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A Two-Stage DEA–PROMETHEE II Framework for Fully Ranking Global Retail Firms in a Competitive Environment

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ABSTRACT

Objective: In the competitive global retail industry, achieving sustainable competitive advantage is a key factor for long-term success. This advantage arises when companies effectively utilize their unique resources and capabilities to outperform competitors. Operational efficiency and financial performance are critical for evaluating competitiveness and investment attractiveness. Data Envelopment Analysis (DEA) is a standard method for measuring efficiency, but classical DEA cannot fully rank efficient units. Integrating DEA with multi-criteria decision-making (MCDM) methods addresses this limitation, considering investor-relevant financial ratios. This study proposes a two-stage approach to evaluate and rank retail companies comprehensively.

Methodology: In the first stage, an input-oriented CCR model of DEA is applied, with assets, operating expenses, and the number of employees as inputs, and total revenue and net profit as outputs, to assess relative efficiency. In the second stage, financial indicators—asset turnover, dividend yield, return on equity (ROE), return on assets (ROA), and return on investment (ROI)—alongside DEA efficiency scores are evaluated using the PROMETHEE II method to generate a complete preference-based ranking of retailers.

Results: DEA in the first stage provides relative efficiency insights but cannot rank efficient units. Employing PROMETHEE II in the second stage, and considering financial ratios, overcomes this limitation and produces a comprehensive ranking. Validation against DEA, hybrid DEA–PROMETHEE II, and hybrid DEA–AHP rankings demonstrates a strong alignment of the results with the actual market positions of retailers.

Conclusion: The proposed method enables investors to identify high-performing companies and provides retailers with a strategic tool to monitor competitiveness, identify strengths and weaknesses, optimize resource allocation, and achieve a sustainable competitive advantage.

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Introduction

In today's volatile, uncertain, complex, and ambiguous (VUCA) environment, organizations must adopt strategies that focus on process innovation, enhancing customer experience, and leveraging advanced technologies to survive and maintain sustainable competitiveness. Such strategies not only improve operational efficiency but also increase financial returns and help secure long-term competitive advantage. In the retail industry, the financial performance of retailers—including revenue streams, profitability, return on investment, and market share relative to competitors—is recognized as a critical factor for maintaining competitive position. At the same time, operational efficiency, which encompasses the optimization of internal processes, cost reduction, and the effective use of resources, plays a crucial role in an organization's ability to respond quickly to market changes and mitigate operational risks. Recent studies have shown that companies able to combine high operational efficiency with strong financial performance not only sustain a stable competitive advantage but also create a positive perception among investors, facilitating long-term investment. Financial metrics such as return on equity (ROE), return on assets (ROA), return on investment (ROI), dividend yield, and asset turnover are key tools for measuring financial performance and predicting a company's capacity to generate sustainable value for investors and stakeholders.

In the literature, Data Envelopment Analysis (DEA) has been widely used to evaluate the operational efficiency of retailers. However, the classical DEA model cannot provide a complete ranking, as multiple units may be efficient simultaneously.

Moreover, a retailer may excel in terms of resource efficiency but not hold a favorable position in financial metrics. For example, a company may use its resources efficiently and achieve high operational efficiency but generate insufficient returns for shareholders (low ROE), or conversely, it may be highly profitable but operate with significant resource wastage. While high financial returns can be attractive, low operational efficiency may lead to reduced profitability and increased risk in the long term. Therefore, investors must carefully assess both dimensions to make informed decisions. By combining DEA with multi-criteria decision-making (MCDM) methods, different performance dimensions can be considered simultaneously.

The objective of this study is to develop a systematic framework for evaluating and fully ranking global retailers using a two-stage DEA–PROMETHEE II approach. This framework examines retailer performance across operational efficiency and financial dimensions, providing an analytical tool to support investors' decisions in selecting suitable investment options and guiding retail managers in choosing an appropriate business strategy.

The remainder of the paper is structured as follows: Section 2 reviews the related literature on evaluating retailer performance using DEA and other hybrid or two-stage methods, as well as the application of these methods in various contexts. Section 3 explains the proposed two-stage DEA–PROMETHEE II methodology. Section 4 applies the proposed method to rank ten selected global retailers, and finally, Section 5 concludes with findings and suggestions for future research.

Literature Background

In the literature, DEA models have been widely used to evaluate the relative efficiency of organizations, particularly retail companies. Sellers-Rubio and Mas-Ruiz (2007) examined the economic efficiency of chain supermarkets in the Spanish retail industry using DEA. They evaluated a sample of 100 chain supermarkets from 1995 to 2001, revealing high levels of economic inefficiency in Spain’s retail sector. Yu and Ramanathan (2008) applied three methods, i.e., DEA, the Malmquist Productivity Index (MPI), and a Tobit regression model, to assess the economic efficiency of 41 retail firms in the UK from 2000 to 2005. First, the MPI was used to analyze productivity changes over a six-year period. Then, DEA measured retailer efficiency considering two outputs (revenue and pre-tax profit) and three inputs (total assets, shareholders’ equity, and number of employees). Finally, the Tobit regression was used to test key hypotheses regarding the impact of environmental variables on UK retail performance. Mostafa et al. (2009) measured the performance of retail firms in Greece using both financial and non-financial dimensions. Financial performance was evaluated based on total sales, sales growth, and gross margin. In contrast, non-financial performance included market share, space productivity, and stock tenure, revealing a positive relationship between market orientation and retailer performance. Yadav et al. (2009) used BCC and CCR models of DEA to measure the efficiency of 29 e-retailers. De Jorge Moreno (2010) applied the BCC model of DEA to analyze retail efficiency in six European countries. Sharma and Choudhary (2011) studied 43 food retailers in India using DEA, with inputs including total warehouse area, number of sales devices, number and working hours of employees, and outputs such as sales volume and number of customers. Patel (2014) examined 46 retail stores in Delhi, India, using DEA. Takouda and Dia (2016) evaluated three Canadian hardware retailers using DEA with outputs of sales and profit and inputs of store numbers and employees. Le and Wang (2017) applied Grey DEA to measure efficiency in Vietnam’s apparel retail industry. Kou et al. (2021) used DEA to assess 32 family goods stores considering sales, number of buyers, store size, rent, and staff.

