40	0.21	0.31	12	1	1	1	20	0.85	0.76	0.81	18
	Daily equipment				L	0.19	0.15	0.17	7	0.45	0.51	0.48	13	0.48	0.53	0.51	12
	Plastic products				VL	0.41	0.25	0.33	14	0.16	0.29	0.23	6	0.24	0.12	0.18	3
	Rubber products				VL	0.39	0.26	0.33	15	0.08	0.12	0.10	3	0.31	0.19	0.25	5
Modern service industry	Transport				M	0.66	0.28	0.47	16	0.57	0.81	0.69	17	0.17	0.21	0.19	4
	Logistics				H	1	1	1	20	0.70	0.85	0.78	19	0.00	0.00	0.00	**1**
	Travel				VH	0.00	0.06	0.03	2	0.23	0.41	0.32	12	0.77	0.41	0.59	15
	Real estate				H	0.00	0.00	0.00	**1**	0.33	0.31	0.32	11	0.81	0.65	0.73	17
	Wholesale and retail				M	0.40	0.21	0.31	13	0.60	0.81	0.71	18	0.46	0.71	0.59	14

Discussions

Due to the advantages of superior natural conditions, convenient transportation and complete infrastructure, real estate is developed industry in Zone I. In Zone III, convenient transportation, rich land resources, superior geographical location, policy support, multiple logistics hubs equip logistics an advantage industry of the Zone. In addition, according to the calculation results in Table

3, the real estate and logistics rank first among all the industries in Zone I and Zone III respectively. Considering the current situation and industrial planning programme of the regional development, these two advantage industry sectors are discussed in this study. Therefore, in the following analysis, the real estate and logistics are listed separately from the modern service industry and ranked together with other major industries.

Combining with the factors of industry, economy, society and environmental sustainability comprehensively, it can be referred from Table 3 that the leading industries of the three zones (Zone I, Zone II, Zone III) are real estate, electronic information industry and logistics through the comprehensive selection model.

In order to take the leading industries of different sub-regions into further consideration as well as industrial planning to the connecting areas of the sub-regions, the comprehensive evaluation model is constructed to deeply analyze the rank of the six major industries in different core areas. The obtained comprehensive evaluation results are shown in Figure 2.

As showed in Figure 2, for High-tech Zone I, the ranking order of the industries is real estate, electronic information industry, automobile industry, assembly manufacturing industry, chemical industry and logistics, of which are mostly producer service industries. Therefore, it is suitable to be the residential and commercial area of the high-tech zone. The ranking order of the industries in Zone II is electronic information industry, assembly manufacturing, chemical industry, automobile industry, real estate and logistics. For Zone III, the suitable industrial categories for development are logistics, assembly manufacturing, chemical industry, electronic information industry, automobile industry and real estate.

In order to clarify the comparative advantage industries of the three zones, the related comparison from the industry viewpoint in terms of three sub-regions is performed to identify the discrepancy of each objective advantage industrial sector. This further comparison analysis is based on the four indicators, namely, comparative advantage, industrial scale, correlation effect and regional competitiveness, which is regarded as also a multi-criteria decision-making problem. The comparison analysis result of competitive industries among the three high-tech zones is found in the following Figure 3.

Figure 2. Industrial Analysis of sub-regions

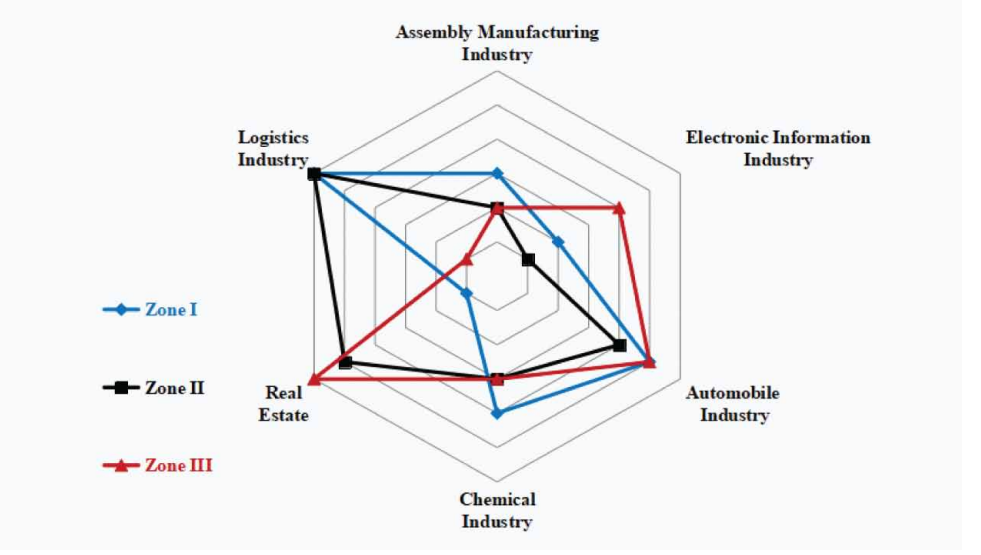
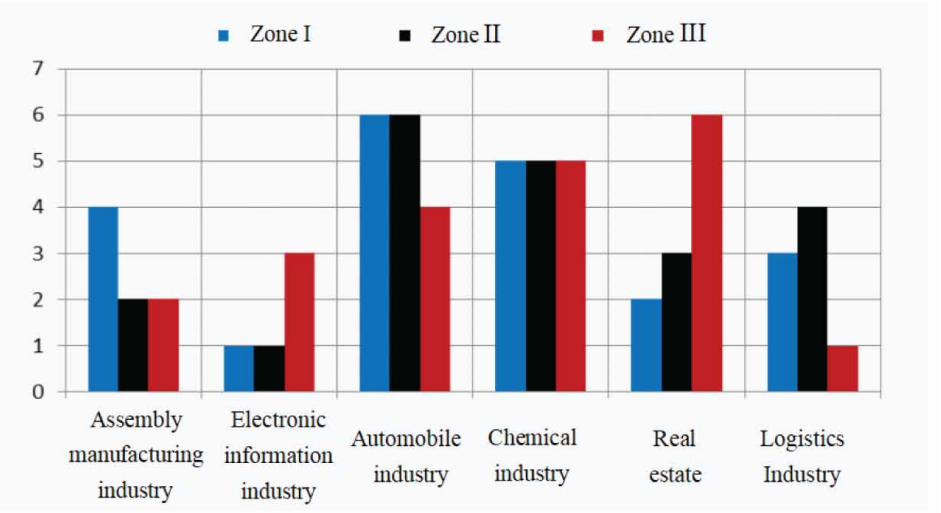


