BRAND PERFORMANCE EVALUATION AND RANKING OF MOBILE PHONE USING DATA ENVELOPMENT ANALYSIS

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Abstract

The purpose of this paper is to benchmark the mobile brand available in Indian market for relative efficiencies. In this paper, a method for benchmarking performance of mobile brand services based on data envelopment analysis (DEA) is presented. The paper discusses some concepts between quality performance and benchmarking and the results include performance efficiency of services. Also, peer-to-peer comparison of inefficient with efficient utilities is provided. Based on these results, inefficient utilities can develop strategic plans to improve performance. DEA to measure comparative efficiencies of mobile brand and DEA CCR model is applied to evaluate the relative efficiency of mobile brand available in India market. Comparisons of DEA efficiencies from the CSR and VRS model show the impact on efficiency. Data include price and brand image as input and product related configuration are taken as output are showing various quality parameters.

Keywords: Mobile Phones; Efficiency Measurement; Data Envelopment Analysis; Ranking; Benchmarking; Relative Efficiencies

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Introduction

To survive in a competitive economy, today's organizations must develop the capacity to learn, accept and change. Holding on to the traditional ways of operations and strategies can not only reduce an organization static, but also make it different for its products to grow and brand building. A brand not only be better positioned by combining the name with desirable benefit but also it attributes safety, caring, adventure, guaranteed delivery, performance and quality about the value systems of the society enable marketers to satisfy the needs of consumers by relating the product attributes with their needs. It plays a major role in tailoring consumer perceptions and behavior [1] and influences the lifestyle and values of the society.

The brand symbolizes and indicates intrinsic and extrinsic value to consumers, enabling them to distinguish products by allocating emotional attributes to them. It conveys several meanings to consumers, and they develop emotional affection [2], affiliation, and feelings with brands. For consumers brands represent quality and status [3,4,5]. The intrinsic meanings of brands have a better impact on consumer purchase behavior than their extrinsic components [6,7].

Consumers assess brands not only by price and quality elements but also through experiential qualities [8]. The foreign branding the strategy of pronouncing or spelling a brand name is a foreign language triggers cultural stereotypes and influences product perceptions and attitudes [9]. A brand signifies image and status, the physical components of brands are difficult to differentiate. This indicates if a consumer consuming and buying by indicating reasons for adopting a macro level perspective that focuses on products, rather than brands, as the units of analysis [10]. The physical attributes or extrinsic components become more relevant for consumers research suggests that attitudes of consumers toward brands in developing economies are being created and developed, as consumers become a part of the global community [11,12,13](Riefler 2012; Alden et al., 2006; Steenkamp & Baumgartner 1992).

In developing countries main challenges on brand come in the form of inexperience, lack of resources and capabilities, the market dominance of well-established rivals and consumer loyalty to existing brands. It is interesting, therefore, to explore in what way, given their relative disadvantages, firms from emerging markets are able to compete successfully against their more established rivals in developed markets [4]. Here brands communicate status consumption [3,1415], changing the behaviour with reference groups, self-monitoring, and gender roles [16,17,18,19,20]. The brand’s assessment may be done on its quality and exclusiveness and ability to symbolize style, to enhance self-image, and to provide identification within the group. Hence, it needs primary survey to understand competency-based approach applied by Indian organizations for brand building. Implication of social intelligence can be empirically justified looking at the managers of Indian organizations. To this end, this paper presents a performance analysis of brand attributes evaluation of mobile phone available in Indian market using data envelopment analysis (DEA). It address directly customer's need for constant benchmarking, targeting positioning and designing focused on lifestyle values scale to understand Indian youths' attitude toward brands.

Literature Review

Keller (1993) [21] has developed a model to explain the brand knowledge consisting of two main dimensions: brand awareness and brand image. He defined brand awareness as the "strength of the brand node or trace in memory, as reflected by customers' ability to identify the brand under different conditions" with two components: brand recall and brand recognition. Aaker & Keller (1990) [22] have studied the potential success of brand extension based on how the customer perceived the quality of the original brand and the relationship of "fit" between the original and the extension product classes. Subsequently, Keller (1993) [21] has explained two basic approaches to measuring Customer-based Brand Equity (CBBE): the indirect approach through measuring the brand knowledge (brand awareness and brand image) and the direct approach through assessing the impact of brand knowledge on customer response to different elements of the firm's marketing program. The indirect approach uses a combination of surveys and focus groups, whereas the direct approach uses experiments (with the "blind" test as the main activity under this approach).

