BENCHMARKING FACILITY MANAGEMENT BY RELATIVE EFFICIENCY

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Abstract:

Benchmarking is often claimed to be a powerful means of continuous improvement for facility managers but benchmarking tools in facility management are less developed than for other services businesses. The most common information which Facility Managers can get from benchmarking results is their positions of performance. Rankings on performance, without further analysis, cannot help much for the achievement of continuous improvement. A new approach, called Data Envelopment Analysis (DEA), is proposed in this article to evaluate and improve the efficiency of facility management operation units. By applying DEA in two cases with collected and computer generated facility management data respectively, we showed facility managers not only could identify inefficiencies but also be given hints on the ways to catch up with their efficient peers. Based on the cases, it was illustrated that DEA could work with facility management quantitative data with clear indications for improvements. One of the cases demonstrated how DEA could be applied with Excel formulae. Further research is suggested with more collected data to test the sensitivity and reliability of DEA application on facility management and whether DEA can produce satisfactory results with qualitative data in Facility Management.

Keywords: Benchmarking; DEA; Facility Management

INTRODUCTION

Facility managers in the Hong Kong property market must recognize that efficiency and competitiveness are the keys for survival these years: Since 2000, office property market has experienced a significant downward adjustment. Based on the average rental rate, the rental premium in Central fell 59 per cent from HK$17 per square foot in 2000 to HK$7 per square foot in the second quarter, 2003. The overall occupancy rate of Grade A office has fallen from more than 91 per cent in 2000 to about 87 per cent in the second quarter of 2003.[5] Competition for tenants is intensive.

Property developers in Hong Kong, via their facility management divisions, are trying their best to create more values for their leassees and the end users of their facilities. These can often be achieved through facility management benchmarking with goals, like reducing costs, enhancing the willingness of customers to pay higher price or improving efficiency of the operation units. The facility manager then decides the benchmark metrics which are usually easy to be identified and compared against those of one's counterparts. The main problem, as pointed out by Massheder & Finch (1998)[6], lies in the process of comparison and the analysis of comparison results. Some systematic benchmarking methodologies which can improve the quality of comparison analysis are necessary.

A mathematical tool called Data Envelopment Analysis (DEA) has been applied in the benchmarking of financial services, police service and regulated services and proved to be useful, especially when inputs and outputs within the operation unit are not easy to define.

This paper is intended to introduce the application of DEA to assist in evaluating the efficiency of facility management units. After a brief discussion on the trends of benchmarking, a simplified example with graphical description will present the basics of DEA. A facility management case then demonstrates how to set up and use DEA method in Excel spreadsheet to better facilitate facility management benchmarking. Before conclusion, guidelines will be given on how facility managers can apply DEA and interpret the results. Mathematical formulations of DEA model are listed in Appendix.

A TREND OF BENCHMARKING: MULTIPLE MEASUREMENTS

In 1979, after realizing increasing competition, Xerox started investigating the cause of their lagging by comparing the unit manufacturing cost of their copying machines with that of their main competitors: They identified performance gaps relative to its competitors; then analyzed how the performance gap could be narrowed and ultimately eliminated. Since the success of Xerox in applying benchmarking, significant developments have been seen by applying benchmarking.

During the Xerox era of benchmarking, single-measure based gap analyses were common. The benchmarking subjects were confined to costs, profits in monetary terms and energy consumed. Organization performances are now often evaluated in terms of more complicated measures, like return on investment (ROI) and return on sales (ROS). Apart from completeness of comparison and better consideration of subjects' interactions and tradeoffs, Camp (1995)[2] pointed out another advantage of benchmarking by multiple measurements: Absolute values are not revealed in the benchmarking report.

Multiple measures can take account of the integration of interactive data but require techniques that are more sensitive. For example, in facility management benchmarking, energy costs, maintenance and number of users are all interactive and their relationships are difficult to define. A better management tool is necessary for accurate facility management benchmarking results.

Benchmarking facility management operation units by DEA

A facility management operation may be considered by the end-users as competent when the qualities of security and cleaning services provided to them exceeded their expectation. However end-users' satisfaction cannot reflect the complete picture whether the facility management services are managed efficiently. The executive needs to know whether the resources are utilized productively. Conventional single measures ignore the interactions and tradeoffs among various performances.

In the financial field, return on investment or other ratios are well recognized as a good measure of performance. In some unique service organizations, operations have been standardized: Quality and quantity of product outputs per labor and time inputs are clearly described, like some large fast food restaurant chains. Where the standardization of facility management services is not yet achieved (if possible), benchmarking tools which can measure outputs versus inputs in an empirical sense are required.

