Efficiency Analysis of Higher Education Institutions Using the BCC Model of DEA: A Case Study of Colleges in Guangdong, China

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Abstract. The efficiency of three provincial public colleges in Guangdong Province (Case A, Case B, and Case C) is assessed using the BCC model of Data Envelopment Analysis (DEA). Despite their similar institutional status, the colleges differ in location, history, disciplinary focus, and resource availability, which influence their operational efficiency. Case A demonstrates both pure technical efficiency (PTE = 1.00) and scale efficiency (SE = 1.00), indicating optimal resource use and scale management. Case B shows full technical efficiency (PTE = 1.00) but inefficiencies in scale (SE = 0.90), suggesting room for improvement in scale adjustments. Case C operates near the efficient frontier with a BCC efficiency score of 0.97, indicating a 3% potential for improvement. These findings offer valuable insights for policymakers to enhance efficiency in Guangdong's higher education system. Future research could broaden the scope by including more institutions and exploring dynamic efficiency changes over time.

Keywords: Higher Education Efficiency, BCC Model, DEA (Data Envelopment Analysis)

1 Introduction

This study focuses on assessing the efficiency of three provincial public colleges in Guangdong Province (Case A, Case B, and Case C) using the BCC model of Data Envelopment Analysis (DEA). These institutions, offering bachelor's degrees, play crucial roles in the local higher education system [1]. Evaluating their efficiency is vital, given the limited educational resources and the need for optimal utilization to enhance educational quality and performance [2]. Despite being similar in institutional status, the colleges differ in geographical location, history, disciplinary focus, and resources, potentially affecting their operational efficiency [3].

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The research aims to fill a gap in the literature by analyzing these institutions' efficiency, offering insights to policymakers and administrators for improving higher education provision. It has two main objectives: applying the BBC model to measure the technical and scale efficiencies of the colleges and identifying factors contributing to efficiency variations. The study ultimately seeks to provide practical recommendations for improving efficiency in higher education in Guangdong Province.

2 Higher Education Efficiency and DEA (Data Envelopment Analysis)

2.1 Higher Education Efficiency

Higher education institutions (HEIs) play a critical role in economic development by fostering innovation, generating knowledge, and preparing a skilled workforce [4]. However, the increasing pressure from stakeholders, including governments and students, has brought attention to the need for improved efficiency in resource utilization [5]. Efficiency in higher education refers to how well HEIs transform inputs (e.g., faculty, funding, facilities) into valuable outputs such as graduates, research publications, and societal impact [6]. Efficient universities are not only cost-effective but also produce higher-quality education and research outcomes. Previous studies have highlighted the importance of evaluating efficiency in higher education, noting that inefficient use of resources could undermine educational quality and limit opportunities for students [7]. As competition for resources intensifies, HEIs must focus on performance measurement frameworks that allow for comparative analysis and benchmarking [8]. Understanding the factors that drive efficiency is essential for policymakers aiming to improve the overall performance of the higher education sector.

2.2 DEA (Data Envelopment Analysis)

Lee and Johnes (2022) used network DEA to analyze the teaching quality of higher education in England, providing policymakers with empirically supported recommendations and highlighting the method's value in policy analysis [9]. Jiang et al. (2020) employed DEA to assess research efficiency among Chinese higher education institutions, revealing differences in resource utilization and offering suggestions for improvement [10]. Moreno-Gómez et al. (2020) applied a two-stage DEA approach to measure the efficiency of the Colombian higher education system, demonstrating the method's effectiveness in addressing multi-stage efficiency issues in complex educational systems [11]. Overall, the application of DEA across different countries and educational systems illustrates its broad applicability and theoretical contributions to evaluating higher education quality and informing policy.

3 Data and Method

3.1 Data

Relevant data analysis obtained from the Guangdong Provincial Education Bureau/Office and the target university's website, and after data processing and verification, preliminary data acquired. The organized data shown that in Table 1 illustrates DMU (Decision-Making Unit) consisting of three schools: Case A, Case B, and Case C. Input 1 refers to the school area, input 2 to the budget, input 3 to the teacher total, input 4 to the ratio of doctoral faculty, and input 5 to the total student.

Table 1. Input.

Case	Input 1 area	Input 2 budget	Input 3 Teacher total	Input 4 PhD ration	Input 5 Total student
Case A	2573	10.4	1607	37.7	26200
Case B	1802	10.1	1432	19.2	25000
Case C	2421	6.76	1157	47.3	19000

In the outputs part (see Table 2), output 1 represents the graduate employment rate, output 2 denotes the number of patents, and output 3 corresponds to the university ranking of China, with output 3 being treated as a reverse indicator.

