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A process for evaluating retail store efficiency: a restricted DEA approach

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Abstract

A managerial process is developed for assessing the efficiency of 552 individual stores for a multi-store, multi-market retailer employing Data Envelopment Analysis (DEA). Incorporating assurance regions into a DEA model allowed for a more complete specification of inputs and outcomes than usually found in DEA applications. This procedure permitted the researchers to capture top management's strategic thinking. Practical usefulness of the process' results is illustrated with respect to two management issues: evaluating store managers and identifying critical success factors (CSFs).

Keywords: Strategy; Decision making; Retail; Efficiency

Numerous methods have been proposed for evaluating retail efficiency for a single location retailer, retailers in a specific category, and the retail industry as a whole (Sherman, 1984; Lusch and Jaworski, 1991; Bharadwaj and Menon, 1993). There is a paucity of research, however, on the measurement and evaluation of individual store productivity within a large, multi-store multi-market chain operation (recent exceptions include Parsons, 1994a,b; Balakrishnan et al., 1994; Anthanassopoulos, 1995; Kamakura et al., 1996). Multi-store, multi-market chain retailers have expanded rapidly and account for over 50% of nondurable goods sales (Dunne et al., 1992).

Within-chain comparative store efficiency is a key factor in a number of important strategic management decisions. First, the evaluation, promotion and development store management personnel relies on assumptions about factors affecting store financial performance. Second, strategic resource-allocation decisions—such as advertising budgets, store expansions and store closings—are based on top management's understanding of what drives store performance. For instance, if the factors that contribute to low performance are deemed to be unalterable or prohibitively expensive to modify, management may choose to close the store. Third, adopting a 'best practices' approach to continuous improvement and corporate learning requires ongoing monitoring of store management procedures and their influence on store performance.

This study describes an evaluation process, based on Data Envelopment Analysis (DEA), to assess the efficiency of individual stores within a chain. DEA is particularly appropriate for this evaluation because it

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integrates a variety of performance metrics and provides a structured methodology for evaluating retail store performance. Unlike most previous applications of DEA in marketing, however, this study incorporates a relatively large number of senior management derived practices/resources that could affect a store's performance. This is accomplished by a process incorporating top management judgments for weighting the relative importance of various resources. This process also helps ensure conformance of store efficiency results with the chain's overall business strategy. The process for deriving restricted DEA results is described. Finally, we illustrate the application of the evaluation process to two strategic management decisions—individual store performance evaluation, and identification of critical success factors (CSFs).

1. Retail store efficiency

Efficiency has been an important issue in retailing and one that enjoys a rich research tradition (Lusch et al., 1995). Early studies tended to focus on labor productivity because labor expenditures were and continue to be of great importance (Ratchford and Brown, 1985). More recent studies, however, have examined other factors that may influence store productivity, such as merchandise assortment, location, pricing, and promotion (Mahajan et al., 1985, 1988; Weitzel et al., 1989; Dickinson et al., 1992; Wileman, 1993). Specifically, Parsons (1992) makes the distinction between efficiency, effectiveness, and productivity, which is the combination of efficiency and effectiveness. Efficiency refers to the relationship between inputs and outputs, while effectiveness focuses on outputs relative to a particular objective. Given this distinction, Parsons argues that retail productivity studies are more accurately classified as efficiency studies.

The ratio of inputs to outputs has been the typical conceptualization of efficiency (Ingene, 1983; Lusch and Moon, 1984). Though widely used, a number of criticisms have been leveled at the use of simple input-to-output ratios to measure productivity (see Parsons, 1992; Thurik, 1992; Kamakura et al., 1996). Issues relevant to this discussion include:

- When multiple inputs or outputs are present, weights must be applied to each input and output. These must be combined to form a composite, usually through weighted sums, performance matrix. The weights are chosen to reflect both their units of measure and their relative significance. Arriving at these weights can be problematic, particularly when changes occur in product mix, product quality, or service levels (Parsons, 1992).
- Many factors influencing productivity, such as economies of scale, age and location of store, assortment composition, employment patterns, business cycles, and trading area factors, are not typically captured by productivity ratios (Doutt, 1984; Lusch and Moon, 1984; Ratchford and Stoops, 1988; Tucker and Tucci, 1994).
- The input/output relationship has traditionally been established using ordinary least squares regression, which is based on averages. The efficiency of a particular unit is compared to the average of all units being considered. Parsons (1992) argues that best practices should be used as the basis of store comparison and not average performance.

The use of efficiency measures for practical managerial evaluative purposes, however, raises additional problems. First, relevant individual store differences must be considered within the model to take into account advantages and disadvantages of particular stores, e.g., location, labor situation, competitive intensity (Kamakura et al., 1996). Second, motivating and rewarding store personnel is much more effective when specific practices can be observed and transferred to other stores. Efficient practices should be identified, described, and used as benchmarks for less efficient stores. Third, a distinction must be made between resources under the control of store personnel vs. those they have little or no influence over (e.g., labor costs when wages are set at headquarters). Fourth, more than one outcome usually needs to be considered because stores are responsible for multiple and sometimes conflicting performance measures (e.g., sales and profits). An appropriate balance must be achieved so that one measure does not dominate the evaluation process.

Given the importance of assessing retail store efficiency, our evaluation process uses DEA to overcome these concerns. This methodology is summarized in Section 2.

2. DEA

DEA is a nonparametric approach for evaluating the efficiency of individual units within a given population. The units, referred to as *decision making units* (DMUs), may be any set of entities that transform comparable inputs into comparable outputs. Examples of DMUs include schools (Bessent et al., 1982), banks and bank branches (Oran and Yolalan, 1990; Barr et al., 1993) and even individuals (Mahajan, 1991; Howard and Miller, 1993). Extensive reviews of DEA can be found in Norman and Stoker (1990), Boussofiane et al. (1991), and Charnes et al. (1994b).