Data Envelopment Analysis(DEA), a linear programming based technique, can measure the relative performance of organizational units where multiple inputs and outputs make comparisons difficult. This was first introduced by Charnes, Cooper and Rhodes in 1978.[3] It can combine many performance measures into an indicator of efficiency and help the facility management units achieve their goals with checking during the improvement process. It is commonly applied for assessing efficiencies of operational units. The efficiencies assessed are relative in the sense that they reflect scope for resource conservation and output augmentation at one unit relative to other comparable units. The following hypothetical example with adjusted real data illustrates the basics of DEA.

Mr. Chan is a facility manager of a property investment company in Hong Kong. The property investment company owned two office buildings, Building A and Building B, in the same region with comparable services and leassees compositions. Mr. Chan was given a duty "to present to the company executive how efficient the two facility management units of the two buildings among their peers are".

Mr. Chan can only collect the following two types of data for benchmarking Buildings A and B with the other 14 comparable buildings in the same region:

1. Building services (BS) cost per square feet: BS cost includes costs of electrical service, air conditioning service, plumbing and drainage, sea water system (if applicable), fire services, vertical transport services and general cleaning.

2. Rent per square feet.

Despite the lack of other conventional facility management data for benchmarking, Mr. Chan is convinced that meaningful information can still be drawn from the benchmarking study with the use of DEA because:

1. The BS cost represents a substantial operation cost of the whole building's facilities.
2. Though rent is largely determined by demand and supply within its owned market sector, it does reflect the competitiveness of the quality of facility management service, assuming the property market has reasonably perfectness with respect to information, market competition and completeness.
3. When assessing organizations' efficiency with DEA, financial evaluations are not necessary. DEA just requires activity information (Homburg (2001)[4]).

The usual measure of efficiency, i.e. units of output per unit of input, cannot be applied in Mr. Chan's case since BS cost and rent are not the only input and output of the facility management unit though they may be the main ones.

Some statements concerning the relative efficiency of the buildings can be made:

1. BS cost of Building A is lower while rent per feet charged is higher than Building B. Clearly if the input and output are representative, Building A's facility management unit is more efficient than Building B's.
2. From Table 1, we see that Building A and Building 4 are with the lowest cost in building services. The two buildings may be considered as the most productive from this limited aspect. However, from the same table, it is noted that the rent per square feet of Building 3 is the highest among the 16 buildings.

Table 1: Building services cost and rent per square feet of 16 buildings of the year 2001.

Building	BS cost per square feet (HKD)	Rent per square feet (HKD)
A	59	19
B	74	18
1	65	17
2	76	17
3	75	20
4	55	16
5	63	18
6	58	19
7	76	17
8	72	19
9	65	18
10	75	19
11	59	16
12	67	18
13	69	18
14	63	19

The cost on building services per square feet and the rent per square feet are plotted for each building in Figure 1: Buildings A, 3, 4, 6 and 14 form an "efficiency frontier". It was named so because they produce the most outputs in closed cases for a reported amount of costs. Buildings closed to the frontier are relatively efficient and those inside the frontier are inefficient. The facility manager of Building B may either become as efficient as A by decreasing its cost on building services or become Building 3 by increasing the rent charged. These possible transformations of Building B's facility management unit to those efficient ones near the frontier show the basic idea of DEA.

As shown, facility managers can develop an empirical efficient frontier based on their own observation as a benchmark with limited data. However, DEA users are always suggested to collect more data of representative performance measures and incorporate them to refine the model and check any breakthroughs on the frontier with up-dated data. In the paper by Schaffnit *et al.,* it is shown that DEA can deal with 291 benchmarking participants with 5 inputs and 8 outputs.[7]