Liu (2002) [23] has proposed to find out the effects of the different activities on consumer choice of mobile phone brands using regression analysis. Ghodeswar (2008) [24] has developed a framework for building brand identity in sequential order, namely, positioning the brand, communicating the brand message, delivering the brand performance, and leveraging the brand equity. Aaker & Jacobson (2001) [25] have proposed that measuring brand performance has become a crucial management task. While a number of researchers have attempted to measure the efficiency of brands, the existing approaches have exclusively centered on measuring the increased financial returns that the brand generates. Khare (2011) [26] has purposed to understand the role of collectivist/individualist lifestyle variables on brand meanings by Indian university students using correlation and multiple regression tests. Petruzzellis (2010) [27] have analyzed a technology to overcome customer preference and needs with respect to its influence in shifting customer preferences from the technical performances (tangible elements) to the emotional/symbolic ones (intangible elements).

Hawass (2013) [28] have explored the relationship between brand trust and consumer doubts towards new products in the Egyptian mobile phone market. The study controls for the effects of age differences and risk aversion using multiple regression analysis in order to predict the hypothesized relationships. Kimiloglu et al. (2010) [29] have developed a behavioral segmentation tool in the mobile phone market using cluster analysis in a high technology product market and successfully identifies four distinct consumer groups with alternative decision-making styles. Martensen (2007) [30] have identified best practices for tweens' (8 to12 years' olds) satisfaction and brand loyalty in the mobile phone market in Denmark. Wang & Li (2012) [31] have examined the relationships between the identified key value proposition attributes of mobile value added services and the core factors of brand equity using structural equation modeling.

Alamro & Rowley (2011) [32] have applied Principal component analysis (PCA) followed by multiple regression to identified eleven nos. of antecedents and investigate the relative impact of the identified factors of brand preference for mobile telecommunications services in Jordan. These antecedents of brand preference clustered into three groups: awareness antecedents, image antecedents and customer attribute antecedents. Kasper et al. (2010) [33] have studied the insight into how consumers cope with confusion caused by overload in information and/or choice. They investigate whether consumers who face different degrees of confusion use different coping strategies depending upon their decision making styles. Baker et al. (2010) [34] have identified brand equity theory into the context of ancillary product sales and demonstrate that branded ancillary services can command a price premium and are less sensitive to price increases than unbranded alternatives.

Roach (2009) [35] has studied consumer's perception of the relative advantages, compatibility and complexity associated with mobile phone marketing, and their involvement with their mobile phone, influenced their intention to accept marketing communication sent via their mobile phone. Roh & Choi (2010) [36] have compared and contrast the efficiency of different brands belonging to the same restaurant franchisor using DEA. Chiaravutthi, Y. (2010) [37] has proposed hedonic price approach to quantify the brand equity of information and communication technology (ICT) products, narrowed down to laptop computers, laser printers, liquid crystal display computer screens, and mobile phones. Sigala (2006) [38] has analyzed the mass customization strategies (MC) that enhance both extrinsic and intrinsic customer value and to identify the types of customer value perceived by mobile phone users that customize services to their profiles. Lee et al. (2014) [39] have developed brand equity for port brand equity (PBE) and explore the PBE into three steps: port service quality as the precedent of PBE, the PBE dimensions, and the antecedent of PBE using Structural Equation Modeling. Banerjee and Chaudhuri (2014) [40] have studied a product evaluation of mobile phones by Indian consumers the effect of country of origin (COO) from three different dimensions, viz., country image (CI) effect, COO image effect and awareness level about the COO of the brand and its resultant effect on product evaluation (PrEva) using structural equation modeling.

Odoom (2016) [41] have proposed brand marketing efforts and consumer loyalty among mobile phone users and measures the degree of importance of the brand marketing programs on high and low loyalty consumer segments within an emerging market framework. Urumsah (2015) [42] has analyzed using a partial least square (PLS) based structural equation modelling (SEM) technique to produce the contributions of links in the e-services model in Indonesian Airline Companies.