DEA calculates a DMU's efficiency by determining the minimum possible inputs needed to capture a set of outputs or by determining the maximum possible outputs that can be generated from a given set of inputs (Parsons, 1992). The term relative efficiency is used because each DMU's efficiency is estimated relative to other units in the sample or cohort group. Moreover, instead of using a single optimization for all observations as in least squares regression, DEA uses a series of optimizations, one for each DMU. This process separates efficient and inefficient units. For each inefficient DMU, the analysis also indicates the efficient reference set—those units on the efficient frontier against which the DMU is directly compared (instead of a hypothetical 'average store' as done in regression).

While there are many variants of DEA, we used as our starting point the original fractional programming for assessing the efficiency of DMU 'o' (Charnes et al., 1981), which is as follows:

$$\text{maximize:} \quad \frac{\sum_r U_r O_r^{(o)}}{\sum_i V_i I_i^{(o)}}, \tag{1}$$

$$\text{subject to:} \quad \frac{\sum_r U_r O_r^{(j)}}{\sum_i V_i I_i^{(j)}} \leqslant 1, \quad j = 0,1,\ldots m, \tag{2}$$

$$U_r, V_i \geqslant 0, \tag{3}$$

where j is a unique index number associated with each of the m DMUs, o is the index of the DMU under analysis, O_r^j is the rth observed output of unit j, I_i^j is the ith observed input of unit j, and U_r and V_i are the (unknown) weights attached to positive output O_r and positive input I_i, respectively. The objective is to maximize the efficiency of DMU o by optimizing weights U and V. The constraints ensure that, when this set of weights is applied to each DMU in the population, no unit's efficiency exceeds 1. The maximum value obtained for DMU 'o' is that unit's 'efficiency score', and a value of 1 signifies a frontier-efficient unit. Thus, DEA produces a single measure of how efficiently inputs are utilized to attain outputs.

It is important to note the assumptions underlying DEA and how they differ from other approaches to estimating performance, conventional regression analysis in particular (Charnes et al., 1989). DEA does not require an explicit specification of the functional form of the production function, prespecification of the weights, or the ordinal scaling analysis often required with parametric statistical approaches. DEA focuses on efficient frontiers rather than central tendencies, as is done in least-squares regression. Instead of fitting a regression plane through the center of a data set, DEA constructs a piecewise linear 'surface' that interpolates between (envelopes) the most efficient observations. Because of this approach, DEA is particularly adept at uncovering relationships that remain hidden using least-squares approaches (Banker et al., 1986; Varian, 1990). DEA has also been shown to be more accurate than regression analysis in identifying efficient and inefficient DMUs and in quantifying the factors influential in defining efficiency (Charnes et al., 1989). This is because DEA considers each observation separately, comparing it only to its most similar efficient neighbors.

Several DEA models and extensions were employed in this study. All models assumed constant returns-to-scale (Charnes et al., 1978) because the store units, which were the focus of this investigation, were found to be of similar functionality and scale therefore allowing for a more narrow band scale within the analysis. The constant returns-to-scale model provided a better picture of efficiency because size is similar and scale was not an issue.

The DMU ranking the procedure incorporated the extended technical efficiency technique developed by Anderson and Petersen (1989, 1993). This technique allows for a ranking among the efficient units. Efficient DMUs all receive scores equal to one in the traditional DEA analysis. This does not allow for discrimination or comparison within the group of efficient units. The extended technical efficiency process facilitates a comparison and ranking of relative efficiency within the group of efficient DMUs by allowing efficiency ratings to exceed one. The basic notion is that an efficient DMU may still be able to increase its vector input proportionally, beyond the linear combinations of the efficiency frontier of the sample, thereby yielding an efficiency score greater than one. This enables a sequential ranking of all DMUs within the study rather than generating a cluster of apparently equivalent performers.

Non-discretionary inputs were modeled using the formulations of Banker and Morey (1986). The use of discretionary and non-discretionary variables is well documented in previous DEA studies (Charnes et al., 1994a) where the marketing environment is considered relevant to a unit's performance.

The problems were solved using the PIONEER code (Barr and Durchholz, 1994) and its successor, PIONEER-11. Early runs were made on a Sequent S81B parallel computer, and later results were obtained on DEC stations. Both the input and output orientations were applied. Input and output values were scaled using their geometric means prior to the imposition of the R-1 and R-2 restrictions. The efficiency measure used in this study is θ.

3. Efficiency evaluation process

Our approach for evaluating the efficiency of store operations within a multi-store, multi-market chain is outlined in Fig. 1. A four-phase process was utilized to advance the practical applicability of DEA in two meaningful ways. First, a comprehensive configuration of input factors were incorporated into the DEA model. Most applications of DEA consider only a very limited number of input factors. The sensitivity of DEA results to omission of critical factors has only recently been investigated (Ahn and Seiford, 1990). Second, we wished to make the results meaningful to the focal organization by capturing the importance of top management's strategic perspectives at a store level analysis. Though strategy is typically formulated at the corporate level, execution of a strategy occurs at the store level. Evaluation of store efficiency, therefore, should incorporate top management's strategic assessments of those factors that can be controlled at headquarters and/or by store personnel. The remainder of this section describes each of the four phases in the evaluation process and how each was executed for a particular large retail chain.

3.1. Phase I: issues identification

The focal organization for this study is a leading specialty retailer with over 500 domestic retail outlets. The merchandise carried in the stores consists primarily of moderately priced home furnishings and household items with an emphasis on uniqueness and self-expression. Customer purchases are almost entirely discretionary in nature, so adept merchandise acquisition and presentation are important. Stores are situated in high-traffic locations, such as malls and strip shopping centers, in both urban and suburban neighborhoods.

Initially, top management was interested in a chain-wide evaluation of store manager performance. The evaluation of a store manager in this chain had been an onerous task for top management for two reasons. First, the performance appraisal scale developed by the Human Resources Department required regional managers (store manager's direct reports) to evaluate each store manager reporting to them. Since these managers had numerous direct reports and were not able to accurately observe behaviors, halo and central tendency problems occurred. That is, most regional managers rated their store managers as either a 4 or a 5 on a five-point likert scale. They were unable to differentiate store manager performance. Second, while top managers agreed that a store manager's performance could only control a small fraction of the store's total performance, less than 10%, it was an importance percentage because this fraction dropped directly to the store's bottom line.

