Evaluation and Influencing Factors of Urban Renewal Efficiency Based on SBM Model: A Case Study of the First Batch of Pilot Cities for Urban Renewal

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Abstract China is already in the second half of the urbanization process, which means that the urbanization path in China needs to shift from "large-scale expansion development" in the past to "comprehensive and refined operation". To explore how to efficiently carry out urban renewal work, from the perspective of urban renewal efficiency, the first batch of pilot cities for urban renewal released by the Ministry of Housing and Urban Development in 2021 are selected as the objects. And the SBM model and Malmquist index are used to calculate and analyze their urban renewal efficiency. The results indicate that among the 20 pilot cities, Beijing, Tangshan, Suzhou, Tongling, and Jingdezhen are of high grade, and Hohhot, Xiamen, Huangshi, and Yinchuan are of medium grade, while the rest of the cities are of low grade. The regression results of the Tobit model indicate that population density, real estate investment, and regional economic development level are the main influencing factors of urban renewal. Finally, constructive suggestions are proposed for urban renewal from four aspects: concept, technology, real estate, and policy.

Keywords Urban renewal, SBM model, Urban renewal efficiency
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Since the reform and opening up, China's urbanization process has been continuously accelerating, and urban construction has achieved rapid development for over 40 years. As of the end of 2022, China's urbanization rate has reached 65.22%, and the urbanization process in China has entered the latter half of the period. The focus of urban construction and development has gradually shifted from "incremental construction" led by the real estate industry to "stock improvement" to improve urban production and quality of life. The future urbanization path urgently needs to be transformed from "large-scale expansion development" in the past to "comprehensive refined operation"[1]. The "14th Five-year" Plan proposes to accelerate the transformation of urban development mode, coordinate urban planning, construction and management, implement urban renewal actions, and promote the optimization and quality improvement of urban spatial structure[2]. This means that urban renewal has become the theme of urban development in China. Urban renewal, as an important part of new urbanization, is the continuous improvement and enhancement of urban functions, optimizing urban spatial structure, improving urban quality, and enhancing people's well-being in a way that meets the needs of modernization.

1 Literature review

1.1 Urban renewal

Urban renewal has a history of over 200 years. After World War II, Western countries initiated large-scale bulldozer style reconstruction, focusing on urban renewal and slum clearance. Although large-scale renovations have effectively improved the quality of living environment and economic development, low-income groups forced to relocate have formed new slums on the outskirts of cities[3]. In 1958, the concept of "urban renewal" was first proposed at the first urban research conference held in the Netherlands. After the 1990s, with the emergence of the concept of sustainable development and humanistic thinking, the connotation of urban renewal shifted from the initial material space renewal to the comprehensive renewal of multiple goals such as social economy, living environment, and basic public life.

Urban renewal activities in China started relatively late. After the founding of the People's Republic of China, under the guidance of the policy of "transforming consumer cities into production cities," China has always given priority to the development of heavy industry[4]. After the 1990s, China's socialist market economy system gradually matured, and urban renewal changed from traditional "old city renovation" to "old city redevelopment". It explored new mechanisms for urban renewal and development, such as using cultural industries to drive the development of old industrial zones and the mechanism of government-private-society co-construction. Under the overall framework of the concept of ecological civilization and the "five in one" development concept, the focus of urban renewal has shifted from "incremental development" to "stock planning"[5]. Urban renewal places more emphasis on putting people first, improving the living environment, and emphasizing comprehensive urban development[6]. Overall, urban renewal in both Western and Chinese countries currently places greater emphasis on people-oriented and improved living environments. As an urban construction and fixed assets investment activity to stimulate the vitality of existing land and improve the quality of urban space[7], the essence of urban renewal is to realize resource reallocation and improve the efficiency of land space utilization[8].

1.2 Urban renewal efficiency and evaluation

In terms of urban renewal evaluation, Ng[9] constructed a quality of life evaluation index system at the social and economic levels to evaluate Hong Kong's urban renewal. Using three blocks in the UK as research subjects, Turcu[10] evaluated urban renewal work from six aspects, including public facilities, housing construction, and social livelihoods. Zhang Jiankun et al.[11] designed an urban renewal evaluation index system based on the DPSIR model, which integrated economic, social, and ecological aspects, to quantitatively evaluate the effectiveness of old city renewal and transformation. Zhang Jiali et al.[12] selected 39 policy tool indicators to construct a PMC index model for quantitative evaluation of urban renewal policies in the Beijing—Tianjin—Hebei region.

In terms of research on urban renewal

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efficiency, multiple scholars in China have constructed an evaluation index system for urban renewal efficiency based on input–output logic to calculate urban renewal efficiency. Wang Meng et al.[13] first constructed an input–output evaluation index system, and then used the DEA model to calculate the renewal efficiency of Xicheng District in Beijing. Yi Zhiyong[14] conducted research from two aspects: efficiency evaluation and benefit evaluation. Efficiency evaluation was conducted using data envelopment model and binomial Logic model, while benefit evaluation was based on urban residents' satisfaction, taking into account the economic and social aspects of urban renewal work. Ke Xinyi et al.[15] used the Malmquist index to calculate the performance level of urban renewal in different cities in Guangdong Province.

Scholars at home and abroad have conducted extensive research on urban renewal, but there is relatively little research on its impact mechanisms. Melchert et al.[16] focused on the renovation activities of Boston's central urban area and used the Logistic regression method to explain the specific impact mechanism of urban renewal. Chan et al.[17] processed the collected questionnaire data using factor analysis (EFA) and summarized six major factors that affect sustainable urban renewal. Lv Yajie[18] believed that location conditions, property ownership, land use status, and urban planning are the main factors affecting urban renewal activities. Zhang Ting[19] established a system dynamics model to verify that urban renewal and high-quality economic development mainly rely on the coupling relationship among population, land market, and industrial structure.

