USAGE OF DEA TECHNIQUE FOR MEASURING PRODUCTIVITY OF GROCERY RETAIL OUTLETS

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PURPOSE

TO measure the productivity of Indian grocery retail outlets with specific reference to Delhi and NCR region.

Design/Methodology/Approach: *Productivity measurement rests on the right selection of input and output variables. For this study, literature review, professional opinion of Retail Managers in the area concerned, and the academia people helped to validate the variables and factors used to study the productivity in Retail. These variables were refined using the stepwise regression. The data was collected from 180 organized grocery retail outlets. The retail outlets were divided into two categories based on area i.e., outlets having square feet area of less than 2000 sq.ft., and retail outlets having square feet area of more than 2000 sq.ft. Data Envelopment Analysis (DEA) was used for measuring the efficiency of 180 retail outlets for two consecutive years namely 2009-2010 and 2010-2011, which makes it 360 observations.*

Findings: *As per research findings, it was found out that there were 81 highly efficient firms, 206 efficient firms, and 73 are less efficient firms out of 360 observations in total for the two years. If we compare the performance of the firms from 2010-2011 to 2009-2010 then we can say that their overall performance has improved as the number of efficient firms has increased from 98 to 108.*

Research Limitations/Implications: *Our results cater to the retail establishment in Delhi and NCR region, and are area specific, so they cannot be generalized to every type of retail outlets, and every part of India. Therefore, there exists scope to carry out such study on all India level. Only one output variable in terms of sales has been taken to measure the output, and there exists further scope to include more output variables in future studies.*

Practical Implications: *The findings can be used by the retailers to keep a check on their retail outlets' input factors, and develop strategies for success to improve their productivity in future.*

Originality/Value: *This research will be a value addition in the area of grocery retailing where an application of DEA has been shown to keep a quick check on the efficiency and performance of grocery retail outlets.*

Key Words: *Grocery, Indian Retail, Productivity, Measurement Techniques, DEA.*

Introduction

The Indian retail industry has experienced growth of 10.6% between 2010 and 2012, and is expected to increase to USD 750-850 billion by 2015[1]. Food and Grocery is the largest category within the retail sector with a 60 per cent share. The retailers are running from pillar to post to penetrate deeper into the Indian wallet. The scenario is changing, and the shift is towards the betterment, it is estimated that the organized segments will double its share to 12% by end of this decade. The organized retail segment for food and grocery is estimated at USD 9 bn, and accounts for 70% of all organized retail. For organized formats, India serves as a land of opportunities with a brewing billion plus population supporting a superb high and middle income class segment. In metros consumers love pushing their trolleys down the long, straight aisles, that offer array of brands and fresh products at similar or little higher rate than the local mom and pop store offerings down the lane.

The organized retail supports different formats of outlets depending on catchment, spending power, proximity from major residential and consumption clusters. The offline mode of organized retailing is majorly categorized into Hypermarket, Supermarket, and Convenience depending on the surface coverage and product range. Last year witnessed flourishing hyper stores in India; major players expanded their stores covering spar in retail and best price in cash and carry space. The super market and convenience stores have seen a pause in scaling up from major retailers. 2011 almost recovered the economic slowdown but the retailers invested wisely on only profitable formats. Retailers concentrated on reshuffling the store layouts, and new marketing communications aspects to attract additional customers in the existing outlets followed by launching new stores in new geographies.

The recent wave of reforms by the Government to initialize Foreign Direct Investment (FDI) in various sectors is bringing a new zeal to the investment climate in India. The Government has now notified 51 per cent FDI in multi-brand retail, with this change, in coming days big brands are going to witness a tough challenge in terms of product offerings and pricing. Apart from various infrastructural constraints and operational challenges, organized retailers also face shrinking margin share challenges from leading brands and competition from local mom and pop stores. To deal with these immediate challenges private labels evolved as the mid-way. Retailers have started coming up with similar products within same price range. Staples, noodles, honey, juices, pickles, snacks, breads are some of the key categories in which private labels are flourishing. Almost all the retailers have their private labels in place, and wide acceptance from consumer boosts the emotion of selling better quality products at comparatively low price. To sum up, it can be said that the organized food retail has attained a promising size which is bound to grow manifolds in the coming years.

With lots of potential changes in the grocery retail climate, one can easily sense the challenges laid down by the environment. So, this is the right time to measure the productivity and performance of retailers to identify the right potential across the formats, and to understand the areas which need to be reconsidered for the future growth.

Retail Productivity

Retail productivity is usually measured as ratios of outputs to inputs. Ratchford and Stoops, 1998 defined productivity as a ratio of output measured in specific units, and any input factor also measured in specific units. A higher ratio of measured output to measured input factors can be directly interpreted as higher productivity.

From the proposed literature we can say that productivity is the measure through which performance of the retailers can be judged by looking at the blend of input and output of the firm or in more simple term it is the ratio of inputs vs. outputs, which can also be describe as:

$$\text{Productivity} = \frac{\text{Inputs}}{\text{Outputs}}$$

The analysis of productivity and efficiency has become an important activity in retailing (Barros and Alves, 2003; Lusch and Ray, 1990). In the retail industry, retail productivity plays an important role in the control and management of retail companies, and providing vital information for a number of tactical, strategic, and policy related decisions (Dubelaar, Bhargaia and Ferrarin, 2002; Ricardo and Francisco, 2007). Productivity of retailing is a significant component in influencing the cost of marketing goods, and it will give marketers tools to help compare productivity in retailing/marketing sectors of the economy with productivity in other sector of the economy (Charles and Robert, 1999).

However, it has been well-recognized that attempts to measure efficiencies and productivities of firms in the retail sector face a number of challenges owing to the difficulties in identifying the level of retail services. Despite its popularity in literature, the output-to-input ratio approach to retail productivity has several problems.

First, retail productivity has been used interchangeably with labor or salesperson productivity simply because retailing is often a labor-intensive activity (Bush, Bush, Ortinau, and Hair, 1990; Ingene, 1984, Ingene and Lusch, 1999), even though there is a large non-sales portion of labor force in retail industries. As a result, retail productivity has sometimes been treated as an issue of sales management. Focusing on an individual salesperson does not directly meet the measurement criteria of retail productivity because labor is simply one of the input factors (Good, 1984).

Traditional retail productivity studies have often focused on too micro units of analysis, e.g., salesperson evaluation; Bush et al., 1990 or too macro units of analysis, e.g., retail industries or aggregation of stores; Goldman, 1992; Donthu and Yoo, 1998. Previous researches have ignored retail productivity with respect to individual stores, and have not applied macro techniques to any extent as a managerial tool. Measuring productivity of individual stores would make the evaluation and control of managerial activities more feasible and objective. Retail managers need such store level productivity measurement tools.

Previous studies in this area have presented a number of measures, models, and methods to assess retail productivity and efficiency, including regression (Donthu and Yoo, 1998), stochastic frontier analysis (Barros and Alves 2005; Ricardo and Francisco, 2007), and data envelopment analysis (Thomas, Barr and Cron, 1998; Ratchford and Stoops, 1998; Donthu and Yoo, 1998; Keh and Chu, 2003; Barros and Alves, 2003, 2005; Kamakura, Lenartowicz and Ratchford, 1996).