After describing how DEA could derive a valid efficiency measure for each store, discussions broadened to how a better understanding of store efficiency would be strategically useful. First, improvement of store operations could be enhanced by iden-

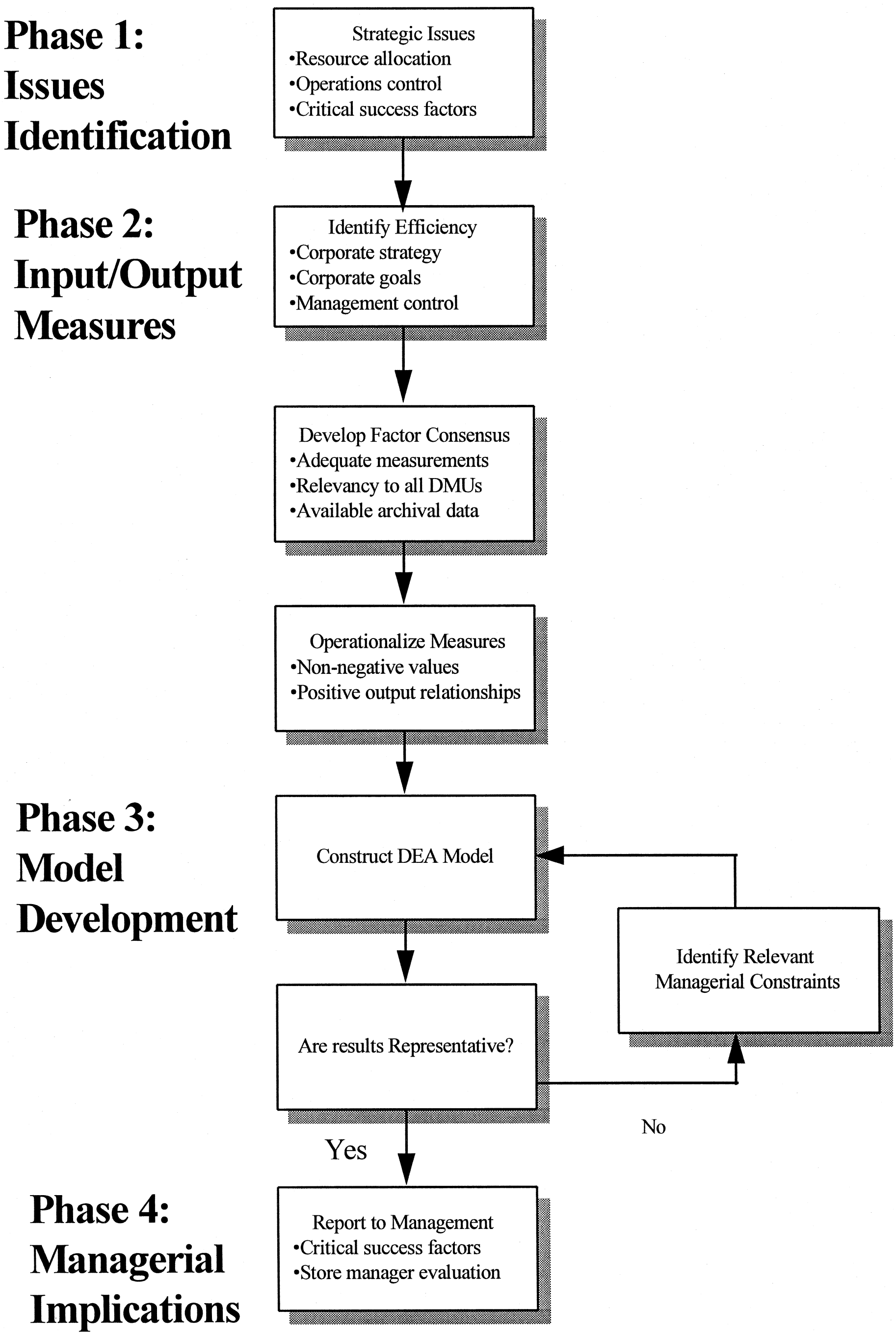

Fig. 1. Store efficiency evaluation process.

tifying highly efficient individual stores. The unique procedures of highly efficient stores could be observed and eventually applied to other stores. Second, CSFs could be identified by observing 'best practices' stores as a means for continuous improvement and corporate learning for other stores.

3.2. Phase II: input / output measures

3.2.1. Identifying efficiency factors

DEA evaluation requires the designation of inputs (resources) and outputs (transformation results). It is important for the applicability of the DEA results and for management 'buy-in' to the process and final recommendations that the measures be derived from the organization's strategy and objectives. The measures chosen and our results are unique to the focal organization.

While there was general and quick agreement by management as to the two outcome variables, sales and profits, early discussions with senior management indicated that a wide variety of factors could influence a unit's efficiency. A Delphi approach involving a series of nine meetings with the eight member executive team and a regional manager panel consisting of 26 regional managers was used to generate a comprehensive list of possible inputs. Fifty-five possible input variables were ultimately identified, compiled, and recorded through these series of meetings. At each meeting, the lists of possible input measures suggested by each functional area within the organization were reviewed and discussed. Additional variables were added to the list over the course of these discussions, yielding this set of 55 suggested measures. The top management team then reduced this list to the 16 variables they deemed most central to their operations and strategy. Uncovering top managers' mental processes and the way they were able to link concepts that they believed affected store performance resulted in a valid set of performance appraisal categories. Since senior managers primarily use intuition to make performance judgments (Jolly et al., 1988), the Delphi procedure permitted them to articulate their own preferences. Using managerial judgement to assist in the development of appropriate variables is common to many DEA studies (Charnes et al., 1994b).

3.2.2. Developing factor consensus

Based on discussions with the executive team, two store-level outcomes were identified as being particularly relevant to overall organizational effectiveness: dollar sales and contribution dollars. A store's dollar sales was defined as its gross sales minus returns and allowances. Store contribution dollars was the store's net sales minus cost of goods sold and store operating expenses; that is, profit before allocation of corporate overhead.