Whether it is the comprehensive evaluation or efficiency measurement of urban renewal, most scholars only focus on positive output factors such as economic and social benefits of urban renewal, without considering unexpected products such as environmental pollution beyond economic benefits. The traditional DEA model is based on radial and angular directional distance functions to calculate efficiency values, which cannot calculate and explain the impact of unexpected outputs on urban renewal. In view of this, a non radial and non angular directional distance function (SBM model) is used to evaluate and measure urban renewal efficiency.

2 Research content and data sources

2.1 Evaluation index system for urban renewal efficiency

Through the review of existing research results, there is little literature considering the impact of unexpected output factors on urban renewal efficiency. In view of this, referring to research content of Nie Zihan[20], a comprehensive evaluation index system for urban renewal efficiency is constructed (Table 1).

(1) Input. As an urban transformation activity with urban space as the carrier, urban renewal is closely related to fixed assets investment and land resources. Considering the availability of data, it plans to select the area of urban construction land and fixed assets investment of urban municipal public utilities construction as the input indicators of urban renewal.

(2) Expected output. Urban renewal is a comprehensive transformation activity towards the city under the guidance of planning, involving multiple levels of economy, society, and environment. Its output should have economic, social, and spatial benefits, ultimately achieving comprehensive development of the city. Therefore, it evaluates from four aspects: economic development, living environment, urban spatial structure, and social livelihood.

Economic development is divided into economic scale and economic structure. The economic scale is represented by regional GDP, while the economic structure is represented by the proportion of added value of the tertiary industry to GDP and the industrial upgrading index (industrial upgrading index = proportion of the primary industry × 1+ proportion of the secondary industry × 2+ proportion of the tertiary industry × 3). The living environment is directly related to the social benefits of urban renewal. This paper selects relevant indicators from two perspectives: greening and garbage disposal. "Stock construction" is the key content of urban renewal at present. In terms of urban spatial structure, this paper selects three indicators: the proportion of construction land area to urban area, the proportion of residential land area to urban area, and the average GDP of land (regional GDP/urban construction land area) as the spatial transformation and utilization effectiveness of urban renewal. Social livelihood is an important manifestation of the "people-oriented" concept in urban renewal. Therefore, this paper selects indicators such as infrastructure, educational resources, and residents' lives to reflect the comprehensive development benefits of human beings brought about by urban renewal.

Unexpected output. In the process of urban renewal, environmental pollution is an indispen sable and unexpected output factor. Meanwhile, urban renewal includes industrial transformation or structural adjustment, which may lead to unemployment problems for local residents. Therefore, this paper selects the emissions of sulfur dioxide, industrial wastewater, and industrial smoke and dust as the unexpected output indicators of environmental pollution, and the registered number of urban unemployed population at the end of the year as the unexpected output indicators of social livelihood.

Table 1 Evaluation index system for urban renewal efficiency

Type (primary indicators)	Secondary indicators	Tertiary indicators
Input		Urban construction land area//km^2
		Fixed assets investment in construction of urban municipal public facilities//10^8 yuan
Expected output	Economic development	GDP//10^4 yuan
		Proportion of added value of the tertiary industry to GDP//%
		Industrial upgrading index
	Living environment	Greening rate in built-up areas//%
		Per capita green space area//m^2
		Pollution-free rate of urban household waste treatment//%
	Urban spatial structure	Ratio of construction land area to urban area//%
		Ratio of residential land area to urban area//%
		Average GDP of land//10^4 yuan/km^2
	Social livelihood	Average wage of staff and workers//yuan
		Number of teachers per 10,000 people
		Number of beds in hospitals and health centers per 10,000 people
		Per capita urban road area//m^2
		Urbanization rate//%
Unexpected output	Social livelihood	Number of registered urban unemployed population at the end of the year//10^4 persons
	Environmental pollution	Sulfur dioxide emissions//t
		Industrial wastewater emissions//10^4 t
		Industrial smoke and dust emissions//t

2.2 Data source

In November 2021, the Ministry of Housing and Urban Development issued a *Notice on Conducting the First Batch of Urban Renewal Pilot Work*, which includes 20 pilot cities: Beijing, Tangshan, Hohhot, Shenyang, Nanjing, Suzhou, Ningbo, Chuzhou, Tongling, Xiamen, Nanchang, Jingdezhen, Yantai, Weifang, Huangshi, Changsha, Chongqing, Chengdu, Xi'an, and Yinchuan. In this paper, the above 20 cities are taken as the research object, and the urban renewal efficiency of 20 cities in 2011−2021 is calculated, analyzed and evaluated. The relevant indicator data comes from the *China Urban Statistical Yearbook,* the *China Urban−Rural Construction Statistical Yearbook*, as well as the statistical yearbooks of various provinces and cities. The missing data is supplemented using interpolation method.

The data envelopment model follows the principle of "less is better than more" in selecting indicators. Therefore, a combination weight method combining entropy method and CRITIC weight method is used to reduce the dimensionality of the 14 indicators of expected output and unexpected output, ultimately forming two input indicators: urban construction land area and fixed assets for construction of urban municipal public facilities, and three output indicators: comprehensive level index of urban renewal (including economic development, living environment, urban spatial structure, and social livelihood), and number of registered urban unemployed population at the end of the year.

2.3 Research methods

2.3.1 Combination weighting method of entropy method and CRITIC method.

(1) Data normalization processing.

For positive index: $Z_{ij} = \dfrac{X_{ij} - X_{\min}}{X_{\max} - X_{\min}}$;

For negative index: $Z_{ij} = \dfrac{X_{\max} - X_{ij}}{X_{\max} - X_{\min}}$;

$$P_{ij} = \frac{Z_{ij}}{\sum_{i=1}^{d} Z_{ij}};$$

where i is region (i = 1, 2, ..., d); j is index (j = 1, 2, ..., e). $X_{\max}$ and $X_{\min}$ respectively show the maximum and minimum values of the j^{th} indicator; X_{ij} and Z_{ij} respectively show the j^{th} indicator before and after standardization treatment.

