Chapter 18
Efficiency Assessment Through Peer Evaluation and Benchmarking: A Case Study of a Retail Chain Using DEA

Anshu Gupta, Nomita Pachar, and Mark Christhian Barrueta Pinto

Abstract Retail industry in developing countries like India has observed immense growth in the past two decades and has marked a significant position in the global retail market due to technological advancements, globalization, rise in customer expenditure, emergence of multiple retail formats and increasing interest of investors in this sector. The growth in the retail sector is coupled with intense competition, shrinking revenues and rising expenditure on promotional activities, drawing attention of the decision-makers towards efficient operations. It is imperative to develop a robust approach for efficiency measurement for retail stores to support planning and implementation of efficient operations and expand the supply chain capabilities. The existing literature for retail stores efficiency assessment has mostly considered the self-appraisal approach, limiting its practical application due to inherent issues of total weight flexibility and pseudo-efficiency. In this study, we have presented an approach for efficiency assessment of retail stores through peer evaluation using the cross-efficiency models of Data Envelopment Analysis (DEA) to address these issues. The study also identifies pseudo-efficient stores using the concept of maverick index and defines benchmarks for all inefficient stores including maverick stores for developing improvement strategies. A case study of Indian electronic retail chain is presented to demonstrate the application.

Keywords Retail performance assessment · Cross efficiency · DEA · Benchmarking · Maverick stores · Pseudo-efficiency

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V. Laha et al. (eds.), *Optimization, Variational Analysis and Applications*,
Springer Proceedings in Mathematics & Statistics 355,
https://doi.org/10.1007/978-981-16-1819-2_18

18.1 Introduction

Indian retail industry has inhabited a phenomenal position in global retail ranking with its emergence as a dynamic industry, accounting for more than 10% of GDP and around 8% employment in the country [12]. Fostered by high market potential and low economic risk, the retail sector has witnessed enhanced profitability in the highly competitive and ever-changing marketplace. Competitiveness and complexity are continuously soaring in this industry due to overabundance of consumer choice, fast changing technology and blooming of multi-format retailing [41]. To survive in the competitive marketplace and meet the challenges of today's business environment, retailers are evolving continuously with improved operational efficiency and supply chain capabilities [18, 20]. Retail chains can manage the flow of goods in an efficient and effective way by ensuring availability of the right product in the right place at the right time and satisfying constantly changing market demand [40]. Sustained performance and continuous improvement are key for long-term sustainability of any business including the retail trade. Along with devising strategies in this direction it is imperative for the retail firms to develop an approach for efficiency measurement scientifically. An efficiency measurement approach is useful for businesses, for monitoring and evaluating the performance of its several business units and its stakeholders accounting the input resource utilization to yield well-defined outputs [30]. When a business involves multiple comparable units such as stores in a retail chain in such a case apart from measurement of efficiency of the individual units (commonly known as Decision-Making Units (DMUs)), firms also need to identify the best practices group [46] for benchmarking the inefficient units. In this direction, our study presents a data envelopment analysis (DEA)-based efficiency measurement approach through peer assessment of multiple stores of an electronic retail (ER) chain. Further benchmarking reference sets are derived using multiple correlation clustering (MCC) to help decision-makers deal with the inefficiencies of the inefficient and pseudo-efficient DMUs in comparison to the best performers.

DEA and some of its extensions including cross-efficiency DEA model are well-accepted approaches for relative efficiency measurement of comparable DMUs [15]. Several characteristics of DEA and cross-efficiency DEA model encourage the use of this methodology for efficiency measurement of a group of retail stores operated by a centralized management. These include—(1) measurement of efficiency based on multiple dimensions of performance, (2) objective assessment of efficiency as no subjective scoring is required form the decision-maker or based on qualitative criteria, (3) dimensions of performance measured on non-homogeneous scales can be included and (4) input and output (I/O) dimensions could be differentiated which is beneficial for further use of the results for devising improvement strategies [5, 16]. Introduced from the seminal work of Charnes, Cooper and Rhodes [6] (commonly called as CCR model), the traditional CCR model provides the relative efficiencies of DMUs in comparison to others based on self-appraisal assuming constant return to scale. The CCR [6] model is then extended by Banker, Charnes and Cooper [3] (commonly called as BCC model) under variable return to scale assumption. The conventional approach has two major issues—(1) it does not provide a ranking for the best performers in the set of DMUs under consideration [14] and (2) the problem of pseudo-efficient DMUs [39]. Given the characteristic of total weight flexibility in the conventional model several DMUs may be identified as efficient gaining the highest level of efficiency (equal to 1) leading to the issue of pseudo-efficient DMUs and also the requirement of ranking the efficient units [5]. The self-evaluation model could not eliminate unrealistic weights without collecting the weight restriction from decision-makers [27]. The cross-efficiency model helps to overcome these issues [14, 27, 28].

