

# EVALUATION OF THE OPERATIONAL EFFICIENCY OF MEDIA COMPANIES BASED ON SUPER-EFFICIENCY DEA

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## Abstract

The role of media has always been the core of social construction and identity construction. Mass media is changing the way people study, work and live. It leads the social fashion and ethos, it can timely report and comment on the social life of the major events and it can also play the role of public opinion guidance, thus, safeguard the healthy development of society. At the same time, the media is critical in presenting quality content that nourishes the human spirit, stimulates the imagination, and overcomes future challenges. During quarantine, interaction and experience now rely mostly on media, whose value and integrity are important. Based on the financial data of ten media enterprises in the past five years, this paper USES the super-efficiency DEA and the Malmquist index method to evaluate the efficiency of the media industry in the past five years. The research shows that in the past five years, the operating efficiency of listed companies in the media industry in my country was good overall. At the same time, the scale efficiency of the entire media industry is showing a slow upward trend, indicating that the scale efficiency of some companies needs to be improved. Therefore, companies should find their own efficiency defects, so as to improve their operational efficiency in a targeted manner.

**Key words:** super efficiency DEA; Data envelopment analysis; Media industry; Input index, output index

## 1. Introduction

In recent years, with the rapid development of the Internet technology, new media technology has emerged in China. New media technology has been reformed and innovated on the basis of the development of traditional media, and has brought into the network media technology and other scientific and technological factors, so that new media has vitality and can occupy a place in the complex media industry. For this reason, the traditional media has been severely impacted by the new media, and may have to face the risk of bankruptcy crisis, debt or contract breach, and even the stock settlement breach in the stock market. This situation clearly shows that many companies fail to manage the emerging risks in an appropriate way, and even worse, they seem not to have clear understanding of the risks they are facing to. Therefore, many experts and scholars who focus on the operation and management of Chinese enterprises have begun to pay attention to the study of on Chinese enterprise operations.

This paper investigates the management performance of Chinese media enterprises. Firstly, the financial data of ten Chinese media enterprises

in recent five years are collected. Then, the data envelopment analysis method is used to study the enterprise management performance. The effective decision-making units are sorted by the theoretical research of super-efficient DEA model. It is expected that the research results of this paper can be a reference for enterprise management. The structures are as follows: In the first section, it introduces the comments, the related background and the research direction. The second section is related literature review. The third section analyzes the data envelopment analysis (DEA) and some methods of super efficiency model. In the fourth section, we will provide the efficiency analysis table and efficiency analysis results of the empirical research. Finally, some basic conclusions and suggestions for further research are discussed in the fifth section.

## 2. LITERATURE REVIEW

Pablode Llano Mondos (2014) et al. used DEA method to study the early warning of financial crisis, and took 491 small and medium-sized enterprises in Galicia, including 384 financial failure enterprises, and 107 normal enterprises, as samples for

empirical study, proving that DEA method could further determine the companys' financial status on the basis of other models.[1]

Tian Ze (2016) and others ,based on the panel data of Chinese direct investment in 2008-2014 to 35 key countries along "the Belt and Road", with super efficiency DEA and Malmquist index method , conducted of comprehensive evaluation of investment efficiency and its changes.Their research shows that our country's investments in countries along the"the Belt and Road" do not have a high total efficiency and do have a high national difference, investment scale gains in most of the countries remain in effective investment or increasing investment stage.[2]

Cheng Guangbin and Long Wen (2017) calculated resource and environmental efficiency by using super-efficiency DEA model to measure the sustainable development ability of 71 cities at or above the prefecture-level along the "Silk Road Economic Belt" from 2009 to 2014, and selected panel Tobit model to conduct empirical analysis on the factors affecting resource and environmental efficiency. The results show that the sustainable development ability of the cities along the Silk Road Economic Belt is constantly improving, but most cities are still low, and the gap between cities is large. [3]