(2) Calculate the entropy method weight of various indicators W_j (entropy).

$$E_j = -k\sum_{i=1}^{d} P_{ij} \ln P_{ij};$$

$$k = \frac{1}{\ln(d)};$$

$$D_j = 1 - E_j;$$

$$W_j\,(\text{entropy}) = \frac{D_j}{\sum_{i=1}^{e} D_j}$$

(3) Calculate CRITIC weights for each indicator.

$$S_j = \sqrt{\frac{\sum_{i=1}^{d}\left(Z_{ij} \frac{1}{n}\sum_{i=1}^{d} Z_{ij}\right)^2}{e-1}};\ R_j = \sum_{i=1}^{e}(1 - r_{ij});$$

$$C_j = C_j \times R_j;\ W_j\,(\text{CRITIC}) = \frac{C_j}{\sum_{j=1}^{e} C_j};$$

(4) Calculate the comprehensive level index of urban renewal for each city G_i.

$$W_j = \frac{1}{2}[W_j\,(\text{entropy}) + W_j\,(\text{CRITIC})];$$

$$G_i = \sum_{i=1}^{e} \mathrm{P}_{ij} \times W_j$$

2.3.2 SBM model. Most traditional DEA models are radial and angular, without considering the relaxation issue of input or output. Tone established a non radial and non angular SBM model[21], which incorporates relaxation variables into the objective function, solving the problem of input and output relaxation while also considering the impact of unexpected output efficiency, making the calculation results more accurate. Therefore, the SBM model is used to calculate the efficiency of urban renewal. Supposed that there are d decision units (cities), each decision-making unit (city) uses m types of input elements required for urban renewal $x \in R^m$, and generates s_1 expected outputs $y^a \in R^{s_1}$ and s_2 unexpected outputs $y^b \in R^{s_2}$. Correspondingly, $X = (x_1, x_2, x_3, \ldots, x_d) \in R^{m\times d}$, $Y^a = (y_1^a, y_2^a, y_3^a, \ldots, y_d^a) \in R^{s_1\times d}$, $Y^b = (y_1^b, y_2^b, y_3^b, \ldots, y_d^b) \in R^{s_2\times d}$.

Supposed that $X > 0$, $Y^a > 0$, $Y^b > 0$, the SBM model containing unexpected outputs can be represented as:

$$\varrho^* = \frac{1 - \frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{i0}}}{1 + \frac{1}{s_1 + s_2}\left(\sum_{r=1}^{s_1}\frac{s_r^a}{y_{r0}^a} + \sum_{r=1}^{s_2}\frac{s_r^b}{y_{r0}^b}\right)}$$

$$s.t.\begin{cases} x_0 = X\lambda + s^- \\ y_0^a = Y^a\lambda - s^a \\ y_0^b = Y^b\lambda + s^b \\ s^- \geqslant 0 \\ s^a \geqslant 0 \\ s^b \geqslant 0 \\ \lambda \geqslant 0 \end{cases}$$

where s_i^-, s_r^a, s_r^b, respectively show input redundancy, insufficient expected output, and unexpected output exceeding standards; s^-, s^a, s^b are corresponding relaxation variables. λ is weight vector. When its sum is 1, it indicates variable return to scale (VRS), otherwise it indicates constant return to scale (CRS). When $\varrho^* \geqslant 1$, it indicates that the decision-making unit (city) is effective. When $0 < \varrho^* < 1$, it indicates that the decision-making unit (city) has not reached an effective state, and there is a need for improvement in input-output factors.

3 Analysis of urban renewal efficiency results

3.1 Expected output—comprehensive level index of urban renewal

Fig.1 shows the comprehensive level index of urban renewal of each pilot city in 2011−2021. The average comprehensive level index of Beijing is 0.610 4, ranking first. The average comprehensive level index of Suzhou is 0.522 2, second only to Beijing. Next are Nanjing (0.480 2) and Changsha (0.460 8), and the two cities with the lowest average comprehensive level index are Huangshi (0.277 9) and Chuzhou (0.251 2), both below 0.3. The average comprehensive level index of other cities is between 0.3 and 0.5.

3.2 Urban renewal efficiency

Table 2 shows the urban renewal efficiency values of the first batch of urban renewal pilot cities in 2011−2021 calculated by MATLAB software, and Fig.2 shows the average renewal efficiency values of each pilot city over the years. In general, the average urban renewal efficiency of the first batch of pilot cities in 2011−2021 is 0.437 2, which shows that there is a great loss of renewal efficiency. The overall change trend of urban renewal efficiency in each pilot city from 2011 to 2021 is shown in Fig.3. The urban renewal efficiency showed an upward trend from 2011 to 2013, a serious decline from 2013 to 2014, an upward trend from 2014 to 2017, and a downward trend from 2017 to 2021. The lowest overall renewal efficiency value was 0.318 5, which occurred in 2014; the highest value was 0.545 5, which appeared in 2017. From a city perspective, if the average urban renewal efficiency values of 0−0.4, 0.4−0.8, and 0.8−1.0 are classified as low, medium, and high, then Beijing, Tangshan, Suzhou, Tongling, and Jingdezhen are classified as high, Hohhot, Xiamen, Huangshi, and Yinchuan are classified as medium, and other cities are classified as low. Among them, the average urban renewal efficiency of Xi'an is below 0.1, indicating that the urban renewal efficiency is too low.

