



MEASURING EFFICIENCY IN MALAYSIAN REAL ESTATE INVESTMENT TRUSTS

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Abstract

This paper highlights the necessity of evaluating the efficiency of Malaysian Real Estate Investment Trusts (M-REITs) across the pre-pandemic, pandemic, and post-pandemic phases. While the sector holds significant strategic value, there is a lack of empirical research focusing on the technical, managerial, and scale efficiencies of M-REITs. To address this gap, the study analyses M-REITs efficiency between 2015 and 2024 by applying a non-parametric Data Envelopment Analysis (DEA) methodology. Specifically, the input-oriented Variable Return to Scale (VRS-DEA) model was employed to determine the efficiency scores for M-REITs. The findings indicate the average technical efficiency score is 0.633, indicating moderate overall performance. Pure technical efficiency is relatively high at 0.801, while scale efficiency averages 0.783. This suggests that M-REITs demonstrate strong relative resource-conversion capabilities under managerial control, but efficiency losses are partly due to operating at a non-optimal scale. Ultimately, this study highlights the importance of better resource utilisation and appropriate scale adjustments to improve performance.

Keywords: data envelopment analysis, efficiency, REITs

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INTRODUCTION

The real estate industry plays a vital role in driving economic expansion and enhancing the maturity of capital markets. In recent years, there has been a significant shift toward indirect property investment, as it provides investors with a pathway to gain market exposure without the complexities of managing physical properties. The REIT has emerged as a primary vehicle for this purpose, serving as a corporate entity that owns, manages, or invests in various types of income-producing real estate. REITs provide a mechanism for investors to access large-scale property investments and returns without having the responsibilities of directly owning, managing, or funding any properties themselves (Zhang *et al.*, 2023). Operating in a manner comparable to mutual funds, REITs specialize in the ownership and management of various real estate assets, including commercial properties, office buildings, retail centres, hospitality venues, and industrial warehouses. Their primary objective is to generate consistent rental income and long-term capital gains for their investors (Haslam *et al.*, 2015).

Despite the strategic importance of this sector, there is currently a lack of comprehensive research evaluating the efficiency of M-REITs. Therefore, this study seeks to fill that gap by providing an empirical assessment of their performance. Most previous studies on real estate performance have predominantly relied on conventional methods, with relatively few studies adopting modern methods like efficiency and productivity analysis (Chuweni & Eves, 2019). This reliance on conventional methods has left a significant gap in the understanding of technical, managerial, and scale efficiencies within the Malaysian context. Therefore, this study addresses the research gap by conducting a comprehensive ten-year assessment from 2015 to 2024 using a non-parametric frontier approach. By categorising the data into three distinct economic phases, namely pre-pandemic, pandemic COVID-19, and post-pandemic phases, this study offers a unique perspective on how shifting market conditions and external shocks influence the operational and scale efficiency of M-REITs.

LITERATURE REVIEW

Concept of Efficiency

Efficiency is broadly defined as the operational ratio of outputs to inputs, serving as a metric to evaluate how effectively a system utilizes its available resources to generate desired outcomes (Ayres *et al.*, 2011). In an organizational context, a firm is deemed efficient when it successfully maximizes its output from a predetermined set of inputs or, conversely, achieves a targeted level of output by employing the minimum necessary volume of resources (Alfiero & Esposito, 2018). Within the specific framework of property investment, efficiency represents the capacity of a REIT to convert operational and financial inputs into meaningful returns for stakeholders. In this study, efficiency is analyzed through

an input-output framework where the primary objective is to maximize outputs, such as distribution per unit (DPU) (sen) and property revenue, from a given set of inputs. These inputs typically include the major costs of managing and financing assets, such as property operating expenses, interest expenses as well as administration and management fees.