Table 2. Output.

Case	Output1 Employment rate	Output2 Patent rights	Output3 University ranking.
Case A	95.3	234	2 (566)
Case B	97	207	3 (565)
Case C	94	474	1(361)

3.2 Method

The BCC (Banker, Charnes, and Cooper) model in DEA is used because it accommodates variable returns to scale, providing a more accurate efficiency assessment when scale effects are significant. The model offers flexibility in evaluating scale efficiency and reflects the true performance of entities operating at different sizes, making it particularly useful for realistic performance measurement in varied operational contexts. This study utilizes Excel Solver for data analysis, employing its capabilities to solve linear programming problems and conduct DEA calculations for effective performance evaluation and optimization.

4 Data Analysis

After calculation, it is found that there are some slight differences among the three universities, as shown in Fig. 1.

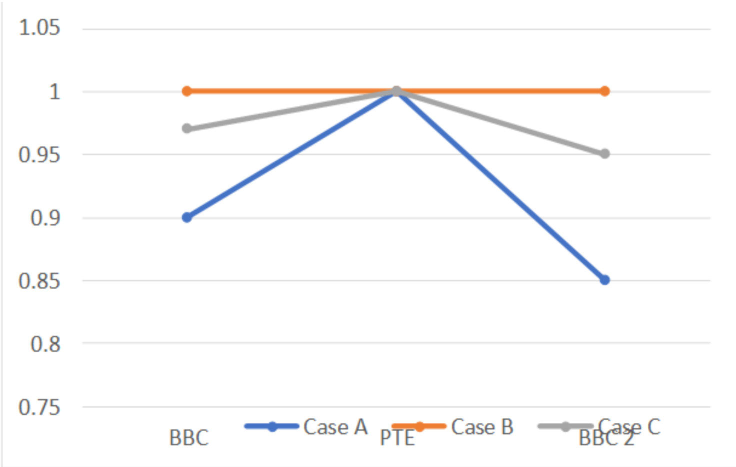

Fig. 1. Efficiency Analysis.

After calculation, it is found that there are some slight differences among the three universities, as shown in Fig. 1. Case A efficiency score under the BCC model remains 1.00, indicating that it is not only efficient under constant returns to scale (CCR model) but also efficient under variable returns to scale (BCC model). This means it exhibits both pure technical efficiency (PTE = 1) and scale efficiency (SE = 1), meaning its operations are at an optimal scale. In the BCC model, Case B efficiency score is 0.90, with a pure technical efficiency (PTE) of 1.00. This implies that resource use is effective at the given scale. However, the scale efficiency (SE = 0.90) indicates that the scale is not ideal, and there is inefficiency in returns to scale. Case 3 BCC efficiency score is 0.97, meaning it is close to the most efficient state but still has a 3% improvement potential. The pure technical efficiency (PTE = 1.00) shows effective resource use at the current scale. The scale efficiency (SE = 0.97) suggests that the college might need to adjust its scale to achieve complete efficiency.

5 Conclusion

5.1 Efficiency

The efficiency analysis of the three universities in Guangdong Province reveals distinct performance outcomes under the BCC model. Case A demonstrates optimal operational efficiency with both pure technical efficiency (PTE = 1.00) and scale efficiency (SE = 1.00), signifying effective resource utilization and optimal scale management. In contrast, Case B, while achieving full pure technical efficiency (PTE = 1.00), presents inefficiencies related to scale (SE = 0.90), indicating suboptimal returns to scale. This suggests the need for operational adjustments to improve its scale efficiency. Case C, with an overall BCC efficiency score of 0.97, shows near-optimal performance, yet retains a 3% potential for further improvement. Although it operates with full technical efficiency (PTE = 1.00), its scale efficiency (SE = 0.97) suggests that the institution could benefit from further scale adjustments. These findings highlight that, while resource use across the universities is effective, addressing the scale inefficiencies could lead to enhanced overall operational efficiency.

5.2 Future Research

Future research should expand the scope of efficiency analysis in higher education by incorporating additional institutions and broader regional comparisons. A more comprehensive dataset including different types of colleges and universities could provide deeper insights into the factors influencing operational efficiency. Additionally, further studies could explore the dynamic changes in efficiency over time, investigating the impact of policy changes, funding variations, and external environmental factors. The integration of qualitative data, such as institutional governance structures and leadership strategies, could also enhance understanding of how internal and external conditions affect efficiency. Finally, employing alternative efficiency models, such as the Malmquist Productivity Index or stochastic frontier analysis, could provide a more nuanced view of efficiency trends and potential improvement areas within the higher education sector.

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