Regarding financial evaluation, Liu et al. (2018) evaluated retail performance in a competitive environment using DEA with metrics like asset turnover, receivables turnover, total assets, gross margin, and long-term return on equity. Putra and Muzakir (2020), using the input-oriented CCR model of DEA, assessed 10 global retailers with inputs of assets, operating costs, and number of employees, and outputs including total revenue, net profit, and financial ratios (asset turnover, dividend yield, ROE, ROA, ROI), identifying six efficient retailers that could not be thoroughly ranked.

To address the limitation of the classical DEA model, i.e., its inability to differentiate and rank efficient units, which are considered as first-generation ranking models, second-generation DEA models have been proposed in the literature, such as the super-efficiency models (Andersen & Petersen, 1993), cross-efficiency models (Sexton et al., 1986), target setting (Torgersen et al., 1996), dominance-based ranking (Bardhan et al.,1996), and reference-set perturbation ranking (Jahanshahloo et al., 2007), to name a few. The primary goal of these models is to overcome the problem of indistinguishable efficient units by extending the DEA framework itself, without relying on human judgment or external weighting. Adler et al. (2002) provided a comprehensive review of these DEA ranking models, with a particular focus on ranking efficient units.

There are also some other attempts to rank efficient units. For example, Khazaei and Izadbakhsh (2009) attributed the inability to rank efficient units to the large number of inputs and outputs. They proposed Principal Component Analysis (PCA) in combination with DEA for full ranking of decision-making units. Rakhshan and Alirezaee (2014) proposed two new nonlinear models: the first computes efficiency, and the second ranks the efficient DMUs, ensuring that these models always have a feasible solution.

Another approach for ranking efficient units is the use of multi-criteria decision-making (MCDM) methods. In the literature, hybrid or two-stage DEA–MCDM approaches are recognized as third-generation ranking models because they overcome the classical DEA limitation of simultaneously recognizing multiple efficient units. Furthermore, they leverage external weighting and human preference through MCDM. The first attempt to rank efficient units using third-generation ranking models is attributed to Sinuany-Stern et al. (2000), who combined the strengths of DEA and AHP to propose the hybrid DEA-AHP method for ranking efficient units. In this approach, the relative efficiency of decision-making units (DMUs) was compared pairwise to construct a comparison matrix. Alirezaee and Rafiei Sani (2010) identified limitations in Sinuany-Stern et al.'s (2000) method and proposed an improved hybrid DEA-AHP model for ranking efficient units. Later, Alirezaee et al. (2012) introduced the cross-efficiency DEA-AHP hybrid approach, which focuses on inefficient units surrounding efficient ones and reduces computational complexity compared to the previous model proposed by the authors. To reduce pairwise comparisons, Tavana et al. (2025) used a BWM-DEA hybrid method for ranking efficient units.

Exploiting the preference ranking property of PROMETHEE II as an MCDM method, Bagherikahvarin et al. (2016) applied the DEA-PROMETHEE II hybrid method to evaluate the solid waste management system in Finland. In this method, a DEA model is employed for each pair of DMUs, and the resulting pairwise comparison matrix is used in PROMETHEE II to produce a complete ranking. Bagherikahvarin et al. (2019) applied DEA-PROMETHEE II with a CCR approach to evaluate the locations for 12 stores in Belgium, producing a complete ranking of candidate sites. Mahad et al. (2021) evaluated the efficiency and ranked 22 life insurance companies in Malaysia from 2017 to 2018 using DEA-PROMETHEE II. In this approach, after identifying efficient units via DEA, PROMETHEE II was used for complete ranking based on inputs (fees, commissions, management costs) and outputs (net costs, investment income). Mohd Rashid et al. (2023) employed DEA-PROMETHEE II to assess and fully rank water supply services for 14 Malaysian states in 2017.

In addition to the hybrid DEA-MCDM methods mentioned above, two-stage or multi-stage DEA-MCDM methods have been proposed for different applications in the literature. Duman (2019) developed an approach to measure the performance of 20 grocery stores in the United States using a combination of Fuzzy AHP, DEA, and TOPSIS. In this approach, Fuzzy AHP was used to determine the weights of qualitative criteria (product quality, operational monitoring, food safety), DEA was employed to evaluate service performance, and TOPSIS was applied to rank the stores. Alidrisi et al. (2021) employed a two-stage DEA-PROMETHEE II approach to evaluate the productivity of nine logistics warehouses within an international automotive and spare parts company in Saudi Arabia. In this method, the effectiveness scores from PROMETHEE II were combined with the efficiency scores obtained from DEA, yielding final productivity scores that represent the overall performance of each distribution center. Rouyendegh et al. (2020) evaluated the performance of the retail sector in Turkey by combining the TOPSIS and DEA methods. In this approach, the TOPSIS output for each decision-making unit was treated as an output in DEA. In other words, after calculating the TOPSIS score or ranking for each retailer, that value was used as an output in the DEA model. Karasakal et al. (2022) applied a two-stage DEA–PROMETHEE method to rank 100 business management programs across 20 criteria, where the results of DEA were used to determine the weights in PROMETHEE.

Two-stage or multi-stage DEA-MCDM approaches have also been proposed in the literature to incorporate multiple dimensions in evaluating decision-making units. Okur and Ercan (2023) employed a two-stage DEA-AHP method, in which the first stage used DEA to evaluate the efficiency of clothing retailers in Turkey, considering the number of employees as an input and pre-tax profit as an output. Then, the Analytic Hierarchy Process (AHP) was applied to rank qualitative criteria, such as customer satisfaction, employee competence, and branding, which influence retailers' efficiency. The two-stage DEA-PROMETHEE II method was applied by Jalalvand et al. (2011) to evaluate supply chains across seven meat industry centers in Iran. In this study, efficiency was calculated using DEA, and alongside criteria such as flexibility, reliability, customer responsiveness, agility, cost, and asset management, the supply chains were ranked.

The latter idea, which utilizes two-stage MCDM methods to incorporate multiple dimensions into ranking decision-making units, is adopted in this paper to rank global retailers from both efficiency and financial standpoints comprehensively. A summary of the reviewed studies is presented in Table 1.

