Research on TFP change and convergence of China's regional real estate industry

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Abstract: The added value method is used to screen the input and output indicators of the real estate industry. The DEA-Malquist method was used to measure the total factor productivity (TFP) of the real estate industry in China's 30 provinces from 2006 to 2017. Further, the convergence test of the real estate industry TFP in eastern, central and western China was conducted. It was found that the average growth rate of real estate industry TFP in China's 30 provinces during the period was 3.3%. Technical efficiency was the main driving force for TFP growth, and the contribution of technological progress was relatively small. In the improvement of technical efficiency, pure technical efficiency is obviously improved, and the improvement of scale efficiency is limited. The absolute β convergence test was carried out. From the national perspective, the TFP gap in the real estate industry in each province has a significant narrowing trend; In terms of regions, the TFP gap in the real estate industry in the eastern provinces has a narrowing trend, but it is not significant; The growth of TFP in the real estate industry in the central region has a significant catch-up characteristic, and the TFP gap between provinces has gradually narrowed; The TFP gap in the real estate industry in the western provinces has significantly expanded.

1. Introduction

As the pillar industry of China's national economy, the real estate industry has developed rapidly since the reform and opening up. The proportion of GDP has increased from 2.2% in 1978 to 6.5% in 2017. It is an important growth point for economic development and actively promotes the development of the national economy. However, the phenomenon of unfinished buildings and high vacancy rates has exposed problems such as excessive investment and low efficiency in the real estate industry in China. The productivity of the real estate industry should be improved by expanding effective investment. As an indicator to measure the comprehensive productivity level of input factors, total factor productivity has attracted widespread attention from scholars at home and abroad, and is increasingly used to measure the production efficiency of other industries[1-3] and real estate industry[4-5].

For the research on the production efficiency of China's real estate industry, the DEA method is the most used. Numerous studies have basically obtained input and output indicators based on qualitative analysis (see Table 1), and there is no statistical persuasiveness.

Table 1. A summary of variables in the real estate efficiency evaluation.

| author | input | output |
|--------|-------|--------|
| Junjun Zheng [4] | paid-in capita | Total operating income |
| | Total value of land purchased | |

For the research on the production efficiency of China's real estate industry, the DEA method is the most used. Numerous studies have basically obtained input and output indicators based on qualitative analysis (see Table 1), and there is no statistical persuasiveness.
Moreover, although the literature [4], [6] used the DEA-Malmquist method to analyze the TFP of China's real estate industry from 1997 to 2008 and 2007 to 2015, its sample data is short in duration and lacks the latest data. The results are prone to bias and lack of practical guiding significance. In addition, the literature [6] did not conduct convergence test, lacking in-depth excavation and refinement of the development law of real estate industry in different regions.

In order to make up for the lack of literature, and to comprehensively and objectively screen input and output indicators, this study uses the added value method to screen indicators. At present, the added value method has been applied to the selection of DEA efficiency evaluation indicators in the financial industry[10] and the construction industry[3].

This paper comprehensively adopts the methods of added value, DEA-Malmquist, absolute convergence test, etc., and analyzes the real estate industry panel data of 30 provincial-level units in China from 2006 to 2017, and analyzes the trend of the real estate industry TFP in the above provinces. The convergence of TFP in the real estate industry in the eastern, central and western regions was tested.

2. Selection of input and output indicators for real estate industry based on added value method

2.1. Added value method principle and step analysis
The development of the real estate industry in each province can be reflected by the added value of the real estate industry in each province, and the real estate industry investment and output will eventually have an impact on the added value of the real estate industry. The added value of the real estate industry in each province is selected as the dependent variable. According to the literature review and statistical yearbook data, regardless of input and output indicators, unified determination as independent variables, carry out statistical regression analysis, identify the key factors affecting the dependent variable.

