

PERFORMANCE EFFICIENCY OF MALAYSIAN FOOTBALL CLUBS USING BI-OBJECTIVE MCDEA CCR INPUT-ORIENTED AND SUPER EFFICIENCY MODEL

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Abstract: Professional football clubs operate with different levels of player resources, squad composition, infrastructure, sporting achievement, and financial performance. Evaluating club performance solely on the basis of league position may therefore provide an incomplete representation of how efficiently available resources are utilized. This study evaluates the relative performance efficiency of 14 football clubs participating in the 2023 Malaysia Super League (MSL) using a two-phase Data Envelopment Analysis (DEA) framework. In the first phase, the Bi-Objective Multi-Criteria Data Envelopment Analysis (Bi-O MCDEA) CCR Input-Oriented model is employed to evaluate the efficiency with which clubs transform market value, squad size, and stadium capacity into league points, goals scored, and revenue. In the second phase, the Super Efficiency (SE) model is applied to provide further discrimination among frontier-efficient clubs. The mathematical models were implemented using LINGO 20.0, while secondary data were obtained from Transfermarkt and publicly available information relating to the 2023 MSL season. The results identify Johor Darul Ta'zim (JDT) and PDRM FC as frontier-efficient clubs, each obtaining an efficiency score of 1.000. Among the remaining clubs, Sabah FC and Selangor FC recorded relatively high efficiency scores of 0.898 and 0.892, respectively, whereas Kuching City FC recorded the lowest score of 0.598. Super-efficiency analysis further distinguishes the two frontier-efficient clubs, with JDT recording a score of 1.211 and PDRM FC recording a value effectively equal to unity. The findings demonstrate

substantial differences in relative resource utilisation across Malaysian football clubs and provide a quantitative basis for performance benchmarking and managerial evaluation.

Keywords: *Performance efficiency; football clubs; Malaysia Super League; Bi-Objective MCDEA; Data Envelopment Analysis; Super Efficiency*

Introduction

Football is one of the most widely followed sports in Malaysia and represents an important component of the country's sporting and commercial environment. The Malaysia Super League (MSL), as the highest level of domestic professional football competition, consists of clubs operating with different levels of playing resources, squad structures, infrastructure, commercial capacity, and sporting performance. In an increasingly competitive professional football environment, evaluating a club solely according to its league position may provide an incomplete assessment of organisational performance. Clubs must also manage the resources available to them effectively in order to generate sporting outcomes and maintain financial sustainability.

The concept of efficiency is particularly relevant in this context because high resource availability does not necessarily guarantee proportionately high performance. A club with a large playing squad, substantial player market value, or extensive infrastructure may still perform inefficiently when these resources are considered relative to sporting and financial outcomes. Conversely, clubs operating with more modest resources may demonstrate relatively strong efficiency when they achieve comparable outputs. An appropriate efficiency assessment must therefore consider several inputs and outputs simultaneously rather than rely on individual performance ratios.

Data Envelopment Analysis (DEA) provides a non-parametric mathematical programming framework for evaluating the relative efficiency of homogeneous decision-making units (DMUs) with multiple inputs and outputs (Charnes et al., 1978). DEA constructs an empirical efficiency frontier from observed data and evaluates each DMU relative to the best-performing units within the sample. The methodology has consequently been applied extensively to performance measurement and benchmarking where organisational units use heterogeneous combinations of resources to produce multiple outcomes.

Applications of DEA in professional football have examined sporting, financial, managerial, and player-level performance. Studies have evaluated football clubs using variables relating to financial resources, player expenditure, league performance, revenues, and other sporting indicators (Leksowski, 2021; Guzmán-Raja & Guzmán-Raja, 2021; Ellul et al., 2022; Šíma et al., 2023; Alwadood et al., 2024). DEA has also been applied to individual football players and specialised playing positions (Pelloneová & Tomíček, 2022a, 2022b), while multi-criteria approaches have been used to extend the discriminatory capability of conventional efficiency analysis (Arsu, 2021; Kolbowicz et al., 2024). Collectively, these studies demonstrate the usefulness of DEA for assessing football performance beyond conventional league rankings.