The idea of self/peer-evaluation is often related with the performance assessment of an individual as in personnel management. However, the application of cross-efficiency through peer evaluation is not limited to people and has been used in the literature in different contexts such as for measuring the efficiency of nursing homes, coastal cities, public procurement and portfolio selection [16, 27, 28, 36]. Studies in the literature have discussed the efficiency evaluation of retail stores applying DEA models. Most of these studies are based on the conventional DEA models (CCR or BCC), there is no notable article in the literature in the context of retail stores, in general, and an Indian electronic retail chain, in particular. Our study presents an application of the cross-efficiency DEA models for objective efficiency evaluation of stores of an Indian electronic retail chain. Further our study also identifies the pseudo-efficient stores and benchmarks for improvement of inefficient as well as pseudo-efficient stores.

Structure of the remaining chapter is as follows: Sect. 18.2 elaborates the relevant review of literature; Sect. 18.3 defines the problem of the study; Sect. 18.4 explains the methodology; the results and findings are discussed in Sect. 18.5 and Sect. 18.6 demonstrates the conclusion.

18.2 Literature Review

The focus of the study is to analyse the peer efficiency of retail stores of an Indian ER chain based on DEA through peer evaluation. The existing studies related to efficiency evaluation in retail have generally considered conventional DEA (self-appraisal) approaches ignoring the peer evaluation. Our manuscript considers this issue and presents a DEA-based methodology for evaluating peer efficiency of multiple retail stores. DEA is a well-known technique and the conventional model of self-appraisal has two formulations: CCR [6] and BCC [3]; various theoretical extensions have been discussed in the literature for different contexts including cross-efficiency [36], super efficiency [2], attractiveness [37], variable benchmark model [11] and slack-based model [7]. These models have been widely employed in different fields including transport [4], banking [8], retail [24] and health [23] in the literature. The efficiency evaluation in the retail sector based on basic DEA has been explored by some researchers [17, 22, 24, 25, 44]. The following paragraph provides a glimpse of the last 10 years of research related to performance evaluation in retail based on basic DEA.

Yu and Ramanathan [44] evaluated Chinese retail organization's economic efficiency based on two inputs (carpet area and staff) and two outputs (profit and sales) employing CCR DEA model. Authors used Malmquist Productivity Index (MPI) to examine the changes in efficiency with respect to different years for the period 2000–2003 and the influence of environmental variables applying bootstrapped Tobit Regression (TR). Gupta and Mittal [21] measured the productivity of grocery retail firms located in National Capital Region (NCR), India through CCR model of DEA, based on six inputs (store area, check points, SKUs, number of employees, employees cost and working hours) and two outputs (sales and customers conversion ratio). Lau [26] investigated the retail distribution network's efficiency measurement approach as an alternative to conventional optimization approach using transportation cost as I/O defined in terms of sales data in the basic DEA model. Pande and Patel [32] examined cost efficiency of retail stores of a pharmacy company in NCR, India and derived the effect of footfalls, sales and operating expenses on efficiency using the TR model. Gandhi and Shankar [17] followed the approach of [44] and measured the economic efficiency of Indian retail firms of the period 2008–2010. In a similar study, Xavier et al. [43] presented efficiency analysis for retail stores of a clothing retail firm of Portugal. Ko et al. [25] demonstrated the measurement of efficiency for a household retail chain in Korea and examined the effect of competitive environment and assortment on efficiency values using the TR model. Gupta et al. [22] demonstrated DEA-based methodology for analytical selection of performance dimensions and efficiency measurement of multiple retail stores with a case study of an Indian ER chain again based on the CCR model. It is evident that the major focus of the researchers for efficiency measurement related to retail sectors remained on the conventional models employing self-appraisal models.

As discussed in the introduction section, the DEA self-appraisal model has some practical issues limiting the application of the models including—no ranking of efficient DMUs and pseudo-efficiency. To deal with these issues, Sexton et al. [36] proposed an extension of the basic DEA model which is known as a cross-efficiency approach for measuring peer efficiency of DMUs based on multiple I/O. Cross-efficiency models provide a solution to the issue of unrealistic weights without collecting prior information on weight constraints and also provide unique ranking of all DMUs [14, 27, 28]. Doyle and Green [14] proposed extension of the concept of cross-efficiency and developed aggressive and benevolent formulations considering secondary objectives for resolving ambiguity, and also discussed the concept of maverick index to deal with the issue of pseudo-efficiency. Higher values of this index indicate overestimation of efficiency of the concerned DMU through self-appraisal. The concept of cross-efficiency in DEA has gained a lot of attention by researchers and practitioners [1, 16, 34, 36]. This section reviews and identifies gaps in literature and highlights the contributions of our study.

