Analysis on Industrial Land Efficiency in Sichuan Province from the Perspective of Sustainable Development

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Abstract. To promote the efficiency of industrial land in Sichuan province is an inevitable requirement of realizing sustainable development. Through the improvement of the Cobb-Douglas production function to construct the Two-way Fixed Effects panel model of output efficiency of urban industrial land, the data regression analysis of 93 prefecture-level cities since 1998 has found that the growth rate of industrial land efficiency indexes in Sichuan province is higher than the national level and has fallen back in recent years, but the absolute level is always lower than the national average, due to the fact that in the chase of national level, Sichuan industry did not fundamentally eliminate the root cause of low efficiency of industrial land. As a result,it is necessary to realize the improvement of optimal land utilization and land use efficiency through scientific planning, progressive construction steps and industrial transformation and upgrading, etc.

1. Introduction

As is known to all, "Our Common Future" advocates sustainable development which can not only meet needs of contemporary people, but also cause no harm for the future generations to meet their needs. (WCED, 1987). Land resource utilization is an important domain in sustainable development theory. But for a long time, people generally emphasize the prevention of soil degradation in cultivated land use, and pay little attention to sustainable use of industrial land. However,"Empty Towns" and "Commuter Towns" are not rare due to large industrial land area in Sichuan province, the lack of industrial investment and insufficiency of industrial population agglomeration. Both Xi Jinping and Li Keqiang sharply criticized the problem of overuse of urban industrial land and inefficient use of urban land [1]-[2]. Therefore, how to improve efficiency of industrial land under the guidance of sustainable development theory, save land, and do not damage land security needed by future generations because of extensive industrial land, is a question worth studying.

The efficiency of industrial land can be measured by investment intensity, employment density and output efficiency,etc. From the perspective of micro-enterprises to explore the factors affecting the output efficiency of industrial land, Lin Zhang and Yahui Wang found that the output efficiency, elastic coefficient of average capital of industrial land is 0.346 and elastic coefficient of average labor of industrial land is 0.142[3].Antonio Ciccone and Robert E. Hall(1996) found that employment density in counties of the United States was doubled, and average labor productivity could be increased by 6%[4]. Some scholars emphasize that Total Factor Productivity (TFP), especially technological progress, has an important impact on the output rate of industrial land[5]-[6]. Scholars

also found that the Plot Ratio and investment intensity cannot reach construction control standards[7]-[8], the proportion of land supply and demand in urban industrial land is too high[9], land and labor input is too much[10], which makes industrial land low in efficiency. After retrieving, it is found that the study on efficiency of industrial land in Sichuan province is very rare and needed to be strengthened.

2. Data and Descriptive Analysis

In order to carry out the evaluation and comparison of present situation, from "Yearbook of China Development Zone"、"China Statistical Yearbook"、"China City Statistical Yearbook" 、"China Urban Construction Statistical Yearbook", "Sichuan Statistical Yearbook" and other channels, the research group collected data. For the sake of comparative convenience, urban industrial land in central cities of provincial capitals were not included, while urban industrial land within urban districts of the prefecture level cities were mainly investigated. From this, 1998-2014 years of balance panel data collected from 23 prefectural cities in Sichuan province have been formed. As a reference, by stratified sampling method from 26 provincial administrative regions (excluding 4 municipalities), they selected 93 prefectural cities sample units, including 33 sample units within the scope of western prefecture-level cities. We obtained the balance panel data of industrial land,industrial employment,industrial enterprises fixed assets and gross industrial output value in 1998 -2014. Since the establishment date of each industry park is different, and many data is missing, the panel data obtained by the research group is unbalanced panel, but it has little effect on the analysis.

The work of data processing includes: (1) according to "China Statistical Yearbook" to calculate the GDP deflator,then gross industrial production over the years and the value of fixed assets are converted in accordance with the price in 1990, in order to achieve comparability; (2)in series of sample individual time, the individual missing data and obviously too high or too low data is inferred as statistical errors, replaced by mean value of sample data before and after the year or inferred by the average growth rate several years ago; (3) if a variable of a sample point for 2 consecutive years shows evident outliers or missing values, then observation value should be deleted of the year ; (4)ordinary Box-plot-- taking "75% quantile+1.5 times quartile spacing" within the side of fence on Box-plot, taking "25% quantile－1.5 times quartile spacing " as within the side of fence below the Box-plot -- find out outliers and delete them.