To provide a comprehensive assessment, this study decomposes efficiency into three specific metrics. Technical Efficiency (TE) assesses a firm's overall capacity to maximize output from its resources, which, according to Mohan (2020), indicates that a firm is operating on the production frontier where increasing output requires additional input. To further refine this, the study distinguishes between management and structural factors by examining Pure Technical Efficiency (PTE) and Scale Efficiency (SE). Under the Variable Returns to Scale (VRS) framework, PTE isolates internal managerial effectiveness by removing the influence of firm size, thereby measuring how successfully a decision-making unit utilizes its assets (Wang, 2009; Jha et al., 2013). Meanwhile, Scale Efficiency (SE) evaluates whether a REIT is functioning at its most productive scale size, calculated as the ratio of TE to PTE to determine if inefficiency arises from the firm being too large or too small (Jha et al., 2013; Ray, 2015). By evaluating these three components, the study determines whether the success of Malaysian REITs stems from superior management or the structural benefits of their operating scale.

Measurement of Efficiency

There are two methods that are commonly used to evaluate efficiency namely parametric and non-parametric. Parametric methods involve specifying a functional form for the production or cost function and estimating the parameters of this function. The most widely used version is Stochastic Frontier Analysis (SFA), which assumes that any deviations from the efficiency frontier are caused by a combination of inefficiency and random error (Mateo, 2012). While these methods are beneficial because they allow for statistical testing and the estimation of confidence intervals, the process can be complex. This complexity arises from the requirement to make specific assumptions about how inefficiency and error terms are distributed (Bannour & Labidi, 2015). Conversely, non-parametric techniques avoid the need for a predetermined functional form, offering greater flexibility across diverse datasets (Murillo, 2004). Data Envelopment Analysis (DEA) stands as the primary non-parametric tool, utilizing observed data to develop a piecewise linear frontier (Mateo, 2012; Sharma et al., 2013). Unlike parametric models, DEA operates without a fixed production function, allowing the efficiency frontier to be dictated directly by the data. This characteristic makes the analysis more flexible and helps reduce potential bias (Amin & Boamah, 2025). Furthermore, DEA is particularly useful for complex scenarios like REIT performance because it can handle multiple inputs and outputs simultaneously

(Amin & Boamah, 2025). By using this approach, the study can effectively capture how various factors influence the overall efficiency of the M-REITs. Despite these methodological strengths, DEA has certain limitations. Because it is a non-parametric technique, it does not include a statistical error term. This means that any reporting mistakes, data errors, or unexpected market shocks are treated entirely as inefficiency rather than random statistical noise. Additionally, DEA is sensitive to outliers. Since the efficiency frontier is built using the best-performing units in the sample, a single extreme data point can alter the shape of the frontier and affect the scores of other units. Even though parametric methods like Stochastic Frontier Analysis can handle random errors, DEA is still preferred here for its ability to handle multiple inputs and outputs at the same time without needing a fixed production formula.

RESEARCH METHODOLOGY

Data Collection

This study employs secondary data obtained from annual reports of M-REITs for the period 2015 to 2024. The selected time frame was used to capture three important economic phases defined by global health milestones and market shifts. The pre-pandemic period is categorized as the years 2015 to 2019, representing stable market conditions before the World Health Organization (WHO) declared COVID-19 a global pandemic in March 2020 (Coughtrey et al., 2025; Dhariwal et al., 2025). The pandemic phase spans from 2020 to 2022, aligning with the duration of the international public health emergency and significant market uncertainty (Coughtrey et al., 2025; Lundberg et al., 2024). Finally, the post-pandemic period covers 2023 and 2024, following the WHO's May 2023 declaration that the emergency had ended and the transition to long-term management of the virus had begun (Lundberg et al., 2024; Wu et al., 2024). Segmenting the timeline along these public health and economic milestones is essential because it isolates how structural shocks, sudden lockdowns, and subsequent monetary policy normalization uniquely impacted the operational and scale efficiency of M-REITs across different market cycles. In addition, a total of 174 annual reports were collected and analysed over the ten years. While 16 M-REITs were active and tracked continuously since the baseline year of 2015, additional trusts were included as they entered the market during the study period, resulting in an unbalanced panel dataset comprising 19 REIT entities overall. However, one observation for the year 2016 was excluded from the analysis due to the non-disclosure of interest expense, which serves as a required input variable in the efficiency model. Omitting this single missing observation does not compromise year-to-year comparability, as Data Envelopment Analysis (DEA) evaluates relative efficiency on an annual cross-sectional basis where the frontier is independently constructed for each specific year. This exclusion merely ensures consistency and reliability within that year's specific efficiency

estimation without distorting the longitudinal trends across the broader ten-year timeline. The omission of this outlier ensures consistency and reliability in the estimation process.