DEA has many advantages in measurement of productivity as it- a) utilizes *both* output and input observations, b) accommodates *multiple* inputs and outputs, c) accommodates *both* controllable and uncontrollable factors, d) computes a *single index* of productivity, e) develops a *relative* measure of performance for each retail outlet using best performers as the basis, f) does not force *one* functional form relating the inputs and outputs of all observations (Donthu and Yoo, 1998)

Measures of Productivity and DEA Applications in Retail Sector

This section makes a literature review of DEA, and other techniques used for measuring the productivity of retail sector (Table 1).

Data Envelopment Analysis (DEA), these days has became a most sought after technique of productivity and efficiency measurement. Farrell (1957), and Charnes, Cooper, and Rhodes (1978) first introduced the term DEA to describe as a mathematical programming approach to the construction of production frontiers and the measurement of the efficiency of the constructed frontiers. The later authors proposed a model that had an input orientation, and assumed constant returns-to-scale (CRS). This model is known as the CCR by the name of Charnes, Cooper, and Rhodes model in the literature. Later studies have considered alternative sets of assumptions. Banker, Charnes, and Cooper (1984) first introduced the assumption of variable returns-to-scale (VRS). This model is known in the literature as the BCC model by the name of Banker, Charnes, and Cooper.

DEA has been applied successfully as a performance evaluation tool in many fields including manufacturing, schools, banks, pharmacies, small business development centers, nursing homes chains, maintenance units of the US Air Force, and hospitals, to name a few. Seiford (1990) provides an excellent bibliography of DEA applications. Kamakura, Ratchford, and Agrawal (1988) used DEA to measure market efficiency and welfare loss. Mahajan (1991) examined operations of insurance companies in a state. Parsons (1990) studied performance of salespersons using DEA.

Table 1: Studies on DEA Technique

Technique Used	Units of Measurements	Inputs	Outputs	Author	Year	Source
DEA	11 french generalist retailers	Labour, Capital, Total costs,	Turnover, Profits	Barros and Perrigot	2008	Journal of Retailing and Consumer Services
DEA	234 hypermarkets in Spain	Square meters, Employees	Sales	De Jorge	2008	International Journal of Retail & Distribution Management
DEA and Malmquist	96 supermarket chains in Spain	Number of full time equivalent employees, Number of outlets, Capital (equity/debt)	Sales, Operational results	Sellers-Rubio and Mas-Ruiz	2007	International Journal of Service Industry Management
DEA and Stochastic frontier	491 grocery retailers in Spain	Number of full time equivalent employees, Capital (equity / debt)	Sales	Sellers-Rubio and Mas-Ruiz	2007	International Journal of Service Industry Management
DEA	100 supermarket chains in Spain	Number of full time equivalent employees, Number of outlets, Capital (equity/debt)	Sales, Operational results	Sellers-Rubio and Mas-Ruiz	2006	International Journal of Retail & Distribution Management
Stochastic econometric frontier	47 retail outlets of one of the leading hypermarket and supermarket Portugal chains	Price of labour, Price of capital, Population density, Selling area of competitors, Index of per capita purchasing power, Rate of temporary workers, Staff absenteeism	Sales, Earnings	Barros	2005	International Journal of Retail & Distribution Management
DEA	47 retail outlets of one of the leading hypermarket and supermarket Portugal chains	Number of full time equivalent employees, Cost of labour, Number of cash-out points, Stock, Other costs	Sales, Profits	Barros and Alves	2003	International Journal of Retail & Distribution Management
Cobb Douglas function	245 departmental stores of USA	Labour: No. of hrs. worked in year, and No.	Sales	Ingene & Lusch	1999	International Journal of Physics Distribution &

		of employees; Capital: Total floor space in foot				Logistics Management
DEA & MANOVA	552 outlets of a USA multi-store, multi-market retailer	Labour: employees and wages, Experience: employee, store manager and store, Location related costs: occupancy, operating expenses, Internal processes: Inventory, transactions	Sales dollars, Profits dollars	Thomas et al.	1998	International Journal of Research in Marketing
DEA and Regression Models	24 outlets of a fast food restaurant chain for three years	Store size, Store location, Store manager experience, Promotion/give away expenses	Sales and Customer satisfaction	Donthu and Yoo	1998	Journal of Retailing
DEA	Restaurants	Adjustable inputs: the bar area (ft2), The number of covers; Uncontrollable inputs: market size (potential customers), the number of restaurants in a 1-mile radius, the number restaurants in a 3-mile radius	Food sales (in value), Sales of beverages (in value)	Anthana-ssopoulos	1995	Journal of Productivity Analysis

DEA is an operations research-based, non parametric statistical method for measuring the performance efficiency of decision units that are characterized by multiple inputs and outputs. DEA converts multiple inputs and outputs of a decision unit into a single measure of performance, generally referred to as relative efficiency. The most distinguishing feature of DEA is that in computing the relative performance efficiency, the best performing outlets are used as the bases for comparison. Comparing a retail outlet's performance with that of the best performing outlets (often referred to as benchmarking) is an important step towards achieving a retailing operation oriented excellence. Retail firms can use internal (own retail outlets) or external (outside retail outlets) standards as their benchmark.

Generally speaking, DEA is an extension of the traditional ratios analysis that identifies a firm as efficient when no other firm is capable of producing a higher output from the same input (output orientated) or, alternatively, of producing the same output from less input (input orientated), Unlike measuring one input output ratio at one time in ratio analysis this technique can measure all the combinations in one go, and analyze the efficiency based on all the parameters concerned.

Unlike the econometric stochastic frontier, DEA easily allows the use of multiple inputs and outputs. The standard econometric approach to estimate frontier functions for multi-input, multi-output technologies is to estimate dual frontier cost or profit functions where the scalar-valued cost or profit is used as the dependent variable. However, this requires that input and output prices are available, and that the behavioral assumptions of cost minimization or profit maximization are valid for the producer under study. These requirements restrict the applicability of frontiers models in the presence of multiple outputs since there are situations where input and output prices are unavailable or the behavioral assumptions are invalid.

Furthermore, estimating technical efficiency in the presence of multiple outputs is also possible replacing production frontiers (used in the case of single output) with distance functions. Inputs distance functions are used to define an input-oriented measure of technical efficiency, and output distance functions are used to define an output-oriented measure of technical efficiency.

Though DEA is a very useful technique in evaluating efficiency, this approach is not free from drawbacks. The results of DEA are sample specific and hence cannot be generalized for the entire population. Further, the scores obtained using DEA are relative measures of efficiency and not absolute measures. This implies that the most efficient unit in the sample is given a score of 1 or 100 percent, and all the other firms in the sample would be benchmarked against the best performing firm. Another way of expressing this is to say that an efficient unit does not necessarily produce the maximum output feasible for a given level of input (Miller and Noulas, 1996). Furthermore, since DEA is a non-parametric technique, it does not impose any functional form on the production function, nor does it make distributional assumptions for the inefficiency term. Gong and Sickles (1992), shows that neither technique uniformly dominates the other. Both approaches have been criticized as they make inferences about individual observations rather than about measures of central tendency.