Observing sample mean over the years (see Table 1), it can be found that the national, the west of China and Sichuan urban industrial land output efficiency and investment intensity in general is in a gradual upward trend and employment density are generally in a downward trend year by year, possibly due to improvement in total factor productivity such as technological progress. It is worth noting that the output efficiency, investment intensity and employment density of industrial land in Sichuan cities are lower than the national average and also lower than the western average (see Figure 1-Figure 3). According to the efficiency index of industrial land, City-Industry Space Integration level in Sichuan province needs to be improved.
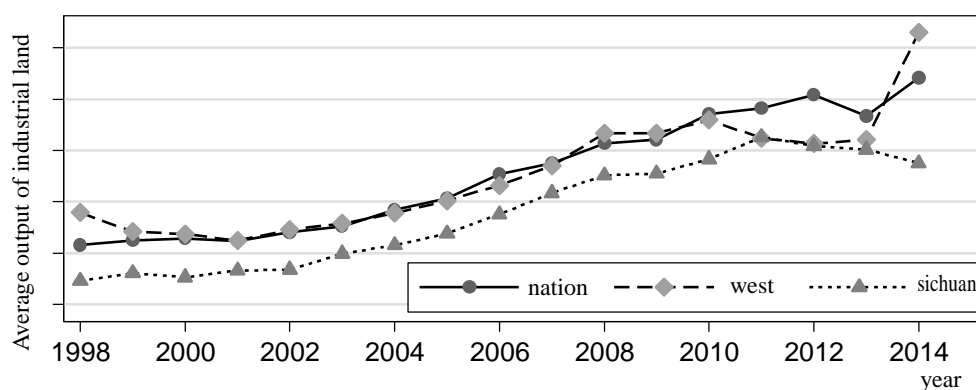
Figure 1. comparison of output rate of urban industrial land between Sichuan province and the nation and the west**Table 1.** comparison of mean value over the years of efficiency index of industrial land in cities[a]

Year	Average output of industrial land (100 million yuan / sq km)			Average investment intensity of industrial land (100 million yuan / sq km)			Average employment intensity of industrial land （10 thousand people/ sq km）		
	whole nation	the west	sichuan	whole nation	the west	sichuan	whole nation	the west	sichuan
1998	5.814	8.939	2.328	3.799	4.056	1.826	0.8	0.756	0.657
1999	6.222	7.075	3.053	4.201	3.815	2.047	0.748	0.683	0.659
2000	6.437	6.852	2.651	4.353	5.837	2.195	0.656	0.567	0.558
2001	6.196	6.207	3.306	3.955	3.656	2.184	0.577	0.486	0.507
2002	7.07	7.287	3.387	4.225	3.943	2.221	0.551	0.453	0.435
2003	7.586	7.889	4.946	4.151	3.733	2.849	0.532	0.449	0.482
2004	9.243	8.877	5.789	3.911	3.695	3.038	0.515	0.435	0.469
2005	10.34	10.11	6.893	3.95	3.919	3.184	0.464	0.424	0.44
2006	12.7	11.61	8.774	4.675	4.588	3.421	0.484	0.451	0.499
2007	13.74	13.5	10.86	4.839	5.001	4.557	0.462	0.452	0.401
2008	15.66	16.68	12.58	5.03	5.493	4.287	0.427	0.443	0.369
2009	16.05	16.68	12.75	6.07	6.191	4.883	0.394	0.388	0.319
2010	18.57	17.97	14.16	6.901	8.13	4.944	0.391	0.365	0.272
2011	19.11	16.2	16.3	6.512	6.531	5.393	0.405	0.377	0.298
2012	20.39	15.67	15.44	7.07	7.587	5.75	0.443	0.436	0.287
2013	18.37	16.05	15.1	6.587	6.498	4.972	0.428	0.365	0.302
2014	22.11	26.5	13.77	6.517	7.235	5.114	0.462	0.424	0.282