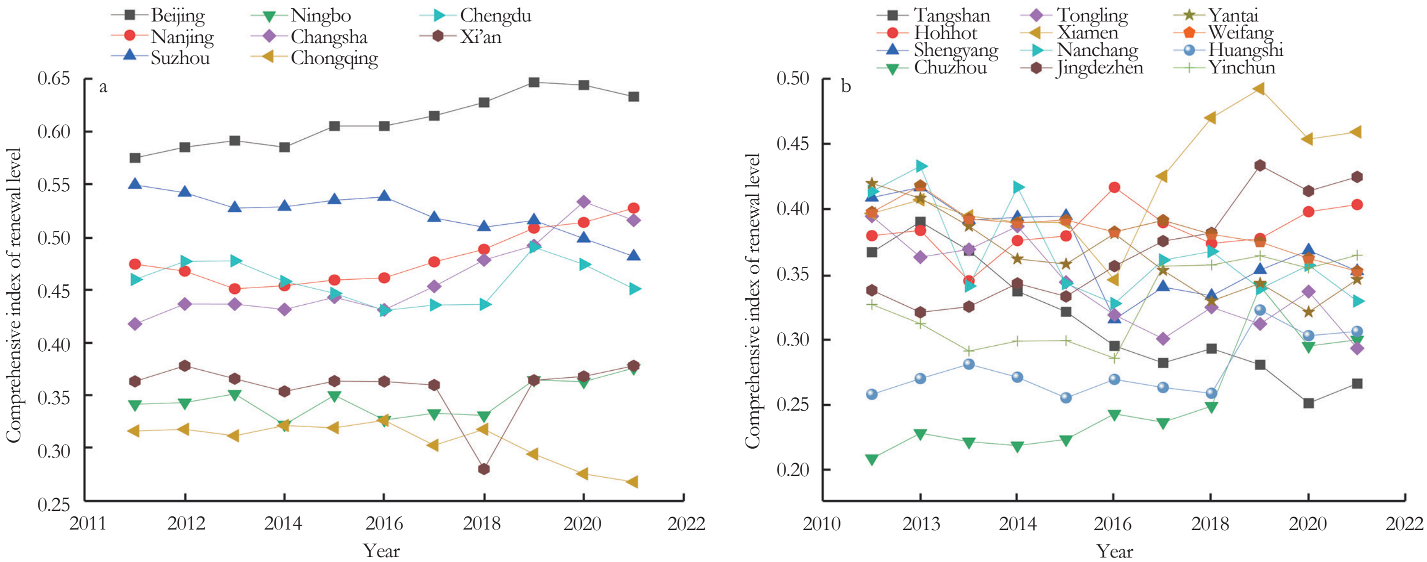
3.3 Analysis of urban renewal efficiency based on Malmqiust index

Based on the efficiency values calculated by the SBM model, Malmquist index of each pilot city is analyzed to obtain the Malmquist index and its decomposition results for the renewal efficiency of each pilot city from 2011 to 2021 (Table 3). Among them, if $ML_0 > 1$ (< 1), it indicates an increase (decrease) in urban renewal efficiency compared to the previous year. If $TC > 1$ (< 1), it explains that the technical level of decision-making units has improved (decreased) compared to the previous period. If $EC > 1$ (< 1), it explains that the technical level of the decision-making unit is close to (away from) the forefront of technology[22]. Seen from Malmquist index, half of the pilot cities have Malmquist indices greater than or equal to 1, indicating that the urban renewal efficiency level of most pilot cities has been improved to varying degrees. The Malmquist index in Hohhot is the highest, while the Malmquist index in Chengdu is the lowest. From the index decomposition results of each pilot city, it can be seen that the technical efficiency change index (EC) is greater than or equal to 1 in all cities except Nanchang, Weifang, and Chengdu, which are below 1. The technical efficiency progress index (TC) is less than 1 in all cities except Chuzhou, Tongling, Yantai, Weifang, Huangshi, and Yinchuan, which are more than 1.

3.4 Experimental results

Based on the SBM model, the renewal efficiency values of the first batch of pilot cities in China are calculated, and the Malmquist index is integrated for dynamic analysis of urban renewal efficiency (Table 3).

(1) From the perspective of expected output alone, cities such as Beijing, Nanjing, and Changsha are China's first tier cities, where various factor resources are relatively concentrated, and the overall economic level is relatively high. On the one hand, this provides more employment opportunities and a good living environment for the people, and the sense of belonging and happiness of residents is improved. On the other hand, the rapid



Note: a. Comprehensive index of renewal level in first-tier cities; b. Comprehensive index of renewal level in non first-tier cities.

Fig.1 Comprehensive level index of urban renewal of pilot cities in 2011–2021

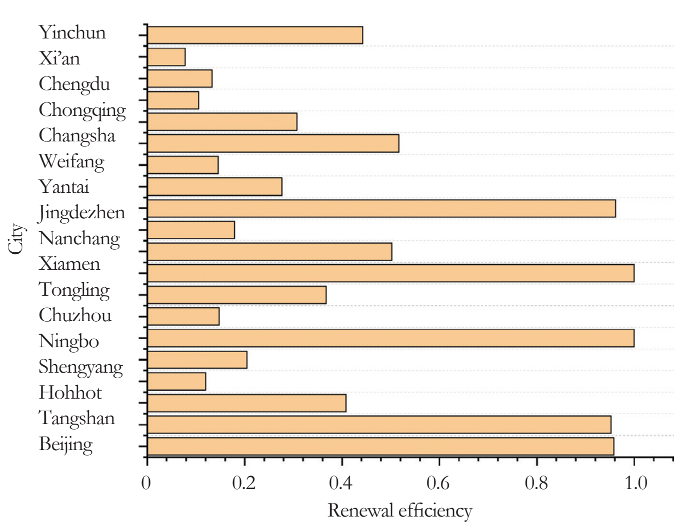


Fig.2 Average urban renewal efficiency of pilot cities in 2011–2021

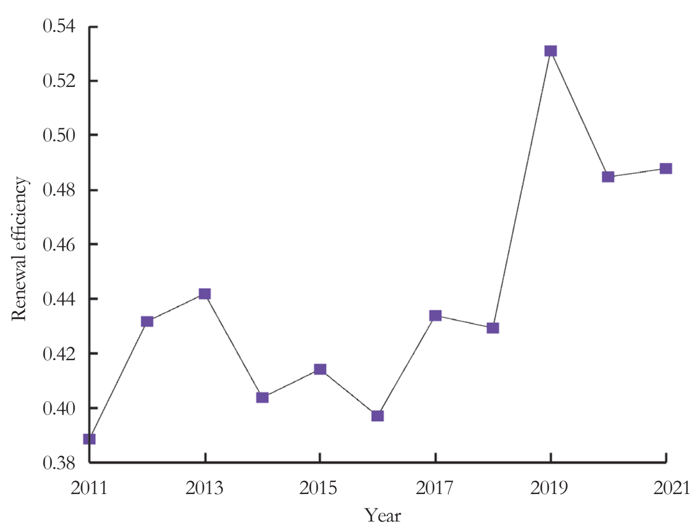


Fig.3 Trends in overall urban renewal efficiency of pilot cities

development of urban economy also promotes industrial agglomeration in another direction, accelerates industrial transformation and structural adjustment, which also promotes the orderly progress of urban renewal activities.

