Evaluation of the Economical and Intensive Use of Industrial Land in Chizhou Economic and Technological Development Zone

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Abstract Based on the subdivision of industrial land in Chizhou Economic and Technological Development Zone, this paper builds the evaluation indicator system for the economical and intensive use of industrial land in the development zone, to analyze the current situation of economical and intensive use of industrial land. The results show that the levels of economical and intensive use of industrial land vary in the development zone; the factors affecting the intensive degree of various industries also vary; the industry in Chizhou Economic and Technological Development Zone is still in the transition phase from inefficient use to low level of use to intensive use.
Key words Industrial land, Economical and intensive use, Evaluation, Development zone

Due to the impact of the common development ideas and trends of global economy, the world industries have adjusted the internal and external division of labor, and the industrial division of labor choosing to be transferred abroad or outside is becoming more and more obvious. Since the 1990s, Anhui Province has made great efforts to promote the development and opening up of Wanjiang Region, and accelerate the process of integration with the Yangtze River Delta to constantly undertake the transfer of industries and lay a good foundation for the establishment of demonstration zones[1]. As one of the demonstration areas for carrying on the industrial transfer of the Wanjiang cities, Chizhou is located in the heart of Anhui Province, and the construction of its economic zone is of great significance to developing the Wanjiang cities, and helping promote the central regions to undertake the eastern industrial transfer. Currently, the economic and social development of Chizhou is getting faster and faster, and the way of its development is being transformed into new eco-city. With the ceaseless transfer of industry, there is a state of imbalance between supply and demand of industrial land, and the industrial land is in short supply[2]. In the case of short land resources and a growing demand for industrial land, how to balance the relationship between them to make a harmonious relationship between people and land, and promote the economical and intensive land use and social sustainability is a challenge that the development zone has to face at present[3-4]. In accordance with the current situation, problems and features concerning the industries to be emphatically undertaken by Wanjiang City Belt and economical and intensive use of industrial land, this paper considers different influencing factors on the basis of the division of five industries, to build the corresponding evaluation indicator system and model with the purpose of providing some guidance and basis for the industrial transfer.

1 Object of study and methods
1.1 Object of study
1.1.1 Current situation of industrial land. According to the interviews of officials in the development zone, it is learned that since 2011, the industrial structure has been incessantly optimized in Chizhou Economic and Technological Development Zone, the industrial chain has been gradually extended and the industrial agglomeration benefits are increasingly clear, becoming an important part of industrial distribution and market cycles of Wanjiang City Belt. Currently the development zone has formed an electronic information industry-led industrial development path, and its industry influence affects Anhui Province and neighboring provinces. It gradually becomes the core gathering zone of the regional technology industry.

1.1.2 Land use structure. The statistical analysis is performed on various types of land within the scope of the evaluation, and the land in the development zone is divided into three categories: used land, unused land and unavailable land (see Table 1). The total evaluation area of the development zone is 480 ha. The area of land having been used for urban construction is 411.72 ha, accounting for 85.81% of the total area of the development zone; the area of unused land is 24.53 ha, accounting for 5.11% of the total area of the development zone; the area of unavailable land is 43.55 ha, accounting for 9.08% of the development zone.

As to the land having been used for construction in the development zone, warehousing and mining occupy the highest proportion of land, 66.10% of the total area of the development zone, and 77.03% of the area of land having been used for urban construction; it is followed by the residential land mainly for resettlement housing and some commercial residential buildings, accounting for 50.32% of the total area of the development zone, and 12.22% of the area of land having been used for urban construction; the transportation land accounts for 6.19% of the total area

of the development zone, and 7.21% of the area of land having been used for urban construction; the land for public administration and public services only accounts for 3.04% of the total area of the development zone, and 3.54% of the area of land having been used for urban construction.

The area of unused land is 24.53 ha, 14.08 ha of such land has reached the condition of land supply, accounting for 2.93% of the total area of the development zone, and 10.45 ha of such land does not meet the condition of land supply, accounting for 2.18% of the total area of the development zone.

The area of unavailable land (all for rivers and lakes) within the development zone is 43.55 ha, accounting for 9.08% of the total area of the development zone.