The selection of appropriate football resources is an important consideration in such analyses. Zambom-Ferraresi et al. (2019) examined the distinction between ex-ante and ex-post inputs in football efficiency analysis and identified player market value as a meaningful ex-ante representation of the playing resources available to a football team. Chaiwuttisak (2019)

similarly incorporated stadium capacity within a DEA framework for professional football clubs and combined CCR DEA with super-efficiency analysis to discriminate among efficient clubs. Arsu (2021) subsequently applied Bi-Objective MCDEA to European football clubs using market value as a resource variable alongside sporting and financial outputs. These studies provide methodological precedent for evaluating football performance through the relationship between resource endowments and achieved outcomes.

An equally important methodological consideration concerns the orientation of the DEA model. Cook et al. (2014) emphasised that DEA orientation should be selected according to the purpose of the performance evaluation rather than mechanically determined. An input-oriented approach is appropriate when analytical attention is directed towards how efficiently available resources are utilised in producing observed outcomes. Input-oriented DEA has also been applied directly within professional football settings, including operational-efficiency assessments of football teams (Xu, 2018). This resource-utilisation perspective is consistent with the purpose of the present study.

Within the Malaysian football context, there remains scope for an efficiency framework that simultaneously incorporates player-related resources, squad size, infrastructure, sporting achievement, and financial performance while also providing discrimination among clubs located on the efficiency frontier. Accordingly, this study applies the Bi-Objective Multi-Criteria Data Envelopment Analysis (Bi-O MCDEA) CCR Input-Oriented model together with the Super Efficiency model to evaluate 14 football clubs participating in the 2023 MSL season. Market value, squad size, and stadium capacity are used as inputs, while league points, goals scored, and revenue are considered outputs. The study first estimates the relative efficiency of the clubs and subsequently applies super-efficiency analysis to distinguish among the frontier-efficient DMUs. The resulting framework provides a quantitative basis for benchmarking resource utilisation among professional Malaysian football clubs.

Research Methodology

This study adopts a quantitative efficiency-evaluation framework based on DEA. Fourteen football clubs participating in the 2023 Malaysia Super League constitute the DMUs. The analysis is conducted in two sequential phases. The first phase applies the Bi-O MCDEA CCR Input-Oriented model developed from the multi-criteria DEA framework of Li and Reeves (1999) and subsequently extended by Ghasemi et al. (2014). The model evaluates the relative efficiency of the football clubs under the constant returns-to-scale assumption. The second phase applies the Super Efficiency model introduced by Andersen and Petersen (1993) to provide additional discrimination among DMUs identified as efficient in the first phase.

Three input variables and three output variables are incorporated into the efficiency framework. Market value represents the aggregate market value of the players registered by each club. Squad size represents the number of registered players during the 2023 MSL season. Stadium capacity represents the scale of the home infrastructure available to the club. The output variables comprise league points, goals scored, and revenue. League points measure overall competitive achievement during the season, goals scored represent attacking performance, and revenue represents the commercial output generated by the club through activities such as ticketing, sponsorship, and broadcasting.

The mathematical models were implemented using LINGO 20.0. Secondary information relating to the football clubs was obtained from Transfermarkt and publicly available information associated with the 2023 Malaysia Super League.

Justification for the Input-Oriented Specification

The choice between input- and output-oriented DEA specifications depends on the managerial question being addressed. Cook et al. (2014) emphasised that model orientation should correspond to the underlying purpose of the performance assessment. An output-oriented model addresses the extent to which outputs could be expanded from a given resource base, whereas an input-oriented model focuses on the relative utilisation of resources for observed levels of output.

The present study adopts the latter perspective. Its primary analytical interest concerns how efficiently football clubs utilise their available player, squad, and infrastructure resources in generating observed sporting and financial outcomes. The input-oriented model therefore provides an appropriate basis for evaluating the resource-performance relationship among MSL clubs. Similar input-oriented DEA applications have been employed in football efficiency research, including Xu's (2018) analysis of operational efficiency in the Chinese Super League. The three selected inputs differ in their degree of short-term managerial discretion. Squad size is comparatively manageable through recruitment, player registration, retention, and release decisions. Squad market value is not a direct expenditure variable, but it reflects the aggregate value and composition of the playing resources assembled by a club and can be influenced over time through recruitment and player-development strategies. Stadium capacity is less adjustable in the short run and primarily represents the infrastructure endowment available to a club. Its treatment as a football-efficiency input is nevertheless supported by previous professional-football DEA applications such as Chaiwuttisak (2019).

