Analysis of Land Use Efficiency in Provincial-Level Development Zones—Case Study of Wanjiang City Belt, China

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Abstract. Analyses of land use efficiency in development zones can provide insight into promoting effective land use and improving development efficiency. However, few studies have systematically evaluated land use efficiency in development zones at the provincial level. This study aims to analyze the economic efficiency of land use in 40 provincial-level development zones in the Wanjiang City Belt. By conducting a data envelopment analysis (DEA), we derive the following results. First, there remains considerable room for efficiency improvement. Second, the zones located on the development axis along the Yangtze River demonstrate high economic efficiency in land use. Third, the land use inefficiency of development zones located in a county is worse than that in a prefecture. In conclusion, as for efficiency improvements at the provincial level, development zones in county areas, especially in the north area of the Yangtze River, need attention.

1. Introduction
A land development zone is a multi-input and output system. Analyzing the economic efficiency of land use can be understood as studying the effects of developing park land, capital, labour, technology, and other input factor on economic output[1-2]. It reflects a reasonable degree of land resources and various factors included in configuring a comprehensive development zone, also known as the level of economic land use. A quantitative evaluation of the economic land use efficiency includes the ascertaining of the utilization efficiency of resources and analyzing land situations, problems, and obstacles. In addition, it contributes to the timely adjustment and improvement in land management practices and industrial policies. However, several Chinese scholars have expressed their concern regarding the efficiency of various land evaluations.

Many existing studies have proposed static and dynamic measures to evaluate the overall efficiency of decision-making units (DMUs) in terms of land use efficiency[1, 3-11]. Although studies have adopted research methods that are based on DEA[1][4-6][8-11], their results tend to differ[5][7][12]. Related research focuses on the national and regional levels as well as the economic and technological development of high-tech land analyses; however, few studies analyze land at a provincial level. Recent studies, nevertheless, are gradually extending to different sectors[12], thus offering diverse insights into land use at the micro level[7][12].

The Wanjiang City Belt is the first to relocate its industries to the national demonstration area in China. Land analyses at the provincial level include industrial transfers, although few studies have systematically evaluated efficiency at the provincial level. This study attempts to bridge this gap by conducting a provincial-level analysis using 2012 land data for 40 provinces in the Wanjiang City Belt.
To do so, it performs a DEA that categorizes land, capital, labour, science and technology, and other economic factors under four output efficiency levels to evaluate economic land use efficiency. The analysis provides us with an overview of the land area situation at the provincial level, land use efficiency in development zones, and other characteristics and problems. The results serve as a foundation to adjust industrial policy, improve land management zones, and promote the transformation and upgrading of quality and efficiency development.

2. Study Area
The Demonstration Zone for Industrial Transfer of the Wanjiang River City Belt (hereinafter Wanjiang City Belt) was established in 2010 and is located in Anhui of the Yangtze River basin (Fig. 1). Its regional land area is $7.79 \times 10^4$ km$^2$ and was the first and currently remains the only region to relocate its industries to China’s national demonstration area. The Demonstration Zone is the first area to demonstrate collaborative scientific development. The central region is important to the growth of the country and is an advanced manufacturing and modern service industry base that has undertaken the industrial transfer process from within the country to abroad\cite{13}. The demonstration area includes Hefei, Wuhu, Maanshan, Tongling, Anqing, Chizhou, Chuzhou, Xuancheng, Jinan, and Shucheng of Lu’an city. The area’s industrial development structure lies on the development axis along the Yangtze River. Its two central regions are Hefei and Wuhu and Chuzhou and Xuancheng show an industrial distribution pattern along the axis.

As can be seen, important regional industries have been relocated and the present economic demonstration zones (technology), development zones, industrial parks, and processing zones have transferred from coastal regions to the eastern Anhui Province to accelerate the upgrading and restructuring of the regional industrial structure and promote industrialization in these regions. By the end of 2013, the demonstration area reported 108 types of development parks, covering a total area of 2,350 km$^2$ and accounting for 61.71% and 55.62% of the province’s development zones. As shown in Fig. 2, as of 2013, the region has 47,884 companies and 231.51 million practitioners. The total fixed assets was 590.677 billion yuan, the total imports and exports was $22.053 billion, operational (sales) income was 2.31345 trillion yuan, total industrial output value was 1.683716 trillion yuan, and state tax revenue was 66.601 billion yuan. The provincial-level development zones occupy half of the demonstration area and the transfer of industry is indispensable.