Table 1　Land use types in Chizhou Economic and Technological Development Zone Unit：ha

Land use types	Used land	Unused land	Unavailable land	Mining and warehousing land	Transportation land	Residential land	Land for public administration and public services
Area	411.72	24.53	43.55	317.14	29.69	50.32	14.57
The share in the total area of the development zone	85.81%	5.11%	9.08%	66.10%	6.19%	10.49%	3.04%
The share in the area of land having been used for urban construction	100.00%	5.965	10.58%	77.03%	7.21%	12.22%	3.54%

1.2　Research methods

1.2.1　Literature analysis. On the basis of analysis of relevant data and literature, this paper learns the results of others to study the economical and intensive use of industrial land.

1.2.2　Combination of empirical and normative approaches. The field survey is adopted to examine and understand the objective circumstances, directly obtain the relevant materials, and analyze these materials.

1.2.3　Qualitative and quantitative analysis. The qualitative analysis is used to analyze the role of industry clustering in promoting the economical and intensive use of industrial land in the development zone, and the quantitative analysis is used to analyze the current intensive use of industrial land through the existing statistics.

1.2.4　Comprehensive study. This paper contains the content of many disciplines, so there is a need to perform the comprehensive study from multiple perspectives.

2　Evaluation of the economical and intensive use of industrial land in the development zone

2.1　Evaluation methods　Due to the complexity and diversity of factors influencing the evaluation of economical and intensive use of industrial land in the demonstration area, this paper uses comprehensive weighted scoring method for the evaluation of economical and intensive use of industrial land. Using the comprehensive weighted scoring method, this paper analyzes the factor having the greatest impact on the economical and intensive use of evaluation object, and establishes the corresponding indicator system. Some certain methods are used to process the indicator data, and calculate the indicator weight. Finally, the evaluation model for the intensive land use is used to calculate the goal of evaluation object and intensity score.

2.2　Building of the evaluation indicator system　Affected by land use conditions, natural and geographical conditions, level of economic and technological development, industrial structure, government decision-making tendencies, land management system and many other factors, we can not adopt the unified evaluation indicators when evaluating the economical and intensive use of industrial land[5-6]. In determining the evaluation indicators for the economical and intensive use of industrial land, it is necessary to start from its own characteristics and geographic conditions, and consider its own development and the development goals.

On the basis of subdividing the industries into equipment manufacturing, raw materials industry, textile industry, High-tech industry and modern service industry, in accordance with *Regulations for the Evaluation of Economical and Intensive Use of Construction Land* (TD/T 1018 – 2008) and *Regulations for the Evaluation of Intensive Land Use in the Development Zone* (*Trial*), this paper chooses the evaluation indicators for the economical and intensive use of industrial land in Chizhou Economic and Technological Development Zone based on the actual situation of industrial land in Wanjiang City Belt, from the perspective of economical and intensive use of management, technology and capital.

The evaluation indicator system consists of goal layer, sub-goal layer and indicator layer. The goal layer is composed of intensive management, intensive technology, intensive capital and output efficiency. The sub-goal layer is composed of industrial land structure, industrial technology, capital and input intensity. The indicator layer consists of administrative office space ratio, unit research funding, gross production per unit area of land, energy consumption per unit of GDP, and solid waste discharge (see Table 2).

2.3　Indicator normalization　Due to differences in the unit for various indicators, the evaluation results will be affected to some extent, so it is necessary to normalize the indicator data. The main processing approach is the maximum difference normalization method[7]. It is calculated as follows：

$$x_{ij}^* = \frac{x_j - x_{min}}{x_{max} - x_{min}} \text{ (The bigger the better)} \tag{1}$$

$$x_{ij}^* = \frac{x_{max} - x_j}{x_{max} - x_{min}} \text{ (The smaller the better)} \tag{2}$$

where x_j is the value of indicator j; x_{max} is the maximum value of

indicator j; x_{min} is the minimum value of indicator j; x_{ij}^* is the value after being normalized.