Table 1. Related Literature

Authors (Year)	Evaluation Method	Application Area
Use of DEA to evaluate retail companies		
Ramanathan et al. (2008)	DEA	Performance evaluation of 41 retail companies in the UK
Sharma & Choudhary (2011)	DEA	Efficiency analysis of 43 retail outlets in India
Patel et al. (2014)	DEA	Efficiency evaluation of 46 retail stores in Delhi
Le & Wang (2017)	DEA	Efficiency assessment of the garment industry in Vietnam
Gandhi et al. (2014)	DEA	Efficiency evaluation of 18 retail companies in India
Dia & Takouda (2016)	DEA	Efficiency assessment of 3 hardware retail companies in Canada
Liu et al. (2018)	DEA	Competitive factor analysis of 24 retailers in European countries
Kou et al. (2017)	DEA	Efficiency evaluation of 32 retail stores
Pande et al. (2020)	DEA	Efficiency assessment of clothing retailers
Putra et al. (2020)	DEA	Evaluation of top global retailers
Use of DEA–PROMETHEE II in various fields		
Jalalvand et al. (2011)	Two-stage DEA–PROMETHEE II	Supply chain evaluation in Iran
Bagherikahvarin (2016)	DEA–PROMETHEE II	Solid waste management system evaluation in Finland and urban welfare assessment in Belgian cities
Bagherikahvarin (2019)	DEA–PROMETHEE II	Evaluation of hypermarket locations in Belgium
Karasakal et al. (2022)	Two-stage DEA–PROMETHEE II	Ranking of business management programs
Mahad et al. (2021)	DEA–PROMETHEE II	Efficiency assessment and ranking of 22 life insurance companies in Malaysia
Alidrisi et al. (2021)	Two-stage DEA–PROMETHEE II	Performance evaluation of 9 logistics warehouses in an international automotive and spare parts company in Saudi Arabia
Rashid Mohd et al. (2023)	DEA–PROMETHEE II	Efficiency assessment and ranking of water supply services in Malaysia
Present study	Two-stage DEA–PROMETHEE II	Evaluation of global retailers considering operational efficiency and financial performance

Most studies in the field of retailer ranking have been conducted using the DEA method, which is based solely on relative efficiency criteria. Only a few studies have examined the combination of DEA with other multi-criteria decision-making (MCDM) methods for evaluating retailers. The results of previous research indicate that the two-stage DEA–PROMETHEE II method, which considers multiple performance dimensions, can effectively combine DEA efficiency analysis with the preference-based ranking capability of PROMETHEE II to rank efficient units fully. This feature enhances managerial analysis and decision-making by making them more accurate and reliable.

In the present study, a two-stage approach is proposed: the DEA technique is employed in the first stage to assess efficiency, and the PROMETHEE II method is applied in the second stage to complete the ranking of global retail companies based on operational efficiency and financial performance criteria. This analytical framework can help retailers achieve a sustainable competitive advantage by enhancing efficiency and financial performance, while also assisting investors in selecting the most suitable investment options.

Materials and Methods

Problem Statement

Large international retailers play a critical role in global markets and supply chains. The performance of these companies directly impacts profitability, market share, and, consequently, investment attraction, making competitive analysis essential for informed strategic decision-making and effective resource allocation. Operationally efficient companies can reduce costs, thereby increasing profit margins. This not only improves financial performance but also helps create a sustainable competitive advantage.

Capital productivity indicators, such as Return on Equity (ROE), Return on Assets (ROA), Return on Investment (ROI), and asset turnover ratio, are practical tools for assessing a company’s financial performance. These capital productivity metrics show how efficiently a company uses its financial resources and assets to generate profit and return, and whether the capital provided by shareholders and creditors is being converted into returns in the most effective manner. Such indicators enable investors to make more informed decisions about investments in retail companies. If a company fails to manage its capital efficiently, its growth becomes limited, which negatively affects market value and stock returns.

Moreover, investors typically seek companies that not only demonstrate strong financial performance (capital productivity) but also possess high operational efficiency. Such companies can respond more flexibly to market changes and deliver sustainable long-term returns. In a recent study, Görçün and colleagues (2025) ranked retailers based on a set of key financial ratios, identifying the position of each company relative to its competitors. Evaluating retailers using financial criteria not only allows for the identification of high-performance retailers and their financial weaknesses but also provides an important tool for managerial decision-making, improving operational strategies, and capturing a clear view of the competitive situations.

In the present study, the performance of ten leading global retailers is evaluated and ranked in terms of operational efficiency, capital productivity, and return on investment. Among them, Walmart, as the world's largest traditional retailer with an extensive network of physical stores and a vast supply chain, despite holding the top position in scale, sales volume, and total revenue, demonstrates weaker performance in terms of return on equity compared to some digital competitors such as Amazon and Alibaba. Alibaba, due to its technology-based business model, ranks higher than traditional retailers on capital productivity indicators, although its asset turnover ratio is lower. In contrast, companies like Costco and Home Depot, with a focus on operational efficiency and optimized supply chain management, have been able to deliver more stable financial performance. Overall, the analysis emphasizes that scale or market leadership alone does not guarantee efficiency or capital productivity, and a comprehensive evaluation of financial indicators is essential for informed decision-making by investors and business policymakers.

Despite the importance of capital productivity and return on investment indicators, due to the relative nature of these metrics and their dependence on specific inputs and outputs, they cannot be simultaneously incorporated into a DEA model. Therefore, this study employs a two-stage approach. In the first stage, the relative efficiency of retailers is calculated based on inputs, including assets, operating costs, and the number of employees, as well as outputs such as total revenue and net profit. In the second stage, retailers are ranked based on capital productivity and return on investment indicators (as defined in Table 2), alongside their efficiency scores. Another advantage of the two-stage approach, in addition to incorporating relative indicators, is that it overcomes the limitation of the classical DEA model, which cannot provide a complete ranking of decision-making units (in this case, retailers).

Table 2. Definition of Retailer Ranking Indicators

Category	Indicator	Definition
Input Criteria	Assets	Resources with economic value owned by individuals, companies, or governments are expected to generate future benefits.
	Operating Costs	Expenses incurred to maintain, operate, and manage a business.
	Number of Employees	Individuals working for an organization (office, company, etc.) with a specified salary.

Output Criteria	Total Revenue	Income generated from the everyday activities of an entity.
	Net Profit	Profit obtained after deducting taxes.
Capital Efficiency Indicators	ROE (Return on Equity)	Measures a company's efficiency in generating net profit for shareholders; indicates net profit per unit of shareholder investment.
	ROA (Return on Assets)	Shows how much net profit is generated per unit of assets.
	ROI (Return on Investment)	Reflects profit obtained relative to cost, indicating how efficiently resources are used to achieve desired outputs.
	Asset Turnover Ratio	Calculated by dividing sales by total assets, this ratio shows the sales generated per dollar of assets.
Capital Return Indicators	Dividend Yield	Amount of cash flow received per unit of money invested in shares.