![Figure 1. Location diagram of the Wanjiang City Belt\cite{14}](image1)

![Figure 2. Development of various development parks in the Wanjiang City Belt](image2)

3. Data and Methods

3.1. Evaluation model
DEA is a relative efficiency evaluation model. It uses an optimal method to determine the weight of input elements to evaluate the relative efficiency for several DMUs with the same type of multi-input and output system\cite{15, 16}. This non-parametric statics method does not require non-dimensionalization or an estimated index and thus, easily provides information to improve DMUs that are not efficient\cite{14}, rendering it an ideal multi-objective decision method. At present, DEA is a universally applied method to estimate land use efficiency, including but not limited to urban areas\cite{17-19}, development zones\cite{9-11},
small towns\textsuperscript{[20]}, and counties\textsuperscript{[21-22]}. The land of development zones is a special multi-input and output system. This research uses the DEA method and CCR model to evaluate land use efficiency in development zones.

### 3.2. Construction of index system and data sources

The present evaluation index system to evaluate the economic efficiency of land use in development zones is based on DEA. It is divides factors into two types, inputs and outputs. Inputs include land, capital, labour, and technology and output are economic benefits. X1 is the supplied construction land area (ha), X2 is the total amount of industrial enterprises’ fixed assets investment (million), X3 is the number of practitioners (people), and X4 is the annual expenditure on scientific and technological activities (million). Explanatory variables are land, capital, labour, and technology. Industry total production value (Y1; million), total income of industrial enterprises (Y2; million), and total annual tax (Y3; million) are explanatory variables.

Assuming a time-lag effect of actual land supply and incorporating production factors\textsuperscript{[23-24]}, we set the lag period to one year. For the index X1, we use refer to the 2012 dataset of intensive-use assessments for development zones in the Anhui Province. Other indicators are from cross-section data for the end of 2013 and are taken from the development report for the Anhui Province. All of the above are positive variables. We select 40 provincial-level development zones with complete data. The sample accounts for 89% of the total study area, of which 26 counties are located within the area and 14 are in the city (prefecture). To facilitate the identification and simplify the analysis, we number the regions as shown in Table 1.

#### Table 1. Provincial-level development zones in the Wanjing City Belt

| Region | Development Zone |
|--------|------------------|
| 1      | Hefei Yaohai Economic development zone |
| 2      | Hefei Luyang Industrial zone |
| 3      | Hefei Shushan Economic development zone |
| 4      | Hefei Baohe Industrial zone |
| 5      | Changfeng Economic development zone |
| 6      | Feidong Economic development zone |
| 7      | Feixi Taohua Industrial zone |
| 8      | Lujiang Economic development zone |
| 9      | Chaohu Economic development zone |
| 10     | Chaohu Fuhuang Industrial zone |
| 11     | Wuhu Jiujiang Economic development zone |
| 12     | Xinwu Economic development zone |
| 13     | Nanling Industrial zone |
| 14     | Wuwei Economic development zone |
| 15     | Anqing Changjiang Bridge Economic development zone |
| 16     | Huaining Economic development zone |
| 17     | Zongyang Economic development zone |
| 18     | Qianshan Economic development zone |
| 19     | Taihu Economic development zone |
| 20     | Susong Economic development zone |
| 21     | Wangjiang Economic development zone |
| 22     | Tongcheng Economic development zone |
| 23     | Lu’an Economic development zone |
| 24     | Shucheng Economic development zone |
| 25     | Xuchang Economic development zone |
| 26     | Xuanzhou Economic development zone |
| 27     | Guangde Economic development zone |
| 28     | Ningguo Economic development zone |
| 29     | Maanshan Cihu Economic development zone |
| 30     | Dangtu Economic development zone |
| 31     | Hanshan Economic development zone |
| 32     | Hexian Economic development zone |
| 33     | Quanjiao Economic development zone |
| 34     | Dingyuan Economic development zone |
| 35     | Fengyang Industrial zone |
| 36     | Mingguang Industrial zone |
| 37     | Tongling Lion Rock Economic development zone |
| 38     | Tongling Bridge Economic development zone |
| 39     | Tongling Jinqiao Economic development zone |
| 40     | Dongzhi Xiangyu Chemical engineering industrial zone |
Note: Every development zone is numbered as follows: Hefei 1–10, Wuhu 11–14, Anqing 15–22, Lu’an 23–24, Xuancheng 25–28, Maanshan 29–32, Chuzhou 33–36, Tongling 37–39, Chizhou 40.