Variables Selection

In this study, a framework consisting of three inputs and two outputs was utilized to evaluate efficiency levels. The selected input variables include property operating expense (x^1), interest expense (x^2), fees related to administrative and management (x^3), following established methodologies (Anderson et al., 2002; Chuweni et al., 2017; Topuz et al., 2005; Topuz and Isik, 2009). Conversely, the efficiency outputs are measured through the distribution per unit (DPU) in sen (y^1) and total property revenue (y^2), as suggested by Chuweni et al., (2017). The selection of the input and output variables is theoretically grounded and justified as follows:

Input 1: Property Operating Expenses (x^1)

Representing the direct costs associated with maintaining, repairing, leasing, and operating physical properties (such as utilities, assessment rates, and maintenance contracts), these variable measures management's ability to control routine overheads. Efficient property maintenance directly impacts net operating income, making cost containment here critical for maximizing overall technical efficiency.

Input 2: Interest Expenses (x^2)

As capital-intensive vehicles, REITs heavily rely on debt financing to fund property acquisitions and expansions. Interest expenses reflect the cost of servicing this debt. Including this variable captures how effectively management utilizes financial leverage to generate revenue without overburdening the trust with excessive financing costs, which is especially vital during periods of macroeconomic monetary tightening.

Input 3: Administrative and Management Fees (x^3)

Encompassing manager remuneration, trustee fees, valuation fees, and corporate overheads, these fees measure structural governance expenses. Lower relative administrative costs indicate superior managerial efficiency and alignment of interest between management companies and unitholders.

Output 1: Distribution Per Unit (DPU) in sen (y^1)

Serving as the ultimate financial return metric for unitholders, DPU captures the income-distributing mandate characteristic of REIT structures. Maximizing DPU from a given set of operational and financing inputs is the primary goal of retail and institutional investors alike, rendering it an indispensable output variable.

Output 2: Property Revenue (y^2)

Representing the gross top-line income generated from rental streams, car park operations, and other asset-derived services, property revenue reflects the core commercial productivity and asset utilization capacity of the REIT portfolio before accounting for operating expenses and financing costs.

DEA Application in Measuring REITs' Efficiency

To evaluate efficiency, this study utilized the Variable Return to Scale (VRS) DEA model, which effectively accounts for the diverse operational sizes and scale fluctuations inherent in M-REIT portfolios. An input-oriented perspective was selected, given that REIT managers have greater control over input costs such as operating expenses, interest expenses, and management fees, rather than output levels. The efficiency scores were estimated in the form of technical efficiency (TE), pure technical efficiency (PTE), and scale efficiency (SE). TE reflects the overall ability of a REIT to convert inputs into outputs, PTE isolates internal management performance by adjusting for scale, and SE assesses whether the REIT functions at its most productive size. Efficiency is measured on a scale from 0 to 1, where a score of 1 signifies that the REIT is positioned on the efficient frontier, serving as a benchmark for the industry. Conversely, scores below 1 suggest inefficiency, meaning the REIT could reduce resources while maintaining the same level of output. Although an input-oriented model was selected because managers have direct control over operational costs, a robustness check was also performed using an output-oriented DEA specification and the resulting scores remained consistent with no significant differences, confirming the stability of the empirical findings.

ANALYSIS AND DISCUSSION

A standard guiding principle in DEA analysis suggests that the number of observations should be at least three times the sum of the input and output variables (Chuweni & Eves, 2019; Avkiran, 2004; Coelli *et al.*, 2005; Sufian *et al.*, 2014). This ensures the model has sufficient discriminatory power to identify efficient and inefficient units. For this study, the dataset spans an unbalanced panel of 19 distinct M-REITs, featuring 16 M-REITs tracked continuously since 2015. Given that the model utilizes three inputs and two outputs, the total number of variables is five. Applying the rule of thumb ($3 \times 5 = 15$), both the baseline cross-section of 16 firms and the total panel successfully exceed the minimum required threshold. Consequently, the dataset is considered valid and statistically sound for calculating the technical, pure technical, and scale efficiency scores of M-REITs from 2015 to 2024.

