European Journal of Operational Research 209 (2011) 129–140

Contents lists available at ScienceDirect

European Journal of Operational Research

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

Innovative Applications of O.R.

Applying integrated DEA/AHP to evaluate the economic performance of local governments in China

Ming-Ian Lin [a,*], Yuan-Duen Lee [a], Tsai-Neng Ho [b]

[a] Graduate School of Business and Operations Management, Chang Jung Christian University, Tainan 711, Taiwan
[b] Department of Business Administration, Chang Jung Christian University, Tainan 711, Taiwan

ARTICLE INFO

Article history:
Received 19 May 2009
Accepted 9 August 2010
Available online 15 August 2010

Keywords:
Data envelopment analysis
Analytic hierarchy process
CCR model
BCC model
Economic performance

ABSTRACT

This paper aims at integrating data envelopment analysis (DEA) and analytic hierarchy process (AHP) to evaluate the economic development achieved by local governments in China. Since most similar evaluations are multi-objection problems, which both DEA and AHP are capable of solving, the integration of these two approaches is shown to be even more powerful. The proposed integrated DEA/AHP model can evaluate and rank different alternatives. In addition, a time-scale comparison of the economic performances of local governments in China was carried out using the malmquist productivity index (MPI), which indicated that there is a trend of economic growth. However, empirical results indicate that after discounting the advantages of location and political connections, the east district provinces of China do not have superior economic performance or a better MPI index, as compared with other districts. This result is contrary to our original hypothesis.

1. Introduction

The world has changed drastically over the past few decades, especially economic issues. Many developing countries like as BRICs (Brazil, Russia, India and China) are becoming influential in the economic growth of the world; among those nations, China has achieved the highest level of economic development and growth and is endeavoring to attract foreign direct investments (FDI) to successfully develop their economy. Additionally, China has the largest market and the most important base of manufactured products in the world. Its major strength is an abundance of skilled and inexpensive manpower. All facets of China's economy have exhibited growth trajectories, suggesting that it will remain attractive to investors. In 2001, China joined the World Trade Organization (WTO). After that time, China's economic development has grown at a higher rate than any other nation in the world, 10.7%. This is higher than the average worldwide GNP growth rate of 5.1% in 2006. In addition, in 2006, China had a foreign exchange reserve approaching 2000 billion USD, a national economic contribution to the world of approximately 13%, and was the third largest trade country as well as possessing the fourth largest economic entity. Additionally, the FDI growth rate was 4.5%, fourth in the world. All relevant information in the 2007 Chinese trade yearbook indicates that it has become an integral player in the world economy.

Although China has taken progressive steps in economic development, there still exist significant differences among different regions, and it is a commonly held conception that the economic development of the coastal east region is better than that of the middle and west regions. Even local governments have taken different measures for major initiatives of industrial development, simplification of investment procedures, enactment of investor-friendly laws, liberalization of trade policy, safeguards of intellectual property rights, etc. Significant variation may also be due to location, support from the central government and the management effectiveness of local governments.

DEA and AHP are methods that have been extensively used to evaluate and rank multi-objective decision alternatives. This paper aims to clarify and understand the different phenomena between regions and to the rank economic performance of local governments using an integrated quantitative (DEA) and qualitative (AHP) approach. Moreover, we hope to examine the true economic performance of every local government in China and to provide a metric by which to compare them after accounting for the advantages given by location and political connections.

2. Literature review

AHP was developed by Saaty in 1980. For over 20 years, this approach has been used and studied extensively and has been applied especially to multi-criteria decision making (MCDM).

* Corresponding author. Tel.: +886 6 2383682; fax: +886 6 2093709.
E-mail addresses: r78511013@mail.cjcu.edu.tw (M.-I. Lin), ydlee@mail.cjcu.edu.tw (Y.-D. Lee), david@mail.cjcu.edu.tw (T.-N. Ho).

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doi:10.1016/j.ejor.2010.08.006

AHP also has been applied in several different fields, such as activity planning, alternative choosing, optimization, resource allocation, conflict resolution, etc. (Ahmad et al., 2006). Furthermore, AHP has been used to evaluate multi-objective design alternatives from Muther's systematic procedure (1973) for facility layouts and to integrate mathematical linear approaches such as Linear Programming (LP), Integer Linear Programming (ILP), Mixed Integer Linear Programming (MILP), Goal Programming (GP), and Dynamic Programming (DP) (Vaidya and Kumar, 2006); Ho (2008) found some researchers had focused on integrating this method with Fuzzy Theory, Artificial Neural Networks (ANN), cost-benefit analysis, Quality Function Deployment (QFD), SWOT analysis, and simulation approaches, among others. AHP software, called the Multi-Media Authorizing System (MAS), has been in use since 2002 (Lai et al., 2002). This software uses the group decision-making technique, which involves six software engineers. MAS has been used to evaluate numerous products. The decision tool for the selection of advanced technology is another proposed model (Kengpol and Brien, 2001). This model integrates a cost-benefit analysis model, a decision-making effectiveness model, and a common criteria model and is available from Time Compression Technologies (TCT).

