An Research on Influencing Factors of Urban Land Use Efficiency Based on Tobit Model

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Abstract. The purpose of this research is to, by taking Wuhan city as an example, build Tobit model to calculate and analysis the influencing factors of urban land use efficiency so as to provide reference for improving urban land use efficiency. Methods employed include Tobit model. The results show that: 1) the significant factors influencing the land use efficiency of Wuhan city in 2014-2016 are urban per capita disposable income, urban fixed asset investment and urban population scale, 2) the influencing factors of urban land use efficiency and its influencing degree change dynamically at different time periods, and can be greatly influenced by land policy, 3) Tobit model can analyze the specific influencing factors of land use efficiency and the degree of influence from the quantitative point of view.

1. Introduction
Land use efficiency refers to the ability to achieve the maximum economic output under a given amount of land input, or the ability to minimize the amount of land input under a given level of economic output[1]. Based on the measure and calculation of land use efficiency, the results can offer facilities for further research on influencing factors of land use efficiency. Scholars used natural geography theory to analyze the influence from the angle of single factor, such as city function and nature, city planning, and land allocation methods. As research continues, more and more scholars have studied the influencing factors of land use efficiency from the multiple factors angle. Yang et al used quantitative regression analysis method, proposed that urban location and urban industrial structure had significant effect on the urban land efficiency, and confirmed the positive association between urban location and urban land use efficiency[2]. Starting with the connotation of land uses economic efficiency, Liu et al analyzed empirically the urban land use efficiency of Sichuan province, and put forward that urban fixed investment, scale of urban land use and urbanization rate had significantly affect on urban land use efficiency[3]. Li et al use methods of GIS spatial analysis and panel data to analyze the spatial characteristics of urban land use efficiency and its influence factors, the result of research shows that the urban land use efficiency has a significant positive correlation with the level of economic development[4]. Li using PCA-DEA method to measure China urban land use average efficiency between 1981 and 2012, the results show that the low urban land use efficiency in China is mainly affected by fixed asset investment, built-up area and the number of employees in the tertiary industry[5]. Chen et al offered to analyze the key factors of urban land use efficiency from multiple aspects, such as the urban land quality, society and technology[6]. Zhan has studied the influencing factors of urban land use efficiency, considering that urban construction land area, fixed asset investment, fiscal expenditure and the number of people employed in the secondary industry.
have significant influence on urban land utilization[7].

According to the literature, these studies have the deficiencies that the influencing factors of urban land use efficiency were analyzed qualitatively in the existing researches. However, there is no quantitative analysis on how these factors affect the land use efficiency and how the effects change over time. In view of the shortage of the existing literature, Tobit model is used to analyze the influencing factors and the influencing degree of urban land use efficiency quantitatively. The paper empirically analyzes land use efficiency of 13 districts in Wuhan, China during the period of 2010-2016.

2. Methods and index system

2.1. Tobit model

For one decision making unit, DEA model can find the reasons that result in invalid internal system on the basis of slack variable. But, it does not find the influencing factors of land use efficiency as a whole. For this reason, it is necessary to introduce multivariate regression analysis techniques to find out the influencing factors of land use efficiency[8]. Tobit model is used in this thesis. Tobit model was first proposed by James Tobin who won the Nobel Prize in Economics. The model using maximum likeness estimation can make up for the shortcomings of the least square method[9]. Tobit model is expressed as follows.

\[
Y = \begin{cases} 
Y' = \alpha + \beta X + \varepsilon, & Y' \geq 0 \\
0, & Y' < 0
\end{cases}
\]

(1)

In the expression, \(Y\) is truncated dependent variable vector, namely efficiency value vector. \(X\) is the independent variable vector. \(\alpha\) is the intercept term vector. \(\beta\) is the regression parameter vector. \(\varepsilon\) is random disturbance term, \(\varepsilon \sim N(0, \sigma^2)\).

2.2. The index system

Using Tobit model to analyze the influencing factors of land use efficiency, the key is the selection of the indexes measuring the influence. On the basis of referring to the previous literatures[10], considering the quantifiable and availability of data, selected indicators measuring influencing factors are as follows: 1) National economic level that expressed by the ratio of regional GDP to Wuhan's GDP, Local financial revenue that expressed by the ratio of regional Local financial revenue to Wuhan's, and Urban per capita disposable income that reflect the development level of economy and society. 2) Fixed-asset investment that reflects the influence of capital investment on the urban land use efficiency, which expressed by the ratio of regional Fixed-asset investment to Wuhan's. 3) Urban population size that reflects the potential of labor supply, represented by urban population density. 4) City industrial structure that reflects the influence of different industrial structure on urban land use efficiency, represented by the ratio of the third industry and the second industry output value. 5) The scale of urban land that reflects the influence of the input of urban land on urban land use efficiency, represented by the ratio of regional land area to Wuhan's land area.