Two-Stage DEA-PROMETHEE II Method

The DEA-PROMETHEE II ranking method operates in two stages. In the first stage, the DEA method is used to evaluate the relative efficiency of each retailer compared to other retailers, considering the income and profit generated relative to the resources employed. In the second stage, the PROMETHEE II method is applied to provide a complete ranking of the retailers.

- **First Stage: Using the DEA Model to Calculate Retailers' Efficiency**

The DEA model used is the input-oriented CCR multiplicative model (Charnes et al., 1978), in which the indices n, s, and m represent the number of decision-making units (DMUs), the number of inputs, and the number of outputs, respectively. The indices i and r correspond to the inputs and outputs, while the index o denotes the decision-making unit under evaluation (DMU_o). Here, x_{io} represents the i-th input and y_{ro} represents the r-th output of the DMU under consideration. V_i and U_r denote the weight coefficients associated with the i-th input vector and r-th output vector, respectively. The optimal efficiency of the DMU under evaluation (EO) is obtained by solving the following model:

$$MAX \quad E_o = \sum_{r=1}^{S} U_r Y_{ro} \tag{1}$$

s.t.

$$\sum_{i=1}^{m} V_i X_{io} = 1 \tag{2}$$

$$\sum_{r=1}^{S} U_r Y_{rj} - \sum_{i=1}^{m} V_i X_{ij} \leq 0 \quad , j = 1,2, \dots , n \tag{3}$$

$$U_r \, , V_i \geq 0 \text{ و } i = 1,2, \dots , m \text{ و } r = 1,2, \dots , s$$

In the CCR model, each decision-making unit (DMU) under evaluation seeks to find the weight vectors for inputs and outputs such that the weighted sum of outputs is maximized (objective function (1)), subject to the condition that the weighted sum of inputs for the DMU under evaluation equals one (constraint (2)), and for all other DMUs, the ratio of the weighted sum of outputs to the weighted sum of inputs does not exceed one (constraint (3)).

- **Second Stage: Implementation of the PROMETHEE II Method**

The PROMETHEE method is a multi-criteria decision-making (MCDM) approach that enables the comparison and ranking of alternatives (in this case, retailers) based on multiple criteria by calculating positive and negative preference flows for each alternative. Taherdoost et al. (2023) provide a comprehensive review of PROMETHEE applications. Specifically, in the context of financial evaluation of retailers, Cilek and Seyranlıoğlu (2024) applied the PROMETHEE method to assess the financial performance of companies operating in the retail sector of the Istanbul Stock Exchange (BIST) from 2022 to 2023.

The following outlines the steps for implementing the PROMETHEE II method.

- **Step 1: Pairwise Comparison of Alternatives and Construction of the Preference Matrix**

In this method, the alternatives are compared pairwise for each criterion, and a preference matrix is constructed using the usual preference function. Specifically, if the difference in evaluation between two alternatives on a given criterion is positive, the preference value is considered 1; otherwise, it is 0 (Vincke & Brans, 1985).

- **Step 2: Determination of the Cumulative Preference Index**

To determine the overall preference of alternative a over alternative b across all criteria, Equation (4) is used, where:

$$\pi(a,b) = \sum_{j=1}^{k} w_j \, . P_j(a,b) \tag{4}$$

Here:

- $\pi(a,b)$ represents the overall preference of alternative a over b across all criteria.
- $P_j(a,b)$is the preference of a over b with respect to criterion j.
- w_j is the weight or importance of criterion j.
- k is the total number of criteria.

The higher the value of $\pi(a,b)$, the stronger the preference for alternative a over b. Each retailer (DMU) is then ranked based on a comprehensive view of performance across all criteria.

- **Step 3: Calculating the Outgoing ($\varphi^{+}(a)$) and Incoming ($\varphi^{-}(a)$) flows for alternative *a***

In this step, the preference of each alternative over all other alternatives, as well as the preference of all other alternatives over the considered alternative, is determined.

- **Outgoing flow (Φ^{+})**: This is the positive ranking flow, representing how much the alternative ***a*** dominates other alternatives.
- **Incoming flow (Φ^{-})**: This is the negative ranking flow, representing how much other alternatives dominate the alternative a.

$$\varphi^{-}(a) = \frac{1}{n-1}\sum_{x\in A}\pi(x,a) \tag{5}$$

$$\varphi^{+}(a) = \frac{1}{n-1}\sum_{x\in A}\pi(a,x) \tag{6}$$

- **Step 4: Calculating the Net Flow and Complete Ranking of Alternatives**

To achieve a complete ranking of alternatives, the net flow, which represents the balance between the positive (outgoing) and negative (incoming) ranking flows, is calculated using equation (7). A higher net flow indicates a superior alternative, allowing the alternatives (e.g., retailers) to be thoroughly ranked from best to worst.

$$\varphi(a) = \varphi^{+}(a) - \varphi^{-}(a) \tag{7}$$

In the proposed PROMETHEE II method, the retailers' ranking is based on the overall balance among efficiency, capital productivity, and return on investment criteria. This approach provides a more realistic and comprehensive picture of the overall performance of the companies.

Results

Research Data

In this section, the two-stage DEA-PROMETHEE II method is applied to evaluate the performance of 10 major global retail companies, such as Walmart, Amazon, and others. The retail companies studied in this research are listed in Table 3. The data for these companies were obtained from financial reports published on the website investing.com.

Table 3. Overview of the Companies under Study

DMU	Company	Country	Industry
1	Walmart	United States	Retail (Consumer Goods & Groceries)
2	Amazon.com Inc	United States	E-commerce Retail (Electronics & General Merchandise)
3	Carrefour SA	France	Retail (Groceries)
4	Tesco PLC	United Kingdom	Retail (Groceries)
5	Costco	United States	Retail (General Merchandise)
6	Walgreens Boots Alliance Inc	United States	Retail (Pharmaceutical & Health Products)
7	Kroger Company	United States	Retail (Groceries)
8	Home Depot Inc	United States	Retail (Home Improvement)
9	JD.com Inc ADR	China	E-commerce Retail (Electronics & General Merchandise)
10	Alibaba Group Holdings Ltd ADR	China	E-commerce Retail (Multi-category Platform)

In this study, criteria such as assets, operating costs, and the number of employees are used as inputs. At the same time, total revenue and net profit are considered as outputs in the Data Envelopment Analysis (DEA) model. Capital efficiency and return on investment criteria, including Return on Equity (ROE), Return on Assets (ROA), Return on Investment (ROI), Dividend Payout Ratio, and Asset Turnover Ratio, are considered alongside efficiency scores for the complete ranking of retailers using the PROMETHEE II method. The values of these criteria for the retail companies under study are presented in Tables 4 and 5.