Guo Mengya (2017) innovatively used super-efficiency DEA method combined with SFA method to study the logistics efficiency of Guangdong province.He constructed the evaluation index system of logistics efficiency, obtained the conclusions related to the overall logistics efficiency of Guangdong province and the logistics efficiency of guangdong province, and analyzed the influencing factors according to the empirical results. The results showed that the average technical efficiency of Guangdong province from 2001 to 2014 was 0.970, the average pure technical efficiency was 0.977, and the average scale efficiency was 0.993. The overall logistics efficiency of Guangdong province is higher and the development is better. [4]

Zhao Chunying et al. (2019) discussed effective units from the perspective of efficiency value through the super-efficiency model and gave the concept of projection. The research shows that DEA projection can not only give reasons for the invalid units, but also can figure out the advantages of the effective units, thus making up for the deficiencies of the traditional super-efficiency DEA model. [5]

Zhang Heng (2019) et al. took the urban agglomeration of the Yangtze River Delta as the main research object.They used the input and output data from 2010 to 2016, established the super-efficiency DEA model, and evaluated the

development efficiency of the five major subdivided science and technology service industry in the urban agglomeration of the Yangtze River Delta by using window analysis. The results show that there are significant differences in the level and trend of the comprehensive technical efficiency of the science and technology service industry in the Yangtze River Delta urban agglomeration. [6]

Zhong Yunyun (2020) et al. used the super-efficiency DEA model to estimate the logistics efficiency of 11 provinces and cities in the Yangtze River Economic Belt from 2012 to 2017. The empirical results show that the development of logistics efficiency in the reaches of the Yangtze River Economic Belt is unbalanced. The development level of logistics efficiency in the lower reaches of the Yangtze River Economic Belt is much higher than that in the middle and upper reaches of the Yangtze River economic Belt. The logistics efficiency in the upper reaches of the Yangtze River Economic Belt is still relatively backward and far below the average value of logistics efficiency of the Yangtze River Economic Belt.[7]

### 3. RESEARCH METHOD

Data Envelopment analysis (DEA) is a method proposed by Charnes et al., a famous American operations research scientist to evaluate the relative efficiency of similar decision making units. The DEA method has greatly enriched the theory of production function and its application technology in microeconomics. Meanwhile, it has advantages that cannot be underestimated in avoiding subjective factors, simplifying algorithms and reducing errors. DEA method is a new field of interdisciplinary research intersected by operations research, management science and mathematical economics, and has become an important analytical tool and research means in the fields of management science, system engineering, decision analysis and evaluation of technology.[8]

The super-efficiency DEA model includes several models such as CCR, BCC and SBM. The traditional DEA method is a self-evaluation system with all the evaluated decision making units as its reference set. The efficiency value of the effective decision making unit is 1, and the improved value of its projection is 0. Therefore, less information can be provided for effective units. In order to overcome the deficiency that traditional DEA method cannot distinguish the efficiency of effective decision units, Andersen et al. proposed a Super Efficiency Model to further measure the efficiency value of effective decision units in 1993.

The super-efficiency DEA model solves the problem that the traditional DEA model cannot distinguish the efficiency value of effective decision making units and is used in the ordering of decision making units. In addition, the super-efficiency DEA model can also be used to detect abnormal data and analyze the sensitivity and stability of DEA model.[9]

The efficiency evaluation is carried out for the M decision unit, and the fractional programming model is:

$$\begin{aligned} \max p_m &\equiv \frac{a^k y_m}{a^k x_m} \\ \text{s.t.} &\begin{cases} p_i \equiv \frac{a^k y_i}{b^k x_i} \leq 1 (i = 1, 2, \dots, n; i \neq m) \\ a \geq 0, b \geq 0 \end{cases} \end{aligned}$$

Where, the variables of the model are A and B.