(2) The pilot cities cover China's first, second, and third tier cities, which reflect the actual situation of nationwide urban renewal to some extent. From the perspective of the overall renewal efficiency of pilot cities, the average renewal efficiency in 2011–2021 is less than 0.5, which means that the urban renewal efficiency is low and there is much room for improvement.

(3) The urban renewal efficiency of Suzhou and Beijing is at a high level. Beijing is a metropolis with high-level economic development, while Suzhou is the city with the highest total industrial output value in China. Various resources are relatively concentrated, which is the main reason for the high level of urban renewal efficiency. However, the technological efficiency progress index in Suzhou is all less than 1, indicating that technology is far from the forefront. Suzhou is currently the city with the largest industrial output value in China, but existing research data shows that many industrial parks are in the process of industrial chain integration and transformation, and most parks are facing problems such as land resource shortage and low plot ratio at this time. At the same time, the sulfur dioxide emissions in Suzhou in 2021 are about 20 times that of Beijing, and environmental pollution control should become a major focus of Suzhou's urban renewal in the future renewal.

(4) The urban renewal efficiency of Tongling in 2011–2021 is 1, and the average urban renewal efficiency of Jingdezhen and Tangshan is above 0.9. According to the Malmquist index decomposition results, the following explanation can be made: ① the high efficiency value of urban renewal in Tongling is due to the fact that the technological efficiency change index and technological efficiency progress index are greater than 1, and the technology is closer to the forefront. Tongling is a city characterized by the copper industry since ancient times. At the beginning of the 21st century, the Economic and Technological Development Zone of Tongling became the first batch of national level development zones in China's prefecture level cities. It went hand in hand in controlling copper industry pollution and improving copper smelting technology. After more than 20 years of development, the contribution rate of the copper industry to economic growth reached as high as 70%. ② The technical efficiency change index of Jingdezhen is greater than 1, indicating that the technology in Jingdezhen has improved every year compared to the previous year. As an international trading city for China's porcelain industry, Jingdezhen has always retained a large number of ceramic cultural characteristics in the process of urban development, adhered to the development policy of keeping up with the times and innovating, and strove to build itself into a socialist modern international porcelain capital. ③ The change index of technological efficiency in Tangshan is greater than 1, indicating that the technology in Tangshan has improved annually compared to the previous year. Since the 1990s, Tangshan has been in the process of industrial transformation and economic development. Relying on its abundant natural resources, it has made progress in improving industrial technology. However, due to relatively backward equipment and weak overall competitive strength, its technological efficiency progress index is less than 1.

4 Analysis of factors influencing urban renewal

4.1 Establishment of Tobit model

To improve the efficiency of urban renewal, a Tobit model is established based on the value of urban renewal efficiency to analyze the influencing factors. Due to the fact that the efficiency values calculated by the SBM model are all between (0, 1], consistency testing cannot be obtained through the least squares method (OLS), and parameter estimation has serious errors. The fixed effects Tobit model cannot find sufficient statistics for individual heterogeneity when processing truncated data, and cannot perform maximum likelihood estimation processing, resulting in inconsistent results. For this reason, this paper chooses to establish a Tobit regression model with random effects:

$$Eff_{it} = \alpha + \beta_1 Dens_{it} + \beta_2 Inds_{it} + \beta_3 Realest_{it} + \beta_4 Eco_{it} + \beta_5 Land_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

where Eff_{it} is explained variable, namely the urban renewal efficiency value of pilot city i in

Table 2 Urban renewal efficiency of pilot cities in 2011–2021

City	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Mean
Beijing	1	1	1	1	1	1	1	1	1	1	0.542 7	0.958 4
Tangshan	0.478 3	1	1	1	1	1	1	1	1	1	1	0.952 6
Hohhot	0.168 2	1	0.271 1	0.174 0	0.266 7	0.412 7	0.349 2	0.329 3	0.289 2	0.674 4	0.557 2	0.408 4
Shenyang	0.097 0	0.116 9	0.136 5	0.168 2	0.179 3	0.057 8	0.130 9	0.083 4	0.143 6	0.103 8	0.098 1	0.119 6
Nanjing	0.185 6	0.158 0	0.147 5	0.184 4	0.217 1	0.215 4	0.183 7	0.246 3	0.249 1	0.301 5	0.167 2	0.205 1
Suzhou	1	1	1	1	1	1	1	1	1	1	1	1.000 0
Ningbo	0.098 1	0.122 3	0.157 6	0.083 7	0.188 7	0.121 0	0.139 3	0.150 2	0.179 8	0.189 8	0.195 2	0.147 8
Chuzhou	0.282 4	0.240 2	0.338 3	0.228 1	0.224 6	0.287 3	0.425 7	0.333 5	1	0.297 5	0.385 9	0.367 6
Tongling	1	1	1	1	1	1	1	1	1	1	1	1.000 0
Xiamen	0.319 3	0.301 8	0.350 5	0.327 4	0.302 7	0.132 2	0.336 1	0.456 3	1	1	1	0.502 4
Nanchang	0.209 1	0.260 1	0.191 7	0.248 9	0.149 8	0.113 3	0.153 6	0.209 5	0.150 4	0.147 4	0.138 5	0.179 3
Jingdezhen	1	0.581 3	1	1	1	1	1	1	1	1	1	0.961 9
Yantai	0.409 2	0.329 9	0.329 4	0.160 2	0.191 0	0.316 7	0.304 2	0.222 1	0.384 4	0.194 1	0.202 0	0.276 7
Weifang	0.099 5	0.093 8	0.125 1	0.125 1	0.145 7	0.141 3	0.140 9	0.174 6	0.188 0	0.196 0	0.172 7	0.145 7
Huangshi	0.424 9	0.393 5	0.638 6	0.498 1	0.464 6	0.389 2	0.615 5	0.321 4	0.673 2	0.542 1	0.725 3	0.516 9
Changsha	0.143 7	0.203 2	0.253 9	0.205 3	0.318 0	0.275 7	0.275 0	0.441 7	0.434 2	0.470 9	0.357 0	0.307 2
Chongqing	0.089 7	0.093 7	0.090 7	0.150 9	0.144 9	0.101 1	0.089 0	0.115 7	0.113 5	0.101 5	0.069 8	0.105 5
Chengdu	0.185 6	0.163 7	0.158 1	0.156 3	0.143 2	0.097 4	0.096 5	0.105 4	0.137 1	0.132 2	0.088 5	0.133 1
Xi'an	0.105 8	0.118 0	0.098 7	0.069 9	0.098 3	0.067 2	0.073 7	0.038 8	0.075 4	0.051 9	0.058 3	0.077 8
Yinchuan	0.475 1	0.458 8	0.549 7	0.296 1	0.249 7	0.213 1	0.364 5	0.359 5	0.603 8	0.293 8	1	0.442 2
Mean	0.388 6	0.431 8	0.441 9	0.403 8	0.414 2	0.397 1	0.433 9	0.429 4	0.531 1	0.484 8	0.487 9	0.440 4