Debnath and Shankar (2008) [43] have compared the relative efficiency of mobile service providers in India using DEA. Brown and Ragsdale (2002) [44] have analyzed the competitive market efficiency of hotel brands and improve their brands' market efficiency with application to Data Envelopment Analysis. Manasakis et al., (2013) [45] have purposed relative efficiency between hotels operating under a brand operating independently and identify the inefficiency causes; and suggest managerial implications to relevant business experts in order to increase hotel efficiency in tourism destinations with similar characteristics using DEA.

Methodology

Data envelopment analysis

The paper employs DEA for a multifactor linear programming model to benchmarking of brand attributes evaluation of mobile phone available in Indian market. DEA, introduced by Farell (1957) [46], measures the efficiency of a single unit, a decision-making unit (DMU), which transforms inputs (resources) to outputs (products and/or services). Efficiency, in the DEA context, deals with the optimization of the resource allocations among alternative uses. DEA yields a linear production surface which, in economic terms, represents the best production possibility frontier. By projecting a DMU to this frontier and comparing it with a single reference unit or a convex combination of other reference units, the DMU's efficiency is estimated.

In the context of mobile brand a DMU is regarded as the entity responsible for converting inputs (i.e. resource, money, etc.) into outputs (i.e. product quality, after sales services etc.). In this study, a DMU refers to different brand of mobile phone available in Indian market. Usually, the investigated DMUs are characterized by a vector of multiple inputs converting to multiple outputs making it difficult to directly compare them. In order to aggregate information about input and output quantities, DEA makes use of fractional programming problem (FPP) and corresponding linear programming problem (LPP) together with their duals to measure the relative performance of DMUs [47,48,49,50,51]. The Charnes, Copper & Rhodes (CCR) model is a FPP model which measures the efficiency of DMUs by calculating the ratio of weighted sum of its outputs to the weighted sum of its inputs. The fractional programme is run for each DMU to subject to the condition that no DMU can have relative efficiency score greater than unity for that set of weights. Thus, the DEA model calculates a unique set of factor weights for each DMU. The efficiency score in the presence of multiple input and output factors is defined as:

$$\text{Efficiency} = \frac{\text{weighted sum of inputs}}{\text{weighted sum of inputs}}$$

Since the efficiency of each DMU is calculated in relation to all other DMUs using actual input-output values, the efficiency calculated in DEA is called relative efficiency. In addition to calculating the efficiency scores, DEA also determines the level and amount of inefficiency for each of the inputs and outputs. The magnitude of inefficiency of the DMUs is determined by measuring the radial distance from the inefficient unit to the frontier.

Assuming that there are n DMUs, each with m inputs and s outputs, the relative efficiency score of a test DMU_j is obtained by solving the following model proposed by Charnes et al. (1978) [47]:

$$Maximize\, H_0 = \frac{\sum_{r=1}^{s} u_r\, y_{rj_0}}{\sum_{i=1}^{m} v_i x_{ij_0}}$$

$$\text{subject to } \frac{\sum_{r=1}^{s} u_r\, y_{rj}}{\sum_{i=1}^{m} v_i\, x_{ij}} \leq 1 \quad \text{for all } j = 1,2,\ldots, n$$

$$u_r, v_i \geq 0\,;\, r = 1,2,\ldots,s \quad \text{and} \quad i = 1,2,\ldots,m$$

Where

y_{rj} = amount of output r produced by DMU_j

x_{ij} = amount of input i utilized by DMU_j

u_r = weight given to output r

v_i = weight given to input i

The model is called CCR output-oriented maximization DEA model. The efficiency score of n DMUs is obtained by running the above LPP 'n' times [52].

This fractional problem is subsequently converted to a linear programming format and a mathematical dual is employed to solve the linear problem. The method creates a frontier using information on the assumed most efficient utilities and measures the efficiency relative to the rest of the utilities. DEA attempts to approximate the efficient frontier by a "piece-wise" linear approximation based on the sample. Efficiency scores are constructed by measuring how far a utility is from the frontier. The technique also computes the input and output alterations that would turn an inefficient unit into an efficient one.

DEA is therefore a measure of relative efficiency in contradiction of the sample group's benchmark best practice. A DMU is said to be efficient if it is not possible to increase the level of output without increasing the use of at least one other input or decreasing the generation of at least one other output. The DMU's that lie on the efficiency frontier are efficient in the DEA model. In contrast, the entities that do not lie on the efficiency frontier are regarded as inefficient.