It is transformed into a linear programming problem model by transformation

$$\begin{aligned} \max p_m &= \mu^k y_m \\ \text{s.t.} &\begin{cases} \gamma^k x_i - \mu^k y_i \geq 0 (i = 1, 2, \dots, n; i \neq m) \\ \gamma^k x_0 = 1 \\ a \geq 0, b \geq 0 \end{cases} \end{aligned}$$

Its dual linear programming can be expressed as:

$$\begin{aligned} \min \theta - \omega &\left( \sum_{j=1}^u t_j^- + \sum_{\sigma=1}^v t_\sigma^+ \right) \\ \text{s.t.} &\begin{cases} \sum_{\substack{i=1 \\ i \neq m}} x_i \lambda_i + t^- = \theta x_m \\ \sum_{\substack{i=1 \\ i \neq m}} y_i \lambda_i - t^+ = y_m \\ \lambda_i \geq 0 (i = 1, 2, \dots, n) \\ t^- \geq 0, t^+ \geq 0 \end{cases} \end{aligned}$$

Where: X is the input index; Y is the output index;  $\theta$  is a super productive value; T - is the input relaxation variable; T + is the output relaxation variable.

In this model, the evaluated DMU is removed from the reference set. The efficiency value of the evaluated DMU is obtained by referring to the front surface composed of other DMU. The efficiency value of the effective DMU may be greater than 1, so that the effective DMU can be ordered.

## 4 EMPIRICAL RESEARCH

### 4.1 Evaluation object

The super-efficiency DEA model has strict requirements for the selection of research objects and various indicators. In a sense, the application structure of the super-efficiency DEA model depends on the selection of the above two. This article mainly considers the number of samples when selecting research objects, it needs to strictly follow the relevant requirements of the super-efficiency model, that is, the sample size is greater than or equal to twice the product of the input and output indicators. Therefore, when selecting the sample, we selected the data of 25 companies in the media industry from 2015 to 2019. However, in the research process, some companies whose input and output indicators are negative and need to be corrected before applying the model. In order to draw a more accurate conclusion, we excluded companies whose input and output indicators were negative, and finally left Ten listed media companies, They are Simei Media、City Media、Southern Media、Focus Media、Enlight Media、People's Daily Online、Chinese Publishing And Media、Xinhua Media、China Literature、Time Publishing

### 4.2 Select indicator

The choice of input indicators and output indicators is an important prerequisite for the application of the DEA model, which will directly affect the analysis process and final results of the model application. At present, many scholars use the number of employees as one of the investment indicators when studying the operational efficiency of enterprises, Many employees in the media industry work freely, and it is difficult to obtain accurate data on employees. So, we choose total operating cost as one of the investment indicators. Finally, we selected four items in the corporate financial data, namely, total operating costs, total assets, total liabilities, and total shareholder equity as the investment indicators, and in terms of the output indicators we selected four items: total operating income, operating profit, total profit and net profit.

4 input indicators, 4 output indicators, the data sources and descriptive statistics of input-output indicators are shown in Table 1.

**Table 1 2015-2019, corporate efficiency evaluation indicators**

Indicator type	Indicator name	Data Sources	Initial observation	Observations used in the final study
Input index	Total operating costs	Sina Finance Data	125	50
	Total Assets	Sina Finance Data	125	50
	Total Liabilities	Sina Finance Data	125	50
	Total owner's equity	Sina Finance Data	125	50
Output index	Total operating income	Sina Finance Data	125	50
	Operating profit	Sina Finance Data	125	50
	Total profit	Sina Finance Data	125	50
	Net profit	Sina Finance Data	125	50

Substitute the data of various indicators into MATLAB software to calculate the comprehensive efficiency (STE), technical efficiency (TE), scale efficiency (SE), economies of scale (RTS) and

super efficiency DEA of ten media companies from 2015 to 2019, The evaluation results are shown in the table2.[10]

**Table 2 Efficiency model has evaluated the operational efficiency of enterprises in the past five years (Keep only two decimal places)**

