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# Measurement and evaluation on the culture industry operational efficiency in China—empirical research based on the DEA&TOPSIS integrated model

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## ABSTRACT

According to the current development of China's culture industry, and to quantitatively analyze and appraise China's culture industry operational efficiency, then to research its main features and uncover the possible problems. The results show that: China's culture industry operational efficiency is low in overall level, and the efficiency developing level of the 9 sub-sectors of culture industry is imbalanced obviously. The traditional "high input, low output" dilated extensive mode of development has not changed a lot, and thus, to put forward some industrial strategies to improve the operational efficiency of China's culture industry.

## KEYWORDS

Culture Industry; Efficiency; Measure; Strategies.



## INTRODUCTION

Culture industry is primarily towards the production and delivery of products as the main activities to meet the cultural needs of the public as a target refers to the cultural significance of their own creation and sales[1].

In recent years, although China's culture industry has sustained growth rapidly, the field of culture industry expands a lot, the stock of assets expands a lot, there are still many tissues, such as small industrial scale, low levels of development, lack of professional management talent and so on. Now to take the development of book industry as an example in 2012, China has 579 publishing houses, with total sales of about $10.10 billion USD, while in Germany, just for one publishing house, "Bertelsmann", its sales reached $17.39 billion USD[2]. Then it is necessary to evaluate China's culture industry operational efficiency, and to provide relevant theoretical guidance for the depth mining of China's cultural resources and its orderly and sustainable development.

Currently, refer to the relevant research on literature of culture industry, which is primarily centered on the culture industry of regional development on a standalone basis[3], from the perspective of culture industry development strategy[4], the culture industry contribution to regional economic development[5] and other aspects, and it is lack of quantitative measurement and effective evaluation of the culture industry operational efficiency.

Based on this status, with the methods of DEA-TOPSIS integrated analysis, to make a quantitative research on the operational efficiency of China's culture industry, build culture industry operational efficiency evaluation model, and put forward the efficiency strategies from the perspective of industry planning, the elements market building, personnel training and so on.

## INTRODUCTION TO RESEARCH METHODS

Currently, there are 2 main types methods to measure the operational efficiency, which are parametric method and non-parametric method. Parametric method is represented by stochastic frontier analysis (SFA), and non-parametric method is represented by data envelopment analysis (Data Envelopment Analysis, referred to DEA)[6], which does not require the establishment of a strict functional relationship between variables, and also has distinct advantages on the multi-input multi-output efficiency measurement, but there are also some disadvantages of DEA method such as "it can not be resorted on the effective decision-making unit", Therefore, TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is introduced to make further analysis for " the effective decision-making unit ".

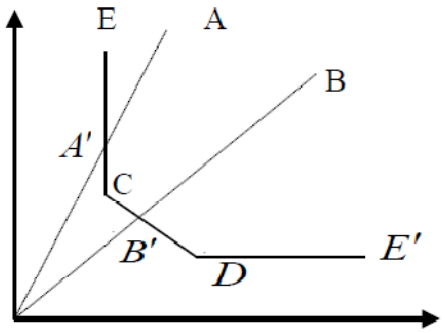


**Figure 1: Constant returns of scale of DEA model efficiency evaluation**

The purpose of DEA mathematical programming method is to build a non-parametric envelope production frontier line, in which“effective decision-making units”are located on the production frontier, while “ineffective internal decision-making units”are in the production frontier. As is shown in Figure 1,

each point represents the same output level of investment portfolio. Put the output level into a unit, the envelope production frontier line (border) is $EE'$, and C, D are in the envelope line for efficient production points, A, B are in the envelope inside, as ineffective production unit points, which means that the same output takes more investment, among them, $\Delta AC = \Delta AA' + \Delta A'C$, and $\Delta AC$ is the distance beween A (ineffective point) and C (effective point) is of ineffective and waste part of the investment, and the larger $\Delta A'C$ and $\Delta AA'$, the lower efficiency point A becames.