Input and output selection of DMUs

In order to identify DMUs, all the items are relevant for evaluating performance of mobile phones not only in Indian context but are quite generic to be adopted anywhere. The responses under each item are collected through field visits to 300 technical and management students of 40 mobile brands (DMU_1 to DMU_{40}) have been considered as shown in Table 1. Each respondent is asked to rate his/her opinion in a Likert type scale 1 to 7 (1 being strongly disagree and 7 being strongly agree). The survey is administered to the respondents via e-mail and personal contacts.

Table 1. Selected DMUs

DMUs	Type of Brand
DMU_1	Apple
DMU_2	Sony
DMU_3	Samsung
DMU_4	HTC
DMU_5	Nokia/ Microsoft
DMU_6	Xiaomi RedMi
DMU_7	VIVO
DMU_8	Lenovo
DMU_9	Blackberry
DMU_{10}	Micromax
DMU_{11}	OPPO
DMU_{12}	Motorola Moto
DMU_{13}	Honor
DMU_{14}	LYF
DMU_{15}	Infocus
DMU_{16}	Infosonics
DMU_{17}	LG
DMU_{18}	Intex
DMU_{19}	Lava

DMU_{20}	LeEco
DMU_{21}	Google
DMU_{22}	iball
DMU_{23}	Asus Zenfone
DMU_{24}	Coolpad
DMU_{25}	Ulefone
DMU_{26}	Panasonic
DMU_{27}	Philips
DMU_{28}	Spice
DMU_{29}	OnePlus
DMU_{30}	Xolo
DMU_{31}	Huawei
DMU_{32}	Karbon
DMU_{33}	10.Or
DMU_{34}	RealMe
DMU_{35}	JioMobile
DMU_{36}	Gionee
DMU_{37}	Videocon
DMU_{38}	Smartron
DMU_{39}	Gfive
DMU_{40}	Smartron

Selecting the appropriate inputs and outputs constitute the most important task of evaluating the performances. The choice of variables depends on not just the choice of methodology and technical requirements of the chosen model, but also on data availability and its quality, as well as on country's socio-economic structure. There is no such generally applicable rational template is available for selection of variables. However, in general, the inputs must reflect the resources used and the outputs must reflect the service or quality levels of the utility and the degree to which the utility is meeting its objective of good quality and low cost to consumers. A study of standard literature reveals significant insights into the choice of variables. The ranking of DMUs is made based on total score summed over perceptual score and factual score obtained from each DMU. The benchmarking of mobile brand considers two input and eight output parameters incorporates a wide range of variables that characterize the performance of mobile phones (Table 2).

Table 2. Inputs and output parameters for brand evaluation

Input	I_1	Price
	I_2	Brand Image
Output	O_1	Battery Durability
	O_2	Camera (Primary and secondary)
	O_3	Guarantee, after sales maintenance and Services
	O_4	Screen Size
	O_5	Storage capacity
	O_6	Availability of different colors/Size
	O_7	Ease of use
	O_8	Availability in different store and shops

The input/output selection for the present study was made in view of those parameters that directly affect the consumers in terms of quality and cost. The choice of variables was also based on the study of available literature to sort out the right indicators from a potential group of parameters [53,43].

Results and discussions

The DEA results have been calculated by using the software "DEA-Solver" by Cooper et al. (2007) [54]. The DEA results can be calculated in several ways. In order to solve the CCR and BCC, DEA problem, three characteristics have to be specified: input-output orientation, returns to scale and weights to be assigned to the inputs and outputs. First, if the model is input oriented, it means that the inputs are in the control of the DMU and therefore the inefficient firms are suggested to reduce their inputs for the given outputs to become more efficient and in the case of output-oriented models, the inefficient firms are suggested to increase their outputs for the given set of inputs to become more efficient. This research has used input-oriented models as in today's competitive markets, outputs may not be in the direct control of the manufacture, though will aim to maximize the outputs, but may be able to influence the inputs to a larger extent. Two types of models such as CRS and VRS are used. A DMU is regarded as a benchmark unit when its objective function (technical efficiency (TE)) becomes unity. The general input-oriented maximization CCR-DEA model is used to obtain efficiency score.