During three subsequent meetings with the executive team, input factors were eliminated for a number of reasons—no means of adequate measurement, factor not relevant to all stores, and no appropriate archival data available. Many of these inputs, such as 'days of sunshine', 'quality of signage', and 'location' could not be controlled by the store manager and, in any case, were not amenable to measurement. These measures were deleted from consideration. The focal organization maintained market statistics, trade-area characteristics, and extensive operating information for each store. These archival data were utilized in this study. For DEA purposes, such archival data is preferable to other forms since they avoid the problem of reactivity associated with survey or self-report measures (McGrath et al., 1982). DEA methodology is especially well suited to use of either ordinal or interval archival data where measurement error is minimized (Lewin et al., 1982). The advantage of archival data is evidenced by its dominance in DEA studies (Thomas, 1994).

3.2.3. Operationalize measures

By the end of the final meeting, there was consensus on 16 input factors. These input and output factors reflect top management's decisional processes, and as such cannot be generalized to other settings. Table 1 presents each input variable and its operationalization.

The 16 inputs are classified into four general categories. The labor input variables are reflective of both the cost of labor (pay) and the intensity of labor at each store (FTSQFT). Since the hours of a store's operation are established by headquarters, these inputs should provide a valid measure of labor usage. The ratio of full-time to part-time employees (FTPT) is important both as an indicator of labor expense and as an investment in customer service. Full-time people are more expensive to support than part-timers; however, they benefit their employer by establishing long-term customer relationships.

The three experience variables are all expected to be positively related to store sales and profits. Employees with longer tenure (ETEN) are felt to be more satisfied employees, better at providing posi-

Table 1
Operationalization of input variables

Category	Variable		Operationalization
Labor	Full-time employees per square foot	FTSQFT	Average number of full-time employees per square foot of selling space times 10,000
	Full-to-Part-time employees	FTPT	Ratio of the average number of full-time workers to part-time employees
	Salaries	PAY	Total of annual salaries and wages divided by total payroll hours
Experience	Employee tenure	ETEN	Average hourly employee tenure in years
	Store manager tenure	MGTEN	Average store manager's tenure in years
	Store age	AGE	Age of store in years
Location related costs	Occupancy costs	OCC	Base rent plus other occupancy expenses divided by total selling square footage
	Operating Expenses	OPEXP	Dollars of annual operating expenses per store
	Population	POP	Population per store in market
	Household Income	HHINC	Average annual household income in 2-mile radius
	Households	HHS	Number of households in 2-mile radius
	Proximity	PROX	Distance in miles to nearest company store
Internal processes	Inventory	INV	Total average dollars inventory at cost
	Transactions	TRANS	Average dollar size of transactions
	Employee Turnover	TURN	Percent of annual turnover[a]
	Shrinkage	SHRINK	Dollar shrinkage divided by inventory dollars[a]

[a]Reverse scored.

tive and more extensive information to customers, and more concerned with store and company success than employees with short-tenure. Experienced managers (MGTEN) are able to better understand the customer, market, necessary merchandise mix, and human resource skills needed to improve store performance than less experienced managers. As a store becomes established within the business community (AGE), awareness and reputation are expected to become more widespread and positive through word-of-mouth. As a consequence, stores' fixtures and frontages are periodically updated to protect and maintain this competitive advantage.

Location-related costs include four standard measures frequently included in retail location studies—population (POP), household income (HHINC), number of households (HHS), and proximity to nearest company store (PROX) (Mahajan et al., 1985, 1988; Conant et al., 1993). Senior management felt that, in addition, occupancy costs (OCC) and store operating expenses (OPEXP), both significantly influenced by location, would have an important impact on sales and profits not captured in the other location variables.

The fourth set of variables reflect important business processes within a store and over which a store manager has responsibility and some control. Included among these measures are average inventory (INV), number of transactions (TRANS), employee turnover (TURN), and shrinkage (SHRINK). DEA requires all input variables to be positive numbers and positively related to outcomes. Measures of employee turnover (TURN) and inventory shrinkage (SHRINK), therefore, are reverse scored to conform with these methodological requirements. An intercorrelation matrix (see Table 2) is provided to illustrate the relationship of the variables used in this investigation.

3.3. Phase III: model development

The basic DMU for this study was the individual store. All stores within the chain were included in the study, except those that (1) were closed for 30 or more days; (2) had opened more than 15 days after the start of the fiscal year; or (3) had closed prior to the end of the fiscal year under evaluation. This resulted in a final sample population of 520 stores.

Table 2
Correlation matrix

	FTSQ	FTPT	CSTHR	ETN	MGTEN	AGE	OCC	OPEXP	POP
FTSQ	1.00								
FTPT	0.47[b]	1.00							
CSTHR	0.17[b]	0.04	1.00						
ETN	0.30	0.04	0.39[b]	1.00					
MGTEN	0.18[b]	0.08	0.28[b]	0.27[b]	1.00				
AGE	0.12[b]	0.06	0.15[b]	0.21[b]	0.17[b]	1.00			
OCC	0.23[b]	−0.08	0.37[b]	−0.04	0.04	−0.26[a]	1.00		
OPEXP	−0.26[b]	−0.08	−0.07	−0.05	−0.22[b]	−0.20[a]	−0.13[b]	1.00	
POP	0.15[b]	−0.02	0.14[b]	0.05	−0.08	0.03	0.21[b]	−0.01	1.00
HHINC	0.13[b]	−0.10[a]	0.33[b]	−0.09[a]	−0.00	−0.06	0.00[b]	−0.18[b]	0.25[b]
HHS	0.16[b]	0.04	0.20[b]	0.10[a]	−0.05	0.21[a]	0.16[b]	−0.09[a]	−0.02
PROX	−0.05	−0.02	−0.27[b]	−0.08	−0.02	−0.08	−0.19[b]	0.02	0.04
INV	0.28[b]	0.05	0.21[b]	0.03	0.27[b]	0.16[a]	0.21[b]	−0.23[b]	0.06
TRANS	0.46[b]	0.09[a]	0.20[b]	0.05	0.32[b]	0.15[a]	0.31[b]	−0.46[b]	0.15[b]
TURN	0.07	0.05	−0.21[b]	−0.43[b]	−0.13[b]	0.04	−0.02	−0.06	0.01
INVLS	0.25[b]	0.02	0.06	−0.00	0.04	0.18[a]	0.23[b]	−0.07	0.18[b]
SALES	0.48[b]	0.10[a]	0.24[b]	0.05	0.34[b]	0.17[a]	0.36[b]	−0.50[b]	0.20[b]
PROFIT	0.36[b]	0.15[b]	−0.10[a]	0.05	0.26[b]	0.33[a]	−0.26[b]	−0.52[b]	0.08
Mean	5.11	0.76	7.37	1.54	6.01	7.96	25.15	9.95	286,901.57
S.D.	2.3	0.90	0.67	0.72	4.37	6.99	9.06	1.34	135,116.37