2.4 Determining the weight of evaluation indicators

The variation coefficient method is used to determine the weight, avoiding the preference of subjective weighting approach[8]. The variation coefficient of the indicator is calculated as follows:

$$V_j = \frac{\sigma_j}{X_j} \tag{3}$$

$$\sigma_j = \sqrt{\frac{1}{n} \sum_{j=1}^{n} (X_j - \overline{X})^2} \tag{4}$$

$$\overline{X_j} = \frac{1}{n} \sum_{j=1}^{n} X_j \tag{5}$$

$$A_j = \frac{V_j}{\sum_{i=1}^{m} V_j} \tag{6}$$

where V_j is the variation coefficient of indicator j, also known as standard deviation coefficient; σ_j is the standard deviation of indicator j; $\overline{X_j}$ is the average number of indicator j; A_j is the weight of the indicators.

According to the indicator value of the development zone, the variation coefficient method is used to determine the weight of the indicators[9]. Firstly, the data are standardized, and then the above formula is used to get the weight of the indicators (see Table 3).

Table 2 The evaluation indicator system for the economical and intensive use of industrial land in the development zone

Goal layer	Sub-goal layer	Indicator layer
Intensive management	Industrial land structure	Administrative office and supporting facility land ratio
		Green land rate
		Plant and supporting facility ratio
Intensive technology	Industrial technology input intensity	Research funding per unit area of land
		The number of patents per unit area of land
		The number of technological innovations per unit area of land
Intensive capital	Industrial capital input intensity	Building density
		Investment in fixed assets per unit area of land
Output efficiency	Industrial output intensity	Gross production per unit area of land
	Resource costs	Energy consumption per unit of GDP
		Water consumption per unit of GDP
	Environmental costs	Wastewater discharge per unit of GDP
		Emissions per unit of GDP
		Solid waste per unit of GDP

Table 3 Land use weight in Chizhou Economic and Technological Development Zone

Goal layer	Weight	Sub-goal layer	Weight	Indicator layer	Weight
Intensive management	0.412 9	Industrial land structure	1.00	Administrative office and supporting facility land ratio	0.320 9
				Green land rate	0.3395
				Plant and supporting facility ratio	0.3395
Intensive technology	0.146 6	Industrial technology input intensity	1.00	Research funding per unit area of land	0.359 7
				The number of patents per unit area of land	0.337 0
				The number of technological innovations per unit area of land	0.303 1
Intensive capital	0.180 0	Industrial capital input intensity	1.00	Building density	0.778 6
				Investment in fixed assets per unit area of land	0.221 3
Output efficiency	0.260 3	Industrial output intensity	0.5040	Gross production per unit area of land	1.00
		Resource costs	0.326 8	Energy consumption per unit of GDP	0.500 0
		Environmental costs	0.169 1	Water consumption per unit of GDP	0.499 9
				Wastewater discharge per unit of GDP	0.331 2
				Emissions per unit of GDP	0.337 9
				Solid waste per unit of GDP	0.330 7

2.5 Calculating the score of economical and intensive level of industrial land

2.5.1 Calculating the score of sub-goal.
The sub-goal score of economical and intensive use level of industrial land is calculated according to equation (7):

$$F_{ij} = \sum_{k=1}^{n} (S_{ijk} \times W_{ijk}) \tag{7}$$

where F_{ij} is the score of intensive use level of industrial land of sub-goal j subordinate to goal i; S_{ijk} is the normalized value of indicator k of sub-goal j subordinate to goal i; W_{ijk} is the weight of indicator k of sub-goal j subordinate to goal i relative to sub-goal j; n is the number of indicators.

2.5.2 Calculating the score of goal.
The goal score of economical and intensive level of industrial land in the development zone is calculated according to formula (8):

$$F_i = \sum_{j=1}^{n} (F_{ij} \times W_{ij}) \tag{8}$$

where F_i is the score of intensive use level of industrial land of goal i; F_{ij} is the normalized score of intensive use level of industrial land of sub-goal j subordinate to goal i; W_{ij} is the weight of sub-

goal j subordinate to goal i relative to goal i; n is the number of sub-goals.

2.5.3 Calculating the comprehensive score of economical and intensive level. The comprehensive score of economical and intensive level of industrial land in the development zone is calculated according to formula (9):

$$F = \sum_{i=1}^{n} (F_i \times W_i) \qquad (9)$$

where F is the comprehensive score of intensive use level of industrial land; F_i is the score of intensive use level of industrial land of goal i; W_i is the weight of goal i; n is the number of goals.