The results thus obtained are summarized in Table III (CRS model).The first column of the table represents the selected DMUs arranged in a sequential manner. The second column specifies the efficiency score of the corresponding DMUs. Based on the efficiency score, the DMUs are ranked as shown in the third column. The fourth column shows the peers or the benchmarking units for the corresponding DMU. The fifth column indicates the weight of each of the peers or the benchmarking unit. The last column shows the peer count of the DMUs. Ranking based on relative efficiency scores indicate that eighteen DMUs out of forty DMUs have emerged as benchmarking units for the other 22 DMUs. The eighteen efficient or benchmarking units are listed as DMU_1, DMU_2, DMU_3, DMU_4, DMU_5, DMU_6, DMU_7, DMU_8, DMU_9, DMU_{11}, DMU_{12}, DMU_{13}, DMU_{17}, DMU_{21}, DMU_{29}, DMU_{31}, DMU_{33} and DMU_{36} as shown in Table 3. The efficiency score for these DMUs approach unity while that of DEA-inefficient DMUs show relative efficiency less than unity. The inefficient unit scan refer the DMUs listed in column four with corresponding peer weight given in column five for the improvement in brand performance. For example, DMU_{10} having efficiency score of 0.956 can refer DMU_2, DMU_1, DMU_9 and DMU_{13} can assign a weightage of 0.373 to DMU_2, 0.356 to DMU_1, 0.296 to DMU_9 and 0.383 to DMU_3 become a benchmark unit.

It is evident from column four that, there are 14 DMUs (DMU_{10}, DMU_{14}, DMU_{19}, DMU_{20}, DMU_{23}, DMU_{24}, DMU_{25}, DMU_{26}, DMU_{27}, DMU_{28}, DMU_{35}, DMU_{37}, DMU_{38}, and DMU_{39}) consult four benchmarking organizations. Again three DMUs (DMU_{15}, DMU_{34}, DMU_{40}) and three DMUs (DMU_{18}, DMU_{30}, DMU_{32}) which can refer five and six different DEA-efficient units respectively with varying degree of weightages. It is shown that only two DMUs (DMU_{16} and DMU_{22}) which can refer three different DEA efficient units with the corresponding weightages. It is further observed that DMU_1, DMU_2, DMU_3, DMU_4, DMU_5, DMU_6, DMU_7, DMU_8, DMU_9, DMU_{11}, DMU_{12}, DMU_{13}, DMU_{17}, DMU_{21}, DMU_{29}, DMU_{31}, DMU_{33} and DMU_{36} have become peer units 22, 12, 9, 6, 3, 3, 3, 4, 19, 3, 10, 3, 2, 3, 3, 3, 3 and 3 times, respectively. It is to be noted that DMU_1 (Apple) is ranked as best first because, it has efficiency score of one and more number of referring DMUs as far as brand performance is concerned whereas DMU_{32} (Karbon) is ranked last one having efficiency score 0.766 denoted as most inefficient unit. The overall efficiency score of 40 DMUs is found to be 0.935 meaning that there exists a large scope for social context, research and development and awareness is required in improvement of brand performance in Indian environment. Therefore the inefficient brands need immediate attention to become efficient one. On the other hand, marginally inefficient are become efficient, but they are likely to stay there because of low changes in the variables. They can be made efficient only based on a long-term plan to improve all of the variables.

Table 3. Result of DEA CRS Model

DMUs	Efficiency	Ranking by DEA	Peers	Peer Weights	Peer Counts
DMU_1	1.000	1	1	1.000	22
DMU_2	1.000	1	2	1.000	12
DMU_3	1.000	1	3	1.000	9
DMU_4	1.000	1	4	1.000	6
DMU_5	1.000	1	5	1.000	3
DMU_6	1.000	1	6	1.000	3
DMU_7	1.000	1	7	1.000	3
DMU_8	1.000	1	8	1.000	4
DMU_9	1.000	1	9	1.000	19
			2	0.373	
DMU_{10}	0.956	6	1	0.356	0
			9	0.296	
			3	0.383	
DMU_{11}	1.000	1	11	1.000	3
DMU_{12}	1.000	1	12	1.000	10
DMU_{13}	1.000	1	13	1.000	3
			9	0.215	
DMU_{14}	0.866	15	1	0.298	0
			2	0.273	
			3	0.253	
			9	0.449	
			3	0.416	
DMU_{15}	0.907	10	1	0.321	0
			2	0.013	
			9	0.237	
			2	0.266	
DMU_{16}	0.896	11	1	0.432	0
			9	0.301	
DMU_{17}	1.000	1	17	1.000	2
			12	0.216	
			3	0.421	
			2	0.405	
DMU_{18}	0.810	20	6	0.261	0
			9	0.173	
			1	0.062	