Researcher suggests that DEA may be used to assess retail productivity/efficiency, and to address some of the problems with existing retail productivity measures. While traditional approaches are more appropriate for macro-level analysis, DEA is a micro-level or store-level productivity measurement tool that may have more managerial relevance.

Methodology

It can be seen that almost all papers mentioned in Table 1 used the DEA method, either only this technique or along with the other as in case of Thomas et al., 1998, and Ricardo and Francisco, 2007. However, to the knowledge of researcher, there seems to be no study on Indian retail sector using DEA.

In this study, DEA technique has been used for measuring the technical efficiency (it is a reflection of how best a firm can obtain maximal output from a given set of inputs) of 180 retail outlets operating in Delhi and NCR region of Indian retail sector.

DEA is used for the unit assessment of homogeneous units such as hypermarkets. The unit of assessment is normally referred to as a DMU (Decision Making Unit). A DMU converts inputs into outputs. The identification of the inputs and outputs in an assessment is as difficult as it is crucial. The literature review, the availability of data and managers' subjective opinions all play a role in the selection of inputs and outputs. In this paper, all three procedures mentioned above have been followed to select the inputs and outputs used in the study.

While using DEA, one needs to choose an input oriented model or an output-oriented model. The input orientation answers the question: By how many quantities should the inputs be reduced so as to produce the current levels of outputs? The output orientation replies to the question: At the current level of the inputs, by how much can the output quantities be increased?

In order to solve the linear-programming problem, the user must specify three characteristics of the model: the input-output orientation system, the returns-to-scale, and the weights of the evaluation system. In relation to the first of these, the choice of input- or output-oriented DEA is based on the market conditions of the DMU. As a general rule of thumb, in competitive markets, the DMUs are output-oriented, since we assume that inputs are under the control of the DMU, which then aims to maximise its output, this being subject to market demand and outside the control of the DMU. With exogenous inputs, the production function is the natural choice (Khumbhakar, 1987).

This is the status observed in hypermarket and supermarket retailing, and therefore, the one adopted in this paper. In monopolistic markets, the DMUs are input-oriented, because output is endogenous, while input is exogenous, and the cost function is the natural choice. In any case, the input and output orientated models estimate exactly the same frontier and, therefore, identify the same firms as efficient. The application of the model allowed the authors to distinguish units that behave efficiently from those that do not, in such a way that efficient units set the 'efficiency frontier' (Ricardo and Francisco, 2007).

As far as the returns-to-scale are concerned, these may be either constant or variable. Both forms (CCR and BCC model) are for comparative purposes. As far as the weights possibly placed on inputs and outputs in the objective function are concerned, these are subject to the inequality constraints. Weights are endogenously defined by the algorithm, and measure the distance between the DMU and the frontier.

DEA optimizes at each observation for the purpose of constructing the production frontier. Refer Figure 1, which consists of a discrete curve formed solely by efficient DMUs, those that maximize the output. The inefficient DMUs are below the frontier, since they do not maximize the production level.

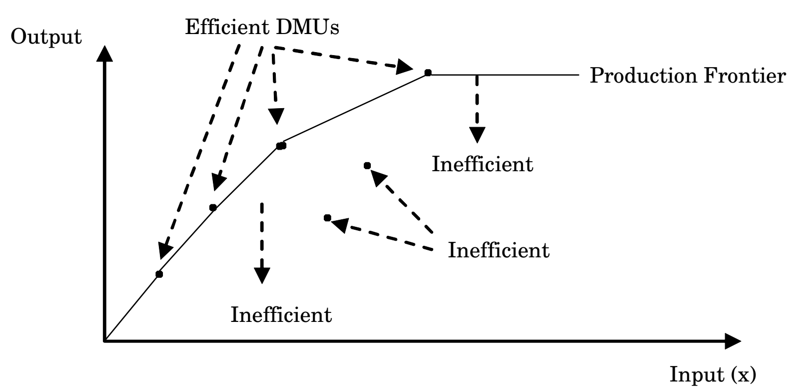


Figure 1: Showing Production Frontier Curve

Researcher has defined a Pareto-efficient or DEA-efficient DMU in cases in which the DMU uses m ≥ 1 inputs to secure s ≥ 1 outputs in either an output or an input orientation. The general-purpose DEA developed by Charnes et al. (1978) considers n DMUs (j = 1,. . .n), using k inputs to secure m outputs. The observed level of the kth input and mth output is being denoted by xij, yij, respectively, at DMU j. An efficient score for the nth DMU can be obtained by maximizing the ratio of total weighted output to total weighted input for all DMUs equation (1), subject to the constraint that all such ratios of the other DMUs in the sample must be less than or equal to one. Mathematically, this can be written as:

$$max_{u,v}\frac{uy_i}{vx_i}$$
$$st\frac{uy_i}{vx_i}-1\leq \mathbf{0} \qquad (1)$$

Where u represents the output weights and v represents the input weights. The system of equation (1) is a fractional programming model of computing technical efficiency, and can be solved with non-linear programming techniques. To simplify computation, a transformation of the fractional programming model allows the system of equation (1) to be formulated as a linear programming problem. For the CCR model with CRS, and strong disposability, the following linear programming is solved to ascertain whether DMU is DEA-efficient:

$$\min_{z,\lambda}\lambda_i \; st \; \sum_{i=1}^{n}x_{ij}z_i - \lambda_i x_{ij}\leq 0 \; \sum_{i=1}^{n}y_{ij}z_i - \lambda_i y_{ij}\geq 0 \;\; z_i\geq 0, \lambda_i free \qquad (2)$$

For the BCC model with VRS, and strong input disposability, the following linear programming is solved to ascertain whether DMU i is DEA efficient:

$$\min_{z,\lambda}\lambda_i \; st \; \sum_{i=1}^{n}x_{ij}z_i - \lambda_i x_{ij}\leq 0 \; \sum_{i=1}^{n}y_{ij}z_i - \lambda_i y_{ij}\geq 0 \;\; \sum_{i=1}^{n}z_i - \mathbf{1} = 0, \lambda_i free \qquad (3)$$

Where, λ is a scalar variable measuring the level of efficiency. The model works as follows. For a given set of feasible λ values, the LHSs of the input- and output-related constraints specify a production point within the production possibility set. The model seeks a point for the production possibility set which offers at least the output levels of DMU j0 while using as low a proportion of its input levels as possible. With the superscript * denoting optimal values, the j0 DMU is DEA-efficient if, and only if, = 1, if ≤ =1; whereas the j0 DMU is DEA-inefficient. is a measurement of the radial DEA efficiency of DMU j0.The model assesses efficiency in a production context. Its dual model assesses efficiency in a value context. By virtue of duality, the primal and dual models yield the same efficiency ratings in respect of DMU j0 (Charnes et al. (1978).