$n = 520$.
[a] $p < 0.05$, two-tailed test.
[b] $p < 0.01$, two-tailed test.

In constructing the DEA model, a strategy of continuous involvement of top management was utilized to maintain their understanding of the process and results. At each step of the process, the executive team was asked to evaluate the reasonableness of the results. When the results were found to be unrealistic and not representative of top management's decisions, additional input was sought from the executive team and incorporated into the model.

The initial step in this phase of the process was to allow the DEA program to assign weights to inputs and outputs. DEA assumes complete substitutability of inputs (and outputs) and will assign weights to derive the highest efficiency score possible for each unit analyzed. Two problems may arise from such an analysis. First, there is a tendency for all or most DMUs to be evaluated as highly efficient when a large number of inputs are considered. This situation is analogous to when a manager notes that almost every store can excel on some performance criteria if a large enough array of criteria are considered. A store, for instance, may be evaluated as being highly efficient because it is able to generate average sales with very few full-time employees. In this instance, intensity of labor (FTSQFT) and the ratio of full-to-part-time employees (FTPT) may be given considerable importance as input variables, and sales might be assigned all of the outcome weight in the DEA evaluation. DEA attempts to maximize the efficiency of each unit by optimizing the combination of weights assigned to each variable. In the above example, the model may give no weight to some variables in order to emphasize the variables that will generate the greatest efficiency score for that unit.

A second problem is that weights assigned by the DEA program are not reflective of management's 'mental map' (Day and Nedungadi, 1994) of intended store operating procedures or of the company's strategic performance objectives. If a strategic objective is to achieve a balance between sales and profits, then the store in the previously described situation does not fit this objective. It should not be evaluated as highly efficient even though it achieves respectable sales results with very few full-time employees because it ignores the store's profitability. Not surprisingly, these two problems arose in the

HHINC	HHS	PROX	INV	TRANS	TURN	INVLS	SALES	PROFIT
1.00								
−0.13[b]	1.00							
−0.24[b]	−0.08[b]	1.00						
0.06	0.05	0.09[a]	1.00					
0.15[b]	0.20[b]	0.10[a]	0.74[b]	1.00				
0.03	−0.02	0.03	−0.00	0.03	1.00			
0.10[a]	0.24[b]	−0.06	0.23[b]	0.26[b]	0.06	1.00		
0.24[b]	0.11[a]	0.05	0.75[b]	0.91[b]	0.02	0.31[b]	1.00	
−0.02	0.03	0.20[b]	0.39[b]	0.65[b]	0.06	0.12[b]	0.71[b]	1.00
42,965.13	19,720.22	14.36	192,435.28	31,806.20	93.13	9338.18	1,054,565.17	73,407.74
12,052.63	15,829.95	27.24	28,943.07	7926.62	49.76	8129.20	304,710.99	100,981.73

initial unrestricted DEA model. To produce more representative results, management's judgments were more explicitly incorporated into the DEA model.

The notion of introducing mental models or expert judgment into DEA has been implemented in a variety of ways (see Charnes et al., 1994b). Expert judgments involve placing assurance restrictions on the possible weight assignments. Our process imposed these restrictions to capture the intellectual discrimination, managerial biases, and strategic operating orientations of the organization's top management team.

In a meeting with the executive team, the purpose and meaning of the restrictions were explained. They were asked to allocate 100 points over each of the four categories of input variables. The level of inter-judge reliability, using Kendall's Coefficient of Concordance (Siegel, 1956), indicated that there was significant agreement among the executives' allocations ($w = 0.94$, $p < 0.01$). The range of scores provided by the managers (see Table 3) established the upper and lower bound constraints on the weights possible for the four input categories. Location related measures, for instance, can be assigned weights that contribute no more than 50%, nor less than 30% of the total input efficiency rating for any store. These are referred to as level 1 restrictions (R-1).

The executive team was also asked to determine R-1 restrictions for the two outcome variables. The managers unanimously agreed that both sales and profits were nearly of equal importance. Both performance outputs were set to contribute at a minimum of 40% to a maximum of 60% of the efficiency calculation. This reflected the organization's strategic intent to balance both financial outcomes.

A second round of DEA results, including the R-1 restrictions, were reviewed with the executive team

Table 3
R-1 restraints on input measures

Input variable	Location related	Internal processes	Labor	Experience
High range	50	32.5	30	17.5
Low range	30	20	15	5

to determine if the model provided adequate discrimination between store efficiencies and matched their judgments of performance. After a close examination of individual store results, it was concluded that some input measures within the four input categories were over-emphasized. In an effort to produce the highest efficiency score for a store, a single input could dominate the category, while more critical inputs were ignored. Top management was concerned that 'essential' elements would be ignored, while less critical measures would be emphasized. These problems occurred within two dimensions—location related costs and internal processes.

Location-related costs and internal processes contain a majority (ten out of 16 total) of input measures in the model and account for a large proportion (ranging from 50% to 82.5%) of an individual store's efficiency rating. Second level (R-2) restrictions were added for these two input dimensions to improve the validity of the results. The executive team was asked to rank the measures within each category based on their judgment as to the importance the variables had in driving sales and profits. These rankings are reflected in Table 4. In the location related cost category, for instance, occupancy costs must be weighted more heavily than operating expenses, which must be weighted more heavily than population, etc.

