JOURNAL OF SIMULATION
https://doi.org/10.1080/17477778.2024.2394051

REVIEW ARTICLE

Integrating discrete event simulation and data envelopment analysis for system performance and efficiency evaluation

Ruzelan Khalid[a], Mohamad Amirrul Muqmin Mohamad Isa[a], Mohd Kamal Mohd Nawawi[a], Sahubar Ali Mohamed Nadhar Khan[a], Wan Laailatul Hanim Mat Desa[a], Razamin Ramli[a] and Ramziddin Kucharov[b]

[a]Institute of Strategic Industrial Decision Modelling, School of Quantitative Sciences, Universiti Utara Malaysia, Sintok, Malaysia; [b]Department of Mathematics, Tashkent International University of Financial Management and Technologies (TIFT), Tashkent, Uzbekistan

ABSTRACT

Healthcare facilities, particularly outpatient clinics, are crucial for local communities' medical needs. To enhance their performance, these facilities need to optimize their operations. Key system performance metrics, such as patient throughput, waiting times and cycle times, can quantitatively be measured using discrete event simulation (DES). DES replicates facility structures and behaviours, offering a valuable platform for assessing the configuration effects of resources on system performance. However, current DES tools cannot identify the best resource configurations for future performance improvement. To address this issue, this paper develops a DES model for an outpatient clinic and improves its performance through data envelopment analysis (DEA). The case study involves a clinic in Northern Malaysia, where relevant data were observed and collected. The analysed data were then input into the DES model. The model measured the clinic's current performance and assessed the impact of its resource configurations. 37 different resource configurations were tested, and their relative efficiencies were evaluated using DEA. The analysis revealed room for improvement in resource allocation.

ARTICLE HISTORY
Received 2 February 2024
Accepted 15 August 2024

KEYWORDS
Discrete event simulation; data envelopment analysis; performance measures; performance efficiency; healthcare systems

1. Introduction

System performance refers to how well a system works and delivers its outcomes in terms of productivity, competitiveness, and reputation (Helmold & Samara, 2019; Holzer & Ballard, 2022). These outcomes are evidenced by streamlined processes, timely service delivery and cost-effective operations. A robust system performance not only guarantees uninterrupted operations and goal attainment but also contributes to enhanced customer satisfaction and stakeholder confidence. Furthermore, sustaining high system performance fosters growth, innovation, and adaptability, helping business stay competitive and responsive. Therefore, maintaining strong system performance is crucial for long-term success.

To effectively manage the performance of a complex system, configuring its available resources is critical (Trost, 2019), especially in a healthcare facility. In this context, resource configuration involves strategically allocating and arranging personnel (doctors, nurses, and technicians), medical equipment (medical devices and machines), and financial assets to optimize patient care delivery. A well-organized resource configuration facilitates streamlined workflows and ensures timely patient access to quality service. Such configuration significantly improves various system performance metrics, such as patient waiting times, cycle times, and crowdedness. Inefficient resource configuration or insufficient resources often lead to challenges in managing patient flow, impacting the performance metrics and resulting in patient discomfort and dissatisfaction (Abdalkareem et al., 2021; Tlapa et al., 2020). Thus, improving the performance through diverse operational strategies is crucial (Potthoff et al., 2020; Slack & Lewis, 2020), particularly considering the constraints of limited public healthcare budgets.

To improve the operational strategies, using a suitable modelling approach for better measurement of performance is crucial. Various modelling approaches – particularly for service systems, including healthcare facilities – have been discussed and documented in literature reviews (Bohr & Memarzadeh, 2020; Potthoff et al., 2020; Tao & Liu, 2019). The approaches can be categorized into two main types: qualitative and quantitative (Kara, 2022). Qualitative approaches focus on the softer aspects of a system's critical processes, helping decision makers understand its complex issues and provide valuable feedback. Quantitative approaches, meanwhile, involve using mathematical models to understand and evaluate a system's processes, giving decision-

CONTACT Ruzelan Khalid ruzelan@uum.edu.my Institute of Strategic Industrial Decision Modelling, School of Quantitative Sciences, Universiti Utara Malaysia, 06010 UUM Sintok, Sintok, Malaysia