Empirical Analysis of Private Investment Efficiency in Xi'an Based on Data Envelopment Analysis Method

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Abstract. This paper uses the data envelopment analysis method to analyze the overall efficiency of private investment in Xi'an, pure private investment and mixed private investment efficiency comparison and private investment and government investment comparison empirical analysis, found that the overall efficiency of private investment in Xi'an is not high, the scale efficiency of mixed private investment relative to pure private investment is high, and presents a slowly rising trend, by 2021 also reached the scale of payoffs unchanged, the government investment in the scale of the initial efficiency is not as good as the private investment, but the government investment in the scale of the efficiency of the continued to improve, and the overall efficiency of the pulling force is higher than that of the private investment.

Keywords: DEA, private investment, efficiency, empirical analysis

1 Introduction

In August 2021, the executive meeting of Xi'an Municipal Government considered and passed the Implementation Opinions on Further Promoting the Healthy Development of Private Investment, which put forward 16 specific initiatives to further improve the docking mechanism and service mechanism between government and enterprises, and actively build a new type of "pro" and "clear" relationship between government and business to provide all-round quality services for private enterprises, and continuously release the potential of private investment. service mechanism, and actively build a "pro" "clear" new type of business relationship, to provide a full range of high-quality services for private enterprises, and constantly release the potential of private investment. As an important part of China's socialist market economic system, the study of private investment is of great theoretical and practical significance for improving China's investment theory and market economic theory, promoting economic growth and increasing employment.

2 Model Construction

2.1 Model selection

DEA model has CCR model and BCC model: CCR model assumes that DEA efficiency is measured under the condition of constant returns to scale, and BCC model assumes that DEA

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efficiency is measured under the condition of variable returns to scale. BCC model corrects the assumption of constant returns to scale in the CCR model to variable returns to scale, and when DMUs are inefficient, it can be judged by the results of BCC model that the inefficiency is caused by technical efficiency or low scale efficiency. or low scale efficiency.[1] The BCC model decomposes the efficiency formula into comprehensive efficiency (TE) = technical efficiency (PTE) * scale efficiency (SE). Therefore, this paper adopts BCC model, and the formula for the BCC model is shown in equation (1):

$$\min \theta_0$$

$$s.t \begin{cases} \sum_{j=1}^{n} \lambda_j x i_j + \bar{s}_i = \theta_0 x_{i0} \\ \sum_{j=1}^{n} \lambda_j y_{rj} - \overset{+}{s}_r = y_{r0}, r = 1,2,\ldots s \\ \lambda_j \geq 0, j = 1,2,\ldots n \\ \theta_0, \bar{s}_i, \overset{+}{s}_r \geq 0 \end{cases} \quad (1)$$

Where, j=1,2,3 "o is the number of decision making units, X and Y are the inputs and outputs respectively, meanwhile, in this model, θ is the effective value of decision making unit DMU, which has the following economic significance:

If θ = 1 and t - = t + = 0, DMU 0 is said to be DEA effective.

If θ = 1 and t - ≠ 0 or t + ≠ 0, then DMU 0 is said to be weakly DEA valid, i.e., it is valid, but not as valid with respect to 1, and can be considered invalid if θ<1[2].

2.2 Indicator selection and data sources

(1) Selection of indicators

The analysis of private investment efficiency in this paper is based on the evaluation and measurement of the effect of fixed asset investment and economic growth.[3] Therefore, the input indicator adopts private investment data; new fixed assets is a value indicator reflecting the results of fixed asset investment, and an important indicator reflecting the progress of construction and calculating the effect of fixed asset investment, private investment as a part of fixed asset investment, so new fixed assets is selected as a value indicator of the results of fixed asset investment; the regional GDP represents the level of economic development of a region, so the selection of GDP as an indicator of the economic growth effect of private investment[4].