Efficiency Scores of M-REITs between 2015 and 2024

Table 1 presents the mean efficiency scores for M-REITs for the years 2015 to 2024. The overall mean TE for the entire ten-year period was 0.633, which indicates that M-REITs generally operated at a moderate level of efficiency. This result shows that there is a 36.7% gap in efficiency, suggesting that many firms are using more inputs than necessary to reach their current level of output. When comparing the different types of efficiency, it is notable that the average PTE of 0.801 was consistently higher than the SE of 0.783. Rather than implying exhaustive corporate governance quality, this high PTE score specifically reflects effective relative control over operational cost conversion at the firm level, while overall productivity is constrained because many firms are not operating at optimal size or scale.

Furthermore, an analysis of the scale properties reveals that the majority of M-REITs operate under decreasing returns to scale (DRS) rather than increasing returns to scale (IRS). Across the ten-year study period from 2015 to 2024, DRS is consistently the dominant scale regime, accounting for more than half of the observations annually, including 62.50% in 2016 and 63.16% in 2023. This indicates that many M-REITs have expanded beyond their optimal scale size, leading to managerial congestion or structural inefficiencies where a proportional increase in inputs yields a smaller increase in outputs. Conversely, a smaller proportion of firms operate under increasing returns to scale (IRS) or constant returns to scale (CRS), suggesting that while a few smaller trusts could benefit from scaling up, the primary sectoral issue is over-expansion rather than sub-optimal size.

The efficiency trends of M-REITs between 2015 and 2024, as illustrated in Figure 1, reveal a decade of significant change and recovery. Throughout the study period, PTE remains constantly higher than TE and SE. This suggests that while M-REIT managers were generally effective at controlling internal costs and daily operations, the sector's overall productivity was often pulled down because the firms were not operating at their most efficient size. The trend started with a noticeable decline in 2016, when all efficiency metrics dropped to a significant low. Following this, the sector faced a steady but uneven recovery leading up to 2019. Surprisingly, during the time of global economic uncertainty, which was from 2020 to 2022, M-REITs showed a consistent improvement in efficiency, whereby SE increased steadily to meet PTE, indicating that the firms were successfully optimizing their size and resource use despite external pressures. However, the sector experienced another sharp downturn in 2023, in which TE fell back to a significant low of 0.500. This represents a time when the sector moved further away from its full potential. Fortunately, the data for 2024 shows a very strong and rapid recovery, with all three efficiency lines trending sharply upward. By the end of 2024, the M-REIT sector had regained its momentum. This suggests that the sector has become more

resilient, ending the decade in a much stronger and more efficient position than in the previous year.

Table 1: Average M-REITs efficiency scores 2015 – 2024

Year	Technical Efficiency		Pure Technical Efficiency		Scale Efficiency	
	Mean	Min. - max	Mean	Min. - max	Mean	Min. - max
Panel A: Malaysian REIT						
2015	0.709	[0.362-1.000]	0.889	[0.512-1.000]	0.791	[0.460-1.000]
2016	0.514	[0.112-1.000]	0.641	[0.227-1.000]	0.733	[0.420-1.000]
2017	0.655	[0.400-1.000]	0.883	[0.520-1.000]	0.742	[0.405-1.000]
2018	0.587	[0.282-1.000]	0.813	[0.346-1.000]	0.713	[0.310-1.000]
2019	0.567	[0.255-1.000]	0.789	[0.348-1.000]	0.718	[0.322-1.000]
2020	0.597	[0.270-1.000]	0.772	[0.306-1.000]	0.777	[0.369-1.000]
2021	0.670	[0.416-1.000]	0.818	[0.486-1.000]	0.824	[0.436-1.000]
2022	0.760	[0.443-1.000]	0.855	[0.508-1.000]	0.893	[0.489-1.000]
2023	0.503	[0.144-1.000]	0.701	[0.233-1.000]	0.727	[0.212-1.000]
2024	0.767	[0.451-1.000]	0.849	[0.464-1.000]	0.908	[0.490-1.000]
2015 - 2019	0.606	[0.112-1.000]	0.803	[0.227-1.000]	0.739	[0.310-1.000]
2020 - 2022	0.676	[0.270-1.000]	0.815	[0.306-1.000]	0.831	[0.369-1.000]
2023 - 2024	0.635	[0.144-1.000]	0.775	[0.233-1.000]	0.818	[0.212-1.000]
Overall (2015 - 2024)	0.633	[0.112-1.000]	0.801	[0.227-1.000]	0.783	[0.212-1.000]