Variables

As discussed, productivity measurement rests on the set of inputs and outputs used for the study as a basis for knowing the performance of the firms. It should be done with a great care because the results will also vary according to the selection of the inputs and outputs done by the researcher, and if not selected with a care it might not be able to reflect the correct picture of the industry chosen. Before going for the discussion ahead it must be clarified what exactly is meant by the term inputs and outputs in case of retail industry.

In service industry, like retail, it is very difficult to define what exactly we mean by the input and output because unlike in the manufacturing industry retailers are not using some inputs, and getting outputs in quantitative terms. Achabal, John, and Shelby, 1984 have done an attempt to define both of them which were well accepted by others too, and the same definition will be used throughout our paper. He defines *Output* (extended product) as the function of the level of resource utilization which measures the capability of the firm to meet demand i.e., sales, gross margin, units sold, customer satisfaction, number of customer served, customer conversion ratio etc., and *Input* are all those factors of production used by the retailing firm which includes personnel, information systems, distribution centers, number of SKUs (Stock Keeping Units) etc., that are components of the firm's ultimate offer to consumers.

Several criteria can be applied to the selection of inputs and outputs. Usually, the available archival data criterion is used. The literature survey is a way of ensuring the validity of the research and, therefore, another criterion to be taken into account. The last criterion for measurement selection is the professional opinion of managers in the area concerned. In this paper, we have followed last two criteria "as no readymade, published data is available on store basis anywhere in India, it is only available at the head offices and regional offices of the companies concerned, where no retail firm from security point of view was ready to share the same with anybody, so we confined ourselves to the last two criteria". For final selection of the variables, Stepwise regression was used to find the important variables accounting for highest variation in terms of R square value from all the listed variables.

Parameters of Inputs

Number of Employees: Since labour makes the crucial contribution in the production of retail services it is likely to have a powerful impact on the productivity of retail firms. (Ricardo and Francisco, 2006, 2007; Barros and Alves, 2003; Dubelaar et al., 2002; Charles et al., 1999; Thomas et al., 1998; Kamkura et al., 1996; Good, 1984).

Numbers of POS Machines/Checkout Counters: Checkout systems with automatic inventory maintenance capabilities are likely to be helpful for the stores having extensive product assortments, and to reduce frequent stock outs (Barros and Alves 2003; Dubelaar et al., 2002). The study conducted by Dion (2003) using a field research team with the interview of 580 Independent Retailers found out that in those retail outlets who were using POS systems, faster check out of customers by scanning items on cash counters was possible which increases the speed of the transactions and thereby reducing the chance of a customer seeing a long line, and not making a purchase which later on increases the sales volume of the retailers.

Area of Outlets (Size of the Store): Productivity of the store and store size are significantly related (Barros and Alves, 2003; Keh and Chu, 2003; Dubelaar et al., 2002; Charles et al., 1999; Thomas et al., 1998; Donthu and Yoo 1998; Kamkura et al., 1996; Arndt and Olsen, 1975) Size of the store is perceived as a most important competitor for the retailers, and a threat to the other's profitability while taking other things of the retailers being equal (Geir and Gronhaug, 1985)

Number of Stock Keeping Units (SKUs): Research on product merchandising has shown that optimum sales depend on a minimum shelf length for each item. This concerns for minimum occupancy argues for a repartition of the shelf space among a limited number of brands (within a sufficient number of SKUs each) rather than to an atomization of the offering (Keh and Chu, 2003)

Distance of the Nearest Store of Similar Type: Short distances between stores make it easy for consumers to choose between them. Thus, nearest store will tend to be perceived as the most important competitor, and posing a threat in the functioning of the retailers. (Geir and Gronhaug, 1985)

Expenses: Expense is also an important input variable for studying the efficiency of the store, as one can see how much expense is incurred for getting particular amount of turnover, and relatively efficiency can be calculated. Barros and Alves, 2003 have taken inventory and other costs, and Thomas et al., 1998 have taken the total average inventory at cost in dollars as an input variable for measuring the efficiency of the retail outlets in their research.

Parameters of Outputs

Sales: Sales volume can generate the throughout necessity to improve the efficiency of fixed assets utilization, and can be taken as an important output for retail sector (Ricardo and Francisco, 2006, 2007; Dubelaar et al., 2002; Charles et al., 1999; Thomas et al., 1998; Donthu and Yoo 1998; Good, 1984).

As per the stepwise regression results in the case of less than 2000 sq.ft. area for 2009-2010, four inputs are found to be important and effecting the store performance as they accounted for 87% variance in the dependent variable. These input variables as per model 4 were- Area, SKU, Distance, and Employee numbers. In the case of less than 2000 sq.ft. area for 2010-2011, three inputs were found to be important as per model 3 and affecting the store performance with 87% variance explained in the dependent variable as- Area, SKU, Distance. Regression has rejected POS for its contribution in the case of small outlets. In the case of more than 2000 sq.ft. area for 2009-2010, five inputs contributed 79% as per model 5 that included- area, distance, POS, employee numbers, and SKU. For more than 2000 sq.ft. area for 2010-2011, same five inputs contributed 78% as per model 5 shown in the Table 2, and also the same results can be seen from the Appendixes 1, 2, 3, and 4. Though expenses were also an important input variable to be taken but as per our data set stepwise regression has rejected its contribution everywhere.

Table 2: Showing Stepwise Regression Results

Different Models	**Less than 2000 Sq.ft. (2009-2010)**	**Less than 2000 Sq.ft. (2010-2011)**	**More than 2000 Sq.ft. (2009-2010)**	**More than 2000 Sq.ft. (2010-2011)**
Model 1	Area (0.79)	Area (0.81)	Area (0.61)	Area (0.60)
Model 2	Area and SKU (0.85)	Area and SKU (0.86)	Area and Distance (0.71)	Area and Distance (0.70)
Model 3	Area, SKU, Distance (0.86)	Area, SKU, Distance (0.87)	Area, Distance, and POS (0.74)	Area, Distance, and POS (0.74)
Model 4	Area, SKU, Distance, Employee Numbers (0.87)	NIL	Area, Distance, POS, and Employee Numbers (0.77)	Area, Distance, POS, and Employee Numbers (0.76)
Model 5	NIL	NIL	Area, Distance, POS, Employee Numbers, and SKU (0.79)	Area, Distance, POS, Employee Numbers, and SKU (0.78)

R-square in brackets for each model

Table 3 shows the final input and output variable taken by researchers for the study of efficiency measurement in DEA. Inputs will vary but the output will remain the same, as sales. The output variable taken by researcher for the study was the sales in terms of value.