Table 1 Pearson correlation test for private investment input-output indicators

	Xi'an New Fixed Increased Production	Xi'an GDP
Xi'an private investment	0.816**	0.889**

* p<0.05 ** p<0.01

As can be seen from Table 1, the input and output indicators of private investment in Xi'an for 12 consecutive years from 2010 to 2021 are significantly and positively correlated at the 1%

level, which indicates that the input and output indicators selected in this part are in line with the principle of "isotropy".[5]

The specific input and output indicators and multidimensional analysis structure of the DEA model in this paper are shown in Table 2.

Table 2 Input-Output Indicators and Analyzing Dimensions of Private Investment Efficiency

Type of indicator	norm	dimensional analysis
Input indicators	Private investment data	Xi'an Overall Efficiency Analysis Analysis of the efficiency of different investment entities
Output indicators	New fixed asset investment in the region	
	Regional GDP	

(2) Data sources and processing

The data in this paper are mainly from Xi'an Statistical Yearbook, Chengdu Statistical Yearbook, Xi'an Statistical Bureau Information Network, etc. for 2010-2021.

Firstly, the acquired data are arranged according to the input and output indicators and sub-years; secondly, we need to consider the "normalization" of the data; [6] the DEA optimal efficiency measurement has nothing to do with the scale of the input and output indicators, but only requires that the data of the indicator is non-negative, and the data of the indicators that we acquired are all non-negative, so there is no need to carry out the data processing.

3 Empirical analysis of private investment efficiency in Xi'an

3.1 Empirical Analysis of the Overall Efficiency of Private Investment in Xi'an City

The collated Xi'an private investment-output data are used to run the model by DEA-BCC, selecting the private investment data as input indicators, selecting the new fixed asset investment and GDP as output indicators, and using the year as the DMU label, and the running results are shown in Table 3.

Table 3 Private Investment Efficiency in Xi'an

particular year	Technical benefits TE	economies of scale SE(k)	Combined benefits OE(θ)	
2010	1	1	1	-
2011	0.948	0.804	0.762	drs
2012	0.541	0.728	0.394	drs
2013	0.537	0.641	0.344	drs
2014	0.604	0.626	0.378	drs
2015	0.699	0.577	0.403	drs
2016	0.812	0.571	0.463	drs
2017	0.845	0.578	0.489	drs
2018	0.792	0.502	0.398	drs
2019	0.96	0.486	0.466	drs
2020	1	0.541	0.541	drs
2021	1	0.505	0.505	drs

As can be seen from Table 3, the change of private investment efficiency in Xi'an in recent years has a certain degree of volatility.

From the perspective of technical efficiency, the change of technical efficiency of private investment in Xi'an ranges between 0.537-1, with the lowest technical efficiency in 2013 and technical efficiency reaching 1 in 2010, 2020 and 2021.

From the perspective of scale efficiency, the value of private investment scale efficiency in Xi'an ranges from 0.486-1, with the lowest scale efficiency in 2019 and the highest scale efficiency in 2010.

From the perspective of comprehensive efficiency, excluding 2010, the value of the comprehensive efficiency of private investment in Xi'an ranges from 0.344-0.762, with the lowest comprehensive efficiency in 2013 and the highest comprehensive efficiency in 2011.

From a comprehensive point of view, the comprehensive efficiency of Xi'an's private investment is strongly effective in 2010 DEA, and non-effective after 2011 DEA, showing decreasing drs-size reward (too large a scale can reduce the scale to increase the efficiency).The BCC model splits the comprehensive efficiency into technical efficiency and scale efficiency, and the technical efficiency reflects the efficiency brought by the technical factors, and a value equal to 1 indicates that the factors are reasonably utilized, and a value less than 1 indicates that there is still room to improve the technical efficiency of the factors.[7] There is still room for improvement in the technical efficiency of factors. Xi'an's technical efficiency was better in 2010, declined sharply in 2011-2012, then rebounded slowly, and reached the optimum again in 2020-2021, indicating that in recent years, Xi'an's private enterprises have improved their technical efficiency through the introduction of new technologies and the improvement of management level. Overall, the scale efficiency of private investment in Xi'an shows a continuous downward trend, indicating that the scale of private investment in Xi'an is insufficient and there is still a lot of room for improvement, and the non-efficiency of the comprehensive efficiency of private investment is mainly caused by the lower scale efficiency[8]. This view can be further verified by combining with Figure 1.