Using the above indicator system and evaluation methods, we can get the intensive level score of lands for five categories of industries (see Table 4, Table 5 and Table 6).

Table 4 Score of sub-goal of intensive level of industrial land (F_{ij})

Industry category	Sub-goal	Score of intensive level of sub-goal//%
High-tech industry	A1	87.14
	A2	0.00
	A3	113.48
	A4	41.44
	A5	12.03
	A6	0.90
Textile industry	A1	81.81
	A2	100.00
	A3	15.82
	A4	26.35
	A5	9.04
	A6	2.28
Modern service industry	A1	98.49
	A2	0.00
	A3	39.71
	A4	32.65
	A5	52.41
	A6	32.69
Raw materials industry	A1	42.74
	A2	0.00
	A3	32.64
	A4	50.41
	A5	41.28
	A6	3.24
Equipment manufacturing industry	A1	61.70
	A2	37.70
	A3	138.45
	A4	32.47
	A5	28.65
	A6	3.92

Note: A1, A2, A3, A4, A5 and A6 represent industrial land structure, industrial technology input intensity, industrial capital input intensity, industrial output intensity, resource costs and environmental costs, respectively.

3 Results and analysis

3.1 Results The scores of intensive use level of land for five industries in Chizhou Economic and Technological Development Zone are 70.57%, 61.11%, 48.24%, 78.47% and 72.87%, respectively, indicating that there are obvious differences in the intensive use between different types of industrial land in Chizhou Economic and Technological Development Zone. The score of

modern service industry is the lowest (48.24), a low degree of intensive level; the score of raw materials industry is the highest (78.87), a medium degree of intensive level. Thus it can be found that the economical and intensive use level of industrial land in the development zone needs to be improved.

Table 3 shows that due to differences in the size of weight, the intensive management and output efficiency have a significant impact on the intensive use level of industrial land in the development zone, accounting for 41% and 26% of comprehensive score, respectively; the intensive technology and intensive capital have a small impact on the intensive use level of industrial land in the development zone, accounting for 15% and 18% of comprehensive score, respectively.

3.2 Analysis

3.2.1 Analysis of factors influencing the intensive management. From the industrial structure, the scores of intensive use level of five types of industrial land are 87.14%, 81.81%, 98.81%, 42.74% and 61.70%, respectively, indicating that except individual industries with low intensive use level, the overall level of industrial land use in the development zone is high.

3.2.2 Analysis of factors influencing the intensive technology. From the intensive level of industrial technology input, the scores of intensive use level of five types of industrial land are 0.00%, 100.00%, 0.00%, 0.00% and 37.70%, respectively, indicating that there are great differences in the intensive use level of five types of industrial land, and the overall level is extremely low. The industrial technology input consists of unit research funding, number of patents and technological innovation. From the score of intensive level, it can be found that the technological innovation of this development zone is at a low level, so it is necessary to attach great importance to increasing science and technology input, promoting economic development and enhancing the intensive use of industrial land.

3.2.3 Analysis of factors influencing the intensive capital. From the intensive level of industrial capital input, the scores of intensive use level of five types of industrial land are 113.48%, 100.00%, 39.71%, 32.64% and 138.42%, respectively, and there are significant differences in the intensive use level between the five types of industrial land and the level of land use varies in the development zone.

3.2.4 Analysis of factors influencing the output efficiency. From the output intensity, the scores of intensive use level of five types of industrial land are 41.44%, 26.35%, 32.65%, 50.41% and 32.47%, respectively, indicating that the overall level of industrial land use in the development zone is low.

From the resource costs, the scores of intensive use level of five types of industrial land are 12.03%, 9.04%, 52.42%, 41.28% and 28.65%, respectively, indicating that the industrial development in the development zone greatly depends on the resources leading to great energy consumption, and the overall intensive use level of industrial land in the development zone is low.

From the environmental costs, the scores of intensive use lev-

el of five types of industrial land are 0. 90% , 2. 28% , 32. 691% , 3. 24% and 3. 92% , respectively, which shows that the industries in this development zone cause great pollution to the environment, the overall intensive use level of industrial land in the development zone is low, and it is urgent to strengthen environmental control and protection.