Talluri and Sarkis [39] illustrated the use of cross-efficiency approach in DEA for evaluating layout of cellular manufacturing systems with two inputs (number of workers and number of machines) and three outputs considered as average (flow time, work in process levels and labour utilization). Sarkis [34] presented an analysis of different DEA ranking techniques (basic DEA model, cross-efficiency model, super efficiency model, ranked efficiency, radii of classification rankings) and Multiple Criteria Decision-Making (MCDM) methods (PROMETHE, ELECTRE and SMART). A case study of solid waste management of Finland is used with five inputs (cost, health effects, global effects, surface water releases and acidificative releases) and three outputs (employees, technical feasibility and resource recovery). The results demonstrated that judgement of DMUs in the DEA technique provided the better results than given by the MCDM techniques. Adler et al. [1] reviewed the ranking approaches in the DEA which are cross-efficiency, maverick index, super efficiency, benchmarking, multivariate statistical techniques, ranked inefficient units through proportional inefficiency. The results of analysis are demonstrated through a numerical illustration of a nursing home as given in [36]. Braglia et al. [5] presented an approach of the efficiency evaluation based on cross-efficiency of Iranian steel plants with 5 inputs and 12 outputs. Further, authors computed the maverick index for determining pseudo-efficiency plants and also employed cluster analysis for benchmarking. Talluri and Narasimhan [38] proposed a framework to identify suppliers for strategic sourcing and calculated efficiency scores of suppliers by using the DEA model. Authors also conducted the peer evaluation of suppliers to overcome the weight flexibility issue of CCR model. Liang et al. [27] extended the model of cross-efficiency that was given by [14] and introduced an alternative secondary goal in cross-efficiency evaluation. The model was illustrated through a numerical example. It selected 13 open coastal cities and 5 special economic zones in 1989 of China based on two inputs and three outputs. Yu et al. [45] measured the SC performance based on different information sharing scenarios through cross-efficiency DEA approach. The result of the study demonstrated that sharing demand information is the most efficient scenario for efficient supply chains. Falagario et al. [16] presented a decision-making tool for selecting the best supplier using aggressive and benevolent formulations of cross-efficiency in DEA. The validity of the approach is supported through a case study of an Italian public procurement agency with two inputs and two outputs which are execution time and price, and enhancement plants and free maintenance after post-delivery, respectively. Lim et al. [28] proposed a strategy for selecting the portfolio by using DEA cross-efficiency technique. Further this study addressed the variation in cross-efficiencies through mean variance framework. The applicability of the approach is demonstrated through Korean stock market with nine inputs and seven outputs. Wu et al. [42] proposed the idea of satisfaction degree in cross-efficiency technique through a max min mode and gave two algorithms to solve the models. Liu et al. [29] evaluated the eco-efficiency of 23 coal-fired power plants of China using a cross-efficiency approach and considered the idea of undesirable output in the model. Omrani et al. [31] evaluated the energy efficiency of 20 zones of Iranian transportation sector with five inputs and four outputs based on cross-efficiency and cooperative game approach. Chen et al. [9] assessed environmental efficiency with undesirable outputs of China during 2006–2015 using DEA cross-efficiency approach. Further, authors proposed the three strategies which are environmental protection, economic development and win-win strategies based on the objective of decision-makers. Goswami and Ghadge [19] developed a DEA-based model considering undesirable and desirable outputs for evaluating supplier efficiency and also measured the cross-efficiency to accomplish peer evaluation. Authors demonstrated the validity of the approach through application of Hyundai Steel Company.

It is noticeable from the above Review of Literature (ROL) that there are ample number of studies that discussed issues related to peer efficiency measurement with different applications. However, the application in the context of retail is limiting.

18.2.1 Contribution of the Study

From the ROL, it is evident that the concept of peer evaluation is explored by a lot of researchers in the literature with diverse applications; however, application of the efficiency measurement approach through peer evaluation is yet to be explored in the context of the retail sector as demonstrated in Table 18.1. With respect to the case study in consideration the decision-makers were interested in exploring the relative efficiency assessment though peer evaluation and comparison with the CCR efficiency.