Consequently, the efficiency scores are interpreted as relative measures of resource utilisation rather than literal recommendations that inefficient clubs should proportionately reduce each individual resource. The input-oriented specification identifies differences in the relationship between available resources and realised outputs across comparable clubs and thus provides a benchmarking perspective on operational performance. Figure 1 below shows the methodological framework of the study.

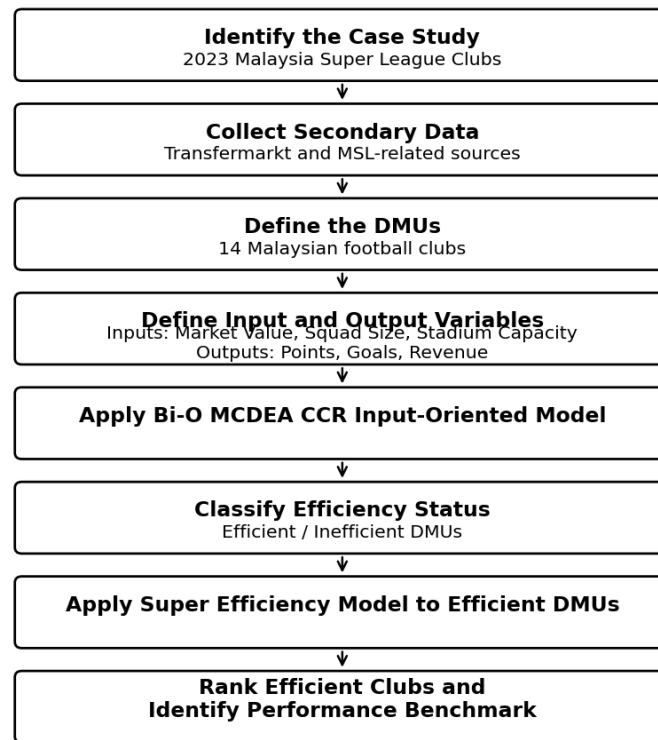


Figure 1: Methodological Framework of the Study

Bi-Objective MCDEA CCR Model

DEA evaluates the relative efficiency of homogeneous DMUs through the simultaneous consideration of multiple inputs and outputs. The traditional CCR model introduced by Charnes et al. (1978) assumes constant returns to scale. Li and Reeves (1999) subsequently introduced a multiple-criteria DEA framework to improve the discriminatory capacity of conventional DEA, while Ghasemi et al. (2014) developed a Bi-Objective MCDEA formulation that incorporates deviation-based criteria.

For the evaluated DMU, the Bi-O MCDEA CCR formulation applied in this study is expressed as follows:

$$\min h = w_2 M + w_3 \sum_{j=1}^n d_j \quad (1)$$

subject to

$$\sum_{i=1}^m v_i x_{i0} = 1 \quad (2)$$

$$\sum_{r=1}^s u_r y_{rj} - \sum_{i=1}^m v_i x_{ij} + d_j = 0, \quad j = 1, \dots, n \quad (3)$$

$$M - d_j \geq 0, \quad j = 1, \dots, n \quad (4)$$

$$u_r \geq \varepsilon, \quad r = 1, \dots, s \quad (5)$$

$$v_i \geq \varepsilon, \quad i = 1, \dots, m \quad (6)$$

$$d_j \geq 0, \quad j = 1, \dots, n \quad (7)$$

In the formulation, n represents the number of DMUs, m denotes the number of inputs, and s denotes the number of outputs. The variable x_{ij} represents the value of input i for DMU j , while y_{rj} represents the value of output r for DMU j . The variables v_i and u_r denote the weights assigned to the inputs and outputs, respectively. The deviation associated with DMU j is represented by d_j , whereas M represents the maximum deviation among the DMUs. The small positive value ε provides a lower bound for the input and output weights. Following the weighting specification employed in the Bi-O MCDEA model, $w_1 = 0$, and $w_2 = w_3 = 0.5$.

The deviation value is subsequently used to determine the reported efficiency score:

$$h_j = 1 - d_j \quad (8)$$

A DMU with $d_j = 0$ therefore obtains an efficiency score of 1.000 and lies on the relative efficiency frontier. Values below 1.000 indicate relative inefficiency compared with the observed frontier.