## OPERATIONAL EFFICIENCY EVALUATION MODEL CONSTRUCTION

### DEA model construction

First, use the constant returns to scale DEA model, as CCR model (A. Charnes & W. W. Cooper & E. Rhodes) to evaluate the overall efficiency of the decision-making unit, CCR model assumes that there are n DMUs, each decision unit denoted by DMU, and each unit has m kinds of inputs and s kind of outputs, $x_{ij}$ represents $DMU_j$ for the i-th kinds input; $y_{rj}$ represents $DMU_j$ for the r-th kinds output, then the input and output vectors of all DMUj can be expressed as: $X_j=（x_{1j}, x_{2j},…, x_{mj}）^T$, $Y_j=（y_{1j}, y_{2j},…, y_{mj}）^T$, （j=1, 2, …, n）; and set weight vector input V＝ $（v_1, v_2,…, v_m）^T$, and output indicators U= $（u_1, u_2,…, u_m）^T$, in which $v_i$ represents the i-th input weight, $u_r$ represents the r-th output weight. Now to make an efficiency evaluation on $j_o$ unit, optimization models can be constructed as follows:

$$\max h_0 = u^T Y_0 / v^T X_0$$

$$s.t.\begin{cases} h_j = u^T Y_j / v^T X_j \le 1 \\ \sum_{r=1}^{s} u_r = 1, \sum_{i=1}^{m} v_i = 1 \\ x_{ij} > 0, y_{rj} > 0, u \ge 0, v \ge 0 \\ j = 1,2...n \end{cases} \quad \textbf{(Model 1)}$$

Since the the objective function is non-linear (As is shown in CCR model 1), and it can be changed into equivalent linear programming models with the Charnes-Cooper way, then each unit of effective decision-making and the overall efficiency can be solved (e.g. model 2) by dual programming efficiency analysis theory.

$$\min \theta$$

$$s.t.\begin{cases} \sum_{j=1}^{n} X_j \lambda_j \le \theta X_0, j = 1,2,...,n \\ \sum_{j=1}^{n} Y_j \lambda_j \ge Y_0, \lambda_j \ge 0 \end{cases} \quad \textbf{(Model 2)}$$

Based on Model 2, to solve linear programming model, then the model parameter $\lambda_j$ and value $\theta$ can be calculated, in which $\theta$ represents input-output efficiency. When $\theta = 1$, it indicates that $DMU_0$ is effective production units, namely among the n evaluation units, input $X_0$ and output $Y_0$ can achieve the optimal level; then when $\theta < 1$, it indicates that $DMU_0$ is ineffective production unit, namely to reduce $X_0$ to $\theta X_0$ (saves inputs) while maintaining constant output $Y_0$.

However, CCR-DEA evaluation method can only distinguish the units from effective and ineffective, while it is unable to further differentiate and sort the effective evaluation units (when $\theta = 1$). Therefore, sometimes it's difficult to meet the actual needs of management decisions.

**DEA evaluation model building based on TOPSIS method**

When there are multiple effective decision-making units of CCR-DEA model results, it is necessary to introduce TOPSIS method to further differentiate and sort the effective decision-making units. TOPSIS principle is to set the ideal solution and negative-ideal solution of decision-making units, then to sort the ideal solution and and negative ideal solution of the multi-target decision making units (The nearer the highly efficient the ideal solution is, the further the negative ideal solution the further is). Then it can be changed into "euclidean norm model way"to get the optimal efficiency evaluation solution. The multi-objective effective DMU calculation is sorted as follows:

(1) To set the ideal sample point and negative-ideal sample point, and construct virtual decision making unit.

To construct the best decision unit as $DMU_{n+1}$ and the worst decision unit as $DMU_{n+2}$, and to set $DMU_{n+1}$ as the positive ideal sample point and $DMU_{n+2}$ as the negative ideal sample point, among them the input unit ($X_{n+1}$) and output unit ($Y_{n+1}$) of the optimal decision $DMU_{n+1}$ are as follows respectively: $X_{n+1} = (x_{1,n+1}, x_{2,n+1}, \ldots x_{i,n+1}, \ldots x_{m,n+1})$、 $Y_{n+1} = (y_{1,n+1}, y_{2,n+1} \ldots y_{r,n+1}, \ldots y_{s,n+1})$, and the input unit ($X_{n+2}$) and output unit ($Y_{n+2}$) of the worst decision $DMU_{n+2}$ are as follows respectively: $X_{n+2} =(x_{1,n+2}, x_{2,n+2},\ldots x_{i,n+2},\ldots x_{m,n+2})$、 $Y_{n+2} = (y_{1,n+2}, y_{2,n+2},\ldots y_{r,n+2},\ldots y_{s,n+2})$.

(2) To calculate the distance between each effective DMU and the ideal sample point and negative ideal sample point.