1. In the literature, peer evaluation of efficiency measurement is discussed with respect to various fields and different countries [9, 16, 28, 29, 31] while no

Table 18.1 Existing gap in the literature

Studies	Methodology			Application of retail sector	Indian case study
	Cross-efficiency	Maverick index	Benchmarking		
Talluri and Sarkis [39]	√	√	√	×	×
Sarkis [34]	√	×	×	×	×
Adler et al. [1]	√	√	√	×	×
Braglia et al. [5]	√	√	√	×	×
Talluri and Narasimhan [38]	√	×	×	×	×
Liang et al. [27]	√	×	×	×	×
Yu et al. [45]	√	×	×	×	×
Falagario et al. [16]	√	×	×	×	×
Lim et al. [28]	√	×	×	×	×
Liu et al. [29]	√	×	×	×	×
Omrani et al. [31]	√	×	×	×	×
Chen et al. [9]	√	×	×	×	×
Goswami and Ghadge [19]	√	×	×	×	×
Our study	√	√	√	√	√

significant study exists for peer evaluation for efficiency assessment in the retail sector and in particular related to Indian retail context.

2. Another limitation of the existing research is that the discussion of pseudo-efficient DMUs and determination of benchmarks for further improvement of inefficient units are explored limitedly [5, 14, 39]. In this manuscript, through comparison of CCR and aggressive (and benevolent) efficiency, we have also identified the pseudo-efficient units and have computed benchmarks for further improvement of inefficient units as well as for pseudo-efficient units.

Considering these arguments specific contributions of the our study are as follows:

1. The study assesses the efficiency of retail stores of an Indian electronic retail chain based on peer appraisal through different models of cross-efficiency and compares the results.
2. Cross-efficiency assessments are compared with the CCR efficiency using Maverick index to identify pseudo-efficiency such that improvement strategies may be devised for inefficient as well as pseudo-efficient stores.
3. Benchmarking reference sets are derived using MCC to determine the closest benchmarks for all inefficient stores.

18.3 Problem Definition

The case company in focus is an Indian ER chain that offers a large assortment of consumer electronic goods [22]. The retail chain manages several stores spread over Delhi NCR area. For efficacious management of the retail chain, the decision-maker is looking for an effective analytical approach for continuous monitoring of the performance of the stores and devises strategies to enhance their performance. The performance of the stores depends on several factors such as size of the store, location and number of personnel and product assortment. The study presents a cross-efficiency-based DEA approach for efficiency assessment through peer evaluation. Subsequently, pseudo-efficient units are identified and benchmark sets are determined for all inefficient and pseudo-efficient stores. The case study discussed here presents the results based on analysis of data related to 24 stores selected for demonstration of results by the decision-maker.

18.4 Methodology

The assessment of efficiency using DEA is conducted identifying the performance measures as I/O, and efficiency is defined by the ratio weighted sum of output and input. In the basic CCR model of DEA [6], each DMU is enabled to propose its own weights in order to maximize its outputs with respect to certain constraints on the inputs of all the DMUs [10]. In this scenario, a unit under evaluation may achieve the status of an efficient unit through a set of I/O weights wherein some I/O achieves nearly zero value and few or just single inputs and outputs get significant non-negative value. A retail store consumes several inputs such as monetary expenses on day-to-day operations, inventory cost, promotional expenses, store area and number of staff to generate outputs in the form of sales and customer satisfaction. Computation of efficiency with positive weights only for some I/O limits the practical applications of the classical DEA model leading to the problem of pseudo-efficiency. Since the cross-efficiency model enables peer evaluation of efficiency and overcomes this problem, this study uses the cross-efficiency model of DEA [36] along with the aggressive and benevolent formulations [14] for assessment efficiency of a group of retail stores. Following the efficiency assessment pseudo-efficient DMUs are identified using Maverick index and benchmarking sets are determined based on MCC [14].

18.4.1 Cross-Efficiency Assessment

The classical model of cross-efficiency assessment enables computation of efficiency through peer appraisal by a two-stage process. In the first stage (known as the 'self-appraisal' stage), for each DMU its CCR efficiency score [6] is computed. In the second stage, efficiency scores are calculated for each DMU using the weights of the other DMUs, resulting in the computation of a Cross-Efficiency Matrix (CEM) (as shown in Fig. 18.1). The efficiency of a DMU is then calculated by aggregation of efficiency scores computed in the second stage. In the CEM, the element at ith row and jth column is the efficiency of DMU j with the optimal weights of DMU i. The diagonal of the CEM represent the CCR efficiency for each DMU. The mathematical formulation of the model is as follows. Assuming there are n DMUs consuming m inputs to generate s outputs, the ith input of jth DMU ($j = 1, 2, \ldots,$ k, ..., n) represented by x_{ij} and rth output of jth DMU denoted by y_{rj}. The basic formulation of cross-efficiency evaluation is the input-oriented CCR DEA model [6] for computing optimal weights of I/O. In the first stage, the weights of kth DMU are computed using the following CCR DEA model:

$$\begin{aligned} \theta_k = \max \ & \textstyle\sum_{r=1}^{s} u_{rk} y_{rk} \\ \text{s.t.} \quad & \textstyle\sum_{i=1}^{m} v_{ik} x_{ik} = 1 \\ \textstyle\sum_{r=1}^{s} u_{rj} y_{rj} - & \textstyle\sum_{i=1}^{m} v_{ij} x_{ij} \le 0 \quad \forall j \\ & u_{rj}, v_{ij} \ge 0 \end{aligned} \tag{M1}$$

where u_{rj} is the weight associated with rth output of jth DMU and v_{ij} is the weight associated with ith input of jth DMU. The solution of the model (1) provides optimal values of the I/O weights and efficiency value of DMU k. Using the optimal solution of stage 1 the cross-efficiencies of DMU l for all $l = 1, 2, \ldots,$ n can be calculated from the following equation in stage 2:

$$\theta_{kl} = \frac{\sum_{r=1}^{s} u_{rk}^{*} y_{rl}}{\sum_{i=1}^{m} v_{ik}^{*} x_{il}} \tag{M2}$$

where u_{rk}^{*} and v_{rk}^{*} denote optimal weights of DMU k according to model (M1). Cross-efficiency of lth DMU is calculated by averaging the efficiency over row/columns as depicted in Eq. (1).

$$\theta_l = \frac{1}{n-1} \sum_{k=1,k\neq j}^{n} \theta_{kl}, \forall l \tag{1}$$

Along the rows each θ_{kl} is interpreted as efficiency that DMU k accords to DMU $l \; \forall \; j$, averaging over rows is DMU k's average appraisal of peers against which it would like to compare itself and along the columns θ_{kl} represent the peer appraisal of DMU l and averaging down column l is the average peer appraisal of DMU l.

Cross-efficiency scores obtained from the basic DEA (as in stage 2) are often not unique as it depends on which of the optimal solutions of the linear programming model of CCR DEA model is employed, again limiting the usefulness of the approach [27]. To deal with this issue, Doyle and Green [14] proposed aggressive and benevolent formulation of cross-efficiency. In the aggressive approach, DMU k determines weights that minimize efficiency of peers and the benevolent approach maximizes the efficiency of DMU k and also the efficiency of peers. These formulations are as follows:

$$\min \sum_{r=1}^{s} u_r \sum_{j=1,j\neq k}^{n} y_{rj} \qquad (M3)$$

or

$$\max \sum_{r=1}^{s} u_r \sum_{j=1,j\neq k}^{n} y_{rj} \qquad (M4)$$

$$\text{s.t.} \sum_{i=1}^{m} v_i \sum_{j=1,j\neq k}^{n} x_{ij} = 1 \qquad (2)$$

$$\sum_{r=1}^{s} u_r y_{rk} - \theta_k \sum_{i=1}^{m} v_i x_{ik} = 0 \forall k \qquad (3)$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} = 0 \forall j;\; j \neq k \qquad (4)$$

$$u_r, v_i \geq 0 \qquad (5)$$

The objective functions (M3) and (M4) are the secondary objective functions of the cross-efficiency model and represent the aggressive and benevolent formulations, respectively, along with the constraints (2)–(5).

18.4.2 Maverick Index

Maverick index represents the deviation between CCR and cross-efficiency [36] and is a measure of the deviation when moving from self-appraisal to the corresponding peer appraisal, i.e. the Maverick index for DMUk is defined as

$$M_k = \frac{\theta_{kk} - \theta_k}{\theta_k} \tag{18.1}$$

Rating DMU	Rated DMU						Averaged appraisal of peers
	1	2	.	.	.	n	
1	θ_{11}	θ_{12}	.	.	.	θ_{1n}	A_1
2	θ_{21}	θ_{22}	.	.	.	θ_{2n}	A_2
.	.	.				.	
.	.	.				.	
.	.	.				.	
n	θ_{n1}	θ_{n2}	.	.	.	θ_{nn}	A_n
Averaged appraisal by peers	$\bar{\theta}_1$	$\bar{\theta}_2$	.	.	.	$\bar{\theta}_n$	

Fig. 18.1 Cross-efficiency matrix

where θ_{kk} and θ_k are the CCR and cross-efficiency, respectively, of DMU k. A DMU may become efficient during self-evaluation while obtaining low efficiency in peer evaluation. Higher value of maverick index indicates that an efficient DMU is over-estimated because of poor discrimination.