Table 4. Input Data of the Retail Companies under Study

Number of Employees	Operating Costs (in million USD)	Assets (in million USD)	Retail Company	DMU
2,200,000	136,349	239,830	Walmart	1
798,000	83,557	225,248	Amazon.com Inc	2
321,383	40,475	55,064	Carrefour SA	3
464,505	38,447	70,758	Tesco PLC	4
149,000	35,979	51,431	Costco	5
232,000	34,339	90,807	Walgreens Boots Alliance Inc	6
435,000	27,720	45,393	Kroger Company	7
415,700	23,276	52,309	Home Depot Inc	8
178,927	24,060	36,725	JD.com Inc Adr	9
116,519	17,236	186,577	Alibaba Group Holdings Ltd ADR	10

Table 5. Output Data of the Retail Companies under Study

ROE (%)	ROA(%)	ROI (%)	Asset Turnover Ratio (%)	Dividend Yeild Ratio (%)	Net Profit (million USD)	Total Revenue (million USD)	Retail company	DMU
20.22	6.67	10.61	2.30	1.68	3,288	127,991	Walmart	1
21.95	5.98	10.01	1.45	17.20	3,268	87,436	Amazon.com Inc	2
0.33	0.44	0.91	1.51	3.26	1,719	41,611	Carrefour SA	3
9.71	2.28	3.65	1.12	3.93	405	39,864	Tesco PLC	4
24.59	8.29	16.61	3.46	0.84	884	37,040	Costco	5
14.41	4.38	6.67	1.73	4.21	884	34,339	Walgreens Boots Alliance Inc	6
19.91	3.63	5.50	2.93	2.00	263	27,974	Kroger Company	7
79.26	23.61	37.38	2.31	3.02	2,769	27,223	Home Depot Inc	8
17.21	5.07	13.81	2.46	17.20	514	24,135	JD.com Inc Adr	9
28.54	15.36	22.16	0.44	17.20	7,397	22,830	Alibaba Group Holdings Ltd ADR	10

Analysis of Results

The first step in implementing the two-stage DEA-PROMETHEE II method is applying the DEA approach to calculate the relative efficiency scores of each retailer. The efficiency values and ranking of the retailers are presented in Table 7. In the second stage, the multi-criteria decision-making method PROMETHEE II is applied. The cumulative preference index matrix and the values of the inflow and outflow for each retailer are presented in Table 6. The results obtained from the DEA method and the two-stage DEA-PROMETHEE II approach are summarized in Table 7.

Table 6. Cumulative Preference Index Matrix and Inflow/Outflow Values Using PROMETHEE II

	i1	i2	i3	i4	i5	i6	i7	i8	i9	i10	outflow
i1		0.501	0.668	0.668	0.167	0.668	0.501		0.334	0.167	3.674
i2	0.501		0.668	0.835	0.167	0.835	0.668	0.167	0.334	0.167	4.342
i3	0.334	0.334		0.334	0.167	0.167	0.334	0.167	0.167	0.167	2.171
i4	0.334		0.668		0.167	0.167	0.167	0.167		0.167	1.837
i5	0.835	0.835	0.668	0.835		0.835	0.835	0.167	0.835	0.167	6.012
i6	0.334	0.167	0.835	0.835	0.167		0.501	0.167		0.167	3.173
i7	0.501	0.167	0.668	0.668	0.167	0.501		0.167	0.334	0.167	3.34
i8	1.002	0.835	0.668	0.835	0.668	0.835	0.835		0.668	0.668	7.014
i9	0.668	0.501	0.835	1.002	0.167	1.002	0.668	0.334		0.167	5.344
i10	0.835	0.668	0.668	0.835	0.668	0.835	0.835	0.167	0.668		6.179
Inflow	5.344	4.008	6.346	6.847	2.505	5.845	5.344	1.503	3.34	2.004	

Table 7. Results of DEA and Two-Stage DEA-PROMETHEE II Methods

Final Rank by two-stage DEA-PROMETHEE II	Net flow in two-stage DEA-PROMETHEE II	DEA Rank	DEA Efficiency	Retailer	DMU
6	-1.67	5	0.86	Walmart	1
5	0.334	3	0.94	Amazon.com Inc	2
9	-4.175	1	1	Carrefour SA	3
10	-5.01	3	0.94	Tesco PLC	4
3	3.507	1	1	Costco	5
8	-2.672	4	0.92	Walgreens Boots Alliance Inc	6
7	-2.004	3	0.94	Kroger Company	7
1	5.511	1	1	Home Depot Inc	8
4	2.004	2	0.95	JD.com Inc Adr	9
2	4.175	1	1	Alibaba Group Holdings Ltd ADR	10

As observed, the rankings obtained from DEA and the two-stage DEA-PROMETHEE II method are not necessarily identical, although they are generally aligned in most cases. Retail companies such as Home Depot, Alibaba, and Costco occupy the first, second, and third ranks, respectively. In contrast, the DEA method considers all three to be fully efficient, making no distinction between their ranks. These companies also perform well in terms of capital productivity criteria.

Carrefour, despite being efficient in DEA, has weak capital productivity criteria and, consequently, has a lower investment attractiveness ranking. By removing this alternative from the first rank, JD is placed fourth after the three efficient companies, which aligns with the DEA ranking. Next in the ranking is Amazon, which also aligns with the DEA results. Tesco, compared to Walmart, has lower capital productivity criteria, so Walmart is placed sixth. Finally, Kroger and Walgreens are ranked slightly differently, with a one-rank difference compared to the DEA model. The main ranking discrepancies occur for Carrefour and Tesco due to their relatively low capital productivity criteria.

Validation of the two-stage DEA-PROMETHEE II method against the DEA-AHP hybrid method

For validation purposes, the two-stage DEA-PROMETHEE II method was compared with the cross-efficiency DEA-AHP hybrid method proposed by Alirezai et al. (2012) to examine ranking distinctions among decision-making units more precisely.

In the cross-efficiency DEA-AHP hybrid method, the first step involves using DEA to construct the pairwise comparison matrix. Specifically, to form the cross-efficiency matrix, all units are first evaluated using the CCR multiplicative model considering the inputs of assets, operating costs, and number of employees, along with the outputs of revenue and net profit. The optimal weights are then extracted from this model. The entry in row t and column k of the cross-efficiency matrix represents the efficiency score of unit t calculated using the optimal weights of unit k.