Table 5   Score of goal of intensive level of industrial land (F_{ij})

Industry category	Goal	Sub-goal	Goal weight	Score of intensive level of sub-goal //%	Score of intensive level of goal //%
High-tech industry	A1	A11	0.412929	87.14	35.98
	B1	B11	0.146673	0.00	0.00
	C1	C11	0.180059	113.48	20.43
	D1	D11	0.260338	41.44	14.16
		D12		12.03	
		D13		0.90	
Textile industry	A1	A11	0.412929	81.81	33.78
	B1	B11	0.146673	100.00	14.67
	C1	C11	0.180059	15.82	2.85
	D1	D11	0.260338	26.35	9.81
		D12		9.04	
		D13		2.28	
Modern service industry	A1	A11	0.412929	98.49	40.67
	B1	B11	0.146673	0.00	0.00
	C1	C11	0.180059	39.71	7.15
	D1	D11	0.260338	32.65	24.93
		D12		52.41	
		D13		32.69	
Raw materials industry	A1	A11	0.412929	42.74	17.65
	B1	B11	0.146673	0.00	0.00
	C1	C11	0.180059	32.64	5.88
	D1	D11	0.260338	50.41	24.71
		D12		41.28	
		D13		3.24	
Equipment manufacturing industry	A1	A11	0.412929	61.70	25.48
	B1	B11	0.146673	37.70	5.53
	C1	C11	0.180059	138.45	24.93
	D1	D11	0.260338	32.47	16.93
		D12		28.65	
		D13		3.92	

Note: A1, A11, B1, B11, C1, C11, D1, D11, D12 and D13 represent intensive management, industrial land structure, intensive technology, industrial technology input intensity, intensive capital, industrial capital input intensity, output efficiency, output intensity, resource costs and environmental costs, respectively.

Table 6   Score of intensive use level of industrial land (F)

Industry category	Goal	Goal weight	Score of intensive level of goal(%)	Comprehensive score(%)
High-tech industry	A1	0.412 929	35.98	70.57
	B1	0.146 673	0.00	
	C1	0.180 059	20.43	
	D1	0.260 338	14.16	
Textile industry	A1	0.412 929	33.78	61.11
	B1	0.146 673	14.67	
	C1	0.180 059	2.85	
	D1	0.260 338	9.81	
Modern service industry	A1	0.412 929	40.67	48.24
	B1	0.146 673	0.00	
	C1	0.180 059	7.15	
	D1	0.260 338	24.93	
Raw materials industry	A1	0.412 929	17.65	78.47
	B1	0.146 673	0.00	
	C1	0.180 059	5.88	
	D1	0.260 338	24.71	
Equipment manufacturing industry	A1	0.412 929	25.48	72.87
	B1	0.146 673	5.53	
	C1	0.180 059	24.93	
	D1	0.260 338	16.93	

Note: A1, B1, C1 and D1 represent intensive management, intensive technology, intensive capital and output efficiency, respectively.

4   Conclusions

Taking Chizhou Economic and Technological Development Zone for example, this paper evaluates the economical and intensive use of industrial land and determines the land use types for various industries, to draw the conclusions that the economical and intensive use level of industrial land is not balanced, there are different influencing factors, and Chizhou Economic and Technological Development Zone is still in the transition phase from inefficient use to low level of use to intensive use.

(ⅰ) The overall intensive use level of industrial land is not high in the entire development zone. The economical and intensive use of industrial land in the development zone shows unbalanced development. The economical and intensive use level of five types of industrial land crosses three levels. The intensive use level of land for raw material industry is the highest and the intensive use level of modern service industry is the lowest. The land for management is at the level of intensive use and the land for equipment manufacturing industry is moderately used. It can be found that the overall level of industrial land use in the development zone is high and Chizhou Economic and Technological Development Zone is still in the transition phase from inefficient use to low level of use to intensive use.

(ⅱ) There are different influencing factors. The main factors influencing the intensive use of land for high-tech industry are intensive technology and output efficiency. The main factor influencing the intensive use of land for textile industry is output efficiency. The main factors influencing the intensive use of land for modern industry is intensive Industrial technology input and output efficiency. The main factor influencing the intensive use of land for raw materials industry is technological input intensity. The main factor influencing the intensive use of land for equipment manufacturing industry is output efficiency.

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