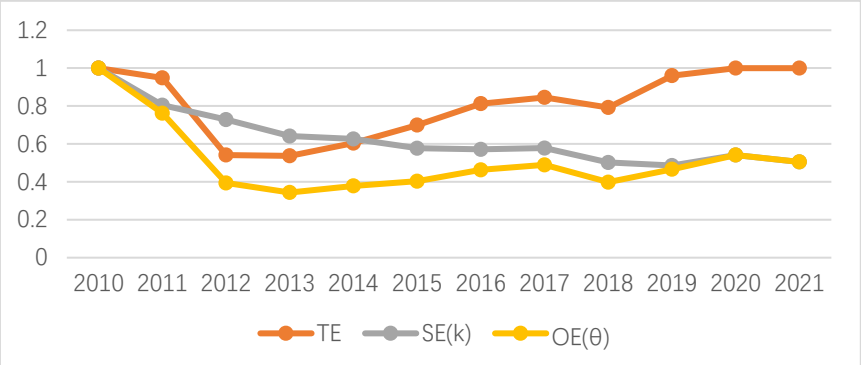

Figure 1 Trend of Private Investment Effectiveness in Xi'an

3.2 Efficiency Analysis of Different Investment Main Bodies of Private Investment in Xi'an City

As can be seen from Table 4, the technical efficiency of pure private investment is relatively good, reaching the optimum in 2010, 2011 and 2019-2021, and the technical efficiency values of the rest of the years are between 0.626-0.854, with the technical efficiency of 2015 being the lowest; the scale efficiency of pure private investment, except for 2011 when it reaches the optimum, has shown a decreasing trend year by year on the whole. The scale efficiency was the lowest in 2021, only 0.533, therefore, the overall performance of the comprehensive efficiency of pure private investment is poor, except for 2011, the value of the comprehensive efficiency is between 0.483-0.948, and the comprehensive efficiency in 2018 is the lowest. The technical efficiency of mixed private investment is lower at the beginning, only 0.131 in 2013, but it improves rapidly in recent years and reaches the optimal state in 2020-2021; the scale efficiency of mixed private investment is higher relative to pure private investment and shows a slow increase, and it reaches the constant return to scale (i.e., the optimal state) in 2021, driving its comprehensive efficiency to achieve DEA strong effectiveness in 2021. In 2021, the combined efficiency of private investment achieves strong DEA efficiency. Since the technical efficiency of mixed private investment is much lower than that of pure private investment, its comprehensive benefit is far from the comprehensive benefit of pure private investment. [9]

In summary, it can be seen that the investment efficiency of different investment subjects shows certain differences, for pure private investment, the focus of improving investment efficiency is to increase the scale of investment and enhance the scale efficiency; while for mixed private investment, the focus of improving investment efficiency is to strengthen management, increase technology introduction and enhance the technical efficiency.

Table 4 Investment Efficiency Analysis of Xi'an Private Investment by Subjects

particular year	Pure private investment				Mixed private investment			
	TE	SE (k)	OE (θ)	validity	TE	SE (k)	OE (θ)	validity
2010	1	0.948	0.948	Non-DEA valid	0.233	0.528	0.123	Non-DEA valid
2011	1	1	1	DEA strong and effective	0.063	0.574	0.036	Non-DEA valid
2012	0.854	0.929	0.793	Non-DEA valid	0.171	0.781	0.133	Non-DEA valid
2013	0.702	0.918	0.644	Non-DEA valid	0.131	0.829	0.108	Non-DEA valid
2014	0.637	0.879	0.56	Non-DEA valid	0.135	0.988	0.133	Non-DEA valid
2015	0.626	0.853	0.534	Non-DEA valid	0.162	0.907	0.147	Non-DEA valid
2016	0.673	0.811	0.546	Non-DEA valid	0.232	0.864	0.201	Non-DEA valid
2017	0.826	0.852	0.704	Non-DEA valid	0.385	0.96	0.369	Non-DEA valid
2018	0.639	0.757	0.483	Non-DEA valid	0.453	0.972	0.441	Non-DEA valid
2019	1	0.844	0.844	Non-DEA valid	0.575	0.951	0.547	Non-DEA valid
2020	1	0.728	0.728	Non-DEA valid	1	0.936	0.936	Non-DEA valid
2021	1	0.533	0.533	Non-DEA valid	1	1	1	DEA strong and effective