Next, using equation (8), the AHP pairwise comparison matrix is formed, and the weights of the retailers are calculated to produce a complete ranking of the units. The results obtained from the cross-efficiency DEA-AHP hybrid method are presented in Table 9.

$$a_{ij}=\frac{\theta_i^i+\theta_j^i}{\theta_j^j+\theta_i^j} \quad i,j=1,\ldots,n \quad ,a_{ii}=1\,,a_{ij}=\frac{1}{a_{ji}} \tag{8}$$

Table 9. Cross-Efficiency Matrix

	i1	i2	i3	i4	i5	i6	i7	i8	i9	i10
i1	0.860	0.844	1.000	0.939	0.991	0.812	0.942	1.001	0.952	0.523
i2	0.823	0.941	0.970	0.935	0.999	0.920	0.890	1.000	0.946	1.000
i3	0.482	0.580	1.001	0.472	0.945	0.523	0.429	1.001	0.728	0.999
i4	0.854	0.863	1.000	0.941	1.000	0.833	0.933	1.000	0.956	0.573
i5	0.670	0.533	1.000	0.737	1.000	0.528	0.769	0.666	0.883	0.177
i6	0.824	0.942	0.971	0.936	1.001	0.921	0.892	1.001	0.947	1.001
i7	0.858	0.842	0.998	0.937	0.989	0.810	0.939	0.998	0.950	0.521
i8	0.483	0.582	1.004	0.474	0.949	0.525	0.430	1.003	0.731	1.003
i9	0.854	0.863	1.000	0.941	1.000	0.833	0.933	1.000	0.956	0.573
i10	0.056	0.091	0.099	0.025	0.055	0.057	0.022	0.277	0.050	0.999

Table 10. Pairwise Comparisons

	i1	i2	i3	i4	i5	i6	i7	i8	i9	i10
i1	1.000	0.966	1.254	1.003	1.108	0.958	1.002	1.252	1.001	1.311
i2	1.035	1.000	1.208	1.040	1.265	0.998	1.028	1.224	1.037	1.780
i3	0.797	0.828	1.000	0.759	0.973	0.805	0.738	0.998	0.884	1.822
i4	0.997	0.962	1.317	1.000	1.117	0.955	0.999	1.314	1.000	1.479
i5	0.902	0.790	1.028	0.895	1.000	0.795	0.918	0.854	0.963	1.117
i6	1.044	1.002	1.242	1.047	1.258	1.000	1.036	1.258	1.044	1.820
i7	0.998	0.973	1.355	1.001	1.090	0.965	1.000	1.351	1.000	1.430
i8	0.799	0.817	1.002	0.761	1.172	0.795	0.740	1.000	0.886	1.573
i9	0.999	0.964	1.131	1.000	1.039	0.958	1.000	1.128	1.000	1.458
i10	0.763	0.562	0.549	0.676	0.895	0.549	0.699	0.636	0.686	1.000

Table 11. Results of the Combined AHP-DEA Method

DMU	i1	i2	i3	i4	i5	i6	i7	i8	i9	i10
Weight	0.107	0.113	0.092	0.109	0.091	0.114	0.109	0.092	0.105	0.069
RANK	5	2	8	4	9	1	3	7	6	10

To enable a more precise comparison between the proposed two-stage method and the hybrid approach, instead of using the AHP method in the cross-efficiency hybrid approach proposed by Alirezai et al. (2012), the PROMETHEE II method is employed. In this way, based on the cross-efficiency matrix obtained in the first stage, pairwise comparisons of the alternatives are conducted for each criterion. The preference matrix and the input/output flows are then calculated, and finally, the retailers are ranked based on the net flow. The results of the hybrid DEA-PROMETHEE II method are presented in Tables 12 and 13.

Table 12. Preference Matrix of alternatives in the hybrid DEA-PROMETHEE II Method

	i1	i2	i3	i4	i5	i6	i7	i8	i9	i10	OUTFLOW
i1		0.021	0.518	0.085	0.321		0.083	0.517	0.098	0.466	2.110
i2			0.390	0.072	0.466		0.048	0.418	0.083	0.909	2.387
i3										0.900	0.900
i4			-0.528		0.263			0.526	0.015	0.548	0.824
i5			-0.055							0.122	0.067
i6	-0.012	-0.023	-0.449	-0.103	-0.473		0.082	0.476	0.114	0.944	0.556
i7			-0.569	-0.004	-0.220			0.568	0.017	0.499	0.290
i8			-0.003		-0.283					0.726	0.441
i9			-0.272		-0.117			-0.270		0.523	-0.136
i10											0.000
IN FLOW	-0.012	-0.002	-0.967	0.050	-0.043	0.000	0.214	2.236	0.325	5.638	

Table 13. Ranking of the Hybrid DEA-PROMETHEE II Method Based on Net Flow

DMU	i1	i2	i3	i4	i5	i6	i7	i8	i9	i10
Net flow	2.122	2.388	1.867	0.774	0.110	0.556	0.077	-1.795	-0.462	-5.638
Rank	2	1	3	4	6	5	7	9	8	10

In Table 14, the rankings obtained from the proposed two-stage DEA-PROMETHEE II method are compared with those from the DEA method, the cross-efficiency hybrid DEA-AHP method, and the hybrid DEA-PROMETHEE II method.

Table 14. Comparison of rankings from different methods

DMU	Retailers	Hybrid DEA+AHP	Hybrid DEA-PROMETHEE II	DEA	Two-stage DEA-PROMETHEE II
1	Walmart	5	2	5	6
2	Amazon.com Inc	2	1	3	5
3	Carrefour SA	8	3	1	9
4	Tesco PLC	4	4	3	10
5	Costco	9	6	1	3
6	Walgreens Boots Alliance Inc	1	5	4	8
7	Kroger Company	3	7	3	7
8	Home Depot Inc	7	9	1	1
9	JD.com Inc Adr	6	8	2	4
10	Alibaba Group Holdings Ltd ADR	10	10	1	2

As observed in Table 14, the classic DEA method cannot provide a complete ranking because four units receive the same efficiency score. However, the proposed two-stage DEA-PROMETHEE II method provides a comprehensive ranking of the retailers, demonstrating greater alignment with the DEA results. For example, Alibaba ranks last in the hybrid AHP-DEA method and in the hybrid DEA-PROMETHEE II method. In contrast, the DEA method and the proposed two-stage DEA-PROMETHEE II method rank it first or second, which is more consistent with its actual market position.