3. Empirical analysis

3.1. Study area and data sources

Wuhan is located in the middle of Hubei province, China. It is the urban agglomeration which takes Wuhan as the center, which is composed of 13 districts of Jiangan, Jianghan, Qiaokou, Hanyang, Wuchang, Qingshan, Hongshan, Dongxihu, Hannan, Caidian, Jiangxia, Huangpi, and Xinzhou, with a total area of about 85.69×10²km². The influencing factors of land use efficiency of 13 districts in Wuhan from 2010 to 2016 are analyzed by using Tobit model. The quantitative data that is used in the paper comes from statistical yearbook in Wuhan, Hubei province from 2011 to 2017, web site statistical information of statistical bureau of Hubei province and districts.
3.2. Analyzing the influencing factors of land use efficiency

The land use efficiency value calculated by DEA model offers facilities for further studying the influencing factors of land use efficiency. In this paper, Tobit multivariate regression model is built to analyze the influencing factors, by using the super-efficiency value of 13 districts in Wuhan as the dependent variables and taking the influencing factors of land use efficiency as the independent variables. This paper tries to solve the following problems: how the influencing factors affect the land use efficiency respectively and whether the influence of these factors changes dynamically in different phases. Because the calculating results got by panel data are more persuasive than the calculating results got by cross-section data, and considering that the influence of these factors may change dynamically in different phases, the urban land use efficiency in the period of 2010-2016 is chosen as the analysis object. In view of the influence of policy factor, such as Wuhan municipal government implemented the land New Deal in 2014, this paper takes 2014 as a dividing point, tries to use panel data of 13 districts in Wuhan from 2014 to 2016 at first, and applies the software of STATA12.0 to calculate. It should be noted that the panel data regression model has two kinds of random effect and fixed effect. This paper proposes random effects model to make regression analysis.

3.2.1. The analysis on influencing factors of land use efficiency in Wuhan from 2014 to 2016.

To analyze the influencing factors of land use efficiency in Wuhan from 2014 to 2016, Tobit model was used to calculate the results, as shown in Table 1.

| Independent variables | Coefficient | Std  | Z    | P    | Significance |
|-----------------------|-------------|------|------|------|--------------|
| National economic level | 0.1615 | 7.0437 | 0.02 | 0.982 | non-significance |
| Local financial revenue | 0.9796 | 3.4108 | 0.29 | 0.774 | non-significance |
| Urban per capita disposable income | 1.0258 | 0.3424 | 3.00 | 0.003*** | *** |
| Fixed-asset investment | -12.0346 | 2.8820 | -4.18 | 0.000*** | *** |
| Urban population size | -0.9258 | 0.3908 | -2.37 | 0.018** | ** |
| City industrial structure | 0.1400 | 0.0978 | 1.43 | 0.152 | non-significance |
| The scale of urban land | -3.5552 | 2.8032 | -1.27 | 0.205 | non-significance |

Note: Prob >chi²=0.0000. "***" and "**" mean significant at the level of 1% and 5% respectively.

To verify whether the regression analysis using random effect model is reasonable, Hausman test is applied in this paper, getting that Prob>chi²=0.9366, and P value is greater than 0.05. So null hypothesis can’t be rejected, and the regression analysis using random effect model can be thought to be reasonable. The P value is 0.0000 calculated by the random effects model, which illustrates that the regression model is significant as a whole. Analyzing the regression results in table 1, we can get that, in the confidence level of 1%, the factors of urban per capita disposable income and fixed-asset investment have significant influence on urban land use efficiency. In the confidence level of 5%, urban population size has significant influence on urban land use efficiency. National economic level, local financial revenue, city industrial structure and the scale of urban land have non-significant influence.

Per capita disposable income plays positively in improving land use efficiency, urban per capita disposable income is raised by 1 unit, the land use efficiency will be increased by 1.0258 units. Therefore, the Wuhan government should take the reform of the income distribution system, improve the income distribution regulation and control mechanism. Fixed-asset investment and urban population size have a negative correlation with the land use efficiency. Fixed-asset investment has greater negative interaction factor to the land use efficiency than urban population size, and it is increased by 1 unit, the land use efficiency will be reduced by 12.0346 units. It illustrates the more fixed asset is invested, the lower the land use efficiency will be. This may be due to the redundant investment in fixed assets and the extensive investment mode at this stage. Urban population size has less negative interaction factor to the land use efficiency compared to fixed-asset investment.
urban population size is increased by 1 unit, the land use efficiency will be reduced by 0.9258 units. Because that urban population size reflects the input of the labor force, according to the negative regression coefficient of population size, it can be known that the labor resources of Wuhan city should be in a state of oversupply, and the input of labor force is redundant.