Sampling and Research Design

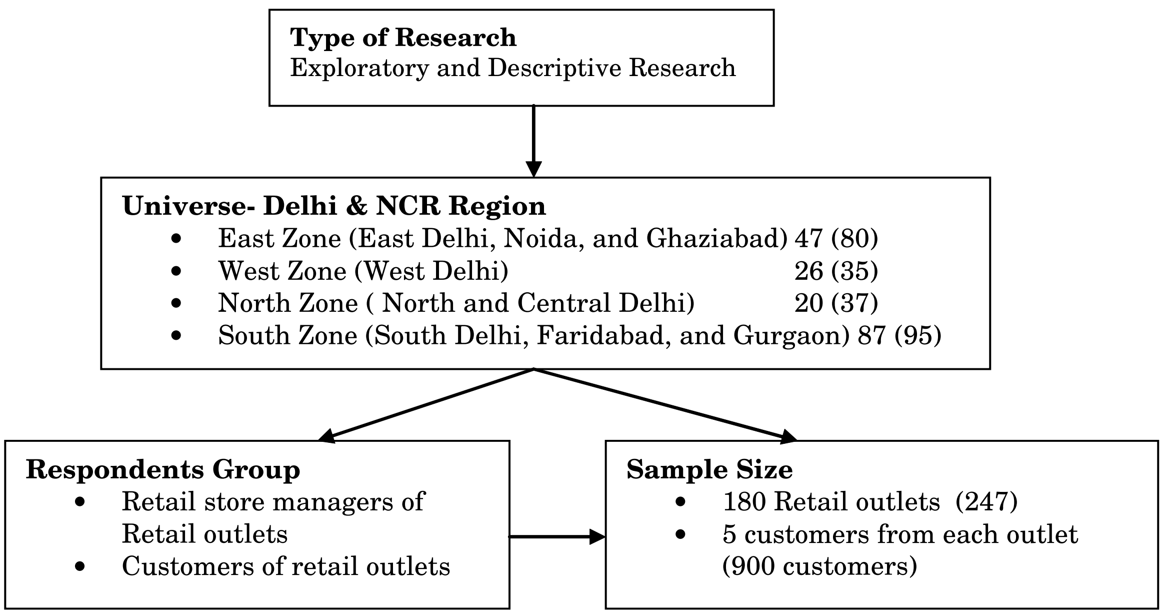
The retail outlets were divided into two categories: outlets having less than 2000 sq.ft. area, they were 93 and outlets having more than 2000 sq. ft area, which were 87. As no data base is available for such settings, so researchers themselves have collected the data from the store managers of the retail outlets with the help of structured questionnaires. The firms which provided the data wish to remain anonymous, and their names cannot be disclosed, that's why their names have not been mentioned anywhere in the study.

Table 3: Inputs and Outputs Variables for the Study

Less than 2000 Sq.ft. (2009-2010)	Less than 2000 Sq.ft. (2010-2011)	More than 2000 Sq.ft. (2009-2010)	More than 2000 Sq.ft. (2010-2011)
Area, SKU, Distance and Employee Numbers	Area, SKU, Distance	Area, Distance, POS, Employee Numbers, and SKU	Area, Distance, POS, Employee Numbers, and SKU

Output in all cases was Sales

Refer Figure 2 below for complete research design.



Figures in brackets were the total universe size available

Figure 2: Showing Research Design for the Study

Data

Authors have followed the DEA convention that the minimum numbers of DMUs are greater than three times the number of inputs plus output, Walters and Laffy (1996). Data from 180 organized retail outlets of various retail firms in the general food and grocery segment (those that caters product of day-to-day needs like-wet and dry groceries including- fruits and vegetables, staples, packed food products etc.) from Delhi and NCR region has been taken. The data is of 2 consecutive years, 2009-2010 and 2010-2011 for the similar 180 firms, 180+180=360 observations in total. The firms that are considered in the analysis are those that are into organized retailing, and have well established themselves at least a year ago so that their teething problems have been sought out, and now they have started their actual functioning.

Results and Findings

DEA scores range from 0 to 1. The score 1 implying, that the firm under consideration is productive, i.e., the output obtained from a given amount of input is maximal. The score 0 implies that the firm is not productive, which means that more output can be produced with the same amount of input. Researchers have divided the retail firms under three heads as per their efficiency scoring. Highly efficient firms are having efficiency score of 1, efficient firms are having efficiency score of 0.7 to 0.9, and less efficient firms are having efficiency score of less than 0.7. On that basis we have following results which have been calculated using the DEA technique through DEAP software, Version 2.1, and the output can be seen from the appendixes 5, 6, 7, and 8.

Table 4: Showing DEA Results

Firm's Efficiency	**Less than 2000 Sq.ft. (2009-2010)**	**Less than 2000 Sq.ft. (2010-2011)**	**More than 2000 Sq.ft. (2009-2010)**	**More than 2000 Sq.ft. (2010-2011)**	**Total**
Highly Efficient	25	10	22	24	81
Efficient	62	72	36	36	206
Less Efficient	6	11	29	27	73
Total	**93**	**93**	**87**	**87**	**360**

In the year 2009-2010, the number of highly efficient firms were 47, efficient firms were 98, and less efficient firms were 35, whereas in the year 2010-2011, the number of highly efficient firms were 34, efficient firms were 108, and less efficient firms were 38. If the performance of the firms from 2010-2011 to 2009-2010 are compared then it can be said that their overall performance has improved as the number of efficient firms has increased from 98 to 108.

It has been found that DEA is a powerful model to differentiate the most efficient units from the inefficient ones. In the Indian context, 81 out of 360 companies considered in the sample emerged as highly efficient, 206 are efficient firms, and 73 are less efficient firms. The average score for all the companies as a group stands at 0.82 for less than 2000 sq.ft. stores, and 0.78 for more than 2000 sq.ft. stores, which is also a good figure. In general, it may be perceived that the retailer is doing well. But for the less efficient retailers to get more out of their inputs used, they need to work on the proportion of the inputs, and their usage patterns.

By various discussions with the managers of the productive stores, it has been found that they were adopting different strategies to keep their business profitable in terms of the usage pattern of their inputs. Some of them are, enumerated below:

- **Store Size:** Area has came as an important input variable by regression. The retailer may not be able to alter the given space, but he can use the space more efficiently, by right placing of the products. There are stores working effectively with lesser store size whereas there are stores working less efficiently with adequate store size, it's because of space management. So, one should maintain it properly by using adequate amount of racks, gondolas, and keeping only working categories.
- **Popular Product Category:** The study indicates that Staples is amongst the most popular category of items being sold followed by Fruits and Vegetables, and FMCG products. The stores give utmost care to stock these products properly. At the same time, what is important is to develop a more accurate understanding of the profitability of the different products they offer in their stores, and more know how to position those products to take advantage of high margins and /or returns. In addition, they need a clarity regarding the profitability of category, whereby eliminating unprofitable products as required, and managing the product offerings, which

further involves the decision concerning the number of SKUs stock under each category, and how much for one particular brand, etc.