Conclusion

In this study, leading global retailers were evaluated and ranked considering input resources (assets, operating costs, and number of employees), outputs (total revenue and net profit), and capital productivity and return on investment criteria. Since capital productivity and return on investment criteria are relative and dependent on specific inputs and outputs, they cannot all be incorporated into a single DEA model. Therefore, they were used as supplementary criteria in the second stage to achieve a complete ranking of retailers and to differentiate between efficient units using the two-stage DEA-PROMETHEE II approach. The results showed that Home Depot, as a traditional retailer, and Alibaba, as an online business model retailer, ranked first and second, respectively. Although Home Depot performs poorly in terms of dividend return compared to Alibaba, JD.com, and Amazon, it secured the top rank because of its high capital productivity criteria. The DEA method does not distinguish between ranks of efficient units. Comparison of the two-stage DEA-PROMETHEE II results with the hybrid AHP-DEA method and the hybrid DEA-PROMETHEE II method reported in the literature demonstrates that the proposed two-stage approach aligns more closely with DEA results and better reflects actual market positions. By employing the PROMETHEE II multicriteria decision-making method in the second stage, the proposed approach provides a complete ranking that balances all influential performance criteria. This ranking enables investors to identify companies with higher efficiency and better returns relative to their resources, facilitating informed investment decisions. Managers of these organizations can also compare their performance with that of top performers, implement improvement strategies, develop new markets, innovate, and allocate resources optimally to maintain or enhance their competitive position. It should be noted that the ranking in this study provides a high-level comparison of operational and financial efficiency, and does not represent an absolute ranking of the best retailers in all dimensions. Investors should also consider other factors such as risk, future growth, and market conditions. For future research, alternative DEA approaches, such as two-stage or three-stage DEA, or combinations with other multicriteria methods, including ELECTRE, DEMATEL, and ANP, are recommended.

Data Availability Statement

Data have been inserted in the paper.

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Ethical considerations

This study uses only publicly available secondary financial data and involves no human participants, so no ethical approval was required. All analyses were conducted transparently, and all sources were cited correctly to ensure academic integrity and avoid bias.

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Conflict of interest

The author declares no potential conflict of interest regarding the publication of this work.

References

Abbasi, M., & Kaviani, M. A. (2016). Operational efficiency-based ranking framework using uncertain DEA methods: An application to the cement industry in Iran. *Management Decision, 54*(4), 902–928. https://doi.org/10.1108/MD-09-2015-0413

Adler, N., Friedman, L., & Sinuany-Stern, Z. (2002). Review of ranking methods in the data envelopment analysis context. *European Journal of Operational Research*, *140*(2), 249–265.

https://doi.org/10.1016/S0377-2217(02)00068-1

Alidrisi, H. (2021). DEA-Based PROMETHEE II Distribution-Center Productivity Model: Evaluation and Location Strategies Formulation. Appl. Sci. *11*, 9567. https://doi.org/10.3390/app11209567

Alirezayee, M. R., & Rafiee Sani, M. R. (2010). A development on AHP/DEA methodology for ranking decision making units. *Industrial Management Journal*, *2(2): 5*, 83–184.

Alirezaee, M., Rakhshan, S. A. & Rafiee Sani, M. (2012). Cross AHP/DEA method for ranking Decision Making Units. *Industrial Management Journal*, *4*(1), 51–68. 10.22059/IMJ.2012.72259

Andersen, P., Petersen, N.C. (1993). A procedure for ranking efficient units in data envelopment analysis. *Management Science*, 39: 1261–1264. https://doi.org/10.1287/mnsc.39.10.1261

Bagherikahvarin, M., & de Smet, Y. (2016). A ranking method based on DEA and PROMETHEE II. *Measurement: Journal of the International Measurement Confederation*, *89, 333–342*.

https://doi.org/10.1016/j.measurement.2016.04.026

Bagherikahvarin, M. (2019). A DEA-Promethee approach for complete ranking of units. *International Journal of Operational Research*, *35*(2), 224–244. https://doi.org/10.1504/IJOR.2019.100726

Bardhan, I., Bowlin, W. F., Cooper, W. W., & Sueyoshi, T. (1996). Models for efficiency dominance in data envelopment analysis. Part I: Additive models and MED measures. *Journal of the Operations Research Society of Japan*, *39*, 322–332. DOI: 10.15807/jorsj.39.322

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

Cilek, A., & Seyranlıoğlu, O. (2024). Portfolio Optimization with Entropy-CRITIC-IDDWS-PROMETHEE Model in BIST Retail Trade Sector. *International Journal of Economics and Financial Issues*, *14*(6), 23. https://doi.org/10.32479/ijefi.16982

Jorge Moreno, J. (2010). Productivity Growth of European Retailers: A Benchmarking Approach. *Journal of Economic Studies*, *37*(3), 288–313. https://doi.org/10.1108/01443581011061285

Duman, G.M. (2019).Intelligent Multi-Attribute Decision Making Applications: Decision Support Systems for Performance Measurement, Evaluation and Benchmarking. University of Bridgeport ProQuest Dissertations & Theses.

Gupta, A., & Mittal, S. (2010). Measuring retail productivity of food & grocery retail outlets using the DEA technique. *Journal of Strategic Marketing*, *18*(4), 277–289. https://doi.org/10.1080/09652540903537055

Gandhi, A., & Shankar, R. (2014). Efficiency measurement of Indian retailers using Data Envelopment Analysis. *International Journal of Retail and Distribution Management*, *42*(6), 500–520. https://doi.org/10.1108/IJRDM-10-2012-0094

Görçün, Ö. F., Shabir, M., Çalık, A., & Işık, Ö. (2025). Evaluation of the Financial Performance of the Textile and Apparel Industry in interval type-2 fuzzy environment. *Applied Soft Computing*, 113830. https://doi.org/10.1016/j.asoc.2025.113830

Jahanshahloo, G.R., Junior, H.V., Lotfi, F.H., Akbarian, D. (2007). A new DEA ranking system based on changing the reference set. *European Journal of Operational Research, 181*(1): 331–337. https://doi.org/10.1016/j.ejor.2006.06.012

Jalalvand, F., Teimoury, E., Makui, A., Aryanezhad, M. B., & Jolai, F. (2011). A method to compare supply chains of an industry. *Supply Chain Management*, *16*(2), 82–97. https://doi.org/10.1108/13598541111115347

Karasakal, E., Eryılmaz, U., & Karasakal, O. (2022). Ranking using PROMETHEE when weights and thresholds are imprecise: A data envelopment analysis approach. *Journal of the Operational Research Society, 73(9), 1978-1995.* https://doi.org/10.1080/01605682.2021.1963195

Khazaei, M., & Izadbakhsh, H. R. (2009). Combination of DEA and PCA for Full Ranking of Decision Making Units. *Industrial Management Journal*, *1*(2).