18.4.3 Identification of Benchmarks

Benchmarking is a technique employed by organizations for improvement of the low performers in comparison to the best performers. Benchmarking measures the performance of a low-performing unit against the best-performing unit [35]. The benchmarking approach based on classical DEA has some limitations. Firstly, the inefficient DMUs and their corresponding reference sets may not be similarly inherent, and may represent an unachievable target for inefficient DMUs [39]. Secondly, benchmarking set for pseudo-efficient could not be determined. In the literature, researchers have discussed benchmarks for the inefficient/pseudo-DMUs through the cluster analysis [5, 35, 39].

Here we have used the Multiple Correlation Clustering (MCC) method developed by [13] to form benchmarking clusters. It is a technique based on an iterative procedure that partitions the set of DMUs in two subsets; these subsets are further segregated until homogeneity is obtained between DMUs. The steps for MCC are as follows:

1. The correlation matrix is computed based on the cross-efficiency matrix of DMUs.
2. If the values of the correlations in step 1 are close to $+1$ or -1 (approximation taken up to a suitable precision) go to step 3 otherwise compute higher order correlation matrices until a correlation matrix with all values $+1/-1$ is obtained.
3. Dataset is partitioned based on negative and positive correlations to form two clusters of DMUs.

4. Steps 1–3 are repeated until one of the condition is satisfied.
   a. The resultant correlation matrix has all values close to +1 implying the units in consideration are alike.
   b. The maximum number of possible iterations is reached.
   c. The number of units in the partitioned matrix is too small to further divide into separate clusters.

This MCC approach has several characteristics that favours its application for clustering including—the method can form clusters of highly intercorrelated units, can detect even small noise signals from large noise, missing data could be inferred from higher order correlations and is impervious to multicollinearity [35]. Within each cluster, the DMU with the highest cross-efficiency score can be considered as a benchmark for the other members of the same cluster. The methodology is demonstrated in the following section with a case study.

18.5 Case Study

This section demonstrates application of the cross-efficiency model for estimating the efficiency of 24 stores of an ER chain. Through ROL and discussion with the decision-maker key I/O performance measures to be used for efficiency computation are identified. The study considers the five inputs: operating expenses [43], average inventory cost [32], number of employees [25], promotional expenses [22] and store size [32]; and two outputs: profits [17] and customer satisfaction [22] to compute the peer efficiency of an ER chain's 24 stores. Rescaled data is obtained from the case organization. The results presented here are computed using the 'MultiplierDEA' package [33] in R software on the PC with 4 GB RAM and intel Core i3-5020U CPU @ 2.20 GHZ.

18.5.1 Analysis and Results

The values of the CCR, cross (CE), aggressive (AE) and benevolent (BE) efficiency are computed using the data obtained from the organization for I/O mentioned above, using models (equations) (M1), (M2), (M3) and (M4), respectively. The efficiency values, maverick indices (MI) and ranking of the stores obtained using these models are listed in Table 18.2.

According to the CCR model, retail stores R3, R4, R15, R17 and R20 have the perfect efficiency score of 1, while if we compare the results of efficiency values of the four different models, store R4 attains the highest efficiency according to all the models and could be considered as leader in terms of its performance. The low value of the maverick indices for this store also supports its leader status. The results are also consistent for the stores R3 and R20 that attain the II and III highest values of efficiency, respectively, in all models along with low values of maverick index. Low value of the maverick index reasserts the performance of these stores as high value of this index is indicative of the pseudo-efficient status of a productive unit. Store R21 though did not attain perfect efficiency in CCR model is ranked above the store R15 due to the higher value of maverick index associated with R15. The retail store R17 is also efficient according to the self-appraisal model while it has attained 7th rank through peer appraisal, again this could be attributed to the pseudo-efficiency issue. The store has been overestimated due to poor discrimination associated with the CCR model as represented by the maverick index for the store. The cross-efficiency models surface the pseudo-efficient units and hence could provide better results for benchmarking in terms of providing benchmarks for the pseudo-efficient as well as inefficient stores.