Efficiency index		2015	2016	2017	2018	2019	Mean	Efficiency index		2015	2016	2017	2018	2019	Mean		
1	STE	1	1	1	1	0.98	0.99	6	S T E S E R T S D E A	1	1	1	1	1	1		
	TE	1	1	1	1	0.99	0.99			1	1	1	1	1	1	1	
	SE	1	1	1	1	0.99	0.99			1	1	1	1	1	1	1	
	RTS	→1	→1	→1	→1	0.99	0.99			↓0.70	→0.00	→0.07	→0.00	→0.50	→0.50	→0.50	
	DEA	.87	.71	.02	.09	↑0.98	1.33										0.25
2	STE	0.97	0.75	1	1	1	0.94	7	S T E S E R T S D E A	0.83	0.57	1	1	0.95	0.87		
	TE	0.97	0.99	1	1	1	0.99			0.83	0.9	1	1	1	1	0.99	
	SE	0.97	0.99	1	0.96	1	0.99			0.99	1	0.9	0.9	0.9	0.74	0.9	
	RTS	0.99	0.75	→0.17	↓0.12	→0.83	0.94			↓0.12	0.83	0.53	3	↓0.04	4	5	1
	DEA	→0.04	↓0.04				0.24				→0.00	↓1.29	0.04	↓0.28	↓0.00	↓0.00	0.32

3	ST E T E S E R T S D E A	0.9	0.6	1	0.9	1	0.9	8	S T E T E S E R T S D E A	0.5	0.9	0.7	0.8	0.8
		↓0.21	↓0.08	→0.16	↓0.14	→0.30	↓0.08			↓0.00	↓0.00	↑0.00	↑0.00	↑0.00
4	ST E T E S E R T S D E A	1	1	1	0.8	1	0.9	9	S T E T E S E R T S D E A	1	1	0.9	0.7	0.9
		↓0.41	→2.21	→4.80	→1.66	→1.17	↓2.05			→0.00	→0.00	→0.00	→0.00	→0.02
5	ST E T E S E R T S D E A	0.7	0.9	1	1	1	0.9	10	S T E T E S E R T S D E A	1	1	1	1	1
		↓0.01	↓0.00	→0.00	→0.00	→0.16	↓0.03			→2.36	→2.59	→2.76	→2.35	→2.25

Note 1 : “1-10” respectively indicate :Simei Media、City Media 、Southern Media 、Focus Media 、Enlight Media 、People's Daily Online 、Chinese Publishing And Media 、Xinhua Media 、China Literature、Time Publishing

Note 2: ”→” Indicates constant return to scale, ”↑” Represents increasing returns to scale, ”↓” Represents diminishing returns to scale.

**Table 3 Comparison of evaluation results between super-efficiency DEA model and other efficiency evaluation models (Take 2019 data as reference)**

Firm \ Index	Comprehensive efficiency value (STE)	Technical efficiency value (TE)	Efficiency scale value (SE)	Super efficiency DEA value	Rank
Simei Media	0.9826	0.9970	0.9918	0.9826	3
City Media	1.0000	1.0000	1.0000	0.8388	4
Southern Media	1.0000	1.0000	1.0000	0.3062	6
Focus Media	1.0000	1.0000	1.0000	1.1714	2

Enlight Media	1.0000	1.0000	1.0000	0.1687	7
People’s Daily Online	1.0000	1.0000	1.0000	0.5036	5
Chinese Publishing And Media	0.9542	1.0000	0.9542	0.0000	9
Xinhua Media	0.8944	0.9149	0.9776	0.0000	10
China Literature	1.0000	1.0000	1.0000	0.0215	8
Time Publishing	1.0000	1.0000	1.0000	2.2550	1

Obviously, the super-efficiency DEA model explains more clearly. Therefore, we choose to use the super-efficiency DEA model as the core theory of this research.