Figure 3. Comparison results of competitive industries among the three high-tech zones



It can be seen from Figure 3 that the comparative advantages of various industries differ significantly from distinct perspectives. Electronic information industry, ranking the first in Zone I and Zone II, has significant advantages while the relative advantages of assembly manufacturing industry are obvious as well, yet the ranking of the automobile industry is relatively lagging. It is related to the different positions of industries in the value chain under the background of the global value chain. The electronic information industry and assembly manufacturing industry, which are the whole machine enterprises as well as the middle and rear end in the industrial chain, can promote the formation of the regional industrial chain more significantly. As for the automobile industry, most of which are part enterprises, mainly provide services for vehicle companies as the upstream of OEM. Therefore, its leading role can hardly compare with the equipment manufacturing and electronic information industry, resulting in its relatively backward comprehensive ranking. For Zone II and Zone III, logistics and assembly manufacturing have relative advantage of comprehensive competitiveness. Logistics is an emerging industry in the modern service industry. Meanwhile, chemical industry, most of which are resource-intensive enterprises, is intermediate forces in the region. It has a relatively low place of comprehensive ranking, due to its characteristics of small scale, scattered layout, low technology content and weak industry leading role. Therefore, it is necessary to coordinate the layout of the chemical industry in the process of regional planning. The industrial structure should be optimized and the industrial efficiency should be enhanced through the innovation of technology and service on the basis of its original advantages.

CONCLUSION

Previous research literature on leading industries is mainly based on benchmarks of Hirschman, Rostow and Miyohei benchmark, few of which take environmental sustainability into consideration. In addition, most researches regarding leading industry selection problem are empirical analysis based on quantitative industrial data. So there are limitations in the case that the industrial planning object is new regions or inadequate development regions such as the central and western in China.

Therefore, a fuzzy extended VIKOR multi-criteria decision-making method is proposed from a comprehensive perspective of industry, economy, society and environmental sustainability, which is a decision-making framework oriented with the qualitative and quantitative mixed criteria. The method

employed expert decision-making along with the advantages of trapezoidal fuzzy numbers in fuzzy and uncertain information processing. Then, the selection of leading industries in Zhengzhou high-tech zone is taken as an example to verify the effectiveness of the method. The relative comparison of the three zones in their respective leading industries is evaluated through pairwise comparison of the four aspects of comparative advantage, industrial scale, correlation effect and regional competitiveness.

The research shows that the leading industries of three zones are real estate, electronic information industry and logistics. Subsequently, it proposed the comparative advantage industries in different zones. The layout of the differential leading industries should be integrated with urban planning under the guidance of city-industry integration while conducting industrial planning. When industrial development tends to cluster, urban functions tend to be high-end as well as industry and city tend to be integrated, the coordinated development of leading industries and relatively advantageous industries will promote the optimization of the economy. Meanwhile, it will promote intensive production and the cooperation among producers, increase the connection between all linkages of production as well as investment in technology. In addition, resource sharing and functional complementarity contain technology, management, labor, power, water supply, transportation and other infrastructures could significantly enhance the overall competitiveness of the industry and the overall attractiveness of the region to external capital. Finally, the sustainable economic development of the region can be achieved based on the current situations of zones through the layout of emerging industries as well as the optimization of traditional industries by considering environmental sustainability.

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