First, the effective DMU indicators are handled dimen-sionlessly with linear scale transformation method, among them the input index value is as small as possible (calculated as Equation 1), the output index value is as large as possible (calculated as Equation 2):

$$X_{ij} = \frac{\max x_j - x_j}{\max x_j - \min x_j} \quad \textbf{(1)}$$

$$Y_{ij} = \frac{y_{ij} - \min y_j}{\max y_j - \min y_j} \quad \textbf{(2)}$$

Then, based on the dimensionless handled data, and to select the Euclidean norm as the evaluation criteria to calculate the distance between each DMU and the ideal sample point and the negative-ideal sample point. In which $d_j^+$ represents the distance beween unit j and the ideal solution sample point $DMU_{n+1}$, $d_j^-$ represents the distance beween unit j and the negative-ideal solution sample point $DMU_{n+2}$, the calculation methods are as follows in Equation 3 and Equation 4:

$$d_j^+ = \sqrt{\sum_{t=1}^{m+s} (r_{ij} - r_i^+)^2} \quad \textbf{(3)}$$

$$d_j^- = \sqrt{\sum_{t=1}^{m+s} (r_{ij} - r_i^-)^2} \quad \textbf{(4)}$$

(3) To calculate the closeness ($d_j$) of each decision making unit between the ideal sample point and the negative-ideal sample point.

If $d_j$ is bigger, it indicates that the j-th decision making unit is more excellent, and it is of the higher operational efficiency, calculated as Equation 5:

$$d_j = \frac{d_j^-}{d_j^+ + d_j^-} \quad (5)$$

## AN EMPIRICAL ANALYSIS OF CULTURRE INDUSTRY OPERATIONAL EFFICIENCY

### Determine the evaluation indicators

The basic premise of using DEA model which can accurately evaluate the efficiency is to select a reasonable input-output system, and to select evaluation industries of the cultural operational efficiency firstly should considered the statistics availability as well as the characteristics of culture industry, currently at the frontier efficiency analysis of the input and the output indicators have three methods, such as production method, intermediary method and asset method. Now to select the production method to determine the input and output indicators, to construct the input dimension from the amount of capital and labor (investment amount and number of employees) of culture industry, and to construct the output dimension from the amount of industrial added value and revenue (concrete content as shown in Form 1), therefore, the output function of culture industry operational efficiency can be expressed as equation 6:

$$f(x_1, x_2, x_3, x_4, x_5) = \{y_1, y_2\} \quad (6)$$

**Form 1: cultural industries operational efficiency evaluation system**

| Category | Input indicator | Output indicator |
|---|---|---|
| Cultural organization and management activities<br>Publishing and copyright services<br>Radio, television, movie services<br>Cultural agent organizations<br>Culture and arts Service<br>Web cultural services<br>Stationery manufacturing<br>Stationery sales<br>Cultural venue construction | X1 number of employees<br>X2 Number of enterprises<br>X3 number of scientific research personnel<br>X4 number of professional management talents<br>X5 the industry fixed asset investment | Y1 industrial added value<br>Y2 revenue |

### Sample selection and data processing

According to the input and output evaluation indaicates of Form 1, combined with 2009-2013 annual statistical data (data mainly from the "China Statistical Yearbook" and "China Cultural Industry Statistical Bulletin"), select 9 decision units like“organization and management of cultural activities”to solve CCR model, the results are shown in Form 2.

### Sort by DEA-TOPSIS Integrated Model

According to the results, the operational efficiency of three decision making units are 1, such as publishing and copyright services, stationery sales and cultural venues construction. Now using TOPSIS method for further distinguish the decision making unit which is 1, calculating its degrees of difference in operational efficiency, then the results about the closeness beween the 3 units ($\theta$=1) and the the ideal sample points and negative-ideal sample points are shown in Form 3.

### Analysis of the evaluation results

To use SPSS17.0 software to make descriptive statistics on its operational efficiency values of the 9 sub-sectors cultural industries, the results are shown in Form 4.