DMU_{19}	0.889	12	12	0.229	0
			9	0.409	
			17	0.413	
			2	0.309	
DMU_{20}	0.954	7	9	0.028	0
			3	0.325	
			1	0.476	
			12	0.389	
DMU_{21}	1.000	1	21	1.000	3
DMU_{22}	0.939	8	2	0.301	0
			1	0.399	
			9	0.315	
DMU_{23}	0.986	3	12	0.589	0
			21	0.504	
			1	0.578	
			9	0.625	
DMU_{24}	0.881	14	9	0.050	0
			21	0.042	
			1	0.361	
			12	0.521	
DMU_{25}	0.852	18	12	0.522	0
			1	0.643	
			9	0.622	
			29	0.604	
DMU_{26}	0.925	9	7	0.566	0
			1	0.166	
			36	0.158	
			9	0.162	
DMU_{27}	0.988	2	29	0.523	0
			31	0.503	
			1	0.511	
			9	0.493	
DMU_{28}	0.886	13	5	0.526	0
			1	0.245	
			33	0.208	
			9	0.326	
DMU_{29}	1.000	1	29	1.000	3
DMU_{30}	0.789	22	12	0.026	0
			1	0.519	
			4	0.326	
			9	0.452	
			2	0.428	
			7	0.385	
DMU_{31}	1.000		31	1.000	3
DMU_{32}	0.766	23	6	0.456	0
			4	0.481	

			3	0.538	
			12	0.521	
			1	0.563	
			13	0.542	
			9	0.433	
DMU_{33}	1.000	1	33	1.000	3
			1	0.652	
			8	0.529	
DMU_{34}	0.982	4	4	0.519	0
			9	0.543	
			11	0.481	
			1	0.523	
DMU_{35}	0.862	16	36	0.507	0
			11	0.516	
			2	0.576	
DMU_{36}	1.000	1	36	1.000	3
			8	0.438	
DMU_{37}	0.829	19	4	0.587	0
			1	0.516	
			13	0.538	
			12	0.243	
DMU_{38}	0.958	5	33	0.289	0
			1	0.368	
			31	0.546	
			4	0.623	
DMU_{39}	0.857	17	1	0.527	0
			2	0.543	
			3	0.495	
			1	0.652	
			5	0.523	
DMU_{40}	0.799	21	3	0.581	0
			2	0.519	
			8	0.541	
Mean Efficiency = 0.935					

DEA with VRS scale assumption

The result of VRS-DEA model is shown in Table 4. In contrast to CRS model, 17 DMUs (DMU_5, DMU_9, DMU_{16}, DMU_{18}, DMU_{19}, DMU_{20}, DMU_{23}, DMU_{24}, DMU_{25}, DMU_{26}, DMU_{27}, DMU_{28}, DMU_{30}, DMU_{34}, DMU_{38}, DMU_{39} and DMU_{40}) with corresponding efficiency scores are found to be the DEA-inefficient units in VRS model. The inefficient units can make adjustments in their inputs/outputs looking into their peer groups to become efficient unit. These units may adopt either input-oriented strategy or output-oriented strategy to become efficient. The input-oriented strategy emphasizes on achieving current level of output using less inputs than the current level whereas output-oriented strategy rests on achieving higher level of output by same level of inputs. The latter strategy is not only preferred but also suitable for brand performance in Indian cellular market. The relative efficiency scores indicate that 17 DMUs out of 40 DMUs have emerged as inefficient units for the other 23 DMUs. Further in VRS model found that, 23 DMUs are efficient units listed as DMU_1, DMU_2, DMU_3, DMU_4, DMU_6, DMU_7, DMU_8, DMU_{10}, DMU_{11}, DMU_{12}, DMU_{13}, DMU_{14}, DMU_{15}, DMU_{17}, DMU_{21}, DMU_{22}, DMU_{29}, DMU_{31}, DMU_{32}, DMU_{35}, DMU_{36} and DMU_{37} as shown in column two. The efficiency score for these DMUs approach unity while that of DEA-inefficient DMUs show relative efficiency less than unity. The inefficient units can refer the DMUs listed in column four with corresponding peer weight given in column five for the improvement in brand performance.