Source: Author's Own

While the earlier discussion focused on longitudinal trends over time, Table 2 summarizes the average efficiency scores for each REIT between 2015 and 2024. The top-performing industry leaders are highlighted with grey shading in the table. The results show a wide range of efficiency levels across the 19 firms studied. There is only one firm, namely REIT 19, had achieved a perfect efficiency score of 1.000 across all three categories, which are TE, PTE, and SE. This highlights that while other firms had gaps in their performance, REIT 19 consistently hit 100% of its potential, proving it could use its resources and manage its scale more effectively than all other firms. The data also reveals that several other firms, specifically REIT 5, REIT 10, and REIT 15, achieved a

perfect 1.000 in PTE. This suggests that their management teams are highly skilled at controlling costs and managing day-to-day operations. However, because their SE scores were slightly below 1.000, these firms were still not operating at their most productive size. On the other hand, several firms struggled significantly during the study period. For instance, REIT 6, REIT 8, and REIT 12 recorded TE scores below 0.400, suggesting they are operating at less than 40% of their optimal efficiency level and reflecting a significant gap from the efficiency frontier, with improvement potential exceeding 60%.

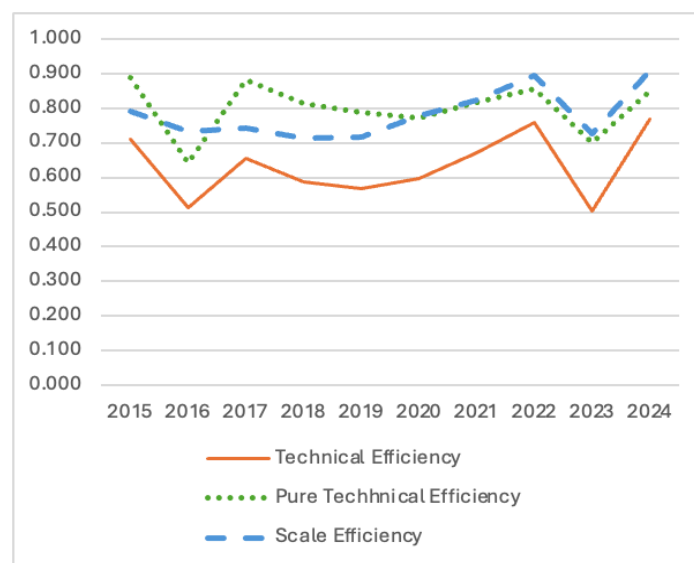


Figure 1: The trend of average M-REITs efficiency scores 2015 - 2024
Source: Author's Own (2026)

Table 2: The mean efficiency scores for 2015 to 2024 by REIT

REIT ID/ Mean Score	Technical Efficiency	Pure Technical Efficiency	Scale Efficiency	Count Return to Scale
REIT 1	0.458	0.562	0.812	0%
REIT 2	0.970	0.993	0.976	50%
REIT 3	0.582	0.828	0.717	0%
REIT 4	0.800	0.971	0.821	40%
REIT 5	0.997	1.000	0.997	90%
REIT 6	0.393	0.595	0.706	0%
REIT 7	0.402	0.476	0.837	0%

REIT ID/ Mean Score	Technical Efficiency	Pure Technical Efficiency	Scale Efficiency	Count Return to Scale
REIT 8	0.393	0.559	0.695	0%
REIT 9	0.462	0.505	0.903	10%
REIT 10	0.976	1.000	0.976	90%
REIT 11	0.414	0.918	0.452	0%
REIT 12	0.391	0.703	0.547	0%
REIT 13	0.499	0.925	0.539	0%
REIT 14	0.510	0.926	0.542	20%
REIT 15	0.974	1.000	0.974	80%
REIT 16	0.898	0.965	0.925	50%
REIT 17	0.657	0.728	0.893	0%
REIT 18	0.474	0.590	0.797	0%
REIT 19	1.000	1.000	1.000	100%

Source: Author's Own

Notes: grey shading indicates that the M-REITs were operating at a technical, pure technical, and scale-efficient frontier; bold font indicates the M-REIT was operating efficiently; count RTS denotes the frequency for REITs operating at the optimum scale between 2015 and 2024.