3.3 Comparative Analysis of Private Investment Efficiency and Government Investment Efficiency in Xi'an City

The model was run using the DEA-BCC approach and the results are shown in Table 5.

Table 5 Comparison of Private-Government Investment Efficiency in Xi'an City

particular	private investment				government investment			
year	TE	SE(k)	OE(θ)		TE	SE(k)	OE(θ)	
2010	1	1	1	-	0.559	0.386	0.216	irs
2011	0.948	0.804	0.762	drs	0.539	0.454	0.245	irs
2012	0.541	0.728	0.394	drs	0.845	0.539	0.455	irs
2013	0.537	0.641	0.344	drs	0.782	0.598	0.467	irs
2014	0.604	0.626	0.378	drs	0.784	0.666	0.522	irs
2015	0.699	0.577	0.403	drs	0.794	0.695	0.551	irs
2016	0.812	0.571	0.463	drs	1	0.735	0.735	irs
2017	0.845	0.578	0.489	drs	0.594	0.822	0.488	irs
2018	0.792	0.502	0.398	drs	0.602	0.891	0.536	irs
2019	0.96	0.486	0.466	drs	0.788	0.955	0.753	irs
2020	1	0.541	0.541	drs	1	1	1	-
2021	1	0.505	0.505	drs	1	1	1	-

According to Table 5, it can be seen that the comprehensive efficiency of private investment in Xi'an is strongly effective in DEA in 2010, and the DEA is non-effective after 2011, showing a decreasing trend of drs-size reward. Technical efficiency was better in 2010, but there was a sharp decline in 2012, with a technical efficiency value of only 0.537, and then slowly improved after 2013, and re-attained the optimum in 2020-2021; the scale efficiency of Xi'an's private investment, on the other hand, showed a continuous decline, resulting in the overall poor performance of the comprehensive efficiency, with the value of the comprehensive efficiency in most years ranging from 0.3 to 0.5.

The change of technical efficiency of government investment in Xi'an is more tortuous, showing the trend of high and low, mainly manifested in two rising periods, 2010-2016 is the first round of rising period, 2017-2021 is the second round of rising period, the scale efficiency of government investment in 2010-2021 maintains a continuous growth trend, the value of the scale efficiency from 0.386 in 2010 continues to grow to 1 in 2020, presenting an increasing irs-scale reward; the comprehensive benefit, driven by the continuous growth of scale benefit, shows an overall rising trend year by year, and the comprehensive benefit of government investment realizes DEA strong validity in these two years because both the technical benefit and scale benefit reach the optimum in 2020-2021.

4 Conclusions

Through the above analysis we find that the overall level of private investment efficiency in Xi'an is low, and the technical efficiency of pure private investment is relatively better compared with the main body of mixed private investment. Compared with private investment and government investment, the scale efficiency of government investment is initially inferior to that of private investment[10], but the scale efficiency of government investment continues to improve, pulling the overall efficiency higher than that of private investment; although the technical efficiency of private investment in Xi'an is better than that of government investment, the downward trend of scale efficiency leads to the decline of the overall efficiency of private investment. Therefore, the Xi'an municipal government can next accelerate the implementation of measures to promote the healthy development of private investment, liberalize private

investment in finance, medical care, infrastructure and other fields, and promote the healthy and orderly development of private investment.

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