2.2. Selection of input and output indicators
Selecting the added value of the real estate industry (Y) as the dependent variable, revenue from principle business (X1), operating profit (X2), average number of employed persons in enterprises for real estate development (X3), total value of land purchased this year (X4), investment completed this year (X5), taxes and other charges on principle business (X6), value of buildings completed (X7), total sale of

| Input indicators | Output indicators |
|------------------|-------------------|
| Investment completed of real estate enterprises | Revenue from the principal business of enterprises |
| Land space pending the development of real estate enterprises | The added value of the real estate industry |
| The net worth of owned equipment and machinery |
| Average number of persons engaged in the real estate industry |
| Average number of employed persons in enterprises for real estate development | Floor space of buildings completed |
| Land space purchased this year | Total sale of commercialized buildings sold |
| Investment completed this year |
| Floor space of buildings under construction | Value of buildings completed |
| Floor space started this year | Total sale of commercialized buildings sold |
| Floor space of commercialized buildings sold |
| Investment completed this year |
| Average number of employed persons in enterprises for real estate development | Real estate GDP |
commercialized buildings sold (X8). Eight indicators were independent variables and statistical regression analysis was performed. Let the multiple linear regression model be:

\[ Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 \] (1)

The 90 sets of data were firstly reduced by the CPI index, and then standardized, and the statistical software SPSS was used for regression analysis. The regression results were shown in formula (2).

\[ Y = -0.121X_4 + 0.445X_6 + 0.661X_8 \] (2)

The significance value of \(X_4\), \(X_6\) and \(X_8\) is 0.007, 0.000, 0.000 respectively, indicating that the above three indicators have a significant impact on the real estate industry added value.

The adjusted \(R^2\) is 0.957, which indicates that the multi-linear regression equation has good goodness of fit, and the three indicators can well explain the change of the added value of the real estate industry.

From the positive and negative of each indicator coefficient of the regression equation, it is judged whether it is input or output. If the coefficient of a certain indicator is positive, indicating that it tends to increase the value added of the real estate industry, it is regarded as output; otherwise, it is regarded as input. The coefficients of \(X_6\) and \(X_8\) are positive and regarded as output; the coefficient of \(X_4\) is negative, which is regarded as input.

These three indicators are reasonable considering the availability of data. Based on this, the initial output indicators are: taxes and other charges on principle business and total sale of commercialized buildings sold, the input indicators are: total value of land purchased this year. However, the investment in the real estate industry cannot be only the cost of land acquisition, but also personnel investment and capital investment. Therefore, two input indicators are added: average number of employed persons in enterprises for real estate development, and investment completed this year.

3. System Analysis of the Trends of Total factor productivity in China's Real Estate Industry

3.1. Source and description of the data

According to the determined input and output indicators of the real estate industry, data collection and collation are carried out, and five sets of panel data of 30 provinces and cities in China (excluding Tibet) from 2006 to 2017 are used to conduct empirical research. All data are from the China Statistical Yearbook (2007-2018). The annual data are converted to the constant price of 2007 according to the Consumer Price Index (CPI).

3.2. Empirical Analysis of the Trends of Total factor productivity in China's Real Estate Industry

3.2.1. Overall timing analysis. According to the DEA-Malmquist method, the total factor productivity (TFP), technical efficiency (EFFCH), pure technical efficiency (PECH), technological progress (TECH) and scale efficiency (SECH) of the real estate industry in 30 provinces of China from 2006 to 2017 analyzes and plots the annual average of the five efficiency indicators between 2006 and 2017 (Figure 1).
Figure 1. 2006-2017 efficiency indicator change trend chart.

The real estate industry TFP in 30 provinces in China reached its highest level in 2009 (1.411) and the lowest in 2008 (0.797). TFP changed dramatically around 2009, due to the 2008 financial crisis and China's series of regulatory policies to deal with the financial crisis.