4. Results
We consider each development zone as an independent DMU. The total amount of investment is two times greater than the number of variables of output units, which is in line with the requirements of the rule of thumb. Using SPSS (20.0), we conducted a Pearson correlation test for the input and output variables (Table 2). In addition to Y1 and X2 being statistically significant at the 5% level, other input and output variables are significant at the 1% level, indicating a significantly positive correlation between the amplitude expansion, which is in line with the requirements for input and output variables.\textsuperscript{[25]} We use DEAP 2.1 package and a CCR model and set a variable status to guide investments and variable returns on the basis of a relative comparison of the effectiveness of DMUs with the same level of output. The evaluation results are presented in Tables 3 and 4.

Table 2. Pearson correlation test results for output and input indicators

|       | X1    | X2    | X3    | X4    |
|-------|-------|-------|-------|-------|
| Y1    | 0.628** | 0.374* | 0.842** | 0.598** |
| Y2    | 0.774** | 0.983** | 0.432** | 0.471** |
| Y3    | 0.575** | 0.469** | 0.780** | 0.449** |

Note: * and ** denote significance at the 5% and 1% levels.

Table 3. Non-DEA efficiency evaluation results for effective DMUs

| DMU | Overall efficiency CE | Pure technical efficiency VE | Scale efficiency Stage | Overall efficiency CE | Pure technical efficiency VE | Scale efficiency Stage |
|-----|-----------------------|----------------------------|------------------------|-----------------------|----------------------------|------------------------|
| 1   | 0.811                 | 1                          | 0.811                  | 19                    | 0.839                      | 1                      |
| 5   | 0.789                 | 1                          | 0.789                  | 20                    | 0.715                      | 1                      |
| 6   | 0.955                 | 1                          | 0.955                  | 24                    | 0.723                      | 0.764                  |
| 7   | 0.895                 | 1                          | 0.895                  | 27                    | 0.885                      | 0.902                  |
| 8   | 0.812                 | 0.942                      | 0.862                  | 30                    | 0.986                      | 1                      |
| 9   | 0.828                 | 0.835                      | 0.992                  | 31                    | 0.898                      | 1                      |
| 10  | 0.936                 | 1                          | 0.936                  | 32                    | 0.830                      | 1                      |
| 13  | 0.868                 | 0.881                      | 0.984                  | 33                    | 0.774                      | 0.806                  |
| 15  | 0.894                 | 0.897                      | 0.997                  | 34                    | 0.706                      | 1                      |
| 16  | 0.938                 | 0.938                      | 0.938                  | 36                    | 0.870                      | 0.884                  |
| 17  | 0.838                 | 0.840                      | 0.998                  | 37                    | 0.931                      | 1                      |

Note: “+” and “−” indicate increasing and decreasing returns to scale.

4.1. Comprehensive efficiency
Overall, the comprehensive efficiency of development zones in the Wanjiang City Belt at the provincial level is high, that is, above 0.7 with an average of 0.918. The industrial park in Hefei Luyang and 17 other development areas meet the CE = 1 and S− = S+ = 0 conditions and achieve the technical and scale efficiency. This suggests that under the present economic and technical levels, input and output of land utilization for the development zones are at its best. The economic efficiency of land utilization is also optimal. The other 22 development zones do not fully achieve DEA
efficiency (Table 3). Among them, Changfeng, Susong, Shucheng, Quanjiao, and Dingyuan are the lowest with less than 0.8. To evaluate comprehensive efficiency by regional distribution, we first calculate the comprehensive efficiency mean of the seven areas and obtain a value greater than two. The average efficiency in ascending order are Tongling (0.977), Xuancheng (0.971), Wuhu (0.967), Maanshan (0.929), Anqing (industry group; 0.9164), and Hefei (industry group; 0.8965). The value for “north core” (Hefei) is less than that for “south core” (Wuhu), the value for “north wing” (Chuzhou) is less than that for “south wing” (Xuancheng), and those for “north core” and “north wing” are lower and along the river development axis (Maanshan, Wuhu, Tongling, and Anqing). It is noteworthy that the land comprehensive efficiency of the “north core” or the Hefei Provincial Development Zone is not ideal. The main obstacle is that the efficiency of the development zone of Hefei’s industrial group is low, while most of the DMUs are not DEA-effective and show diminishing returns to scale. This may be because Hefei’s economic development level is higher than that in other cities. In addition, the higher level and superior technical strength contribute to the industrial transfer process, although its collaboration with advanced local enterprises in the same industry is low. However, the technology advantage is not obvious and thus, the technology spillover is smaller[26]. From a regional development perspective, in the present study area[27], in both zones[14], the industrial transfer formed Hefei forms a single pattern. The demonstration area (dual core)[13] does not match the current pattern and is not conducive to industries in a city layout for coordination and collaborative development[27]. Moreover, some drawbacks were visible in the land use efficiency of the provincial-level development zone. In addition, comprehensive efficiency of spatial distribution in the provincial development zone reflects the industrial belt along the Yangtze River and the process of industrial transfer may be relative to the proper handling of the relationship between efficiency and benefit, which is helpful to future rapid and efficient growth.