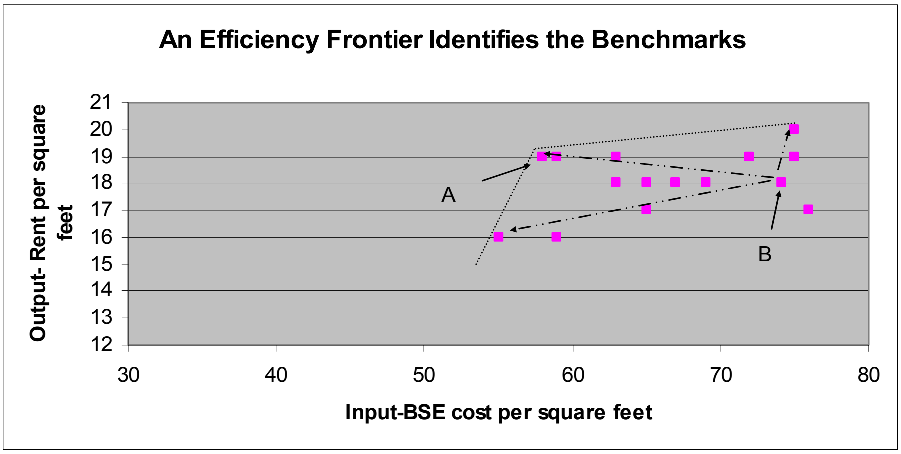

Figure 1: An Efficient Frontier identifies the Benchmarks.

In this case, DEA can indicate the exact targets for the inefficient units with reference to the efficient ones diagrammatically. Facility Managers can check the improvement progress against time from the diagram. Benchmarks may be given in terms of inputs or outputs:

Table 2: Efficiency report for Building B.

	Observed measure (HKD)	Benchmark (HKD)	Potential improvement (HKD)
Output: rent per square feet	18	20	2 (increase)
Input: BS cost per square feet	74	55	19 (reduction)

APPLICATION OF DEA MODEL WITH EXCEL SPREADSHEET

Referring to Mr. Chan's case, after his presentation, Mr. Chan is requested to carry out a more macro benchmarking study of Buildings A and B with 13 buildings. These total 15 buildings' locations and client/ user compositions are not completely known and cannot be assumed similar. The available information includes:

1. Salaries, maintenance and energy costs as input data;
2. Number of visitors; lessees and its staff as output data. (as shown in Table 3)

Table 3. Inputs and outputs as benchmarking data.
(Source: Computer generated figures based on real data)

Building	Salaries (HKD)	Energy cost (HKD)	Maintenance cost (HKD)	Number of lessee and its staff	Number of visitors
A (Ref: 1)	85412	15478	159752	9512	408
B (Ref: 2)	345621	50950	124563	15100	200
ONE (Ref: 3)	159740	45411	95142	158815	168
TWO (Ref: 4)	65478	23346	709000	75412	7878
THREE (Ref: 5)	50269	45632	86245	45214	652
FOUR (Ref: 6)	71439	85214	15973	25896	158
FIVE (Ref: 7)	243283	24547	346990	24156	450
SIX (Ref: 8)	106004	49692	146855	85214	3500
SEVEN (Ref: 9)	91296	40436	82000	12654	6201
EIGHT (Ref: 10)	118012	58986	104000	15429	5212
NINE (Ref: 11)	67871	14762	91921	96321	2841
TEN (Ref: 12)	71621	19907	68771	84589	7542
ELEVEN (Ref: 13)	364763	12547	65709	95142	2462
TWELVE (Ref: 14)	127077	42240	217123	15472	1844
THIRTEEN (Ref: 15)	88884	17274	299300	12548	504

Mr. Chan is also asked to recommend definite benchmarks for buildings A and B. The objective of the company is to control the operation costs of buildings A and B assuming the existing current outputs unchanged.

Given 3 types of input data and 2 types of output, Mr. Chan notes that comparing the efficiency of these 15 buildings' facility management units is not easy as the previous case, different patterns of output levels are supported by different amounts of resources making efficiency comparisons difficult and this is generally the case of facility management benchmarking.

Mr. Chan starts by arranging the data in table 3 in a spreadsheet as shown below (The following presentation is based on Zhu (2003) [9]):