From 2005 to 2007, China's real estate investment was overheated. In order to curb investment overheating, various real estate industry control policies have been issued. For example, in 2007, the Central Bank raised the deposit reserve ratio of commercial banks 10 times and adjusted the benchmark interest rate for deposits and loans six times; The Ministry of Land and Resources issued Order No. 39 to adjust the land hoarding problem in China's existing land development market. In 2008-2009, affected by the 2008 world financial crisis, the Central Bank announced that “double rate” had fallen, and China’s real estate industry changed from a depression to prosperity, and introduced policies to regulate real estate investment, such as land management policy tightening and the Central Bank strict control projects loan management, tightening from an investment perspective. After the investment is tightened, the technical efficiency increases. From 2009 to 2010, the impact of the economic crisis was very obvious. The government's economic stimulus plan and loose monetary policy have expanded output, but there has been no substantial change in technological innovation, and the technological progress index has declined again [6].

The technological progress, TFP growth is mainly caused by the growth of the technological progress. From Figure 1, we can see that the technological progress and the TFP change trend have great similarities. When the technological progress decreases or increases, the TFP is also mostly reduced or increased. Technological progress has become a key factor constraining the further growth of China's real estate industry. It is of great potential to increase the output value of China's real estate industry by introducing and learning advanced technologies from developed countries and regions in the real estate industry.

3.2.2. regional analysis.

| province | EFFCH | TECHCH | PECH | SECH | TFP |
|----------|-------|--------|------|------|-----|
| Beijing  | 0.968 | 1.038  | 0.97 | 0.998| 1.004|

Table 2. Malmquist tables of various provinces.
In the past 12 years, the average growth rate of real estate industry TFP was 3.3%, indicating that the production level of the real estate industry has improved, mainly due to the improvement of technical efficiency. The technical efficiency growth rate is 2.6%, and the technological progress rate is 0.7%. It can be seen that the growth of technical efficiency has contributed to the growth of China's real estate industry TFP, and the growth of technological progress has contributed relatively little to the growth of China's real estate industry TFP. Zhejiang has the highest growth rate of TFP, reaching 10.8%, indicating that Zhejiang's real estate industry has good production efficiency and is of reference to other provinces. The lowest total factor growth rate is Xinjiang, which is -4.6%, due to low pure technical efficiency and low technological progress.

As analyses above show, the technological progress changes synchronically with TFP, which proves that the technological progress is a major indicator for TFP [11]. In 12 years, the technological progress presents positive growth in the real estate sector in 14 provinces, but negative growth in 16 provinces. On the basis of the current investments into the real estate industry, these 16 provinces have a low output growth rate.

The scale efficiency is less than 1 in 9 provinces, namely Beijing, Tianjin, Hebei, Inner Mongolia, Fujian, Shandong, Henan, Hunan, and Sichuan. These provinces need to adjust the input-output ratio to
maximize output.

The overall mean pure technical efficiency is 1.022, and the overall level is high. However, the pure technical efficiency of the real estate industry in the seven provinces of Beijing, Tianjin, Jiangsu, Yunnan, Gansu, Ningxia and Xinjiang showed a negative growth, and these provinces need to improve the efficiency of the input factors.

In the change of the technical efficiency, the change of pure technical efficiency contributed the main force (2.2%), and the scale efficiency contributed 0.4%. The growth of pure technical efficiency has contributed to the growth of China's real estate industry's technical efficiency. The growth of scale efficiency has contributed relatively little to the growth of China's real estate industry's technical efficiency. Scale efficiency is a key factor that constrains the further growth of China's real estate industry. In the future, it is necessary to adjust the industrial structure, improve the management level, and achieve the best scale to increase the output value of China's real estate industry.

4. China's real estate industry regional TFP convergence test

According to the classical regression equations built by Barro [12] to test absolute β convergence, this paper defines the test model of China's real estate industry TFP convergence as follows:

\[
\frac{1}{T} \left[ \ln(TFP_{t,T}) - \ln(TFP_{t,0}) \right] = \alpha + \beta \ln(TFP_{t,0}) + \varepsilon \tag{3}
\]

Where: \(\ln(TFP_{t,0})\) and \(\ln(TFP_{t,T})\) respectively represent the Malmquist index of the real estate industry in the base period and the end period of the \(i\) province; \(\alpha\) is a constant term; \(\beta\) is a regression coefficient; \(\varepsilon\) is an error term. If \(\beta < 0\) and statistically significant, that is, the growth rate of the index is inversely proportional to its initial value, indicating that there is absolute β convergence.