[a] note: (1) For longitudinal comparison, output value and asset value have been converted in accordance with 1990 prices, the same below.(2) The data comes from "Yearbook of China Development Zone"、 "China City Statistical Yearbook" and "China Urban Construction Statistical Yearbook" or "Annual Report on Urban Development of China".
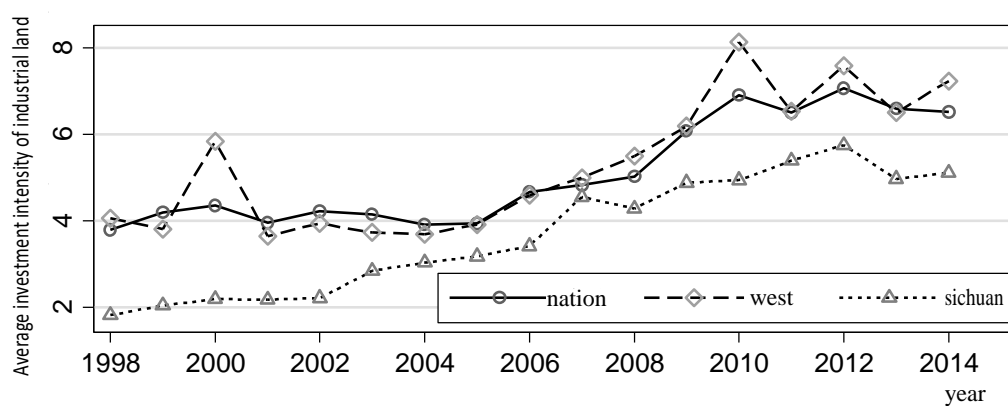

Figure 2. comparison of investment intensity of urban industrial land between Sichuan province and the nation and the west
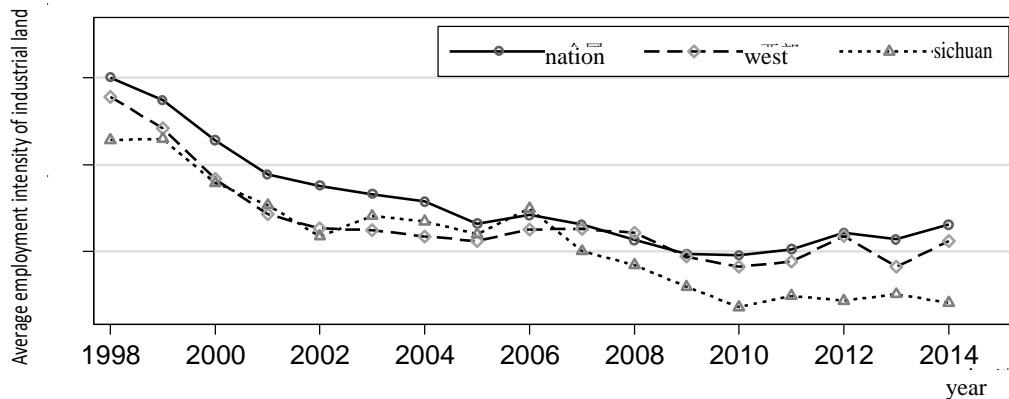
Figure 3. comparison of employment density of urban industrial land between Sichuan province and the nation and the west

3. Variation Model and Regression Analysis of Utilization Efficiency of Industrial Land Use in Sichuan Province

With the aid of expanded Cobb-Douglas (c-d) production function, a further comparison of the total factor productivity between Sichuan and national urban industrial land can be made. In the field of industrial production, land plays a main part of bearing capital and labor, with no substitutional relation with capital or labor. It is proper to make it the denominator of output, capital and labor in the industrial production function, and hereby constructs the efficiency panel model (1) of industrial land output.

$$\left(\frac{y}{m}\right)_{it} = A_{it} \left(\frac{k}{m}\right)_{it}^{\alpha} \left(\frac{l}{m}\right)_{it}^{\beta} \exp(\varepsilon_{it}) \ , \quad i=1,\cdots,n, \quad t=1,\cdots, T \quad （1）$$

Y_{it} represents the total industrial output value of urban industrial land, m_{it} signifies the area of urban industrial land, k_{it} represents the industrial fixed assets of urban industrial land, l_{it} embodies the industrial employment of urban industrial land, α and β indicates output elasticity of the investment intensity and employment density on the urban industrial land. A_{it} is the neutral technical progress, namely the "the abbreviation of variation of production function in any form ", "the economic acceleration or deceleration, the improvement of labor education quality, and the various factors of mobile production function can be classified as' technological change '" (Solow R, 1957). The technical progress changes over time, and may vary between individuals as well.