The last column indicates that DMU_1, DMU_2, DMU_3 and DMU_{11} become the peer units for 17, 11, 10 and 8 times, respectively. Three DMUs (DMU_4, DMU_6 and DMU_{12}) become the peer units of 7 times. It is evident from column for that there are seven DMUs (DMU_7, DMU_8, DMU_{13}, DMU_{21}, DMU_{29}, DMU_{31} and DMU_{33}), which can refer three different DEA-efficient units. Seven DMUs (DMU_{14}, DMU_{15}, DMU_{17}, DMU_{32}, DMU_{35}, DMU_{36} and DMU_{37}) consult two benchmarking organizations whereas DMU_{10} and DMU_{22} which can refer four different DEA efficient units with the corresponding weightages. The overall efficiency score of 40 DMUs is found to be 0.978, which happen to be more than that of CRS-model. Based on the efficiency scores obtained from CRS and VRS model, it is exciting to note that 15 DMUs (DMU_{16}, DMU_{18}, DMU_{19}, DMU_{20}, DMU_{23}, DMU_{24}, DMU_{25}, DMU_{26}, DMU_{27}, DMU_{28}, DMU_{30}, DMU_{34}, DMU_{38}, DMU_{39} and DMU_{40}) have become inefficient unites in both the model.

In order to check for existence of significant difference between brand performance scores calculated using the two models (CRS and VRS), a paired sample t-test for means is carried out [55]. The hypothesis set is as follows:

$$\text{Null hypothesis}: H_0 \text{ TE from DEA (CRS)} = \text{TE from DEA (VRS)}$$
$$\text{Alternative hypothesis}: H_1 \text{ TE from DEA (CRS)} \neq \text{TE from DEA (VRS)}$$

The t-test is conducted using SYSTAT VERSION 13.1 software. The result shows a p-value of 0.002 allowing us to reject the null hypothesis with an α (probability of type I error) value as low as 0.05. This allows us to accept the alternate hypothesis that there is a significant difference between efficiency scores obtained through CRS and VRS models. The test indicates that a DEA models can produce results significant different based on assumption of scale. The company must study the behavior of input and output variables before making any assumption on scale.

Table 4. Result of DEA (VRS model)

DMUs	Efficiency	Ranking by DEA	Peers	Peer Weights	Peer Counts
DMU_1	1.000	1	1	1.000	17
DMU_2	1.000	1	2	1.000	11
DMU_3	1.000	1	3	1.000	10
DMU_4	1.000	1	4	1.000	7
DMU_5	0.964		1 2 3 10 13 33	0.035 0.705 0.263 0.400 0.425 0.305	0
DMU_6	1.000	1	6	1.000	7
DMU_7	1.000	1	7	1.000	3
DMU_8	1.000	1	8	1.000	3
DMU_9	0.967		1 3 4 11 29 31	0.277 0.338 0.342 0.371 0.371 0.340	0
DMU_{10}	1.000	1	10	1.000	4
DMU_{11}	1.000	1	11	1.000	8
DMU_{12}	1.000	1	12	1.000	7
DMU_{13}	1.000	1	13	1.000	3
DMU_{14}	1.000	1	14	1.000	2
DMU_{15}	1.000	1	15	1.000	2
DMU_{16}	0.726		1 2 6 12 14 32	0.358 0.316 0.309 0.341 0.371 0.304	0
DMU_{17}	1.000	1	17	1.000	2
DMU_{18}	0.735		1 3 4	0.352 0.320 0.303	0