In addition, the evaluation results show that in the absence of an effective DEA, of the 22 development zones, the three zones located in the city (district) and 19 in counties (cities) account for 21.43% and 73.08% of all types of development zones. In contrast, the land utilization efficiency at the county level is not optimistic. This can be attributed to the following aspects. First, most of the cities and counties under the jurisdiction of the development zone are located downtown and in the suburbs. In addition, the development zone and central city show an integrated trend for planning and construction and the land utilization efficiency for the county (city) and development zone is lower than that in the city and has a certain rationality. Second, combined with the development of the study area, most of the counties are located in the provincial development zones and the economic volume and scale are too small. The industrial clustering effect is weak and the industry characteristics are not obvious. Further, the industry chain is incomplete and competitiveness relatively low. In particular, during the period of an economic decline, the larger the county development zone, the bigger the total pressure assessment. Some counties (cities) in existing development zones are yet to form a sufficiently large scale and ignore quality in an attempt to achieve quantity.

Figure 3. Non-DEA effective VE-SE DMU map
4.2. Technical and scale efficiency and stage of scale returns

Comprehensive efficiency alone cannot reflect the relationship between the comprehensive efficiency value of each DMU and the technical and scale efficiencies. The above results of each efficiency values are generally higher. Referencing an existing research, we drew a scatter plot based on technical efficiency (VE) and scale efficiency (SE) using SPSS 20.0. We adopt two efficiency means (0.969, 0.948) for all DMUs as the division standard. We were able to draw a VE-SE spatial map for non-DEAs and completely effective DMUs (Fig. 3). Combined with its stage of scale returns (Table 3), the research indicated the following.

First, five economic development zones, Quanjiao (−), Chaohu (−), Zongyang (−), Guangde (−), and Anqing Yangtze River Bridge (+), and two industrial parks, Nanling (−) and Mingguang (−), are located in the fourth quadrant; their comprehensive efficiency is low due to the low technical efficiency. In other words, there are heavy scale and light technology issues in these development zones, mainly owing to scale efficiency needed to maintain a certain level of development. In addition, apart from the economic development zone of the Anqing Yangtze River, all zones show a decreasing returns to scale. Therefore, there is a need to control the scale of land use, improve the management of industrial parks, and promote technological progress to improve the industrial structure and achieve transformation and upgrading.

Second, eight economic development zones, Dingyuan (+); Susong (+); Huaining (−); Taihu (+); He county (+); Shuangfeng, Changfeng Country (−); Yiaohai districts, Hefei city (−); and Shizishan district, Tongling city (+), and three industrial parks, Hanshan; Taohua Town, Feixi Country (−); and Fu huang (+), are located in the second quadrant. Their comprehensive efficiency is low mainly due to the low scale efficiency. Among the 11 development zones, the returns to scale of Huaining, Yaohai district, Shuangfeng, and Taohua Town continue to decrease and thus, continuous attention is needed towards controlling the scale of land use. As for the other seven development zones, while promoting technological progress a certain degree of integration and expansion should be considered and the scale properly expanded if conditions and policies permit, thus taking its scale efficiency to a new level.

The two development zones, Lujiang (+) and Shucheng (+), are in the third quadrant. Both zones report lower than average technical and scale efficiency. The technical efficiency of Shucheng’s economic development zones is at the lowest among all development zones.

