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A Study on the Operational Efficiency of National Supercomputer Resources Based on DEA Model:
Focusing on Specialized Center Resources by Field

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ABSTRACT

As a measure to improve the operational efficiency of the Korean supercomputer joint utilization resources, an efficiency analysis using DEA was conducted to derive the improvement level of the input and output factors of the operation plans of seven specialized centers. The factors that constitute the objective function of efficiency were identified through the operation plans submitted by the specialized centers, and DEA analyzed the improvement factors and levels of inefficient specialized centers through the CCR and BCC models, and then conducted an additional super-efficiency analysis to compare the relative efficiency levels among the efficiency groups. As a result of the analysis, the inefficiency of specialized centers in the meteorological/climate/environmental fields was identified from the reference group, and the need for improvement and the level of improvement of input and output variables were identified. In addition, the authors suggested ways to improve the establishment of resources and operational targets, such as a joint utilization ratio to secure financial efficiency at the government level in establishing a joint utilization resource.

KEYWORDS

BCC, CCR, DEA, operational efficiency, supercomputer

INTRODUCTION

Supercomputing resources are a key infrastructure that determine a country's technological competitiveness, and it is crucial to have adequate resources. In the Top500, a biannual ranking of supercomputers, the top ten positions change every year due to the race to build large-scale supercomputers, and exascale supercomputers have emerged in just a few years since the advent of petascale supercomputers.

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However, in recent years, many countries that do not have the original technology to manufacture supercomputers have adopted a system of sharing multiple small- and medium-sized infrastructures as a single resource instead of building new infrastructures with huge budgets. The sharing economy paradigm has been applied to supercomputer operations. The Republic of Korea has also started to establish a joint utilization system by designating seven specialized centers in 2022 and sharing computing resources among them according to user demand.

Each year, each center determines the proportion of resources for joint utilization from its total resources and utilizes them as computational resources in other fields. The existing resources and resources from other fields are added together to make up for the lack of resources.

Each year, each center submits the ratio to the government for approval. To date, the ratio has been set at an appropriate level by the specialized centers based on their own demand surveys, but the need for more effective joint utilization is emerging due to the continuous increase in supercomputing demand.

For these reasons, this paper applies the method of using the relative efficiency of the operation planning factors of the specialized centers as an optimization method for the most efficient operation of the joint utilization resources. It identified common input and output variables among specialized centers and conducted efficiency analysis using CCR, BBC, and super-efficiency mode (SEM) models. Using the analysis results, we derived the input and output variables that can be improved and the level of improvement to improve the efficiency of inefficient centers.

This paper consists of six chapters. Chapters 1 and 2 present academic value through a qualitative analysis of the background, research purpose, and major theories. Chapter 3 introduces the joint utilization system and describes the operation plan of each specialized center. Chapter 4 presents the research model and describes the research procedures and methods. Chapter 5 presents the results of the efficiency analysis, explains the method and type of research data, and presents descriptive statistics and correlation analysis results. And then, the efficiency analysis results of the CCR, BCC, and SEM models are presented. Finally, in Chapter 6, the results are summarized and the viewpoint was straightened out, and the final point and pursuit plan of this paper is presented.

RESEARCH AND RELATED THEORIES

Prior Research Analysis

In Thore (1996), data envelopment analysis (DEA) was applied to rank the efficiency of United States (US) computer companies during a 10-year period. To reflect the dynamic setting of the computer industry, the inputs included investment in real capital and expenditures on R&D; the outputs were sales revenues, profits, and market capitalization. It developed a procedure for studying the time path of the observed DEA ratings of a high-tech company over its product cycles (Thore, 1996).

Storto (2015) presented a method useful for measuring a supercomputer's performance. This method was based on the implementation of DEA. It used different formulations of the cross-efficiency concept to calculate a comprehensive efficiency index to rank supercomputers. The method was adopted to perform a benchmarking study of the sample, including 77 supercomputers utilized to solve complex problems in research applications (Storto, 2015).

Wang et al. (2021) aimed to assess the performance efficiency of cloud computing service providers in the United States of America by applying the data envelopment analysis models. The efficiency of cloud computing providers was evaluated based on the assumption of the noncooperative game among cloud computing providers in which providers selfishly choose the best strategy to maximize their payoff with three stages (Wang et al., 2021).

Raja and Ramaiah (2016) built up a consumer and cloud-data envelopment analysis (CCDEA) trust assessment model for evaluating cloud services in two stages. In the first stage, the believability index of each cloud consumer (C) was calculated. The second stage incorporated a cloud-data