Super Efficiency Model

The Bi-O MCDEA model can identify DMUs located on the efficiency frontier, but multiple DMUs may obtain the same efficiency score of 1.000. The Super Efficiency approach introduced by Andersen and Petersen (1993) provides additional discrimination among such frontier-efficient units. In the present study, the model is applied only to DMUs identified as efficient during the first phase.

The Super Efficiency formulation is expressed as follows:

$$\max \theta_0 = \sum_{r=1}^s u_r y_{r0} + u_0 \quad (9)$$

subject to

$$\sum_{i=1}^m v_i x_{i0} = 1 \quad (10)$$

$$\sum_{r=1}^s u_r y_{rk} - \sum_{i=1}^m v_i x_{ik} + u_0 \leq 0, \quad k = 1, \dots, n \quad (11)$$

$$u_r, v_i \geq 0 \quad (12)$$

The parameter θ_0 represents the super-efficiency score of the evaluated DMU, while u_r and v_i represent the output and input weights, respectively. The formulation enables additional discrimination among the DMUs identified as efficient in Phase 1 and provides a basis for ranking the frontier-efficient football clubs.

Decision-Making Units and Sample Adequacy

Decision-making units are homogeneous entities whose relative efficiencies are evaluated using the same set of inputs and outputs. Each DMU in this study represents one football club participating in the 2023 Malaysia Super League.

Following Bowlin (1998), the number of DMUs is assessed using the following guideline:

$$n \geq 2(m + s) \quad (13)$$

where n denotes the number of DMUs, m represents the number of inputs, and s represents the number of outputs. With three inputs and three outputs, the minimum number of DMUs required under this criterion is 12. The sample comprises 14 football clubs and therefore satisfies the adopted DMU adequacy guideline.

Table 1: Input and Output Data for the 2023 Malaysia Super League Season

DMU	Football Club	Market Value (RM)	Squad Size	Stadium Capacity	Points	Goals	Revenue (RM)
1	Johor Darul Ta'zim (JDT)	1,340,000	37	40,000	76	100	100,000,000
2	Kedah Darul Aman	870,000	31	32,387	53	52	35,000,000
3	Kelantan	225,000	56	22,000	8	29	10,000,000
4	Kelantan United	375,000	35	22,000	17	29	8,000,000
5	Kuala Lumpur City	640,000	36	18,000	38	44	28,000,000
6	Kuching City	395,000	44	40,000	12	24	12,000,000
7	Negeri Sembilan	525,000	36	45,000	27	33	15,000,000
8	PDRM	335,000	36	18,000	37	35	10,000,000
9	Penang	430,000	40	25,000	24	29	14,000,000
10	Perak	315,000	51	42,500	22	25	12,000,000
11	Sabah	680,000	34	35,000	54	64	25,000,000
12	Selangor	900,000	33	25,000	61	72	50,000,000
13	Sri Pahang	685,000	31	40,000	45	44	20,000,000
14	Terengganu	615,000	37	50,000	40	45	30,000,000

Results and Discussion

The Bi-O MCDEA CCR Input-Oriented model was applied to the 14 football clubs using the three input and three output variables specified in the methodology. Table 2 reports the deviation values and corresponding efficiency scores. A score of 1.000 indicates that the club lies on the relative efficiency frontier, whereas a score below 1.000 reflects relative inefficiency within the observed sample.

Table 2: Efficiency Scores of Malaysian Football Clubs Using the Bi-O MCDEA CCR Input-Oriented Model

DMU	Football Club	Deviation	Efficiency Score
1	Johor Darul Ta'zim (JDT)	0.000	1.000
2	Kedah Darul Aman FC	0.273	0.727
3	Kelantan FC	0.222	0.778
4	Kelantan United FC	0.276	0.724
5	Kuala Lumpur City FC	0.221	0.779
6	Kuching City FC	0.402	0.598
7	Negeri Sembilan FC	0.265	0.735
8	PDRM FC	0.000	1.000
9	Penang FC	0.305	0.695
10	Perak FC	0.269	0.731
11	Sabah FC	0.102	0.898
12	Selangor FC	0.108	0.892
13	Sri Pahang FC	0.319	0.681
14	Terengganu FC	0.153	0.847