The results of cross-efficiency are used as input for the MCC to form the clusters of alike stores wherein a store having highest efficiency in a cluster acts as benchmark for other stores in that group. Comparing the I/O measures of a low-performing unit with the best performer, decision-makers can devise strategies for improvement of the inefficient units. The benchmarks are defined through the MCC clustering approach as described in the methodology section. First-order and higher order correlations are computed using the CEM to obtain correlation values close to ± 1 and I level clusters are obtained as shown in Fig. 18.2. Further clusters are derived following the stopping criteria of MCC and a total of six clusters of stores are obtained. Within a cluster the store with highest efficiency acts as the closest benchmark [39] for the other stores. Retail store R15 is benchmark for R1, R12 and R17 in the I cluster (C1); store R10 is benchmark for R11 in II cluster (C2); store R4 is benchmark for stores R7, R14, R18 and R24 in III cluster (C3); R3 is benchmark for R2, R13, R16 and R22 in C4; R6 is benchmark for R5, R8, R19 and R23 in C5 and store R20 is benchmark for R21 in C6. This analysis gives realistic insights to management for forming improvement strategies for inefficient/maverick stores. For the maverick retail store R17, the closest benchmark is the store R15. Similarly we can define benchmarks for all pseudo-efficient stores following this method. It may be noted here that if benchmarking reference sets are defined based on the CCR efficiency [22] then benchmarks for maverick stores could not be defined and hence DEA efficiency measures could not be used to define the improvement strategies for these stores. Further the results of MCC can also be used for stepwise benchmarking [5]. For example, R11 can benchmark R10 in step one following incremental improvement strategies and later it can follow a higher order benchmark.

Following implications can be drawn based on the analysis and results presented above:

1. Rapid growth of the retail industry in developing economies like India has fueled tough competition in the market with several players striving to capture a notable size of market share and attain a competitive positioning. Firms in the market are required to devise strategies for gaining competitive advantage and nourish their businesses for long-term sustainability and remain profitable. In order to achieve these goals, decision-makers are required to focus on continuous

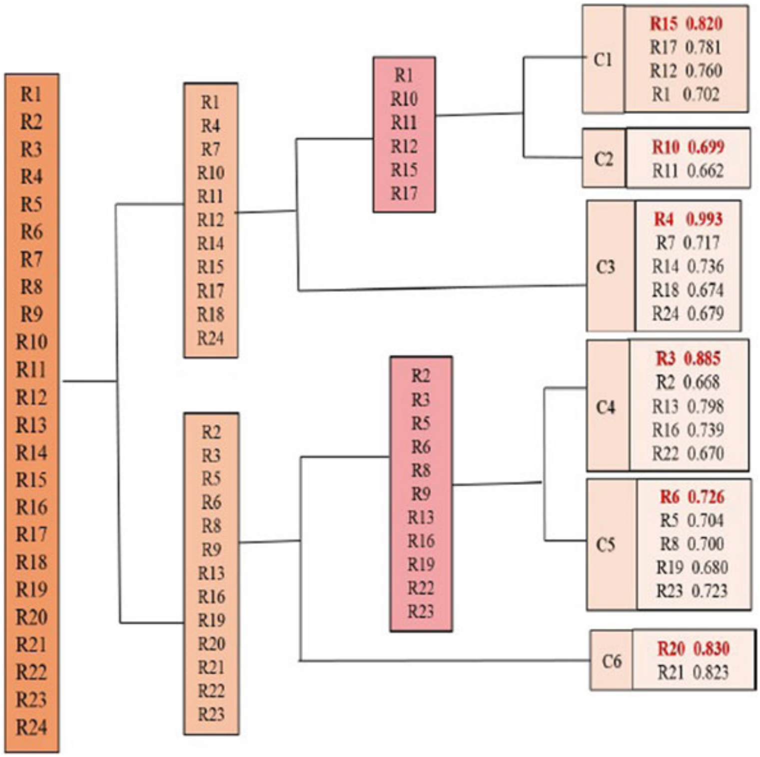

Fig. 18.2 Clusters for benchmarks

improvement of its products and processes, improving supply chain capabilities and adding more value for its potential customers [18]. It is imperative for the firm to devise improvement strategies and monitor their performance. The formulation and implementation of effective improvement strategies require firms to follow robust methods of performance measurement and identification of weaknesses, strengths and opportunities. DEA is a widely accepted and practically implemented methodology in this context and has been developed for different contexts. The existing literature related to efficiency measurement related to retail trade mostly considers the assessment of efficiency through self-appraisal (CCR model of [6]). The self-appraisal approach has some of the inherent issues such as overestimation of efficiency leaving to pseudo-efficient DMUs, poor discrimination and non-uniqueness of I/O weights. The peer assessment of efficiency based on cross-efficiency DEA models helps to resolve these issues. Our study discusses the application of the cross-efficiency DEA models in relation to retail and the case study provides a guideline for application for the practitioners.