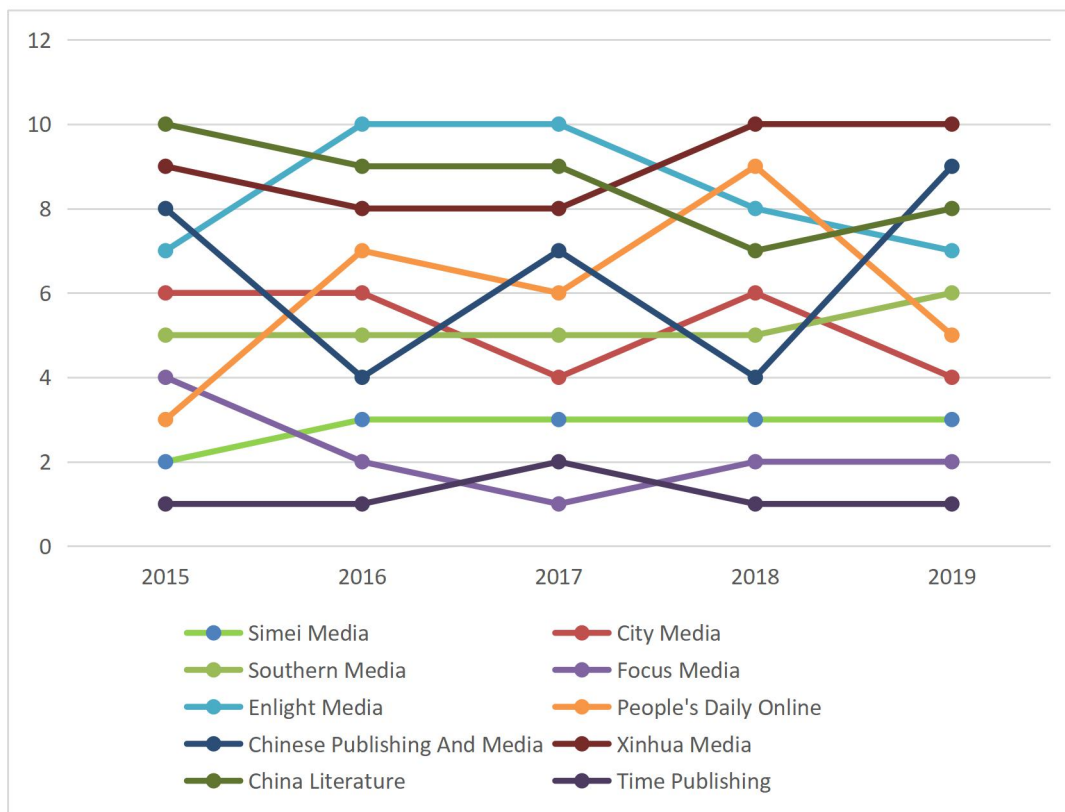


Fig.1 The efficiency ranking of 10 media companies from 2015 to 2019

4.3 The operational efficiency analysis

From Table 3, we can see that in terms of STE, all the 10 companies analyzed have achieved effective comprehensive efficiency and presented a rising trend from 2015 to 2019. Although only People's Daily Online and Time Publishing achieved effective efficiency for five years without interruption, the average STE of other companies in the past five years reached over 0.82, and they all achieved effective standard for two years or more, except for Xinhua Media that only achieved effective efficiency in 2015. This shows that the overall level of operation efficiency of listed companies in China's media industry from 2015 to 2019 is relatively stable and good, which is closely related to the rapid development of the Internet and communication technology. The favorable development trend of the media industry is in line

with the current situation.

The technical efficiency of the 10 sample media companies is particularly outstanding. In terms of TE, People's Daily Online, Time Publishing and Focus Media have all achieved technical efficiency and effectiveness in the past five years, and the average value of technical efficiency of other companies has reached over 0.95 from 2015 to 2019. Only Xinhua Media has achieved two years' technical efficiency, and the other companies have achieved technical efficiency for three or four years. This indicates that the listed companies in Chinese media industry have a particularly excellent performance in technical efficiency during the five-year period, and have the ability to maximize output under certain input conditions. In terms of scale efficiency, the three companies that have achieved technical efficiency and

effectiveness also gained effective scale efficiency for five consecutive years, besides them, China Literature has reached the effective standard. Although the mean value of scale efficiency is lower than the mean value of technical efficiency, it also reaches more than 0.80. There was a big fluctuation in 2016. The efficiency of Chinese Publishing & Media and Xinhua Media was only 0.5822 and 0.5911 in this year, far lower than the average scale efficiency of 0.8506 in that year. In 2019, the average of scale efficiency reached the highest of 0.9924. This indicates that the scale efficiency of listed companies in China's media industry is not bad in the past five years, showing a slow rising trend, but some companies still need to improve their scale efficiency.