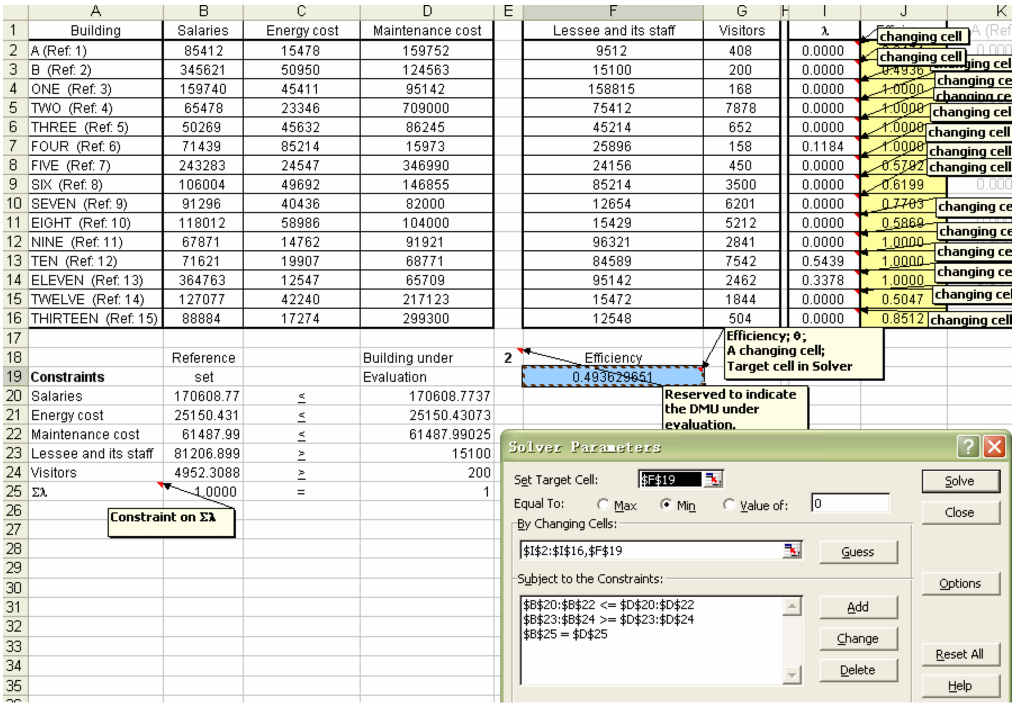

Figure 2: DEA model with Excel spreadsheet.

The DEA model in the Excel spreadsheet comprises of the following 4 elements:

- Scalar variables for the adjustments of the evaluated object's inputs in cells I2: I16.
- Target function, i.e. the efficiency, in cell F19. It is also a scalar variable.
- Reference set of inputs and outputs as benchmark in cells B20: B24.
- The object set under evaluation in cells D20: D24.

The following are the entries in cells of the reference set:

Table 4: Entries in spreadsheet for cells of the reference set.

Cell	Entries
B20	=SUMPRODUCT(B2:B16,$I$2:$I$16)
B21	=SUMPRODUCT(C2:C16,$I$2:$I$16)
B22	=SUMPRODUCT(D2:D16,$I$2:$I$16)
B23	=SUMPRODUCT(F2:F16,$I$2:$I$16)
B24	=SUMPRODUCT(G2:G16,$I$2:$I$16)

The entries for object set under evaluation (cells D20: D24) are:

Table 5: Entries in spreadsheet for cells of the set under evaluation.

Cell	Entries
D20	=$F$19*INDEX(B2:B16,E18,1)
D21	=$F$19*INDEX(C2:C16,E18,1)
D22	=$F$19*INDEX(D2:D16,E18,1)
D23	=INDEX(F2:F16,E18,1)
D24	=INDEX(G2:G16,E18,1)

(See Appendix for the formulations of the DEA model)

Note that the outputs are kept at the original level by cells D23 & D24; while the inputs are minimized by the DEA model and given in cells D20, D21 & D22. The inputs are minimized with reference to all buildings within the benchmarking group, by cell B25 with entries: =SUM (I2:I16) in the spreadsheet.

Remember that when applying DEA with the Excel Solver function (under Tool in the Excel menu bar; if Solver function is not found, use Add-Ins function under Tool menu), we should check scalar variables are non-negative and linear model is chosen by clicking the Option buttons. As indicated in Figure 2, set Target Cell and other solver parameters in the Solver Parameters dialog box and click the 'Solve' button, the efficiency of the building specified in 'Cell E18' will appear in 'Cell F19'.

The DEA results are summarized below and Column J in Figure 2:

Table 6: Benchmarking results.

Building	A	B	One	Two	Three	Four	Five	Six
Efficiency	0.9474	0.4936	1	1	1	1	0.5792	0.6199

Building	Seven	Eight	Nine	Ten	Eleven	Twelve	Thirteen
Efficiency	0.7703	0.5869	1	1	1	0.5047	0.8512

Mr. Chan can also extract the following information for Buildings A and B as benchmarks:

Table 7: Recommendations for Buildings A and B.

Building	DEA efficiency rating	Efficiency Reference Set	Potential improvements (HKD)		
			Salaries	Energy cost	Maintenance
A (Ref 1)	94.74%	NINE, ELEVEN	4489 (Reduction)	813 (Reduction)	8395 (Reduction)
B (Ref 2)	49.36%	FOUR, TEN, ELEVEN	175012 (Reduction)	25800 (Reduction)	63075 (Reduction)

A distinctive output of DEA is the generation of Efficiency Reference Set. With the reference set, facility managers of inefficient buildings can locate the sources of inefficiencies by making comparison within the narrowed set. This distinguishes DEA from the other gap analysis management tools, like Spider charts and AHP. This special character of DEA is especially useful in facility management benchmarking because efficient target peers can be located objectively.