- **Merchandise Display:** The Visual Merchandising teams of these stores make frequent visits to gauge the customer pulse in order to prepare the 'Planogram' for each store, and are quite sensitized towards the needs of the various segments of customers while putting the products on display to instill impulse purchase. For example, stocking chocolates and toffees near bill counter, and stocking low – cost household items on the trolley passage, etc. The results are further supported by Beatty and Ferrell (1998) that atmospheric variables such as in-store promotions and product placement can improve a retail outlet's performance by causing the consumer to undertake unplanned or impulse purchases.
- **Distance:** When the nearest store is perceived as the most important competitor the store has no differential advantage with regard to location. Hence, to create a differential advantage in such a situation the retailer is apt to differentiate his store from the competitor in other ways.
- **Traffic Flow Patterns:** According to the store managers, devising appropriate strategies by monitoring the traffic flow patterns within the store are of utmost importance, so as, to make the most during the high season especially during festivals or holidays, or weekends, when the footfalls are amongst the highest. For example, selling combination gift packs to boost sales during Diwali, Christmas, and New Year Celebrations, etc. The result supports the findings by Turley and Milliman (2000), and others that people attach importance to factors like product signage and price promotions when shopping for themselves.
- **Point of Sales Machines:** Retail managers are very cautious about the number of machines required at a particular outlet to handle the customer traffic in their vicinity properly. At the same time, they ensure that they are efficient enough to deliver the requisite performance, and are well equipped with user-friendly software. Proper training is required for the employees for the usage of machines.
- **Optimal Placement and Usage of Human Resources:** The manager should be cautious about –

  (i) the proper number of recruitment of employees required for the functioning of the store,

  (ii) The managers should hire competent people who have the proper skills to perform their jobs, and help the customers. Competent employees can help customers make purchases, and motivate them to make a repeated visit to the store,

  (iii) Proper training should be given to employees on aspects like- products and brands of the companies, concept of SKU management, how to operate POS machines, and keep track on loyal customers, customer service, etc.

  (iv) Working hours of the employees should be such that, they work for that long where he would be able to deliver his best without feeling tired, and as per the industry standards,

  (v) The wages of the employees should also be such which keeps them motivated to do their job well.

Effect of Store Size and Store Performance

Further it was to be tested whether the store performance varies with respect to the store size for which the Null hypothesis to be tested was:

H0: There was no significant difference in the store performance measured in terms of sales with respect to the store size in area terms. t-test was used to test the hypothesis, and the following output was obtained for the years 2009-2010 and 2010-2011.

As seen from the Table 5 the value of P is less than the level of significance taken as 0.05, hence the null hypothesis stands rejected. Therefore, there exists a positive relationship between the store size in term of square feet, and the sales or store performance. So efforts need to be made on the part of the retailers, to gradually increase the store size, to increase the merchandise and choice for the consumers, they can purchase and sale in bulk, and further to increase their overall sales across product lines so as to beat the competition.

Table 5: Showing t-Test Results for the Year 2009-2010

Group Statistics

	Area in sq.ft.	N	Mean	Std. Deviation	Std. Error Mean
Sales	Less than 2000 sq.ft.	93	2.7902E7	1.15387E7	1.19650E6
	More than 2000 sq.ft.	87	2.2030E8	1.17362E8	1.25826E7

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Sales	Equal variances assumed	85.743	.000	-1.573E1	178	0.000
	Equal variances not Assumed	-1.522E1	8.756E1	0.000		

Table 6: Showing t-Test Results for the year 2010-2011

Group Statistics

	Area in sq.ft.	N	Mean	Std. Deviation	Std. Error Mean
Sales	Less than 2000 sq.ft.	93	3.11E7	1.294E7	1341392.521
	More than 2000 sq.ft.	87	2.45E8	1.290E8	1.384E7

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Sales	Equal variances assumed	8.545E1	0.000	-15.927	178	0.000
	Equal variances not Assumed	-15.412	87.617	0.000		

Conclusions and Implications for Management

All the above discussed factors namely- store size, popular product category, merchandise display, distance, traffic flow patterns, point of sales machines and optimal placement, and usage of human resources have an impact on the productivity performance of the stores. However, as per the discussion with the store managers, the productivity of the stores varies because of other factors like promotional schemes, the quality of the products stocked, and the availability of the products when the customers visit the stores. This is further supported by Noad and Rogers (2008), and Oppewal, Louviere, and Timmermans (1997) studies which highlighted that stock availability, quality of stock, range of stock, speed of service, and information on products, etc. plays an important role for consumers to make a purchase, and further effects the performance of the stores. Retail atmospherics, which includes clean and tidy environment, store ambience, etc., also affect the store performance and productivity.

Such things when explored and seen carefully will help the managers of the retail firms to understand their weaknesses in these areas, and if, due diligence is done the inefficient firms can also improve their efficiency.

Scope for Future Research

There exists scope of future research. Our results cater to the retail establishment in Delhi and NCR region, and are area specific, so they cannot be generalized to every type of retail outlet, and every part of India. Therefore, there exists scope to carry out such study on all India level. Only one output variable in terms of sales has been taken to measure the output, and there exist further scope to include more output variables in future study.

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Appendix 1: Regression Results of Less than 2000 Sq.ft. stores for the year 2009-2010

		Unstandardized Coefficients		Standardized Coefficients			R	Adjusted
Model		B	Std. Error	Beta	t	Sig.	Square	R Square
1	(Constant)	-7.73E+06	1.98E+06		-3.901	0.000	0.793	0.791
	Area	24712.33	1321.69	0.891	18.698	0.000		
2	(Constant)	-8.51E+06	1.66E+06		-5.133	0.000	0.858	0.855
	Area	21244.75	1228.673	0.766	17.291	0.000		
	SKU	3198.421	500.585	0.283	6.389	0.000		
3	(Constant)	-8.66E+06	1.63E+06		-5.322	0.000	0.865	0.86
	Area	20298.39	1282.197	0.732	15.831	0.000		
	SKU	2984.226	500.736	0.264	5.96	0.000		
	Distance	2192.892	1018.137	0.096	2.154	0.034		
4	(Constant)	-9.73E+06	1.67E+06		-5.818	0.000	0.872	0.866
	Area	19095.29	1377.492	0.688	13.862	0.000		
	SKU	2839.566	495.632	0.251	5.729	0.000		
	Distance	2286.707	999.284	0.1	2.288	0.025		
	Empl_No	449232.3	210176.3	0.095	2.137	0.035		

Dependent Variable: Sales

Appendix 2: Regression Results of Less than 2000 Sq.ft. stores for the year 2010-2011

		Unstandardized Coefficients		Standardized Coefficients			R	Adjusted
Model		B	Std. Error	Beta	t	Sig.	Square	R Square
1	(Constant)	-9.307E6	2.117E6		-4.396	0.000	0.813	0.811
	Area	28038.161	1411.149	0.901	19.869	0.000		
2	Constant)	-1.011E7	1.800E6		-5.616	0.000	0.867	0.864
	Area	23372.532	1386.050	.751	16.863	.000		
	SKU	3287.752	543.254	0.259	6.052	0.000		
3	(Constant)	-1.028E7	1.759E6		-5.844	0.000	0.874	0.870
	Area	20298.39	1282.197	0.732	15.831	0.000		
	SKU	3038.511	541.294	0.240	5.613	0.000		
	Distance	2551.698	1100.603	0.099	2.318	0.023		

Dependent Variable: Sales

Appendix 3: Regression Results of More than 2000 Sq.Ft. Stores for the Year 2009-2010