Le, T. N., & Wang, C. N. (2017). The integrated approach for sustainable performance evaluation in value chain of vietnam textile and apparel industry. *Sustainability (Switzerland)*, *9*(3), 477. https://doi.org/10.3390/su9030477

Liu, J., Gong, Y. (Yale), Zhu, J., & Zhang, J. (2018). A DEA-based approach for competitive environment analysis in global operations strategies. *International Journal of Production Economics*, *203,* 110–123. https://doi.org/10.1016/j.ijpe.2018.05.029

Mahad, N. F., Aziz, N. A. A., Amin, F. A. M., & Mahyideen, J. M. (2021). An Integrated DEA and PROMETHEE II Method for Complete Ranking: An Application in Life-Insurance Sector. *International Journal of Academic Research in Business and Social Sciences*, *11*(10), 982 – 992. http://dx.doi.org/10.6007/IJARBSS/v11-i10/11123

Mohd Rashid, N. R., Huza, D. R. N. M., Naem, A. M., & Fauzan, F. A. S. (2023). Efficiency Measurement and Ranking of Water Supply Service Malaysia by Using Hybrid DEA and PROMETHEE II Method. In *4th International Conference on the Future of Asean 2022 (ICoFA, 2023)* (pp. 41–49). Atlantis Press. Doi: 10.2991/978-2-38476-076-3_5

Mostafa, M. M. (2009). Benchmarking the US specialty retailers and food consumer stores using data envelopment analysis. *International Journal of Retail & Distribution Management*, *37*(8), 661–679. https://doi.org/10.1108/09590550910966178

Okur, N., & Ercan, T. (2023). Evaluating retail efficiency using DEA and AHP: a case in the Turkish apparel retail industry. *Journal of Fashion Marketing and Management: An International Journal*, *27*(1), 138–160. https://doi.org/10.1108/JFMM-06-2021-0154

Pande, S., Sengar, R., & Chaudhary, N. S. (2020). Evaluating performance of apparel retail stores using data envelopment analysis. *International Journal of Business Excellence*, *22*(1), 19–32. https://doi.org/10.1504/IJBEX.2020.109211

Patel, G. N., & Bose, A. (2014). Seeking alternative DEA benchmarks. *OPSEARCH*, *51*(1), 23-35. https://doi.org/10.1007/s12597-013-0130-9

Putra, Z., & Muzakir, M. (2020). Competitive Environment Analysis in Global Retail Companies Operation Strategy: A Data Envelopment Analysis (DEA) Based Approach. *AFEBI Management and Business Review*, *5*(1), 16–36. https://doi.org/10.47312/ambr.v5i1.286

Rakhshan, S. A. and Alirezaee, M. R. (2014). Ranking of Decision Making Units by using of super efficiency non-radial model. *Industrial Management Journal*, *6*(2), 303–316. DOI: 10.22059/imj.2014.50680

Rouyendegh, B. D., Yildizbasi, A., & Yilmaz, I. (2020). Evaluation of retail ındustry performance ability through ıntegrated ıntuitionistic fuzzy TOPSIS and data envelopment analysis approach. *Soft Computing*, *24*(16), 12255-12266. DOI:10.1007/s00500-020-04669-2

Sellers-Rubio, R., & Mas-Ruiz, F. (2007). An empirical analysis of productivity growth in retail services: evidence from Spain. *International Journal of Service Industry Management*, *18*(1), 52–69. https://doi.org/10.1108/09564230710732894

Sexton, T. R., Silkman, R. H., & Hogan, A. J. (1986). Data envelopment analysis: Critique and extensions. *New directions for program evaluation*, *1986*(32), 73–105. https://doi.org/10.1002/ev.1441

Sinuany-Stern, Z., Mehrez, A. and Hadad, Y. (2000). An AHP/DEA methodology for ranking decision-making units, *International Transactions in Operational Research*, 7(2), 109–124. https://doi.org/10.1111/j.1475-3995.2000.tb00189.x

Sharma, V., & Choudhary, H. (2011). Measuring operational efficiency of retail stores in chandigarh tri-city using DEA. *Journal of Services Research*, *10*(2), 99. link.gale.com/apps/doc/A243043293/AONE?u=anon~3057ac7b&sid=googleScholar&xid=87e860a6

Taherdoost, H., & Madanchian, M. (2023). Using PROMETHEE method for multi-criteria decision making: applications and procedures. *Iris Journal of Economics & Business Management*, *1*(1). DOI: 10.33552/IJEBM.2023.01.000502

Takouda, P. M., & Dia, M. (2016). Relative efficiency of hardware retail stores chains in Canada. *International Journal of Operational Research*, *27*(1/2), 275–290. https://doi.org/10.1504/IJOR.2016.078465

Tavana, M., Bonyani, A., & Karimi, T. (2025). A full ranking method in data envelopment analysis with multi-criteria decision analysis. *International Journal of Applied Management Science*, *17*(1), 1–26. https://doi.org/10.1504/IJAMS.2025.143653

Torgersen, A. M., Forsund, F. R., & Kittelsen, S. A. C. (1996). Slack-adjusted efficiency measures and ranking of efficient units. *Journal of Productivity Analysis*, *7*, 379–398. https://doi.org/10.1007/BF00162048

Vincke, J. P., & Brans, P. (1985). A preference ranking organization method. The PROMETHEE method for MCDM. *Management Science*, *31*(6), 647–656. http://dx.doi.org/10.1287/mnsc.31.6.647

Yadav, V. K., Padhy, N. P., & Gupta, H. O. (2009). Assessing the performance of electric utilities of developing countries: An intercountry comparison using DEA. *2009 IEEE Power and Energy Society General Meeting, PES '09*, (pp. 1–7). IEEE. https://doi.org/10.1109/PES.2009.5275273

Yu, W., & Ramanathan, R. (2008). An assessment of operational efficiencies in the UK retail sector. *International Journal of Retail & Distribution Management*, *36*(11), 861–882. https://doi.org/10.1108/09590550810911656