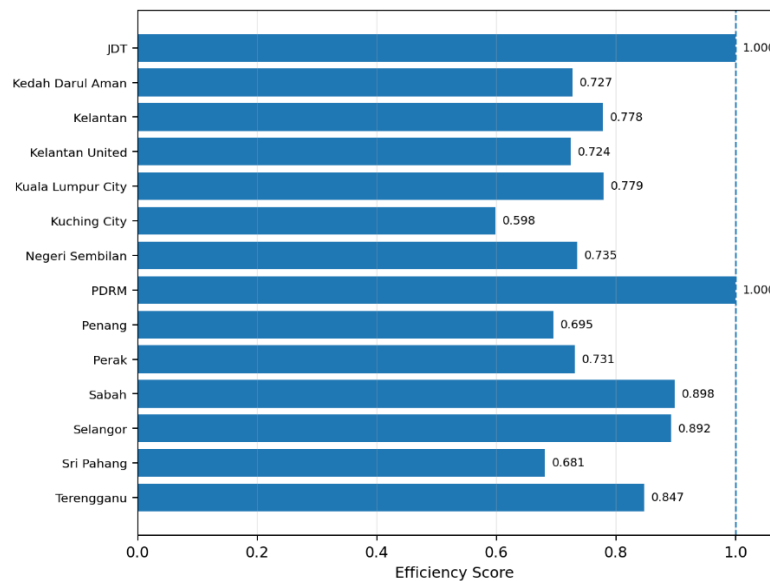


Figure 2: Efficiency Scores of Malaysian Football Clubs Using the Bi-O MCDEA CCR Input-Oriented Model

The efficiency results demonstrate substantial variation across the 14 clubs. JDT and PDRM FC recorded efficiency scores of 1.000 and were therefore positioned on the relative efficiency frontier. The finding indicates that, given the selected inputs and outputs and the observed sample, these two clubs exhibited the most favourable resource-performance combinations.

Among the inefficient clubs, Sabah FC recorded the highest efficiency score of 0.898, followed closely by Selangor FC at 0.892. These results place both clubs relatively close to the efficiency frontier. Terengganu FC also demonstrated comparatively strong efficiency with a score of 0.847. Kuala Lumpur City FC and Kelantan FC recorded scores of 0.779 and 0.778, respectively, while Negeri Sembilan FC, Perak FC, Kedah Darul Aman FC, and Kelantan United FC occupied the middle range of the efficiency distribution.

At the lower end of the distribution, Kuching City FC recorded the lowest efficiency score at 0.598. Sri Pahang FC and Penang FC recorded scores of 0.681 and 0.695, respectively. The variation indicates that clubs with broadly comparable competitive responsibilities differ considerably in the extent to which their observed player resources, squad sizes, and infrastructure are associated with sporting and financial outcomes.

The position of JDT on the frontier is consistent with the club's strong sporting output during the season. JDT accumulated 76 league points and scored 100 goals, both substantially higher than the corresponding outputs of the other clubs in the sample. The club also recorded the highest revenue in the dataset. Its frontier position therefore reflects the simultaneous consideration of sporting and financial outputs relative to the resources incorporated into the model rather than sporting achievement in isolation.

PDRM FC provides a contrasting efficiency profile. Although the club generated lower absolute revenue and sporting outputs than JDT, it operated with a considerably lower market value and relatively modest stadium capacity. Its frontier status illustrates an important feature of DEA: efficiency is relative to the relationship between resources and outcomes and does not necessarily correspond to the largest club, the highest revenue, or the highest league position.

A comparatively smaller club can therefore be positioned on the frontier when its resource-output combination compares favourably with those of the other DMUs.

The interpretation of the efficiency gaps must also reflect the input-oriented nature of the model. The scores measure relative resource utilisation rather than prescribe an identical proportional reduction of every resource. Squad size is comparatively adjustable through player-management decisions, whereas stadium capacity represents a substantially more fixed infrastructure resource. Similarly, squad market value represents the value of the playing resources available to a club rather than a directly adjustable operating expenditure. The results therefore provide comparative evidence regarding resource-performance relationships rather than mechanical resource-reduction targets.