From 2015 to 2019, the 10 listed companies in the media industry analyzed gradually stabilize their returns to scale. The scale income of China Literature and Time Publishing have not changed in 5 years, and the value of the return on scale is 1. Focus Media, Enlight Media, People's Daily Online only saw a decline in the return on scale for only one year, while the remaining four remained unchanged. Simei Media, Xinhua Media present the trend that scale returns increases.

The overall level of DEA of listed companies in Chinese media industry in the past five years is low, with the average value of all the five years being less than 1. Only one year was the closest to 1, and the DEA of the remaining four years is not optimistic. From Fig. 1, we can see that DEA of Time Publishing has been in the first or second place in the past five years, indicating that enterprise can increase investment and obtain greater profits. It was followed by Simei Media and Focus Media, which have been at the upstream of the list of 10 companies. City Media and Southern Media are the stable ranking in the middle. Xinhua Media and China Literature have been located in the downstream. Enlight Media has been steadily improving its ranking from 10 to 7, from which we can see the improvement of efficiency level.

## 5 CONCLUSION

In general, it is beneficial to evaluate the operating efficiency of the media industry based on super efficiency. By selecting the representative ten listed companies in Chinese media industry for transverse comparison, collecting their financial data of the latest five years, and then USING the data envelopment analysis method, we studied the performance of enterprise management, and the theory of super efficiency DEA model was applied to study the effective decision making units for

sorting. The research shows that the efficiency of the listed companies in China's media industry is better as a whole. At the same time, the scale efficiency of the media industry presents a slow rising trend, but some companies still need to improve the scale efficiency. Therefore, it is very crucial to improve the management efficiency of enterprises and increase investment.

The research method selected in this paper is also a highlight. Data envelopment analysis is used to analyze and evaluate the operation efficiency of selected media companies. Compared with other corporate operating efficiency analysis methods, such as financial ratio method, regression analysis method, fuzzy evaluation method, balanced scorecard method, etc., data envelopment analysis method has more prominent advantages. Other analysis methods all need to assign different weights to each evaluation index artificially, so that the distinction and analysis with personal subjectivity will easily affect the objectivity of our analysis results, and thus lead to the deviation of the research conclusion. DEA method, whose analysis basis is relative efficiency, has a good theoretical basis and academic support for evaluating the effectiveness of multi-input and multi-output decision-making units with the same type. So super efficiency DEA model and the data envelopment analysis play a great role in our study of the media industry, with year for horizontal comparison, we analyzed the operating performance of ten listed company in Chinese media industry, and the research methods of appropriate choice also provides more convenience for our research, it is helpful to our study run smoothly and efficient analysis conclusion; At present, there are few papers about the super-efficiency DEA method in the academic circle, and the application of it in this paper is also conducive to the extensive application of such data analysis methods.

The research topic of this paper is to use super efficiency to evaluate the operating efficiency of the media industry. The media industry, whether traditional media or emerging new media, plays an extremely important guiding role in economic development. From macro social development to micro social environment construction, it plays an irreplaceable positive role. Combined with China's current economic development and the increasingly close connection of various sectors of the world under the science and technology, the role of new media in economic and social development is particularly prominent. As a result, we chose to study media industry trend of development and progress, and we believe it can not only provide the class enterprises with guidance and reference to improve operation management and benefit

promotion, but also hope to be able to use the media public opinion potency and the great influence of media to promote national social economic development, to seek ways to further promote the social progress and economic development.

But our study, of course, also have many shortcomings, the number of representative enterprises selected is not large enough, the data annual analysis is too simple, they can not fully represent the overall development of such industry status, and because our knowledge is rather limited, too, this article only at the superficial level conducted brief analysis of the various data, the research conclusion was drew d with a degree of individual subjectivity, we will pay more attention to the skilled application of research methods and rigorous adoption of data in the study of subsequent research.

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This work was carried out in collaboration by seven authors. Author MX and YYL collected the relevant literature which at home and abroad, besides, they also gathered the data that used in the search process. Author CHL and SYX performed the statistical analysis and empirical analysis through the MATLAB. Author YTC and HJ, gave the corresponding According to the analysis results, conclusions and suggestions. Author Wen-Tsan pan organized the team and directed the academic papers, authors read and approved the final manuscript.

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