Additionally, the Count Return to Scale (CRS) column in Table 2 shows how often each REIT reached its best possible size over the ten years. REIT 19 led the group with a 100% CRS, followed closely by REIT 5, REIT 10, and REIT 15. In contrast, ten different REITs (REIT 1, 3, 6, 7, 8, 11, 12, 13, 17, and 18) recorded a 0% CRS frequency. This highlights a major challenge for over half of the M-REITs in the study, as they failed to reach optimal operating scale even once between 2015 and 2024. This reinforces findings that the main struggle for M-REITs is not just management skill but also finding the right size to compete effectively in the market.

Efficiency Performance of M-REITs across Different Phases

Figure 2 categorizes the efficiency performance of M-REITs into three distinct phases to better understand how economic shifts impacted the sector, spanning the period from 2015 to 2024. By examining these phases, the specific periods of strength and the external factors that caused fluctuations in efficiency can be identified.

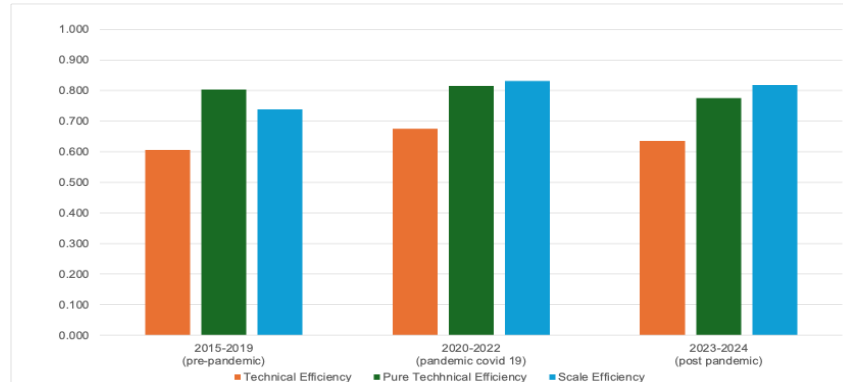


Figure 2: M-REITs efficiency scores across different phase
Source: Author's Own (2026)

Each of the distinct phases are briefly explained as follows:

2015 - 2019: Pre-Pandemic Phase

During the pre-pandemic phase, M-REITs exhibited a moderate TE of 0.606. While managers were generally capable of controlling internal costs, as evidenced by PTE of 0.803, the overall efficiency was still significantly constrained by SE of 0.739. This indicates that prior to global health crisis, the primary structural weakness in the Malaysian market was the failure of trusts to operate at an optimal scale, rather than a lack of managerial competence.

2020 - 2022: Pandemic COVID-19 Phase

Figure 2 depicts a compelling finding between 2020 and 2022. Despite the global economic crisis caused by COVID-19, the efficiency scores did not decline and deteriorate. Instead, the sector demonstrated remarkable resilience, with the mean TE rising to 0.676 and SE reaching its highest sectoral peak of 0.831. This upward trend demonstrates the resilience of the M-REIT sector. This trend suggests that under the pressure of lockdowns and market uncertainty, REIT managers were likely forced to implement rigorous resource optimization and cost-cutting strategies. The fact that SE was the primary driver of efficiency during this phase highlights that firms successfully adjusted their operational scale to withstand market volatility.

2023 - 2024: Post-Pandemic Phase

The post-pandemic recovery phase recorded a noticeable downturn, with TE and PTE declining to 0.635 and 0.775, respectively. This drop during an era of economic reopening can be attributed to the aggressive normalisation of the Overnight Policy Rate (OPR) by the central bank, which significantly increased interest expense as a primary input. Furthermore, the transition toward a new

normal required significant capital reinvestment in property modifications, which may have temporarily lowered efficiency as these new inputs have yet to generate stabilized returns.