Previous football-efficiency studies provide support for this interpretation. Zambom-Ferraresi et al. (2019) demonstrated that player market value can serve as an informative ex-ante input in assessing football-team efficiency. Chaiwuttisak (2019) included stadium capacity within a football DEA framework and demonstrated the use of CCR and super-efficiency models in differentiating professional football clubs. The present findings extend this resource-based efficiency perspective to the Malaysian professional football context.

Super Efficiency Analysis

The Bi-O MCDEA CCR analysis identified two frontier-efficient DMUs: JDT and PDRM FC. Since both clubs obtained an initial efficiency score of 1.000, the first-phase model alone did not provide further discrimination between them. The Super Efficiency model was therefore applied to distinguish their relative positions beyond the initial frontier assessment.

Table 3: Super Efficiency Scores and Ranking of Frontier-Efficient Clubs

DMU	Football Club	Super Efficiency Score	Rank
1	Johor Darul Ta'zim (JDT)	1.211	1
8	PDRM FC	1.000	2

Table 3 shows that JDT recorded a super-efficiency score of 1.211 and was ranked first among the two frontier-efficient clubs. The score provides further discrimination beyond the common Phase 1 efficiency score and indicates that JDT maintained the stronger relative position when the efficient clubs were subjected to the second-stage assessment.

PDRM FC recorded a computational value of 0.9999994, which is effectively unity at the reporting precision adopted in this study. The club was therefore ranked second. The very small numerical difference from unity does not materially alter its Phase 1 identification as a frontier-efficient club; rather, the second-stage analysis distinguishes its relative position from that of JDT.

The super-efficiency result is consistent with the markedly different performance profiles of the two clubs. JDT combined a substantially higher market-value resource base with the strongest league-points, goals, and revenue outputs in the dataset. PDRM FC, by contrast, attained frontier efficiency through a comparatively resource-efficient combination of more modest inputs and competitive sporting outputs. The distinction demonstrates why additional discrimination among DEA-efficient units can be informative: two clubs may occupy the efficiency frontier for different resource-performance reasons.

The result also illustrates the distinction between absolute performance and relative efficiency. JDT represents a high-resource, high-output efficiency profile, while PDRM FC represents a lower-resource profile capable of producing a comparatively favourable output combination. Consequently, the frontier should not be interpreted as representing a single managerial model that all clubs must replicate. Instead, the efficient clubs provide alternative benchmarking profiles against which less efficient clubs may evaluate their own resource utilisation.

From a managerial perspective, clubs positioned below the frontier may use the findings as an initial diagnostic benchmark. Clubs with large playing squads but comparatively modest sporting outputs may examine recruitment, registration, and squad-utilisation strategies. Clubs with substantial infrastructure may assess whether commercial, match-day, and sporting outputs are commensurate with the resources available to them. Similarly, the relationship between player market value and sporting performance may provide information about the effectiveness of player acquisition, development, and deployment strategies.

The benchmarking interpretation should nevertheless remain conditional on the variables included in the model. Football-club performance is multidimensional, and efficiency estimates based on market value, squad size, stadium capacity, points, goals, and revenue do not capture all managerial and institutional factors. Coaching quality, wage expenditure, injuries, player development, match attendance, commercial agreements, ownership structure, and competitive conditions may also influence club performance. The DEA findings therefore provide a structured relative comparison within the selected input-output framework rather than a comprehensive assessment of every dimension of club quality.

Conclusion

This study evaluated the relative performance efficiency of 14 football clubs participating in the 2023 Malaysia Super League using a two-phase DEA framework. The first phase applied the Bi-O MCDEA CCR Input-Oriented model to assess the relationship between three resource inputs—market value, squad size, and stadium capacity—and three sporting and financial outputs comprising league points, goals scored, and revenue. The second phase employed Super Efficiency analysis to provide additional discrimination among the clubs identified as efficient in the initial assessment.

The Bi-O MCDEA results identified JDT and PDRM FC as frontier-efficient, with both clubs recording an efficiency score of 1.000. The remaining 12 clubs were positioned below the relative efficiency frontier. Sabah FC and Selangor FC were the closest inefficient clubs to the frontier, with scores of 0.898 and 0.892, respectively, whereas Kuching City FC recorded the lowest efficiency score of 0.598. These findings demonstrate substantial variation in the relationship between football resources and observed sporting and financial outputs across the MSL clubs.