3.2.2. The analysis on the dynamic change of factors influencing land use efficiency in Wuhan. In order to investigate whether the influence of these factors changes dynamically in different phases, the paper uses panel data of 13 districts in Wuhan from 2010 to 2013 to run a regression. The regression results are shown in Table 2.

| Independent variables       | Coefficient | Std | Z    | P     | Significance       |
|----------------------------|-------------|-----|------|-------|--------------------|
| National economic level     | 3.9390      | 5.3231 | 0.74 | 0.459 | non-significance   |
| Local Financial Revenue     | 9.6859      | 3.1533 | 3.07 | 0.002 | ***                |
| Urban per capita disposable income | -0.1703  | 0.3713 | -0.46 | 0.646 | non-significance   |
| Fixed-asset investment      | -6.2972     | 4.3438 | -1.45 | 0.147 | non-significance   |
| Urban population size       | -1.0843     | 0.3324 | -3.26 | 0.001 | ***                |
| City industrial structure   | 0.1141      | 0.0946 | 1.21  | 0.228 | non-significance   |
| The scale of urban land     | -7.2905     | 1.9035 | -3.83 | 0.000 | ***                |

Note: Prob >chi²=0.0003. "***", means significant at the level of 1%.

By Prob>chi²=0.0003, it illustrates that the independent variables in table 2 can explain the influence of land use efficiency fully. In the confidence level of 1%, the factors of local financial revenue, urban population size and the scale of urban land have significant influence on urban land use efficiency, and national economic level, urban per capita disposable income, fixed-asset investment and city industrial structure land have non-significant influence.

Local financial revenue has positive influence on urban land use efficiency, and it is raised by 1 unit, the land use efficiency will be increased by 9.6859 units. Because the fundamental factor of local financial revenue is the level of economic development, Wuhan government should vigorously develop the economy to improve the urban land use efficiency. Urban population size has a negative interaction with the land use efficiency, and it indicates that expansion of population leads to the decrease of urban land use efficiency, therefore it can be known that the labor resources of Wuhan city should be in a state of oversupply, and the input of labor force is redundant. Wuhan government should encourage the development of tertiary industry and realize the rational allocation of human resources so as to improve the urban land use efficiency. The influence coefficient of the scale of urban land on land use efficiency is -7.2905. It indicates that the scale of urban land has a negative correlation with the land use efficiency. With the acceleration of urbanized advancement and the fast development of economy, the demand of land in urban development will increase gradually, so more land are needed to fulfill the demand. The unreasonable structure of urban use and the low intensive utilization ratio of land existing in the process of urbanization of Wuhan may result redundant input of land. Because of the non-timely development for the land, the land vacancy rate is big, resulting in a decline in the land use efficiency. Comparing the regression results from table 1 and table 2, the significant factors that affect land use efficiency change a lot. The influences of local financial revenue and the scale of urban land are insignificant in 2014-2016, but their influences in 2010-2013 are significant. The influences of urban per capital disposable income and fixed-asset investment are significant in 2014-2016, but their influences are insignificant in 2010-2013. These results proved that with time the influencing factors of land use efficiency can change. In other words, the influence of different factors on land use efficiency changes dynamically in different stages.

4. Conclusions and suggestions
Tobit model is built to analyze the influencing factors of land use efficiency of 13 districts in Wuhan
from 2010 to 2016. The following conclusions and discussions are obtained:

(1) In 2014-2016, the factors of urban per capita disposable income, fixed-asset investment and urban population size have significant influence on urban land use efficiency. The effect of per capita disposable income on land use efficiency is positive. Fixed-asset investment and urban population should be factors to promote land use efficiency, but they have negative effects, this is mainly because the industrial growth rate is smaller than the capital investment growth rate, labor redundancy, and rapid expansion. Therefore, in order to improve the urban land use efficiency, how to improve the level of urban per capita disposable income, increasing employment opportunities, and realize the rational allocation of human resources, will become the focus of future research.

(2) In 2010-2013, the factors of local financial revenue, urban population size and the scale of urban land have significant influence on urban land use efficiency. Compared with the significant influence factors in 2014-2016, the significant factors that affect land use efficiency change a lot. It shows that the factors influencing urban land use efficiency and their degree of influence change dynamically at different stages and are largely affected by land policy. The government should pay attention to the change of land policy, so as to adjust the input of various influencing factors to optimize land use.

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