2. In the direction of devising strategies for improvement and identifying opportunities for improvement, benchmarking is an effective approach. High-performing

Table 18.2 Efficiency scores of the retail stores

Retail stores	CCR	Conventional CE model			Aggressive model			Benevolent model		
		CE	MI	Rank	AE	MI	Rank	BE	MI	Rank
R1	0.794	0.702	0.131	16	0.683	0.162	16	0.706	0.124	18
R2	0.842	0.668	0.260	23	0.649	0.297	23	0.696	0.210	20
R3	1.000	0.885	0.130	2	0.872	0.147	2	0.905	0.104	2
R4	1.000	0.993	0.007	1	0.974	0.027	1	1.000	0.000	1
R5	0.798	0.704	0.134	15	0.689	0.158	15	0.711	0.122	16
R6	0.817	0.726	0.125	12	0.709	0.152	12	0.739	0.105	13
R7	0.851	0.717	0.187	14	0.704	0.209	13	0.725	0.174	14
R8	0.757	0.700	0.081	17	0.682	0.109	17	0.710	0.066	17
R9	0.868	0.737	0.178	10	0.720	0.205	9	0.757	0.147	10
R10	0.832	0.699	0.190	18	0.673	0.236	18	0.719	0.156	15
R11	0.741	0.662	0.119	24	0.645	0.149	24	0.677	0.095	24
R12	0.973	0.760	0.280	8	0.742	0.311	8	0.757	0.286	9
R13	0.878	0.798	0.100	6	0.775	0.133	6	0.805	0.091	6
R14	0.818	0.736	0.111	11	0.717	0.141	10	0.742	0.103	11
R15	1.000	0.820	0.220	5	0.802	0.247	5	0.819	0.221	5
R16	0.853	0.739	0.154	9	0.713	0.196	11	0.758	0.125	8
R17	1.000	0.781	0.280	7	0.762	0.313	7	0.778	0.285	7
R18	0.762	0.674	0.131	21	0.656	0.161	21	0.684	0.115	23
R19	0.739	0.680	0.087	19	0.660	0.119	20	0.696	0.062	21
R20	1.000	0.830	0.205	3	0.810	0.235	3	0.833	0.201	3
R21	0.978	0.823	0.188	4	0.806	0.214	4	0.827	0.183	4
R22	0.837	0.670	0.249	22	0.650	0.288	22	0.696	0.203	19
R23	0.832	0.723	0.151	13	0.702	0.186	14	0.742	0.122	12
R24	0.741	0.679	0.091	20	0.663	0.118	19	0.691	0.072	22

productive units of an organization can act as benchmarks for low performers, wherein an inefficient/maverick DMU can follow an efficient unit to gain competitiveness [39]. Our study presents the MCC method to form clusters of homogeneous units and determines the closest benchmark targets for inefficient units. The clustering method for deriving the benchmarking set also finds implications for incremental benchmarking [5].

3. The results of the study can also be used for devising strategies for optimal reallocation of the centralized resources of an organization according to efficiency targets. Organizations can also use the ranking of DMUs obtained using the cross-efficiency assessment for further decision-making.

18.6 Conclusion

The Indian retail industry has boomed enormously in the past two decades, contributing to the growth of the nation's economy and creating several employment opportunities. While several factors such as globalization, technology advancements and emergence of multiple retail formats have contributed to the growth of the industry, it has also attracted new entrants in the market intensifying competition. Thus, retail firms are required to focus more than ever on their competitive positioning, efficient operations and improvement. A robust method for measuring and monitoring performance is an important prerequisite in this direction. This chapter presents an application of the cross-efficiency DEA models for peer assessment of efficiency of stores of a retail chain with an application of an electronic retail chain. Efficiency measures are computed using the conventional CCR, cross-efficiency, aggressive and benevolent models, and comparison is drawn between different measures. The concept of maverick index is used to identify the maverick stores and benchmarks are obtained for all inefficient/maverick stores based on multiple correlation clustering. Application of the peer assessment methodology proposed in the study is validated with a single case study of an electronic retail chain. To overcome this limitation, future research should extend the applications for other retail firms and industry sectors. Another limitation of the study is that benchmark clusters are determined using the MCC method to establish the consistency of results one need to triangulate the results with other methods. The future work in this area can focus on identifying the dimensions for improvement for inefficiency stores and develop optimization models for centralized distribution of resources.

Acknowledgements The authors are indebted to the anonymous referees whose comments helped a lot to improve the quality of the chapter.

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