			8	0.348	
			31	0.318	
			33	0.327	
			1	0.283	
			2	0.325	
DMU_{19}	0.735		3	0.373	0
			11	0.371	
			15	0.337	
			1	0.362	
			4	0.348	
DMU_{20}	0.847		6	0.405	0
			11	0.400	
			22	0.417	
DMU_{21}	1.000	1	21	1.000	3
DMU_{22}	1.000	1	22	1.000	4
			1	0.500	
DMU_{23}	0.834		2	0.508	0
			3	0.498	
			6	0.424	
			1	0.305	
DMU_{24}	0.755		2	0.342	0
			7	0.311	
			11	0.321	
			1	0.482	
			4	0.527	
DMU_{25}	0.753		10	0.546	0
			17	0.502	
			21	0.579	
			1	0.459	
DMU_{26}	0.907		2	0.030	0
			6	0.314	
			21	0.302	
			1	0.357	
DMU_{27}	0.867		7	0.265	0
			11	0.345	
			12	0.295	
			1	0.552	
			2	0.482	
DMU_{28}	0.894		3	0.461	0
			11	0.480	
			12	0.422	
DMU_{29}	1.000	1	29	1.000	3
			1	0.432	
DMU_{30}	0.884		2	0.301	0
			8	0.267	
			10	0.289	

			22	0.241	
			37	0.231	
DMU_{31}	1.000	1	31	1.000	3
DMU_{32}	1.000	1	32	1.000	2
DMU_{33}	1.000	1	33	1.000	3
			1	0.059	
			2	0.477	
			3	0.153	
DMU_{34}	0.746		12	0.311	0
			13	0.351	
			22	0.348	
DMU_{35}	1.000	1	35	1.000	2
DMU_{36}	1.000	1	36	1.000	2
DMU_{37}	1.000	1	37	1.000	2
			1	0.277	
			3	0.201	
DMU_{38}	0.778		4	0.332	0
			6	0.035	
			36	0.247	
			2	0.042	
			3	0.063	
DMU_{39}	0.866		11	0.263	0
			12	0.491	
			35	0.379	
			1	0.425	
			4	0.361	
DMU_{40}	0.742		6	0.300	0
			12	0.304	
			29	0.294	
Mean Efficiency = 0.978					

Conclusions

This paper attempts to provide a framework for assessing the brand performance of forty mobile brands available in Indian market based on DEA approach. The methodology helps to identity benchmarking the mobile brand so that the best practices of peers can be implemented to become efficient one. It also computes how much efficiency score needs to be enhanced to reach at referring unit's score. With growing interest in the applications of efficiency analysis, this attempted to develop a DEA based methodology for examining mobile phone performances using the cellular phone brands operating in Indian mobile phone market. In an era where customers find new mobile phones being launched in the market almost every day, it becomes difficult for them to choose one. The DEA based analysis presents single efficiency scores for various mobile phones in order to ease purchase decision of a potential customer. Manufactures may also use the DEA based analysis to benchmark and improvise their product performance. In other words company should improve brand characteristic i.e. customer knowledge, clear promise, unique proposition, consistency, storytelling, engagement, authenticity so that they have long term evaluation.

The creation of the work is based on fact that brand performance can be improved through adequate brand effectiveness i.e. price and image. Therefore, DEA approach helps to identify the benchmarking of mobile brand, which can be referred by inefficient units to become efficient one. The two approaches of DEA known as CRS and VRS are considered to obtain efficiency of DMUs. Eighteen nos. of brand out of 40 are found to be efficient in CRS model and twenty three nos. of brands found be efficient in VRS model. The total 14 DMUs (DMU_1, DMU_2, DMU_3, DMU_4, DMU_6, DMU_7, DMU_{18}, DMU_{11}, DMU_{12}, DMU_{13}, DMU_{21}, DMU_{31}, DMU_{33}, and DMU_{36}) have become efficient units in both CRS and VRS model based on their efficiency scores. The efficiency scores obtained by CRS and VRS models are compared using a paired sample t-test. It has been proved that statistical significant difference exists on ranking in the models. Therefore, company must be cautious regarding use of scale assumption. A thorough understanding of behavior of input and output variables is needed while assuming scale. Fifteen nos. of DMUs have resulted as inefficient in both CRS and VRS model. It is to be noted that in the case of VRS model 57.5 percent whereas 40 percent of CRS model of the selected DMUs under study are DEA-efficient. This study has some limitations. This can be a comprehensive approach to compare different mobile phone models based on the desired attributes against price.

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