According to the absolute β convergence test regression model established by equation (3), the convergence of real estate TFP in the eastern, central, western and national regions is tested respectively. In order to reduce the influence of random factors on the convergence test, this paper uses the geometric mean of the Malmquist index from 2007 to 2009 as the base period index, and takes the geometric mean of the Malmquist index from 2015 to 2017 as the end period index, \(T = 9\). The results of the equation (3) using the ordinary least squares (OLS) are shown in Table 3.

| region               | \(R^2\) | Adjusted \(R^2\) | Std Error of the Estimate | \(F\)   | \(\beta\)    | Sig.  |
|----------------------|---------|------------------|---------------------------|---------|--------------|-------|
| The eastern of China | 0.015   | -0.094           | 0.00980                   | 0.141   | -0.016       | 0.716 |
| The central of China | 0.737   | 0.693            | 0.00671                   | 16.787  | -0.114       | 0.006 |
| The western of China | 0.554   | 0.505            | 0.01274                   | 11.190  | 0.113        | 0.009 |
| National total       | 0.383   | 0.361            | 0.01122                   | 17.396  | -0.091       | 0.000 |

The national β value is negative, and the significance value is 0.000. The national real estate industry TFP is significantly convergent, that is, the national real estate industry TFP gap has a significant shrinking trend. In terms of regions, the β values of the 11 provinces in the eastern region were negative, but the significance value was 0.716, indicating that there was convergence of TFP among the provinces. However, the convergence trend is not significant, that is, the TFP gap in the real estate industry in the eastern provinces is shrinking, but not significant. The TFP of the eight provinces in the central region converges at a level of 0.6%, indicating that there is a clear catch-up trend in the real estate industry's TFP growth in the underdeveloped provinces in the central region, and the TFP gap between provinces is gradually narrowing. The real estate TFP in 11 provinces in the western region diverge at a significant level of 0.9%, indicating that the TFP gap in the real estate industry in the western provinces has significantly expanded. In order to achieve a balanced development of the real estate industry in various regions, the country needs to pay attention to the improvement of production efficiency of undeveloped provinces in terms of industry technology investment and market structure adjustment. At the same time, developed provinces should further expand the external and internal driving force of the efficiency improvement of the real estate industry, in order to maintain their regional competitive advantages, and better play the demonstration and spillover effects in the overall development of the real estate industry,
and guide the growth of TFP in the real estate industry.

5. Conclusion
(1) During the period from 2006 to 2017, the average growth rate of TFP in the real estate industry in China's 30 provinces was 3.3%. Technical efficiency is the main driver of TFP growth, and the contribution of technological progress is relatively small. In the improvement of technical efficiency, pure technical efficiency is obviously improved, and the improvement of scale efficiency is limited.
(2) The absolute β convergence test shows that from the national perspective, the TFP gap in the real estate industry in each province has a significant narrowing trend; in terms of regions, the TFP gap in the real estate industry in the eastern regions has a narrowing trend, but not significant; The TFP growth of the real estate industry in the undeveloped provinces in the central region has obvious catch-up characteristics, and the TFP gap between provinces has gradually narrowed; The TFP gap in the real estate industry in the western provinces has significantly expanded.

The enlightenment brought by this paper is as follows: First, in order to promote the healthy development of China's real estate industry, it is necessary to improve TFP. We can start from two aspects: (1) Technological progress: We should actively promote endogenous technological innovation in the real estate industry and bring about a new round of technological development; Exogenous technological progress is achieved through technology spillovers and technology transfer. (2) Scale efficiency improvement: The scale efficiency will be improved by adjusting the industrial structure and improving the management level. Second, the real-estate production efficiency of the real estate industry in China's eastern and western regions is quite different. In order to achieve coordinated development of the regional real estate industry, the country needs to pay attention to the improvement of production efficiency of the undeveloped provinces in the real estate industry in terms of industry technology investment and market structure adjustment.

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