The subsequent Super Efficiency analysis distinguished between the two frontier-efficient clubs. JDT recorded the highest super-efficiency score of 1.211 and was ranked first, while PDRM FC recorded a value effectively equal to 1.000 and was ranked second. The result demonstrates that clubs may attain frontier efficiency through substantially different resource-performance configurations. JDT represents a high-resource and high-output profile, whereas PDRM FC demonstrates that a comparatively smaller resource base can also produce a favourable efficiency relationship.

The findings have practical implications for football-club management. Efficiency benchmarking provides information that complements conventional league standings because it simultaneously considers the resources available to clubs and the outcomes they produce. Clubs positioned below the frontier may therefore examine not only whether additional resources are required, but also whether existing squad, player, and infrastructure resources are being utilised effectively. The analysis may support discussions relating to recruitment strategy, squad planning, infrastructure utilisation, and broader resource allocation.

The input-oriented interpretation requires particular care because the selected resources differ in managerial controllability. Squad size can be adjusted relatively directly, whereas market value can only be influenced progressively through player-related decisions, and stadium capacity remains comparatively fixed in the short run. Consequently, efficiency gaps should be interpreted as relative benchmarking information rather than literal instructions to reduce every resource proportionately. This distinction enables the model to retain its resource-utilisation focus while recognising the operational characteristics of professional football clubs.

The findings may also assist football governing organisations by providing a structured framework for comparing the performance of clubs with different resource profiles. Relative-efficiency information can complement sporting results when identifying patterns of resource utilisation, club development, and benchmarking within the league. Nevertheless, DEA evaluates performance relative to the observed sample; a frontier-efficient club should therefore be interpreted as efficient relative to the other clubs and variables included in the analysis rather than as universally efficient.

Several limitations provide opportunities for further research. First, the analysis is restricted to a single season and 14 MSL clubs, which limits the extent to which temporal changes in efficiency can be examined. Future studies could incorporate multiple seasons to assess the persistence or movement of efficiency over time. Second, the study employs three inputs and three outputs because of data availability and comparability. Additional variables such as wage expenditure, operating expenditure, match attendance, player-development indicators, sponsorship income, and digital fan engagement could provide a broader representation of club operations where reliable data are available. Third, future studies could investigate alternative DEA specifications or sensitivity analyses to examine the robustness of efficiency estimates under different resource and performance structures.

Overall, the combination of the Bi-O MCDEA CCR Input-Oriented and Super Efficiency models provides a useful framework for analysing Malaysian football clubs from a multi-input and multi-output perspective. The approach identifies relative differences in resource utilisation, distinguishes among frontier-efficient clubs, and provides an evidence-based foundation for performance benchmarking within professional Malaysian football.