The results from the refined DEA model incorporating both constraint levels identified seven out of 520 stores as being on the efficient frontier. These results were presented to the executive team and the regional manager panel. They were asked to evaluate the extent to which the results reflected their intuitive store rankings. There was high agreement among that the resulting efficiency rankings were valid. It was concluded that the model accurately captured top management's underlying heuristics for evaluating stores and their implicit operating strategies.

To determine if the DEA results were congruent with perceptions of managers at the store level, the efficiency scores were presented to three senior regional operations managers. These managers were responsible for supervising and evaluating up to 30 stores in their respective geographic regions. Prior to viewing the DEA results, each manager was asked to identify good, average, and poor performing stores in their region. Within each of the three regions, efficiency scores were highly consistent with the regional manager's performance ranking. A Spearman rank correlation coefficient indicated a high level of agreement between the DEA results and their personal performance appraisal ($r = 0.78$ $p < 0.01$).

3.4. Phase IV: managerial implications

Having developed a store efficiency model unique to the focal organization and drawing on the experience of its senior management to weight key inputs and outputs, the next step was to demonstrate its practical applicability. In subsequent meetings with top management, the usefulness of DEA was demonstrated with respect to two issues: (1) evaluating an individual store's manager performance, and (2) isolating CSFs for store performance. We explore these applications in the following sections.

4. Individual store evaluations

Management's task of evaluating individual store manager performance is particularly difficult for a number of reasons. Given the lack of physical proximity between headquarters and individual store

Table 4
R-2 restraints on input measures

Location related costs		Internal processes	
Managerial ranking	Measure	Managerial ranking	Measure
1	Occupancy Costs (OCC)	1	Inventory (INV)
2	Operating Expenses (OPEXP)	2	Transactions (TRANS)
3	Population (POP)	3	Employee Turnover (TURN)
4	Household Income (HHINC)	4	Shrinkage (SHRINK)
5	Households (HHS)		
6	Proximity (PROX)		

managers, the vast majority of efforts to increase store efficiency go unobserved. As a result, evaluations of store performance are subject to a number of cognitive biases (Gentry et al., 1991). One common bias, for instance, is referred to as the fundamental attribution error. This refers to the tendency to over-attribute causation of performance to personal factors and to omit environmental factors as a cause. Another bias is a tendency to heavily weight extreme performance results, thereby ignoring regression to the mean effects, that is the tendency of extreme observations to be followed by less extreme observations.

Indicative of management's difficulties in evaluating store managers is a widespread tendency to rate the performance of all managers approximately the same (Meyer, 1991). In the focal retail chain, for instance, each year 90 to 95% of the over 500 store managers in the chain were rated a five on a five point scale for their annual performance appraisal evaluations even though sales and profitability figures widely differ. Interestingly, one purpose of these evaluations is to assess managers for future promotions.

A systematic process such as the one described in Section 3 should help managers address the difficulties. Two modifications to the DEA analysis were introduced for this task. First, an outcome oriented DEA model was utilized for evaluating individual store managers' efficiency. This type of DEA model compares the outcomes of stores with similar inputs. That is, an efficient store produces the greatest sales and contribution dollars (outcomes) from a particular set of inputs. A second modification was that a distinction was made in this model between the inputs over which store managers have a significant influence and those over which they had no control because the resources are based on store location elements (e.g., number of households) or reflect decisions made at the corporate level (e.g., store age). From discussions with management, store managers are considered to have sufficient influence over six inputs: the ratio of full-to-part-time employees in the store (FTPT), employee tenure (ETEN), total inventory (INV), average transaction size (AVTRANS), employee turnover (TURN), and inventory shrinkage (SHRINK). For purposes of evaluating individual store managers, average transaction

Table 5
Individual store performance evaluation

Variables	Comparison stores[a]				Store 121	
	A	B	C	D	Efficiency projection	Actual
Outcomes						
Sales	US$1,623,930	US$2,806,269	US$1,623,908	US$1,520,191	US$1,474,429	US$1,347,385
Profits	US$449,678	US$754,464	US$491,573	US$370,023	US$261,786	US$153,064
Inputs						
FTSQFT	11.14	14.74	5.92	5.40		6.55
FTPT	1.7	1.37	0.58	0.55		0.64
PAY	39.28	9.37	9.76	7.20		8.97
ETEN	0.99	2.40	2.41	1.94		3.89
MGTEN	3.2	23.1	13.8	19.1		19.8
AGE	1	15	10	7		12
OCC	US$209,151	US$269,603	US$131,499	US$123,479		US$256,635
OPEXP	US$130,408	US$227,216	US$131,499	US$123,479		US$256,635
POP	282,076	187,799	581,047	276,098		249,150
HHINC	US$40,526	US$63,982	US$21,331	US$45,603		US$61,155
HHS	14,356	16,958	18,309	12,586		20,764
PROX	4.6	4.7	78.9	4.2		4.6
INV	US$190,364	US$246,837	US$219,503	US$221,203		US$204,616
AVTRANS	US$30.62	US$41.24	US$41.01	US$35.03		US$32.57
TURN	27%	56%	110%	109%		116%
SHRINK	US$21,076	US$40,549	US$11,300	10,834		US$13,268

[a]The weights for the four comparison stores are 0.068546, 0.085647, 0.010484, and 0.72737, respectively.

size was used because the store manager has greater control over the average size of transactions (e.g., suggestive selling, layout, etc.) than over the total number of transactions which is of greater interest to top management.

As an illustration of this evaluation process, Table 5 presents the resulting efficiency evaluation for store #121. Since this is an outcome oriented DEA model, a target level of store 121's sales and profit contribution are calculated based on the efficient stores with which it is compared. The efficient projection sales figure is calculated based on the sum of the each efficient store's sales times its respective weight. In this case, store 121 is most similar to efficient store 'D'. With an efficiency rating of 0.9138, store 121 is reasonably efficient, though its sales and profit should have been higher by US$127,044 and US$108,722, respectively, to have been perfectly efficient.