year *t*. $Dens_{it}$, $Inds_{it}$, $Realest_{it}$, Eco_{it}, $Land_{it}$ are explanatory variables, and respectively show population density (Dens), industrial structure (Inds), real estate investment (Realest), regional economic development level (Eco) and land use pressure (Land); α is intercept term; β_1, β_2, β_3, β_4, β_5 show coefficients of different explanatory variables; μ_i shows individual fixed effects; λ_t shows time fixed effect; ε_{it} shows random error term; i (i = 1, 2, …, 20) shows different pilot cities; t (t = 1, 2, …, 11) shows year.

4.2 Regression result analysis and robustness testing

Stata software is used to conduct the Tobit model estimation of random effects on relevant variable data, and the following explanation can be made (Table 4).

(1) Population density. The regression results indicate that population density has a positive impact on urban renewal efficiency, and is significantly positive at the 1% level. In the process of urban development, a large influx of population forms population aggregation, causing scale economy effects, injecting vitality into urban economic development, and improving urban renewal efficiency.

(2) Industrial structure. The industrial structure coefficient is positive but not significant, indicating that the adjustment of industrial structure has a potential driving effect on urban renewal efficiency. Industry is the core driving force for urban economic development, and industrial restructuring and transformation both mean a significant investment of capital and labor. The knowledge reserves and technological means of different industries will be improved, thereby improving the efficiency of urban renewal. However, this lack of significance may be due to the inadequate selection of measurement indicators.

(3) Real estate investment. Real estate investment is significantly negative at the 1% level, indicating that it has a significant inhibitory effect on urban renewal. During 2009–2019, many governments relied excessively on land transfer fees and rents, and developers invested excessively, which eventually led to oversupply in the market, forming a foam in the real estate market. Nowadays, high housing prices have weakened the consumption desire of the general population, which is not conducive to the development of the urban economy and thus inhibits the efficiency of urban renewal.

(4) Regional economic development level. The level of regional economic development is significantly positive at the 1% level, and the correlation value is the highest, indicating that the level of regional economic development has a positive promoting effect on urban renewal efficiency. Since the 19th National Congress of the Communist Party of China, China's economic development goals have shifted from high-speed growth to high-quality growth. The improvement of regional economic development level could attract a large amount of social capital, which will provide a large amount of financial support and guarantee for the land market. At the same time, high-quality economic growth will promote healthy competition in the market and have a positive effect on urban renewal efficiency.

(5) Land-use structure. The coefficient of land use pressure is positive but not significant, indicating a potential impact on urban renewal efficiency. To an extent, it indicates that the larger the proportion of built-up area is, the higher the efficiency of land use is, thereby improving the efficiency of urban renewal.

To further verify the robustness of the regression results of the Tobit model, it is tested and compared based on two different models. The specific results are shown in Table 5. The results indicate that under the RE model, there is a significant positive effect between Dens and urban renewal efficiency. The impact of Inds on urban renewal efficiency is not significant. The effect of Realest on urban renewal efficiency is significant but negative. The Eco has the most significant positive impact on urban renewal efficiency, and the effect of Land on urban renewal efficiency is not significant but positive. These results are basically consistent with the Tobit regression results. Except for population density, the significance and variable symbols of all other variables remain consistent, indicating that the regression results in this paper are stable.

Table 3 Malmquist index and its decomposition of renewal efficiency in pilot cities from 2011 to 2021

City	Malmquist index	EC (technical efficiency change index)	TC (technical efficiency progress index)
Beijing	1.007 1	1.000 0	1.007 1
Tangshan	1.107 6	1.109 1	0.990 4
Hohhot	1.467 7	1.576 4	0.994 1
Shenyang	0.995 3	1.128 6	0.961 7
Nanjing	0.963 1	1.017 4	0.967 6
Suzhou	0.963 3	1.000 0	0.963 3
Ningbo	1.058 8	1.147 3	0.971 1
Chuzhou	1.166 4	1.205 5	1.074 3
Tongling	1.031 2	1.000 0	1.031 2
Xiamen	1.192 8	1.249 4	0.949 1
Nanchang	0.950 4	0.999 5	0.947 5
Jingdezhen	0.983 8	1.030 2	0.980 2
Yantai	0.953 7	1.010 9	1.007 2
Weifang	0.962 0	0.954 3	1.020 2
Huangshi	1.024 8	1.144 1	1.006 1
Changsha	1.047 5	1.131 7	0.956 4
Chongqing	0.964 6	1.007 8	0.989 8
Chengdu	0.915 4	0.945 0	0.971 6
Xi'an	0.947 3	1.012 9	0.981 5
Yinchuan	1.165 9	1.266 6	1.025 1