		Unstandardized Coefficients		Standardized Coefficients			R	Adjusted
Model		B	Std. Error	Beta	t	Sig.	Square	R Square
1	(Constant)	1.834E6	2.037E7		0.090	0.928	0.614	0.610
	Area	60314.642	5186.607	0.784	11.629	0.000		
2	(Constant)	5.636E7	2.032E7		-2.774	0.007	0.719	0.713
	Area	46888.213	5052.286	0.609	9.281	0.000		
	Distance	116752.895	20807.562	0.368	5.611	0.000		
3	(Constant)	-1.034E8	2.495E7		-4.144	0.000	0.747	0.738
	Area	42148.865	5078.984	0.548	8.299	0.000		
	Distance	106446.119	20175.489	0.336	5.276	0.000		
	POS	7.383E6	2.460E6	0.185	3.002	0.004		
4	(Constant)	-1.231E8	2.476E7		0-4.971	0.000	0.771	0.760
	Area	35804.780	5304.956	0.465	6.749	0.000		
	Distance	102090.569	19343.660	0.322	5.278	0.000		
	POS	7.353E6	2.351E6	0.184	3.127	0.002		
	Empl_No	6.481E6	2.183E6	0.181	2.969	0.004		
5	(Constant)	-1.867E8	3.320E7		-5.624	0.000	0.791	0.778
	Area	29683.558	5568.349	0.386	5.331	0.000		
	Distance	107041.702	18699.406	0.338	5.724	0.000		
	POS	POS	6.074E6	2.310E6	0.152	2.629	0.010	
	Empl_No	6.815E6	2.104E6	0.190	3.239	0.002		
	SKU	19841.049	7212.260	0.164	2.751	0.007		

Dependent Variable: Sales

Appendix 4: Regression Results of More than 2000 Sq.ft. Stores for the Year 2010-2011

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.	R Square	Adjusted R Square
1	(Constant)	8.188E6	2.247E7		0.364	0.716	0.607	0.602
	Area	65682.871	5734.738	0.779	11.454	0.000		
2	(Constant)	-5.465E7	2.273E7		-2.404	0.018	0.707	0.700
	Area	51251.006	5654.459	0.608	9.064	0.000		
	Distance	125629.960	23374.355	0.360	5.375	0.000		
3	(Constant)	-1.175E8	2.742E7		-4.284	0.000	0.747	0.738
	Area	45308.966	5533.702	0.537	8.188	0.000		
	Distance	111493.221	22193.898	0.320	5.024	0.000		
	POS	9.744E6	2.688E6	0.222	3.625	0.000		
4	(Constant)	-1.362E8	2.754E7		-4.944	0.000	0.766	0.755
	Area	39261.148	5857.798	0.466	6.702	0.000		
	Distance	107460.947	21547.793	0.308	4.987	0.000		
	POS	9.670E6	2.603E6	0.220	3.715	0.000		
	Empl_No	6.207E6	2.430E6	0.157	2.555	0.012		
5	(Constant)	-1.975E8	3.766E7		-5.246	0.000	0.781	0.767
	Area	33713.778	6186.334	0.400	5.450	0.000		
	Distance	109360.745	21008.355	0.314	5.206	0.000		
	POS	8.543E6	2.582E6	0.195	3.309	0.001		
	Empl_No	6.647E6	2.374E6	0.169	2.799	0.006		
	SKU	18958.735	8161.507	0.141	2.323	0.023		

Dependent Variable: Sales

Appendix 5: DEA Results of Less than 2000 Sq.ft. Area Stores for the Year 2009-2010

Store	CRS TE	VRS TE	Store	CRS TE	VRS TE	Store	CRS TE	VRS TE
1	0.365	1	32	1	1	63	1	1
2	**0.405**	**1**	**33**	**0.908**	**1**	64	0.716	0.806
3	**0.58**	**1**	34	0.811	0.83	65	0.82	0.82
4	**0.431**	**1**	35	0.809	0.817	66	0.792	0.872
5	**0.489**	**1**	36	0.881	0.945	67	0.879	0.927
6	0.459	0.724	37	0.851	0.886	68	0.748	0.811
7	0.445	0.689	38	0.891	0.929	69	0.864	0.873
8	0.448	0.62	39	0.811	0.84	70	0.874	0.876
9	0.475	0.716	40	0.736	0.764	71	0.894	0.927
10	0.46	0.718	**41**	**1**	**1**	72	0.842	0.915
11	0.563	0.887	42	0.654	0.698	**73**	**1**	**1**
12	**0.448**	**1**	43	0.74	0.763	74	0.584	0.683
13	0.639	0.85	44	0.929	0.935	**75**	**1**	**1**
14	0.637	0.808	45	0.961	0.961	76	0.757	0.773
15	0.539	0.692	46	0.736	0.736	77	0.734	0.752
16	**0.662**	**1**	47	0.764	0.786	78	0.921	0.921
17	0.752	0.883	48	0.746	0.758	**79**	**1**	**1**
18	0.7	0.816	49	0.764	0.767	**80**	**1**	**1**
19	**0.604**	**1**	50	0.762	0.782	81	0.682	0.752
20	0.627	0.709	51	0.848	0.852	82	0.816	0.867
21	0.652	0.762	52	0.739	0.754	**83**	**0.999**	**1**
22	0.721	0.81	53	0.758	0.763	**84**	**1**	**1**
23	**0.761**	**1**	54	0.894	0.958	85	0.902	0.933
24	**0.941**	**1**	55	0.827	0.842	**86**	**1**	**1**
25	0.717	0.804	56	0.834	0.855	87	0.67	0.69
26	0.756	0.845	57	0.764	0.768	88	0.771	0.791
27	0.658	0.723	58	0.697	0.738	**89**	**1**	**1**

28	0.877	0.906	59	0.66	0.782	90	0.855	0.919
29	**1**	**1**	60	0.764	0.765	**91**	**0.793**	**1**
30	0.887	0.993	61	0.703	0.828	92	0.776	0.847
31	0.915	0.926	**62**	**0.966**	**1**	93	0.63	0.836

CRS TE Constant Returns to Scale Technical Efficiency

VRS TE Variable Returns to Scale Technical Efficiency

Appendix 6: DEA results of Less than 2000 Sq.ft. Area Stores for the Year 2010-2011