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References

- Alwadood, Z., Shahrudin, A. F., Mustafa, A. S., & Mohd Noor, N. (2024). Measuring performance efficiency of Malaysian football clubs using data envelopment analysis. *Transactions on Science and Technology*, 11(3), 175–181.
- Andersen, P., & Petersen, N. C. (1993). A procedure for ranking efficient units in data envelopment analysis. *Management Science*, 39(10), 1261–1264. <https://doi.org/10.1287/mnsc.39.10.1261>
- Arsu, T. (2021). Investigation into the efficiencies of European football clubs with bi-objective multi-criteria data envelopment analysis. *Decision Making: Applications in Management and Engineering*, 4(2), 106–125. <https://doi.org/10.31181/DMAME210402106A>
- Bowlin, W. F. (1998). Measuring performance: An introduction to data envelopment analysis. *The Journal of Cost Analysis*, 15(2), 3–27. <https://doi.org/10.1080/08823871.1998.10462318>
- Chaiwuttisak, P. (2019). Measuring efficiency of Thailand's football premier leagues using data envelopment analysis. In *Proceedings of the Twelfth International Conference on Management Science and Engineering Management* (pp. 691–700). Springer. https://doi.org/10.1007/978-3-319-93351-1_54
- Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, 2(6), 429–444. [https://doi.org/10.1016/0377-2217\(78\)90138-8](https://doi.org/10.1016/0377-2217(78)90138-8)
- Cook, W. D., Tone, K., & Zhu, J. (2014). Data envelopment analysis: Prior to choosing a model. *Omega*, 44, 1–4. <https://doi.org/10.1016/j.omega.2013.09.004>
- Di Simone, L., & Zanardi, D. (2021). On the relationship between sport and financial performance: An empirical investigation. *Managerial Finance*, 47(6), 812–824. <https://doi.org/10.1108/MF-09-2020-0478>
- Ellul, S., Spiteri, J. V., Delice, M. E., & Grima, S. (2022). Managerial decisions on the technical performance efficiency: The impact on elite English Premier League clubs. *Journal of Sports Economics & Management*, 12(1), 23–40.
- Ghasemi, M.-R., Ignatius, J., & Emrouznejad, A. (2014). A bi-objective weighted model for improving the discrimination power in MCDEA. *European Journal of Operational Research*, 233(3), 640–650. <https://doi.org/10.1016/j.ejor.2013.08.041>
- Guzmán-Raja, I., & Guzmán-Raja, M. (2021). Measuring the efficiency of football clubs using data envelopment analysis: Empirical evidence from Spanish professional football. *SAGE Open*, 11(1), 1–13. <https://doi.org/10.1177/2158244021989257>
- Kolbowicz, M., Nowak, M., & Więckowski, J. (2024). A multi-criteria system for performance assessment and support decision-making based on the example of Premier League top football strikers. *Physical Activity Review*, 12(1), 121–142. <https://doi.org/10.16926/par.2024.12.12>
- Leksowski, Ł. (2021). Relationship between sport and financial performance in top European football clubs. *Zeszyty Naukowe Małopolskiej Wyższej Szkoły Ekonomicznej w Tarnowie*, 49(1), 41–59. <https://doi.org/10.25944/znmwse.2021.01.4159>
- Li, X.-B., & Reeves, G. R. (1999). A multiple criteria approach to data envelopment analysis. *European Journal of Operational Research*, 115(3), 507–517. [https://doi.org/10.1016/S0377-2217\(98\)00130-1](https://doi.org/10.1016/S0377-2217(98)00130-1)
- Malaysia Football League. (2023). Johor Darul Ta'zim. Malaysia Football League.
- Özçelik, B. (2021). Efficiency in the European football leagues: Evidence from DEA model between the years 2016 and 2020 [Master's thesis, Eastern Mediterranean University].
- Pelloneová, N., & Tomíček, M. (2022a). Performance evaluation of goalkeepers of Slovak football league. *ACC Journal*, 28(2), 96–105. <https://doi.org/10.15240/tul/004/2022-2-008>

- Pelloneová, N., & Tomíček, M. (2022b). Ranking players by DEA: An analysis of Czech and Danish football. *Studia Sportiva*, 16(1), 76–90. <https://doi.org/10.5817/StS2022-1-8>
- Rahmati, K. (2023). Identifying and ranking key performance indicators in football clubs. *International Journal of Innovation in Management, Economics and Social Sciences*, 3(2), 42–51. <https://doi.org/10.59615/ijimes.3.2.42>
- Šíma, J., Voráček, J., Kraft, J., & Krause, V. (2023). Productive efficiency of Premier League teams using an enhanced data envelopment analysis approach. *AUC Kínanthropologica*, 59(1), 29–44. <https://doi.org/10.14712/23366052.2023.3>
- Tomíček, M. (2022). The efficiency of Premier League clubs according to the country of origin of the majority owner. In *Hradec Economic Days 2022* (pp. 774–784). University of Hradec Králové. <https://doi.org/10.36689/uhk/hed/2022-01-075>
- Transfermarkt. (2024). Malaysia Super League. Transfermarkt.
- Wikipedia contributors. (2024). 2023 Malaysia Super League. Wikipedia.
- Xu, W. (2018). Operational efficiency of the football team in Chinese Super League with DEA. *International Business Research*, 11(3), 1–9. <https://doi.org/10.5539/ibr.v11n3p1>
- Zambom-Ferraresi, F., Iráizoz, B., & Lera-López, F. (2019). Are football managers as efficient as coaches? Performance analysis with ex ante and ex post inputs in the Premier League. *Applied Economics*, 51(3), 303–314. <https://doi.org/10.1080/00036846.2018.1495821>