As an aid in evaluating store efficiency, DEA has a number of attractive features: (1) a production function is derived for each store, rather than being based on an average for all stores; (2) multiple and possibly conflicting outcome measures can be handled simultaneously; and specific dollar gaps can be specified, (3) a distinction can be made between resource factors over which the store manager has some degree of control vs. those that are controlled by headquarters management. The results of this process, furthermore, not only indicate the individual store efficiency evaluation based on peer performance comparisons, but a specific target level of sales and profit contribution of best performing stores can be identified. Best performing units can serve as benchmarks for the less efficient stores. Operating procedures and policies of these best practice stores can be examined in-depth and shared so that managers can learn from cohorts within their organization. Over time, an audit of the entire system can determine whether the proportion of efficient stores is increasing or decreasing over time.

5. CSFs

Critical success factors (CSFs) are those tasks that should receive priority attention because they significantly drive business performance. Boynton and Zmund (1984) describe CSFs as the ''few things that must go well to ensure success for a manager or an organization ... they represent those managerial or enterprise areas that must be given special and continual attention to bring about high performance'' (1984, p. 17). The objective of CSF analysis is to identify those few core factors which distinguish more vs. less successful firms.

A variety of techniques have been utilized in identifying CSFs. These have been categorized as 'industry (macro) vs. company (micro)' issues (Leidecker and Bruno, 1984). Industry-level analysis focuses on industry-structure factors, such as number of competitors, new entrants or substitute products, that significantly shape the performance of any company. Company-specific studies investigate the major activities or investments undertaken by a firm that are critical to its performance. Company level CSF assessment has been criticized for the use of ad hoc subjective judgments of industry experts and managers (Day and Wensely, 1988). The present analysis of CSFs addresses this concern by evaluating store level performance through a combination of subjective judgments in the form of assurances and the direct comparison of *actual resource commitments* in the DEA analysis.

To identify CSFs for store performance, the 16 inputs were evaluated according to their DEA derived efficiency rating. The stores were divided into quartiles according to their DEA efficiency ratings. Efficiency profiles of stores were obtained using this procedure. Multivariate analysis of variance (MANOVA) was used to assess whether there was a significant difference in the sales and profit performance of stores in the four quartiles. The multivariate results were highly significant ($F = 80.41$, $p < 0.001$), indicating important differences in store sales and profitability across quartiles. The average sales and profits for stores in each quartile and the univariate results are presented at the bottom of Table 6. While high performance stores generated more sales and profit dollars than the other stores, the profit differences are particularly striking. The average high performance store generated US$175,000 in profit contributions, while stores in the lowest quartile suffered an average loss of US$45,000.

MANOVA was also used to determine if there were significant differences in the investments made in high-efficiency vs. low-efficiency stores. Because

Table 6
Store profiles based on performance efficiency ratings

Factor	DEA performance efficiency ratings[a]				
	Top quartile	Second quartile	Third quartile	Lowest quartile	Univariate F-value
Labor					
Full-time employees per square foot	5.85	4.94	5.08	4.67	5.54[b]
Full-time to part-time employees ratio	0.99	0.73	0.67	0.63	4.08[a]
Compensation level for hourly employees (US$)	7.18	7.33	7.43	7.54	7.40[b]
Experience					
Average employee tenure (years)	1.57	1.61	1.51	1.49	0.71
Management tenure (years)	7.00	6.18	5.83	5.02	4.67[b]
Age of store (years)	11	8	7	4	26.04[b]
Location related costs					
Occupation costs per square foot of selling area (US$)	19	22	28	34	52.65[b]
Operating costs as a percent of sales (%)	9	10	10	11	1.76
Population per store (000)	261	281	286	321	4.54[b]
Average household income in trading area (000)	40	41	45	46	8.22[a]
Number of households in trading area (000)	20	19	20	23	1.07
Proximity to nearest store in chain (miles)	20	15	12	8	4.43[b]
Internal processes					
Average inventory dollars (000)	190	190	197	197	2.60
Average number of transactions (000)	34	31	32	30	4.59[b]
Annual employee turnover (%)	98	95	89	89	1.02
Inventory shrinkage as a percent of inventory (%)	4.7	4.9	5.0	5.2	0.57
Store performance					
Sales dollars (000)	1,162	1,023	1,081	994	7.59[b]
Profit dollars (000)	175	86	57	(45)	41.49[b]

[a]The range of efficiency scores according to quartile are first quartile: 1.0 to 0.756; second quartile: 0.754 to 0.686; third quartile: 0.685 to 0.618; and fourth quartile: 0.617 to 0.314.
[b]Significant at the 0.001 level.

significant main effects for efficiency ratings were observed (multivariate $F = 57.26$, $p < 0.001$), univariate F-tests and planned contrasts were conducted. The results are reported in Table 6.

Planned univariate contrasts between the four quartiles indicate significant ($p < 0.01$) differences in inputs. Significant differences are found for all three labor factors, though contrasts indicate that the results are primarily due to differences between the top and bottom quartiles. Two of the three experience factors are significant, but contrasts indicated no significant differences between the second and third quartiles. Among the location-related costs, four of the six factors are significant. Except for occupation costs, no significant differences are found between the first and second quartile stores, while all three of the top quartiles are significantly different from the fourth quartile stores on the four location factors. Only the contrasts between the first- and fourth-quartile stores and the third and fourth quartiles are significant with respect to the number of transactions.

Our results indicate that there are a number of factors associated with high store efficiency and demanding of top management's attention. Particularly important input factor differences, however, were observed in the areas of leasing agreements, store location, and human resource management.

5.1. Leasing agreements

The two input factors most strongly associated with high efficiency are older stores and low occupation costs per square foot of selling space. In combination, these factors signal to top management the importance of negotiating favorable leasing terms on a long-term basis, e.g., 10 years. This assumes, of course, that the stores are in a good trade location, kept up-to-date, and of sufficient size to generate necessary sales volumes.