DISCUSSION ON APPLICATION OF DEA IN BENCHMARKING

As a general practice of benchmarking, when applying DEA facility managers should first identify similar peers for evaluation. Common criteria are:

- Similar location;
- Similar client composition;
- Similar levels of services, etc.

Relevant inputs and outputs should then be determined. Facility managers must also note when the measurements are taken . Sherman (1984) proposed the following guidelines to decide the relevant inputs and outputs:

- *Relevant outputs are generally those services that operation units is responsible for in order to achieve its business purpose.*
- *Relevant inputs are those resources which are necessary for the production of the relevant outputs.*

Facility managers should also consider the core businesses or activities of their serving organizations.

Missing, lack or indetermination of **relevant** data is often a limitation on DEA models. A recommended safeguard is that: An efficient unit should respond to an increase or decrease in outputs with a corresponding increase or decease in inputs, Sherman (1984).

DEA compares each unit within the benchmarking group only. The 'efficient' units ('Efficiency' = 100% in the DEA model) are efficient relative to its peers. The 'efficient' units, as rated by DEA, may be interpreted as the best in the benchmarking study but not the optimum one. A breakthrough, i.e. >'100%', is possible by many means, e.g. new technology. If so, DEA model should be adjusted.

Finally, DEA results should be analyzed to locate and improve the inefficiencies. A benchmarking study with DEA is only completed when inefficient units can catch up with their efficient peers. However, as other benchmarking study, facility managers should not be surprised if the causes of inefficiencies are not under their control.

CONCLUSIONS

All facility management units operate with multiple outputs and inputs. The process of turning inputs to outputs within facility management units is difficult to be identified. DEA is a useful method for facility management units to locate ways of improvement where a complete map of operation system cannot be drawn. It can give facility managers guidelines on investigating the source of inefficiencies with reference to the efficiency reference set. In the other words, with DEA, facility managers can allocate time and other resources more effectively to areas where weaknesses have been identified objectively for improvements. Results of the two case studies showed DEA operated satisfactorily with facility management hard data. DEA was proved being able to strengthen the two steps of benchmarking: analysis and adaptation. Further research is suggested to investigate whether DEA can work if facility management soft and hard data are considered under a single DEA umbrella. The problems related to inherent dependency of DEA efficiency scores should also be addressed.

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Appendix

The original formulation of DEA for maximization of outputs is

$$\text{Maximize } u_r, v_i \quad \frac{\sum_{r=1}^{S} u_r Y_{r0}}{\sum_{i=1}^{m} v_i X_{i0}}$$

$$\text{Subject to} \quad \frac{\sum_{r=1}^{s} u_r Y_{rj}}{\sum_{i=1}^{m} v_i X_{ij}} \leq 1$$

where j=1, …, n ; v_i ≥0 ; r=1, …,s ; I = 1, …, m.

Y_{rj} and X_{ij} are observed values of outputs and inputs of the j^{th} units (e.g. a facility management department's inputs: salaries, energy and maintenances costs; outputs: rent, services charge and number of end users). u_r and v_j are the weights.

DEA formulations in forms of linear programming are deduced by Charnes *et al.* in 1978[3]:

$$\text{Maximize} \quad \sum_{r=1}^{S} u_r Y_{ro}$$

$$\text{Subject to} \quad \sum_{r=1}^{S} u_r Y_{rj} - \sum_{i=1}^{m} v_i X_{ij} \leq 0$$

$$\sum_{i=1}^{m} v_i X_{i0} = 1$$

where u_r, v_i > ε; j = 1, …, n; r = 1, …, s; i = 1, …,m.

In 1984, Banker , Charnes and Cooper[1] modified the above and proposed a new version of DEA program:

$$\text{Maximize} \quad \sum_{r=1}^{S} u_r Y_{ro} + w_0$$

$$\text{Subject to} \quad \sum_{r=1}^{S} u_r Y_{rj} - \sum_{i=1}^{m} v_i X_{ij} + w_0 \leq 0$$

$$\sum_{i=1}^{m} v_i X_{i0} = 1$$

where u_r, v_i > ε; j = 1, …, n; r = 1, …, s; i = 1, …,m; w_0 represents input / output slack (s).