Computers and Electrical Engineering 71 (2018) 206–211

Contents lists available at ScienceDirect

Computers and Electrical Engineering

journal homepage: www.elsevier.com/locate/compeleceng

Data envelope analysis on capital allocation efficiency using hybrid fuzzy method☆

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ARTICLE INFO

Keywords:
Hybrid fuzzy evaluation
Allocation efficiency
Executive background
Green development

ABSTRACT

To improve the effectiveness of capital allocation efficiency analysis, an empirical research method of data envelope analysis (DEA) involving fuzzy evaluation of capital allocation efficiency with executive background characteristics is proposed in this paper. First, the DEA-based analysis model appropriate to capital allocation efficiency with executive background characteristics is proposed to evaluate the scale of a decision package and general effectiveness of technology; second, the fuzzy synthetic evaluation method is proposed to perform research and analysis on several factors or indices involved in the capital allocation efficiency analysis. Finally, the algorithm effectiveness is verified by empirical analysis of capital allocation with executive background characteristics.

1. Introduction

Green development has become an important trend in the world today and many countries consider the development of green industries as a key aspect of economic restructuring [1,2]. As a manufacturing power, China has clearly declared the intention to implement the philosophy of green development, and upgrade and transform traditional industries as the major support for the development of our green economy. The household appliance industry is the mainstay of the traditional manufacturing industries; the question of how it should deal with changes in modern manufacturing practices influenced by environmental concerns has become a central issue, both theoretically and practically [3]. Reasonable capital allocation is an important aspect of improving resource utilization efficiency, and as such, capital allocation efficiency with executive background characteristics will be researched and evaluated in this paper [4].

Enterprise capital allocation is a complicated issue. Capitals are the input of capital allocation while various economic performance indicators and interest indicators are the output [5]. Capitals are mainly from equity capital and debenture capital; assets are the external pattern of manifestation. A wide variety of asset types exist; different input portfolios decide the different forms and quantities of output. Capital allocation efficiency evaluation is a multi-input and multi-output decision issue; DEA (data envelope analysis) is a rather effective analysis method for this multi-input and multi-output problem space [6,7]. Therefore, in this paper, the DEA theory and model are applied to the evaluation of capital allocation efficiency with executive background characteristics in the hope of providing an effective approach to solve this problem [8,9].

The paper is organized as follows. Section 2 describes the evaluation of capital allocation efficiency. Additionally, the fuzzy rule base is analysed for the DEA model. In Section 3, the experimental analysis is presented. Section 4 concludes the paper.

☆ Reviews processed and recommended for publication to the Editor-in-Chief by Associate Editor Dr. G. R. Gonzalez.

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https://doi.org/10.1016/j.compeleceng.2018.07.050
Received 13 April 2018; Received in revised form 9 June 2018; Accepted 31 July 2018

2. Thinking of evaluation of capital allocation efficiency

2.1. Description of capital allocation DEA model

As asset is the external form of manifestation of capital. Capital allocation with executive background characteristics will create portfolios of quality and quantity according to the different forms of capital manifestation [10–13] (namely various input indicators). Conversely, capital allocation with different executive background characteristics will show different business performances and interests during the enterprise operation, implying differences in quantity of various output indicators [14–16]. In such a situation, if different asset indicators are taken as inputs and the corresponding business performance indicators and interest indicators as outputs, the DEA analysis of the capital allocation efficiency with different executive background characteristics can be performed so as to make reasonable evaluation and still determine the order of quality.

Charnes, Cooper and Rhodes (1978) proposed the CCR model of DEA to evaluate the scale of decision packages and general effectiveness of technology. The CCR model assumes that there are no decision packages [17] (which are the Chinese listed companies of vehicles in this paper), and each decision package has m kinds of input indicators and t kinds of output indicators, making the efficiency evaluation CCR model:

$$\min \theta - \varepsilon \left[\sum_{r=1}^{t} S_r^+ + \sum_{i=1}^{m} S_i^- \right], \tag{1}$$

$$s.\ t. \begin{cases} \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \partial x_{ij_0} \\ \sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{rj_0} \\ s_i^- \geq 0,\ s_r^+ \geq 0 \\ \lambda_j \geq 0;\ j = 1,\ 2, \cdots, n \end{cases}. \tag{2}$$

Here, θ^*, s_r^+, s_i^-, λ^* are the optimum solutions of the model; when $\theta^* = 1$ and $s_i^{-*} = s_r^{+*} = 0$, DMU adds a constraint, $\sum_{j=1}^{n} = 1$ on the CCR model with DEA efficient. For solutions where DEA analysis is inefficient, the system is not efficient, yet the effectiveness of scale can be further judged; when the data DEA of a decision package is efficient, both the system and scale will be efficient. As there might be several efficient decision packages obtained by the data envelope analysis that cannot be further compared and sequenced, Anderson and Petersen (1993) proposed the super-efficiency data model [18,19], which can compare the efficiency of various decision packages:

$$\min \theta t^{\text{super}} \tag{3}$$

$$s.\ t. \begin{cases} \sum_{j=1}^{n} \lambda_j y_j - s^+ = y_0 \\ \sum_{j=1}^{n} \lambda_j = 1 \\ \sum_{j=1}^{n} \lambda_j x_j + s^- = \theta^{\text{super}} t x_0 \\ \forall\ \lambda_j \geq 0,\ j = 1,\ 2, \cdots, n \end{cases}. \tag{4}$$

In this formula, $s^+ \geq 0$, $s^- \geq 0$, θt^{super} are the super-efficiency values of the decision packages.

2.2. Determination of evaluation indicators

Before the DEA analysis, a scientific indicator system must be determined to make sure the selected indicators can reflect the reality of the decision packages; the selected indicators should be mutually independent and appropriate in quantity for research and analysis [20].

Input indicators are: number of employees, major business cost, and general asset. Here, number of employees can reflect the human resource level of the enterprise: talents are the first resource and core competitiveness indicator that reflects the human resource input of the enterprise [21]. Major business cost means the related cost expenditure corresponding to the company's major business income within a certain period of time [22]. Total asset can reflect the development status of an enterprise.

Output indicators are: major business income, and net profit. Major business income refers to the business income the company obtains by operating its major production and business activities; it reflects the company's profit capacity in the major business. Net profit is an important indicator reflecting the enterprise's profit capacity and can truthfully reflect the reality of input and output.

2.3. Method for fuzzy synthetic evaluation

Basic concept of method for fuzzy synthetic evaluation

Fuzzy synthetic evaluation is the most effective and frequently used method in fuzzy evaluation. In reality, several factors or indicators will be involved to evaluate (or estimate) one thing. We are required to make the synthetic evaluation of this thing according to these factors; in other words, the synthetic evaluation is a comprehensive evaluation of the thing (or object) as influenced by various factors; therefore, fuzzy synthetic evaluation is also called the fuzzy synthetic decision-making or fuzzy multiple