Store	CRS TE	VRS TE	Store	CRS TE	VRS TE	Store	CRS TE	VRS TE
1	0.376	1	32	1	1	63	1	1
2	**0.404**	**1**	33	0.864	0.864	64	0.762	0.832
3	**0.575**	**1**	34	0.795	0.809	65	0.728	0.784
4	0.433	0.878	35	0.752	0.763	66	0.843	0.908
5	**0.462**	**1**	36	0.794	0.864	67	0.716	0.741
6	0.456	0.733	37	0.77	0.833	68	0.74	0.795
7	0.448	0.654	38	0.788	0.844	69	0.81	0.842
8	0.444	0.619	39	0.81	0.831	70	0.796	0.841
9	0.492	0.696	40	0.721	0.741	71	0.954	0.979
10	0.462	0.644	41	0.898	0.928	72	0.808	0.897
11	0.562	0.745	42	0.641	0.672	73	0.897	0.957
12	0.442	0.611	43	0.676	0.719	74	0.596	0.69
13	0.635	0.866	44	0.846	0.888	**75**	**1**	**1**
14	0.669	0.846	45	0.86	0.9	76	0.687	0.704
15	0.541	0.673	46	0.731	0.731	77	0.707	0.707
16	0.609	0.71	47	0.706	0.738	78	0.722	0.722
17	0.762	0.891	48	0.739	0.743	79	0.883	0.9
18	0.688	0.782	49	0.73	0.732	80	0.87	0.876
19	0.556	0.621	50	0.738	0.756	81	0.658	0.715
20	0.611	0.677	51	0.839	0.845	82	0.706	0.741
21	0.646	0.756	52	0.767	0.778	83	0.907	0.916
22	0.706	0.788	53	0.799	0.804	**84**	**1**	**1**

23	0.688	0.828	54	0.803	0.816	85	0.893	0.897
24	0.842	0.978	55	0.779	0.799	86	0.971	0.974
25	0.7	0.795	56	0.776	0.78	87	0.616	0.634
26	0.704	0.799	57	0.754	0.763	88	0.729	0.751
27	0.6	0.677	58	0.759	0.787	**89**	**1**	**1**
28	0.86	0.886	59	0.689	0.803	90	0.804	0.864
29	0.95	0.979	60	0.754	0.757	91	0.799	0.988
30	0.796	0.884	61	0.706	0.816	92	0.747	0.807
31	0.903	0.914	**62**	**0.906**	**1**	93	0.634	0.81

CRS TE Constant Returns to Scale Technical Efficiency

VRS TE Variable Returns to Scale Technical Efficiency

Appendix 7: DEA results of More than 2000 Sq.ft. Area Stores for the Year 2009-2010

Store	CRS TE	VRS TE	Store	CRS TE	VRS TE	Store	CRS TE	VRS TE
1	**1**	**1**	30	0.67	0.675	59	0.465	0.484
2	**0.73**	**1**	31	0.731	0.744	60	0.869	0.87
3	**1**	**1**	32	0.518	0.533	61	0.727	0.788
4	**0.609**	**1**	33	0.558	0.584	62	0.839	0.956
5	**0.514**	**1**	34	0.73	0.732	63	0.931	0.936
6	0.515	0.556	35	0.834	0.84	64	0.633	0.64
7	**0.851**	**1**	36	0.642	0.847	65	0.741	0.856
8	0.626	0.662	37	0.953	0.975	**66**	**0.892**	**1**
9	0.517	0.624	38	0.535	0.535	**67**	**0.966**	**1**
10	0.609	0.691	39	0.83	0.833	68	0.656	0.701
11	0.714	0.871	40	0.511	0.563	69	0.631	0.676
12	**0.618**	**1**	41	0.446	0.742	70	0.969	0.988
13	**0.542**	**1**	42	0.542	0.542	**71**	**0.97**	**1**
14	0.542	0.895	43	0.549	0.57	72	0.591	0.629
15	**1**	**1**	44	0.634	0.637	73	0.525	0.534

16	**1**	**1**	45	0.639	0.71	74	0.916	0.954
17	**0.953**	**1**	46	0.554	0.554	**75**	**1**	**1**
18	0.73	0.743	**47**	**0.833**	**1**	**76**	**1**	**1**
19	0.542	0.544	48	0.514	0.514	77	0.747	0.812
20	0.637	0.639	49	0.73	0.738	78	0.907	0.985
21	0.575	0.578	50	0.921	0.921	**79**	**0.957**	**1**
22	0.73	0.74	51	0.513	0.54	**80**	**1**	**1**
23	0.817	0.827	52	0.792	0.794	81	0.7	0.723
24	0.546	0.548	53	0.643	0.707	82	0.965	0.981
25	0.83	0.844	54	0.722	0.765	83	0.938	0.944
26	0.512	0.513	55	0.413	0.413	84	0.946	0.981
27	0.73	0.737	**56**	**1**	**1**	**85**	**1**	**1**
28	0.363	0.418	57	0.741	0.788	86	0.636	0.815
29	0.518	0.531	58	0.574	0.694	**87**	**1**	**1**

CRS TE Constant Returns to Scale Technical Efficiency

VRS TE Variable Returns to Scale Technical Efficiency

Appendix 8: DEA Results of More than 2000 Sq.ft. Area Stores for the Year 2010-2011

Store	CRS TE	VRS TE	Store	CRS TE	VRS TE	Store	CRS TE	VRS TE
1	**1**	**1**	30	0.626	0.634	59	0.45	0.462
2	**0.695**	**1**	31	0.682	0.707	60	0.843	0.848
3	**1**	**1**	32	0.51	0.518	61	0.751	0.799
4	**0.598**	**1**	33	0.563	0.594	62	0.88	0.986
5	**0.529**	**1**	34	0.739	0.756	63	0.958	0.962
6	0.535	0.574	35	0.864	0.865	64	0.621	0.628
7	**0.854**	**1**	36	0.669	0.872	65	0.726	0.83
8	0.655	0.69	**37**	**0.996**	**1**	**66**	**0.937**	**1**
9	0.545	0.664	38	0.579	0.582	**67**	**0.92**	**1**
10	0.586	0.662	39	0.8	0.811	68	0.684	0.718

11	0.667	0.845	40	0.516	0.574	69	0.611	0.66
12	**0.642**	**1**	41	0.448	0.746	**70**	**1**	**1**
13	**0.568**	**1**	42	0.549	0.551	**71**	**0.992**	**1**
14	0.573	0.912	43	0.574	0.595	72	0.589	0.625
15	**1**	**1**	44	0.652	0.652	73	0.544	0.544
16	**1**	**1**	45	0.638	0.711	74	0.907	0.941
17	**0.953**	**1**	46	0.516	0.517	**75**	**1**	**1**
18	0.76	0.777	**47**	**0.755**	**1**	**76**	**1**	**1**
19	0.572	0.575	48	0.708	0.72	77	0.725	0.772
20	0.68	0.683	49	0.701	0.701	78	0.88	0.961
21	0.559	0.563	50	0.903	0.904	**79**	**1**	**1**
22	0.717	0.728	51	0.498	0.518	**80**	**1**	**1**
23	0.793	0.821	52	0.793	0.801	81	0.678	0.709
24	0.545	0.549	53	0.66	0.739	82	0.934	0.948
25	0.846	0.862	54	0.712	0.742	83	0.859	0.859
26	0.522	0.524	55	0.407	0.409	84	0.992	0.997
27	0.736	0.753	**56**	**0.996**	**1**	**85**	**1**	**1**
28	0.329	0.383	57	0.68	0.721	86	0.642	0.807
29	0.492	0.501	58	0.618	0.713	**87**	**1**	**1**

CRS TE Constant Returns to Scale Technical Efficiency

VRS TE Variable Returns to Scale Technical Efficiency