Table 4 Regression results of Tobit model

eff	Coef.	St.Err.	t-value	p-value	Sig
Dens (population density)	0.351	0.121	2.89	0.004	***
Inds (industrial structure)	0.002	0.003	0.72	0.470	
Realest (real estate investment)	−0.157	0.043	−3.61	0.000	***
Eco (regional economic development level)	0.384	0.084	4.54	0.000	***
Land (land use structure)	0.002	0.003	0.49	0.624	
Constant	−4.919	1.691	−2.91	0.004	***
sigma_u	0.363	0.068	5.30	0.000	***
sigma_e	0.157	0.009	16.62	0.000	***
Rho	0.842	0.052			
Log likelihood = 8.6548931		Prob > chi2 = 0.000 0			
LR test of sigma_u = 0: chibar2 (01) = 231.32		Prob >= chibar2 = 0.0000			

$^{***}p<0.01$, $^{**}p<0.05$, $^{*}p<0.1$

Table 5 Regression results of Hausman test

	(1) FE	(2) RE	(3) Tobit regression result
Dens (population density)	0.236** (2.59)	0.238** (3.16)	0.351*** (2.89)
Inds (industrial structure)	0.001 74 (0.87)	0.00110 (0.56)	0.002 (0.89)
Realest (real estate investment)	−0.084 5** (−2.24)	−0.123*** (−3.88)	−0.157*** (−3.61)
Eco (regional economic development level)	0.252*** (3.74)	0.300*** (4.86)	0.384*** (4.54)
Land (land use structure)	0.003 69 (1.45)	0.002 49 (1.02)	0.002 (0.49)
_cons	−3.510** (-2.60)	−3.417** (−2.94)	−4.919*** (−2.91)
Hausman test	8.41 (0.135 0)		
Log likelihood		8.654 9	

5 Conclusions and relevant policy recommendations

(1) Clarify the development connotation of urban renewal, and guide urban renewal with the concept first. At present, urban renewal is no longer limited to the demolition and reconstruction of old buildings, but focuses more on improving people's living environment, promoting regional economic development, and enhancing people's sense of happiness in the city. In the report of the 20th National Congress of the Communist Party of China, it was mentioned that it must adhere to the principle of building people's cities for the people. People's cities have become a new concept for urban renewal in China. Therefore, it should always adhere to the people-oriented concept, adhere to the ecological development concept of "lucid water and lush mountains are invaluable assets", coordinate multiple dimensions such as economic development, living environment, urban spatial structure, social livelihood, and pollution control, and systematically carry out comprehensive planning for urban renewal work in the future process of urban renewal.

(2) Emphasize industrial upgrading and increase investment in science and technology. The efficiency of urban renewal reflects the relative level of input factors and output outcomes, and the key to improving the efficiency of urban renewal is achieving the maximum expected output under constraint conditions with fewer inputs. From the experimental results, it can be seen that urban renewal efficiency in some second and third tier cities exceeds that of first tier cities. Although its economic level is not high, the Malquist index decomposition results indicate that its technological efficiency change index or progress index is greater than 1, and technological innovation promotes rapid economic growth. Innovation and technological development are the sources of economic development. Therefore, it should adjust the industrial structure, and increase investment in science and technology, providing endogenous impetus for urban economic development and driving the improvement of urban renewal efficiency through economic development.

(3) Strengthen the regulation of the real estate market, and urban renewal should shift to the stage of urban operation and management. From the regression results, it can be seen that the explanatory variable selected for real estate investment is the amount of real estate development investment, which has a negative impact on the improvement of urban renewal efficiency. Existing research has shown that China's urbanization process has shifted from incremental construction to stock enhancement. Urban growth has come to an end, and the urbanization benefits brought by real estate development are gradually weakening. Urban renewal should restrict developers blindly pursuing profits and strengthen regulation and supervision of the real estate industry instead of continuing the excessive investment in real estate in the past. Urban renewal should gradually shift towards operation and management, and emphasize the role of public participation.

(4) Promote high-quality development in the region through urban policies and achieve efficient urban renewal. The fundamental goal of urban renewal is to enhance people's well-being. From the results of the overall evaluation of urban renewal efficiency, the impact of unexpected outputs on urban renewal efficiency cannot be underestimated. Different cities should formulate relevant policies based on their own development advantages and characteristics. On the one hand, it should strengthen the regulation of high pollution behaviors in the process of urban renewal. On the other hand, it should support the reemployment of urban unemployed people. Finally, it should improve the urban housing security system, weaken the degree of gentrification in the city, and achieve efficient operation of urban renewal.

References

[1] Fan, C. X. (2021). Need analysis and practical response of urban development in Liaoning from the perspective of urban renewal. *Journal for Party and Administrative Cadres*, *395*(11), 56-62.

[2] The 14th Five-year Plan for national economic and social development of the People's Republic of China and the outline of the long-range goals for 2035. *People's Daily*, 2021-03-13.

[3] Zhang, Q. B. (2007). *Research on the theory of renewal location, renewal duration, and renewal degree in urban renewal* (Master's thesis). Retrieved from China National Knowledge Infrastructure.

[4] Yang, J. Q. (2000). The status quo, characteristics and tendency of urban renewal in China. *City Planning Review*, (4), 53-55, 63-64.

[5] Zhang, J. X., Zhao, D. & Chen, H. (2013). Termination of growth supremacism and transformation of China's urban planning. *City Planning Review*, (1), 47-52, 57.

[6] Yang, J. Q., Chen, Y. (2020). Review on the development of urban regeneration in China from 1949 to 2019. *City Planning Review*, *44*(2), 9-19, 31.

[7] Ding, H. F., Zhang, R. & Zhou, R. B. (2021). Whether urban renewal is beneficial to urban-rural integration: From the perspective of resource allocation. *China Land Science*, *35*(9), 84-93.

[8] Tang, Y., Zhang, L. & Liu, S. L. (2020). Hotspot review of research and practice of urban regeneration in 2019. *Science & Technology Review*, *38*(3), 148-156.