The DEA initially developed as the CCR model by Charnes et al. (1978) and the BCC model by Banker et al. (1984) have been used for the purpose of evaluating the relative efficiency of similar economic production systems. Studies covering a wide array of empirical work, such as evaluating the socio-economic performance of nations during the last decade, have made it clear that the model must be flexible (Golany and Thore, 1997). Consequently, a number of alternative DEA models have been proposed. Even so, there is often a need for customization of the model to a specific application environment. To address this need, a variety of model extensions that increase the flexibility of DEA models have been proposed. The common set of weights (CSW) model can be applied to all DMUs and their efficiencies to solve a single problem. A method for ranking DMUs has been presented (Jahanshahloo et al., 2005). DEA has been used for the comparative performance analysis of governments (Ramanathan, 2006a). The advantages of applying DEA to the rank economic performance of governments has been comprehensively discussed in several studies, including works by Charnes et al. (1994) and Farrel (1957) among others. A model without inputs or outputs was deployed by Adolphson et al. (1992) as a solution to the superconducting supercollider; a model with pure input but no outputs was also developed. Lovell and Pastor (1999) developed radial DEA models without inputs or outputs based on the above model have shown that (i) a CCR model without inputs (or outputs) is meaningless; (ii) a CCR model with a single constant input (or with a single constant output) coincides with the corresponding BCC model; (iii) a BCC model with a single constant input (or a single constant output) reduces to a BCC model without inputs (or outputs); and (iv) all BCC models, including those without inputs (or outputs), can be condensed to models having one less variable (the radial efficiency score) and one less constraint (the convexity constraint).

There have been limited studies regarding both DEA and AHP methods. Integrated DEA and AHP models are popular in facility layout design. Yang and Kuo (2003) proposed a DEA and AHP approach to a facility layout design (FLD) problem. A computer-aided layout-planning tool, Spiral, has been used to generate a considerable number of layout alternatives, as well as to generate quantitative decision-making unit (DMU) outputs. A weighting of the qualitative output performance measures by DEA/AHP has been used to solve multiple-objective layout problems. However, this approach only considers a constant input case that is different from the standard DEA model, because the cost associated with a change incurred at the layout design stage is usually negligible. Therefore, a Banker–Charnes–Cooper (BCC) model without inputs has been adopted for solving the layout performance frontiers problem. In this field of study, the Charnes–Cooper–Rhodes (CCR) model has been applied to quantitative and qualitative data, transforming the fractional program to an ordinary linear program. In a similar work, Ertay et al. (2006) integrated DEA and AHP for facility layout design (FLD) in a manufacturing system, and presented a decision-making methodology based on data envelopment analysis (DEA) that used both quantitative and qualitative criteria to evaluate the FLD. Takamura and Tone (2003) presented a combined DEA-AHP approach to address the relocation of several government agencies from Tokyo and to compare alternative locations. Saen et al. (2005) proposed a combined DEA-AHP approach to measure the relative efficiency of slightly non-homogeneous decision-making units (DMUs). Since some DMUs lack one or more features (i.e., input and/or output), the AHP was used to provide a real-world estimate of missing values for the DMU. To do this, two alternatives were compared. The alternatives include (i) DMUs that lack the feature(s) and (ii) the series means of other DMUs. The data for the mean of other DMUs was obtained by taking the mean of each feature of all of the DMUs, except for the one that has the missing value. The data was assumed to be normally distributed.

In recent years, some researchers have endeavored to make variety on this domain. Azadeh et al. (2008) integrated DEA and AHP with computer simulation for railway system improvement and optimization; they considered both quantitative and qualitative variables for efficiency assessment and performance optimization by integration simulation. Korpela et al. (2007) proposed an approach for selecting the warehouse operator network by combining DEA and AHP. DEAHP (data envelopment analytic hierarchy process) is a new model that has been developed by Ramanathan (2006b); it is a hybrid methodology of DEA and AHP, used to prove that DEA correctly estimates the true weight when applied to a consistent matrix formed using a known set of weights. The use of DEA was further proposed to aggregate the local weights of alternatives in terms of different criteria to compute the final local weight. Sevkli et al. (2007) used the DEAHP model to evaluate supplier selection; this study focused on one of the most important subjects in supply chain management and provided a better decision for supplier selection using appropriate quantitative approaches.

3. Study framework

The proposed method and hierarchical framework for this study are shown in Fig. 1, which diagrams the procedure and details the research steps. The focus of this study, which integrates DEA and AHP approaches, is to compare local Chinese governments.

3.1. Analytic and evaluation methodology

The first step in this study is to identify which variables are important to the analysis and measurement of the indices of AHP and DEA, followed by weighing and comparing the efficiency of the alternatives. The China People's Daily (2008) published an article entitled "Report of local government and official performance evaluation in China", which indicated that other important factors in addition to the GDP should be used as measuring indices. These include the level at which development is maintained, harmony of the society, work ethic and morality, economic growth rate, Engel's coefficient, environmental quality, etc. In addition, Unite state officials in researches at Oregon State University have presented additional major economic indices: level of employment diversification, creation of new enterprises, professional service, R&D, personal income, international trade growth, net growth of employment, economic diversification, investment, expenses of employee, labor income, labor poverty percentage, and language ability (Thiel and