CONCLUSION

This research provides a rigorous assessment of M-REITs from 2015 to 2024, revealing a moderate mean technical efficiency of 0.633. A critical finding is that pure technical efficiency at 0.801 consistently outperformed scale efficiency at 0.783, suggesting that while relative operational conversion is high, the primary driver of sectoral inefficiency remains the failure to achieve an optimal operating scale. Interestingly, the analysis proves that M-REITs exhibited remarkable resilience during the COVID-19 pandemic phase, where efficiency metrics improved as firms adopted stricter resource management to withstand market volatility. However, the subsequent post-pandemic downturn highlights a heightened vulnerability to external economic shifts, particularly rising interest expenses.

For regulators and policymakers, these results emphasize the necessity of monitoring how rapid interest rate adjustments impact debt capabilities and technical efficiency, ensuring governance guidelines do not inadvertently encourage inefficient bloating among larger trusts. Property trust managers are encouraged to prioritize finding an optimal operating scale by moving away from aggressive, size driven asset acquisition to eliminate managerial congestion and streamline administrative overhead. For investors, evaluation metrics must transcend traditional market capitalization because identifying benchmark performers provides an empirical standard for assessing management quality and directing capital toward trusts with disciplined scale management. Finally, regarding portfolio restructuring, underperforming M-REITs must initiate targeted strategies to right-size their portfolios by divesting redundant assets to return closer to their optimal scale size. Future research should pursue cross border comparative analyses and incorporate ESG variables as output metrics to provide a more holistic assessment of REIT performance. Additionally, while this study implements an input-oriented VRS DEA model and robustness checks using an output-oriented model were incorporated in the methodology, exploring other financial variables for inputs and outputs is recommended for future research to further enhance robustness results.

ACKNOWLEDGEMENT

This research article was financially supported by Universiti Teknologi MARA and the Institute of Postgraduate UiTM.

REFERENCES

- Alfiero, S., & Esposito, A. (2018). Comparative Efficiency Studies. *Global Encyclopedia of Public Administration, Public Policy, and Governance*, 887–891. https://doi.org/10.1007/978-3-319-20928-9_3292
- Amin, G. R., & Boamah, M. I. (2025). Introduction to Data Envelopment Analysis Models. *Decision Making Optimization Models for Business Partnerships*, 1–22. <https://doi.org/10.1201/9781003345206-1>
- Avkiran, N. K. (2004). Decomposing technical efficiency and window analysis. *Studies in Economics and Finance*, 22(1), 61–91. <https://doi.org/10.1108/eb043383>
- Ayres, R. U., Talens Peiro, L., & Villalba Méndez, G. (2011). Exergy Efficiency in Industry: Where Do We Stand? *Environmental Science & Technology*, 45(24), 10634–10641. <https://doi.org/10.1021/es202193u>
- Bannour, B., & Labidi, M. (2015). Statistical inference § parametric approximation of non-parametric frontier: the case of Tunisian banking sector. *International Journal of Mathematics in Operational Research*, 7(5), 485. <https://doi.org/10.1504/ijmor.2015.071272>
- Chuweni, N. N., & Eves, C. (2019). Journal of the Malaysian Institute of Planners. *Journal of the Malaysian Institute of Planners*, 17(1). <https://pdfs.semanticscholar.org/3048/038bda5f679fd73fd19d4fe3d3ea129ee2a2.pdf>
- Chuweni, N. N., Eves, C., Hoang, V.-N., Isik, I., & Hassan, M. K. (2017). How Efficient are Alternative Financial Institutions? An Empirical Investigation of Islamic REITs in Malaysia. *Journal of Real Estate Literature*, 25(1), 107–139. <https://doi.org/10.1080/10835547.2017.12090444>
- Coelli, T., Rao, D. S. P., O'Donnell, C. J., & Battese, G. (2005). *An Introduction to Efficiency and Productivity Analysis* (2nd ed.). Springer US. <https://doi.org/10.1007/978-1-4615-5493-6>
- Coughtrey, A., Pinto, M., Ladhani, S., Shafran, R., & Stephenson, T. (2025). Long COVID in children and young people: then and now. *Current Opinion in Infectious Diseases*, 38(5), 487–492. <https://doi.org/10.1097/qco.0000000000001136>
- Dhariwal, R., Thakkar, K., Vaghela, K., & Jain, M. (2025). Evaluating post-acute COVID-19 sequelae in younger population using symptom burden questionnaire (SQL). *BMC Public Health*, 25(1). <https://doi.org/10.1186/s12889-025-24446-w>
- Haslam, C., Tsitsianis, N., Andersson, T., & Gleadle, P. (2015). Real Estate Investment Trusts (REITS): A new business model in the FTSE100. *Accounting Forum*, 39(4), 239–248. <https://doi.org/10.1016/j.accfor.2015.10.003>
- Jha, S., Hui, X., & Sun, B. (2013). Commercial Banking Efficiency in Nepal: Application of DEA and Tobit Model. *Information Technology Journal*, 12(2), 306–314. <https://doi.org/10.3923/itj.2013.306.314>
- Lundberg, A. L., Ozer, E. A., Wu, S. A., Soetikno, A. G., Welch, S. B., Liu, Y., Havey, R. J., Murphy, R. L., Hawkins, C., Mason, M., Achenbach, C. J., & Post, L. A. (2024). Surveillance Metrics and History of the COVID-19 Pandemic in Central Asia: Updated Epidemiological Assessment. *JMIR Public Health and Surveillance*, 10, e52318–e52318. <https://doi.org/10.2196/52318>