[9] Mee, K. N. (2005). Quality of life perceptions and directions for urban regeneration in Hong Kong. *Social Indicators Research*, *71*(1-3) , 441-465.

[10] Catalina, T. (2012). Local experiences of urban sustainability: Researching housing market renewal interventions in three English neighbourhoods. *Progress in Planning*, *78*(3), 101-150.

[11] Zhang, J. K., Feng, Y. J. & Liu, Z. G. (2010). On evaluation of renovation sustainability of old city on DPSIR model: A case study of Qinhuai District, Nanjing. *Journal of Nanjing Agricultural University* (*Social Sciences Edition*), *10*(4), 80-87.

[12] Zhang, J. L., Xu, C. B. & Zhu, D. J. et al. (2022). Research on mining and quantitative evaluation of urban renewal policy tools: A case study of Beijing, Tianjin, Hebei. *Urban Development Studies*, *29*(7), 30-36.

[13] Wang, M., Li, Y. & Zhang, W. X. et al. (2011). Evaluation of urban renewal performance based on DEA method: A case study of the former Xicheng District of Beijing. *Urban Development Studies*, *18*(10), 90-96.

[14] Yi, Z. Y. (2018). *Research on the evaluation of urban renewal benefits and collaborative*

(To be continued in P40)

Fig.20 Tomb of Zhang Liao

Fig.21 Cangyou garden

Status quo	Site function	Existing problems
1. Cangyou Shibei scenic spot is composed of Cangyou garden and tropical rainforest pavilion	1. Plant science popularization	1. The opening hours of the park are uncertain, and the seating shape is relatively simple.
2. The green brick pavement which is easy to grow moss is upgraded to non-slip marble pavement	2. Leisure tour	2. The effect of plant collocation is not good, and there is a lack of professional explanation for plants
3. Artificial rainfall is set in the park to enhance the sensory experience of rainforest		

Fig.22 Analysis of zone H

suitable for the requirements of modern life, making the park truly a carrier of material experience[10]. Suitable proportion of open communication space and more private and quiet personal space can be created to meet the play and social needs of tourists.

5 Conclusions

The renovation and renewal of old city parks is not just demolition and reconstruction, but a continuous and dynamic renewal process. The transformation of Xiaoyaojin Park should create its own characteristic culture, inherit the cultural context of the Three Kingdoms, and adjust the unreasonable spatial pattern on the basis of preserving the urban memory of Hefei citizens, so as to meet the needs of leisure, entertainment and fitness activities of citizens of different ages. By paying more attention to the psychological needs, subjective feelings and space experience of tourists, a people-oriented city park that meets the psychological needs of the public can be created, so as to revitalize the old park.

References

[1] Liu, Y., Xu, L. F. (2018). Discussion on the problem of city park landscape design. *Chinese Landscape Architecture*, *34*(S1), 82-84.

[2] Ju, C. (2013). *Research on landscape renovation of Mudanjiang Renmin Park* (Master's thesis). Retrieved from China National Knowledge Infrastructure.

[3] Liu, Y., Wang, H. & Wang, H. (2012). A preliminary study on "organic renewal" of urban comprehensive park: A case study of Zhushuishan urban green valley design in Qingdao. *China Forestry Science and Technology*, *26*(6), 113-117.

[4] Shu, M., He, S. Y. & Wang, W. L. (2013). Study on reconstruction of Xiaoyaojin Park. *Acta Agriculturae Jiangxi*, *25*(2), 55-57

[5] Zhan, L. H. Z. (2020). *Research on the street square of Yuexiu old district in Guangzhou* (Master's thesis). Retrieved from China National Knowledge Infrastructure.

[6] Jin, X. (2012). *Preliminary study of city park recreation space construction based on behavioral psychology* (Master's thesis). Retrieved from China National Knowledge Infrastructure.

[7] Huang, J. (2022). Analysis on the upgrading and reconstruction of Xiaoyaojin Park in Hefei City. *Anhui Architecture*, *29*(3), 38-39.

[8] Tian, Y. (2020). *Research on landscape design of urban comprehensive park based on mass behavior* (Master's thesis). Retrieved from China National Knowledge Infrastructure.

[9] Lin, L. (2009). *Case studies on design for the renovation of urban parks in Changzhou* (Master's thesis). Retrieved from China National Knowledge Infrastructure.

[10] Bai, Y., Yu, D. (2013). The method of comprehensive analysis in park renovation. *Chinese Landscape Architecture*, *29*(8), 70-74.

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(Continued from P34)

governance (Master's thesis). Retrieved from China National Knowledge Infrastructure.

[15] Ke, X. Y., Li, J. G. & Li, C. et al. (2022). Spatial-temporal variation characteristics and influencing factors of urban renewal performance in Guangdong Province. *China Land Science*, *36*(6), 44-55.

[16] David, M., Joel, L. N. (1987). Central city revitalization: A predictive model. *Real Estate Economics*, *15*(1), 664-683.

[17] Chan, E., Lee, G. K. L. (2008). Critical factors for improving social sustainability of urban renewal projects. *Social Indicators Research*, *85*(2), 243-256.

[18] Lv, Y. J. (2019). *Analysis of factors influencing the implementation of urban renewal projects* (Master's thesis). Retrieved from China National Knowledge Infrastructure.

[19] Zhang, T. (2021). *A study on the coupling and coordination between urban renewal and high-quality economic development in Shenzhen City* (Master's thesis). Retrieved from China National Knowledge Infrastructure.

[20] Nie, Z. H. (2022). *Evaluation of urban renewal efficiency and research on influencing factors* (Master's thesis). Retrieved from China National Knowledge Infrastructure.

[21] Kaoru, T. (2003). *Dealing with undesirable outputs in DEA: A slacked-based measure approach*. The Operations Research Society of Japan.

[22] Chung, Y. H., Fare, R. & Grosskopf, S. (1997). Productivity and undesirable outputs: A directional distance function approach. *Journal of Environmental Management*, *51*(3), 229-240.