The discussion of capital, labor and output of the unit area of industrial land in the paper implies that the input of land elements is kept unchanged, which is applicable to the law of diminishing marginal returns, and thence $\alpha + \beta < 1$. In other words, with other conditions being unchanged including the technology, if the investment intensity and density of employment of an industrial land with normal bearing function is increased by Φ （φ>0） times, the increase amplitude of output efficiency is in the open interval of （0，φ）.

Considering the individual characteristics, unobservable missing variables and data acquisition problems of sample point, the following Two-way Fixed Effects model of output efficiency of industrial land is designed:

$$\left(\frac{y}{m}\right)_{it} = \left(\frac{k}{m}\right)_{it}^{\alpha} \left(\frac{l}{m}\right)_{it}^{\beta} \exp(z_i'\delta + \lambda_t + u_i + \varepsilon_{it}) \ , \quad i=1,\dots,n, \ t=1,\dots, T \quad （2）$$

Here, λ_t represents the period fixed effect changing over time instead of with the individual, which consists of technological progress, macro-economic changes and industrial policy influences and other variables. z_i is the variable vector of individual characteristic that does not change over time. u_i is the unobservable individual heterogeneity, symbolizing the missing variable changing between

individuals but not over time. It is different from z_i in that it is "unobservable". $z_i'\delta + u_i \equiv \eta_i$ is all the individual fixed effects that are unchanged over time, such as location, natural environment, historic and humanities environment and other variables. $u_i + \varepsilon_{it}$ constitutes a composite error term.

Take the logarithm from both sides of the model (2) :

$$\ln\left(\frac{y}{m}\right)_{it} = \alpha\ln\left(\frac{k}{m}\right)_{it} + \beta\ln\left(\frac{1}{m}\right)_{it} + z_i'\delta + \gamma S_t + u_i + \varepsilon_{it} \quad , \quad i=1,\ldots,n, \quad t=1,\ldots, \ T \ （3）$$

After the F test, LSDV test, Hausman test and excessive identification test, it is found the above-mentioned Two - way FE is correct in form, clustering robust standard error is adopted in the regression process and the regression parameters can be verified in statistical inspection and economic significance. The impact of the above individual fixed effect, time fixed effect and residual error on the output efficiency of industrial land is merged and recorded as logarithm of total factor productivity (lnA), and the above regression parameter is substituted into the model (3), which can be obtained by appropriate deformation:

$$\frac{y}{m} = A\left(\frac{k}{m}\right)^{\alpha}\left(\frac{1}{m}\right)^{\beta} \qquad （4）$$

Based on the Solow's Residual Method, the total factor productivity over the years was calculated by substituting the estimated income parameter, and thus the average growth rate is calculated. Below is derived from further model transformation:

$$\frac{\dot{A}}{A} = \frac{\dot{y/m}}{y/m} - \alpha\frac{\dot{k/m}}{k/m} - \beta\frac{\dot{1/m}}{1/m} \qquad （5）$$

From this, the growth rate $\left(\frac{\dot{A}}{A}\right)$ of total factor productivity (A) is calculated. In combination with the above industrial land output rate, investment intensity and employment density data, the change situation can be found (see Table 2). To note, the growth rate of industrial land output rate, investment intensity and total factor productivity of Sichuan urban industrial land are all higher than the national average. However, it is worth noting that in recent years, the output rate of industrial land in Sichuan cities has experienced negative growth, and the gap with national level has been growing. In addition, as a populous province, Sichuan is endowed with abundant human resources. Employment density has fallen faster than the national in the absence of a fundamental change in the industrial structure, which is worth sharp vigilance.