- Mateo, J. R. S. C. (2012). A Multi-Criteria Data Envelopment Analysis. *Green Energy and Technology*, 55–62. https://doi.org/10.1007/978-1-4471-2346-0_9
- Mohan, P. (2020). Human capital and technical efficiency: a Stochastic Frontier Analysis of Caribbean firms. *Journal of Education and Work*, 33(2), 143–153. <https://doi.org/10.1080/13639080.2020.1747050>
- Murillo, L. R. (2004). Economic Efficiency and Frontier Techniques. *Journal of Economic Surveys*, 18(1), 33–77. <https://doi.org/10.1111/j.1467-6419.2004.00215.x>
- Ray, S. C. (2015). Nonparametric measures of scale economies and capacity utilization: An application to U.S. manufacturing. *European Journal of Operational Research*, 245(2), 602–611. <https://doi.org/10.1016/j.ejor.2015.03.024>
- Sufian, F., Kamarudin, F., Halida, N., & Noor, H. (2014). Revenue Efficiency and Returns to Scale in Islamic Banks: Empirical Evidence from Malaysia. *Journal of Economic Cooperation and Development*, 35(1), 47–80. <https://jecd.sesric.org/pdf.php?file=ART12040601-2.pdf>
- Topuz, J. C., Darrat, A. F., & Shelor, R. M. (2005). Technical, Allocative and Scale Efficiencies of REITs: An Empirical Inquiry. *Journal of Business Finance & Accounting*, 32(9-10), 1961–1994. <https://doi.org/10.1111/j.0306-686x.2005.00653.x>
- Topuz, J. C., & Isik, I. (2009). Structural changes, market growth and productivity gains of the US real estate investment trusts in the 1990s. *Journal of Economics and Finance*, 33(3), 288–315. <https://doi.org/10.1007/s12197-008-9026-6>
- Wang, A. (2009). The Efficiency Variations of Chinese Feed-processing Enterprise of Different Ownership Structures: 2002-2005. *2009 Second International Workshop on Knowledge Discovery and Data Mining*, 440–443. <https://doi.org/10.1109/wkdd.2009.126>
- Wu, S. A., Soetikno, A. G., Ozer, E. A., Welch, S. B., Liu, Y., Havey, R. J., Murphy, R. L., Hawkins, C., Mason, M., Post, L. A., Achenbach, C. J., & Lundberg, A. L. (2024). Updated Surveillance Metrics and History of the COVID-19 Pandemic (2020-2023) in Canada: Longitudinal Trend Analysis. *JMIR Public Health and Surveillance*, 10, e53218. <https://doi.org/10.2196/53218>
- Zhang, W., Li, B., & Roca, E. (2023). Moments and momentum in the returns of securitized real estate: A cross-country study of risk factors driving real estate investment trusts before and during COVID-19. *Heliyon*, 9(8), e18476. <https://doi.org/10.1016/j.heliyon.2023.e18476>

Received: 10th August 2026. Accepted: 13th August 2026