**Form 2: culture industry operational efficiency evaluation results**

| Project Decision-making unit | CCR evaluation model score | CCR order | TOPSIS total order |
|---|---|---|---|
| Cultural organization and management activities | 0.334 | 6 | 6 |
| Publishing and copyright services | 1.000 | 1 | 2 |
| Radio, television, movie services | 0.332 | 7 | 7 |
| Cultural agent organizations | 0.194 | 9 | 9 |
| Culture and arts Service | 0.203 | 8 | 8 |
| Web cultural services | 0.761 | 4 | 4 |
| Stationery manufacturing | 0.601 | 5 | 5 |
| Stationery sales | 1.000 | 1 | 3 |
| Cultural venue construction | 1.000 | 1 | 1 |

**Form 3: order obtained based on effective decision-making unit efficiency of DEA-TOPSIS model**

| Decision unit | publishing and copyright services | cultural venues construction | stationery sales |
|---|---|---|---|
| dj （closeness） | 0.4998 | 0.5404 | 0.4462 |
| TOPSIS order | 2 | 1 | 3 |

**Form 4: Cultural industry sub sectors descriptive statistics**

| DUM number | Minimum | Maxim | Mean | Standard deviation |
|---|---|---|---|---|
| 9 | 0.19 | 1.00 | 0.6028 | 0.3484 |

**(a) Analysis of evaluation results of the cultural industry overall operational efficiency**

According to the results obtained by DEA-TOPSIS model, in the 9 decision-making units, there are 3 decision units'efficiency value are effective ($\theta$=1), and the other six units efficiency value is less than 1, which are in ineffective state.

The mean efficiency of the the 9 decision-making units is 0.6028, that is 39.72% of the inputs are inefficiency. And there are 6 units accounting for 55.6% are lower than the average efficiency, which indicates the overall operational efficiency of the culture industry is still low, and the majority of the industrial added value is not derived from the improve of the investment efficiency, but from the high cost investment.

**(b) Analysis of descriptive statistics of the 9 culture industry sub-sectors**

Seen from Form 4, the standard deviation of operational efficiency of the 9 decision-making unit is 0.3484, It is in a state of a "hourglass-shaped "state, that is, the higher and the less efficient decision making units accounted for a high proportion, and the medium efficiency of decision making units accounts for a low proportion, and they are of significant differences.

**(c) Analysis of decision-making unit sort results of the 9 sub-sector of culture industry**

Combined with Form 2 and Form 3, the higher operational efficiency industries are more concentrated in the traditional basic industries, while the emerging industries such as culture and arts services, cultural intermediary organizations industries etc. are generally in the low level. And the imbalance differences of the various sub-sectors relatively large, the main reason for this phenomenon is

the effect of scale, the culture industry is of significant scale features: generally, the stronger the professional level of production is, the greater the scale-effect is, the higher the efficiency of industrial operations is.

## CONCLUSIONS AND RECOMMENDATIONS

Based on DEA-TOPSIS integrated model, from the perspective of the harmonious development of culture industry sub-sectors, the operational efficiency of China's culture industry is analyzed and evaluated, and according the empirical results the conclusions can be drawn that:

First, China's culture industry overall operational efficiency is low, indicating that the traditional "high input, low output" dilated extensive mode of China's culture industry has not changed a lot.

Second, the efficiency of the 9 sub-sector of culture industry development imbalances presented "hourglass-shaped" distribution type status, which explains that the overall balance is poor uneven in the current development of the culture industry, and from the sub-industry development point of view, the less efficient industries are mainly concentrated in the service of culture and arts, cultural intermediary organizations and other industries, which is mainly due to the market opening degree of China's cultural industry, mainly lack of effective planning and low technical level, resulting in a low level and small industrial scale of culture industry in China.

All in all, based on the characteristics of China's cultural industry, there are some recommendations to improve the operational efficiency of culture industry in China, as following.

### Make good macro-planning of industrial development

Seen from the development of China's culture industry characteristics and industrial planning and industrial legislation, First, it is necessary to accelerate the reform of the market mechanism of culture industry to cultivate a group of market subjects with modern enterprise system, clear property right and strong impetus, focusing on the developing intermediary organizations and arts and culture service sectors to provide an institutional guarantee for China's culture industry.

### Make efforts to improve the technical content of the culture industry

Firstly, highly develop the cultural and arts services and cultural intermediary services, and to encourage the development of high-tech products, promote technological achievements, improve the level of technology, and optionally to introduce some foreign interesting cultural and recreational programs and facilities to meet the consumers' demand for different levels of culture and entertainment. And encourage to carry out cultural consulting and planning, cultural facilities and equipment rental and other types of community service activities to improve China's cultural industry operational efficiency.

### Construct system of professionals

Build a national culture industry talent management information system database, improve brain circulation cultural industry market mechanisms, while expanding the autonomy of schools at all levels of professional training. And to make culture industry talents paid professional training system, focusing on the strengthen of the organization and management talents and intermediary services talents, then the talent team of culture industry can be expanded in China, and it can make great contributions to China's culture industry operational efficiency.

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