Table 2. investment intensity,employment density and TFP of industrial land

year	Growth rate of Output efficiency		Growth rate of investment intensity		Growth rate of employment intensity		Growth rate of TFP	
	Whole nation	sichuan	Whole nation	sichuan	Whole nation	sichuan	Whole nation	sichuan
1999	0.0702	0.311	0.106	0.121	-0.0648	0.00261	0.0246	0.252
2000	0.0346	-0.132	0.0363	0.0724	-0.123	-0.154	0.0372	-0.146
2001	-0.0375	0.247	-0.0915	-0.00513	-0.12	-0.0916	0.0338	0.262
2002	0.141	0.0246	0.0684	0.0169	-0.0454	-0.141	0.112	0.0355
2003	0.0729	0.46	-0.0176	0.283	-0.0337	0.107	0.0885	0.308
2004	0.218	0.17	-0.0578	0.0665	-0.0322	-0.0275	0.256	0.142
2005	0.119	0.191	0.01	0.0482	-0.0998	-0.0608	0.132	0.175
2006	0.228	0.273	0.183	0.0744	0.0436	0.134	0.121	0.218
2007	0.0817	0.238	0.0351	0.332	-0.0444	-0.196	0.0708	0.103
2008	0.14	0.159	0.0396	-0.0592	-0.0766	-0.0796	0.132	0.198
2009	0.0254	0.0139	0.207	0.139	-0.0768	-0.137	-0.0725	-0.0352
2010	0.157	0.11	0.137	0.0124	-0.00858	-0.146	0.0841	0.124
2011	0.0291	0.151	-0.0565	0.0909	0.0353	0.0934	0.0532	0.0941
2012	0.067	-0.0528	0.0857	0.0663	0.0938	-0.0347	0.00367	-0.0803
2013	-0.0992	-0.0223	-0.0683	-0.135	-0.0338	0.051	-0.0561	0.0367
2014	0.204	-0.0877	-0.0106	0.0285	0.0808	-0.0679	0.195	-0.0923
Geometric	0.087069	0.117	0.034305	0.066	-0.03373	-0.051	0.074616	0.0932

mean

4. Study on the Causes and Solutions for Growth Speed Change of Sichuan Industrial Land Efficiency and Low Land Use Efficiency

In brief, the growth speed of several indexes in Sichuan industrial land efficiency has been surpassing the national standard since 1998, and in recent years it has dropped down. Nevertheless, the absolute level of industrial land use efficiency is still lower than the national average. It may be explained as follows:

On the one hand, because of poor industrial foundation and low starting, Sichuan has presented a higher speed than the national average in its course of struggling. It can be seen from Figure 1 that the gap of industrial land output capacity between Sichuan and the whole China is narrowed to a certain extent.

On the other hand, the root cause for low land use efficiency of Sichuan fails to be totally eradicated, which is reflected on as follows. Firstly, it doesn't fully consider the rational expected output value and industrial choice differences of economic, social and industrial developing plan; it plans land scale and structure of development zone on the basis of subjective will or land availability, obviously "launching a large project" and making city planning "an enclosure tool for government". Secondly, the land of development zone is equated with industrial project land; the planned industrial land occupies a too large proportion, while the land for service is insufficient. For one thing, productive service support for industrial enterprises is inadequate, thereby reducing the output efficiency of industrial land; for another, life service support for regional people is also short that impedes regionally agricultural transfer and population citizenization. Thirdly, having ignored the pollution influence, and differences in industry, the mother city service and city level, it considers an industrial park as an independent city and therefore plans land structure in accordance with the Land Use Classification and Construction Land Planning Standard for Cities and Towns (GB 50137, 2011). As a result, residential land and land for commercial and service facilities and public services are left unused or inefficiently utilized.

Accordingly, solutions and suggestions are proposed in this paper. First of all, it's suggested to make a scientific planning based upon rational evidence and avoid the phenomenon of "launching a large project" on industrial land due to excessive optimism; in planning, achieve a balanced and coordinated development and reasonable layout for the functional zones of industrial production, productive service and life service, in a bid to facilitate enterprises to obtain high-quality productive service support, employees of the urban industrial land to get rich life service support, and promote high efficient use of the land. Second, it should carry out construction step by step but never occupy the land abruptly, adjust industrial land scale according to economic tendency, and lower impact caused by unscientific planning and uncertainty. Third is to actively drive industrial restructuring and upgrading; accelerate technology progress and cleaner production; eliminate backward production capacity; set higher standard in technology, environmental protection and other aspects; take initiative to introduce industrial enterprises characterized by high technology content, low resource consumption, less environmental pollution and good economic benefits; vigorously develop strategic emerging industries, intelligent and high-end manufacturing; build ecological park and arrange productive and life service function zone nearby, thus furthering the industrial land output efficiency and population aggregation.

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