Extended Abstract

Purpose

Nowadays, cloud computing has increasingly gained the attention of academic, commercial, and industrial centers due to offering diverse and cost-effective services through the Internet. Although cloud computing has emerged from the convergence of several recent technologies in providing software and hardware services, one of its main driving factors is the economic discussions in the provision and use of services. Currently, various types of cloud services with different prices and efficiencies are available to customers. However, from the customers' perspective, selecting the appropriate cloud service with the lowest cost and highest efficiency that meets their needs is a complex issue. Therefore, evaluating the relative performance of cloud services and ranking them based on their efficiency and price is a necessary task. in this study, the efficiency of cloud services is measured using the Data Envelopment Analysis (DEA) technique, specifically the input-oriented and output-oriented BCC models. The period under review is the year 2023.The software used in this research is Matlab 2019. After executing these models, their correlation with the base CCR model is calculated using the Pearson correlation coefficient. In cloud computing, IT services can be offered to users in a manner similar to public utilities such as water, electricity, gas, and telephone, and users are billed for the usage of these services. In other words, users pay for the hardware and software services based on their consumption. From the consumer's perspective, cloud computing is a cost-saving model that converts capital expenditures into operational expenses. Consequently, various pricing models are introduced by the service providers, allowing customers to choose based on their specific conditions. In this research, input-oriented and output-oriented BCC models are used for ranking virtual machines. In addition to this ranking, new prices are proposed for inefficient virtual machine samples to bring them to the efficiency frontier. The Analytical Hierarchy Process (AHP) is an abstract method for analyzing qualitative criteria related to creating decision-making criteria weights. It is one of the approaches used to address this issue. Data Envelopment Analysis (DEA) is a linear programming method based on multi-variable decision-making. The integrated DEA and AHP method is also employed to select appropriate services for users in a cloud computing environment. While AHP is an effective method for decision-making, it does not account for the uncertainty of human decision-making in pairwise comparison evaluations. The first model of Data Envelopment Analysis is called CCR, which is used for comparing units with constant returns to scale. In 1984, Banker, Charnes, and Cooper introduced a new model named BCC

by modifying the CCR model, which evaluates the relative efficiency of units with variable returns to scale. Since the nature of pricing virtual machines relative to their features (such as memory size, processor power, etc.) Does not follow constant returns to scale, the BCC model is used in this research to compare the efficiency of virtual machines. Each virtual machine is considered as a DMU.

Methodology

This research is an applied study aimed at finding a solution to a problem in the community, an industrial organization, or an administrative organization. It is noteworthy that the term "problem" in an organization here does not imply a defect or error, but rather the aim is to add to the knowledge base of that organization. The objective of this study is to evaluate the relative efficiency of virtual machines and to propose appropriate pricing for inefficient samples to cloud providers.

1. Implementation of the BCC Model

The BCC model is a nonlinear programming model, and there are two methods to linearize it: the input-oriented approach (maximizing the numerator while keeping the denominator constant) and the output-oriented approach (minimizing the denominator while keeping the numerator constant). The BCC ratio model for evaluating the efficiency of the unit under review (unit o) is shown in equation (1).

$$Max: \frac{\sum_{r=1}^{s} u_r y_{ro} + w}{\sum_{i=1}^{m} v_i x_{io}} \; s.t. \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, j = 1,2,\ldots,n \qquad u_r \geq 0, v_i \geq 0$$

2. Input-Oriented BCC Envelopment Model

Whenever inputs are minimized to keep the output at its current level, the DEA model will be input-oriented. Equation (2) shows the objective function and constraints of the input-oriented BCC model. In fact, the objective function increases the efficiency of a DMU by reducing inputs while keeping the output level constant.

$$\theta^* = Min\, \theta$$

$$s.t.$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{io} \qquad i = 1,2,3, \ldots, m;$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{ro} \qquad r = 1,2,3, \ldots, s;$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0 \qquad j = 1,2,3, \ldots, n$$

As previously mentioned, DMU is one of (n) number of DMUs under evaluation. In equation (2) X_{io} and y_{io} represent the ith and rth output of DMU_0, respectively. The efficiency score of DMU_0 is denoted by θ*. If θ* = 1, then the current input level cannot be reduced, indicating that DMU_0, is on the efficiency frontier. Otherwise, if θ* < 1), DMU_0 will be inefficient,

and there will be room for improving efficiency by reducing inputs while keeping the output level constant.

Finding

The obtained results indicate a high correlation between the input-oriented BCC model and the base CCR model. In this article, in addition to ranking the services, suggestions are made for adjusting the prices of inefficient services.

Conclusion

-Cost Analysis: A detailed examination of service delivery costs, including labor, infrastructure, and operational expenses, to identify weaknesses and reduce unnecessary expenditures**.**

-Service Value Assessment: Determining the value that customers receive from the service and adjusting pricing accordingly based on this value.

-By applying Data Envelopment Analysis (DEA) to evaluate the virtual machine samples, the following results have been obtained.

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-There is a higher correlation between the efficiency scores obtained from the input-oriented BCC approach and the conventional CCR model compared to the output-oriented BCC approach".

-With the ranking conducted by this research, cloud customers can easily select the types of virtual machines they need.

-Cloud providers can reduce the prices of virtual machine samples that are not on the

efficiency frontier (from the input-oriented perspective) to attract more customers to use their services.