5.2. Store location

Three location factors are related to high efficiency: moderate household income (US$40,000), moderately populated trading areas (261,000 people), and no other stores in the chain located close by. The first two factors, to a certain degree, are related to the leasing costs. Leases in densely populated, high-income areas are prime locations for competitors. These locations are likely to be quite expensive. A number of the chain's best-performing stores are located in college communities that are some distance from major metropolitan areas. Highly efficient stores are distant from another store in the chain. This reflects both the negative consequences of store cannibalization and the advantages of locating in medium size metropolitan areas where there are likely to be only one or two stores in a competing chain. Given the average sales transaction of around US$35, students and others can afford to frequent these stores for furnishing their dorm room and/or apartment. The transitory nature of students and their lifestyles make the focal chain attractive for them.

5.3. Human resource management

A number of human resource management policies and practices are associated with highly efficient stores. First, highly efficient stores are able to keep compensation levels for hourly employees moderate while not experiencing exceptionally high levels of turnover. Low turnover diminishes hiring and training costs, fosters team work, and provides a foundation for establishing practices designed to enhance customer intimacy. Second, adequate staffing of stores with full-time employees is important. Highly efficient stores not only have a higher number of full-time employees per 10,000 ft^2 of selling space (5.85 vs. 4.67), but also have a higher ratio of full-time to part-time employees (0.99 vs. 0.63). Third, management experience is related to store efficiency. Management tenure at highly efficient stores averaged 7 years, while tenure at low efficiency stores was only just over 5 years. Tenure of hourly employees, on the other hand, was not related to store performance. The transitory nature of this employee base and the routine nature of their work were factors that mitigated their impact on a store's efficiency.

6. Discussion and conclusion

An efficiency evaluation process incorporating DEA is presented as an approach for assessing store efficiency within a large retail chain. While there has been a sizable body of literature on retail efficiency, very little has been published on the efficiency of individual stores within multi-store, multi-market retail chains. Issues to be addressed in measuring individual store efficiency include weighting multiple inputs and outputs, taking into consideration the many factors influencing productivity that are likely to vary from store to store, developing a single index of store efficiency, and establishing the performance capability of each store.

DEA is offered as one approach for addressing these problems. It derives for each store a single summary index of efficiency relative to other comparable stores in the analysis. DEA incorporates the strategic decision making recommendations of senior management regarding inputs and outcomes. In addition, factors not under the control of store management may be incorporated to ensure equity in the evaluation of individual store efficiency and management's strategic emphasis. In focusing on frontiers rather than central tendencies, as in ordinary least squares regression, DEA identifies the limits of each store's outcome producing capabilities given certain resources, rather than the average performance. The organization moved store managers within a region to other stores either as a reward for past successes or for a challenging 'stretch' assignment. According to top management, personnel assignments can impact the efficiency of a store to 10%. Top management found that it was difficult to assess the store manager independently from the efficiency of the store using its traditional performance appraisal system. The DEA methodology permitted us to isolate those decisions over which the store manager had little influence, but greatly impacted the efficiency of their store, e.g., location related costs, age of store, and compensation level of hourly employees. The latter was determined by unique environmental conditions in the store's trading area and headquarters' wage/salary guidelines, while the former were dictated by top management.

The practical usefulness of using DEA to evaluate store efficiency is enhanced by incorporating senior management's 'mental maps' for making performance judgments. These mental maps were incorporated into our DEA model through the use of assurance regions which constrain weights the model places on various inputs and outcomes to reflect management's decisions. This modification in DEA addresses important managerial and methodological concerns. A concern for evaluating operating units in a manner consistent with the corporation's overall strategic intent is addressed by ensuring that an individual store's efficiency rating is consistent with the priorities established by top management. Incorporating constraints addresses an important methodological issue in prioritizing resources and outcomes when deriving efficiency ratings with DEA. Serious misspecification concerns have been noted with many earlier DEA applications that modeled only a very limited number of inputs. Most DEA models included five or fewer inputs because of the tendency of all DMUs to be rated efficient as the number of inputs increased (Thomas, 1994). Additional restrictions, therefore, broaden the application of DEA to derive managerially meaningful efficiency ratings while enhancing the robustness of the model. We have also shown how store efficiency analysis can be used to address a number of important strategic managerial issues, including store manager evaluation and identifying CSFs for improving store efficiency.

This study also identifies practical limitations for applying DEA in a retail setting. First, DEA relies on the availability of valid and reliable archival data. While management was comfortable with the 16 input factors considered in this study, other inputs, if available, could have been considered. Furthermore, future studies may consider increasing the involvement of store managers in the input and output variable selection process since much of the analysis reflects on activities occurring at the store-level. Store managers' input may have produced a different perspective than that of top-level management. It should also be noted that DEA is particularly sensitive to measurement error since there is no process currently available within DEA to identify or deal with measurement error. As a result, future researchers should be cautious when using subjectively derived survey data whose psychometric properties cannot be determined. DEA has traditionally required good archival data. Second, stable DEA results require a large number of observations particularly as the number of inputs and outputs are increased. As a result, DEA may not be appropriate for smaller retail chains. For smaller chains, the number of total inputs and outputs used may have to be reduced, thus rendering the results less valuable for top management. Third, DEA requires considerable access to and the strong support of the top operating management team because of the strategic nature of the research. Over a dozen meetings were held between the research team and top management members. Particularly important were the meetings related to the development of input categories and the individual inputs within each category. It is critical, therefore, that management 'understands' both the DEA methodology and the results of the research.

Management's goal is to get the best possible performance out of each unit. Determining what that means and how to measure store performance is often a problem. With bar codes, modems, microchips and other advances in information technology, the challenge of today's manager is to extract insight from the numbers. One can study and compare stores in terms of their outputs, inputs, key ratios and even use econometric techniques to find out how each variable is affected by the others. However, managers will still be using overall average performance as the benchmark. DEA not only helps make sense of the data in deriving an overall efficiency index, but also identifies the best practice stores within the organization by focusing on the efficiency frontier.

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