We found 20.0% of input redundancy and 22.5% of output deficiency in the provincial development zones at different levels in the study area (Table 4).

| DMU | X1  | X2  | X3  | X4  | Y1    | Y2    | Y3    |
|-----|-----|-----|-----|-----|-------|-------|-------|
| 8   | 11.9| 0   | 0   | 0   | 407313.08 | 0     | 11951.36 |
| 9   | 0.21| 0   | 519.02 | 0   | 418144.90 | 0     | 11753.99 |
| 13  | 3.42| 0   | 158.55 | 0   | 0     | 77880.21 | 59777.41 |
| 15  | 432.41181.00 | 0     | 0     | 0     | 17755.60 |
|     | 51  | 96  | 0   | 0   | 0     | 17755.60 |
| 17  | 1.49| 0   | 4731.03 | 0   | 0     | 0     | 9162.60 |
| 24  | 0   | 0   | 0   | 0   | 128837.18 | 0     | 34828.17 |
| 27  | 0   | 0   | 238.08 | 74318.96 | 0     | 0     | 62596.95 |
| 33  | 16.4 | 0   | 2176.72 | 103.07 | 101335.56 | 0     | 35271.15 |
| 36  | 0   | 0   | 4267.75 | 0   | 477596.71 | 0     | 35460.81 |

Under the precondition of maintaining the existing output level, 40 development zones needed input and structural adjustments in the Wan Jiang City Belt: construction land (465.95 ha), industrial enterprise investment in fixed assets (412 million yuan), employment population (12,100 people), and science and technology activities (744 million yuan) accounted for 2.97%, 0.13%, 1.32%, and 0.13%
of total inputs. From the viewpoint of insufficient output, under the precondition of maintaining the existing investment level, improving the efficiency of production inputs can increase industrial output by 15.332 billion yuan, industrial enterprise income by 779 million yuan, tax by 2.786 billion yuan that, respectively, account for 2.76%, 0.20%, and 13.84% of actual output. Some development zones did not most positively affect tax in leveraging the reversed efficiency of transitioning enterprises and actively adjusting industrial structure. In general, the degree and range of input redundancy and output deficiency are small.

5. Conclusions

The main conclusions from this study are as follows. First, the comprehensive efficiency of the Wan Jiang City Belt’s provincial development zone is high, but there remains room for improvement. Increased capital investment and average land investment in science and technology can improve the land utilization and economic efficiency of the studied area. Second, the comprehensive efficiency of regional distribution shows two characteristics: The comprehensive land use efficiency in Hefei’s “north core” is not ideal, but and the development axis along the river shows good efficiency. Second, the efficiency of county development zone is a focus within provincial development zones in the study area, especially in the north of development zones along the Yangtze River. Third, improving development efficiency should be kept separate from improving technical and scale efficiency. The technical–scale efficiency map is helpful for identifying reasons underlying the low efficiency of the 22 development zones.

6. Policy suggestions

From the above analysis, we propose the following suggestions. First, it is important to manifest a dominant position to undertake industrial transfers of industries along the upper reaches of the Yangtze River, promote coordinated development of regional industrial. Moreover, coastal industrial transfers should be of high quality. In addition, the investment scale should be appropriately increased and land and industrial policies should aim at the development axis along the river to promote the transfer of industries. Finally, the regions must continue to nurture high-tech industries and strategically emerging industries; lead the development of regional clusters of industries; and facilitate technological advances in production efficiency. Second, focus should be on promoting land use efficiency in the development zones of counties. It should encourage high-tech development zones and municipal and county jurisdiction development zones should cooperate to build gardens and other zones and have a certain capacity for independent innovation for multi-level, multi-field cooperation and interactions with other development zones. Third, development zones stocks should be controlled, optimized, and integrated. In addition, a project access system should be established and improved upon and be strictly enforced in industrial land to control land use, monitor multi-story factory buildings, and improve the level of intensive land conservation zones. Development zones short of land and needing expansion should be prioritized through integrated approaches. Efforts should also be made to distribute idle land among development zones, regularly conduct clean-ups, and explore secondary development of inefficient land use in the zones. Finally, taxation should serve as an incentive to advance quality and efficiency. On the one hand, it strengthens tax administrations and can be implemented in every tax system, and on the other hand, it establishes a sound system for differential taxation to encourage and support the strategic emergence of high-tech industries through, for example, tax rebates.

7. Reference

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