Performance Assessment of Residential Building Management Utilizing Network Data Envelopment Analysis

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Abstract –

Apartment buildings and residential buildings in Taiwan have become more and more community oriented. Precise control of residential buildings operational performance is increasingly important. This study uses network data envelopment analysis (Network DEA) to develop a three-phase based residential building operational performance assessment model and use it to assess the operational efficiency of 26 decision making units (DMUs) to obtain the performance index of dimensions. It is found that the model is equipped with three dimensions (with its weight) named staff quality (0.26), customer satisfaction (0.35) and operation performance (0.39) respectively. Most of the total DMU efficiency values fell between 0.75 and 0.90, with only one DMU is equipped with 1. DMU_6 (1.0000) is ranked first, with performance values for each dimension of 1. Aside from the staff quality dimension (0.8134), the other two dimensions for DMU_{10} are both below 0.80, indicating this DMU is most in need of improvement. Sensitivity analysis can show the impact of inputs and outputs on DMU performance.

Keywords –

Residential buildings; Performance assessment; Case management; Network data envelopment analysis

1 Introduction

Urban development and economic growth are driving demand for improved living standards and residential quality of life. In response, the broad development of property management services is realized. Such services are labor-intensive and low-cost, and price is the key consideration for service consumers. Property management companies are generally responsible for the management of multiple residential communities, and accurately assessing the effectiveness of community management performance is important to the formulation, implementation and assessment of overall management strategy. Effective objectives and evaluation models are still lacking for the assessment of community management performance. Most currently used approaches rely on regular or irregular assessments, recommendations of the community management committees (CMC) and contract renewal rates [1]. These methods are susceptible to subjective influence from company supervisors or CMC members, and do not necessarily provide an object reflection of actual operating conditions.

This study implements an expert-constructed questionnaire to assess operations management performance using network data envelopment analysis (Network DEA). The study seeks to (1) use the existing literature and measurement indices to establish input and output dimensions and administration factors and to assign proper weightings to each; (2) establish a Network DEA model to assess operational performance in 26 field cases and (3) identify relatively efficient and

inefficient cases, and to offer proposals for improvements to business strategy as a reference to enhance overall business performance.

2 Network DEA

DEA is widely used in industrial assessments including sewage treatment plants [2], airports [3], telecommunications [4] and energy [5]. It has also been used to simplify evaluation data into a single performance value [6], thus facilitating overall operational assessments. DEA does not consider intermediate activities, but rather directly coverts a single production input indicator into an efficiency value, thus substantially neglecting resource utilization and departmental operations, leaving it unable to effectively determine the root causes of operational problems [7].

To overcome the shortcomings of DEA, Network DEA can be organized into multiple interrelated departments to identify the root cause of organizational performance inefficiency [8]. Network DEA offers many advantages, but it has a relatively short development history, and thus is unable to track usage restrictions as clearly as conventional DEA. For example, the number of DMUs in DEA should be at least twice the number of inputs and outputs.

Traditional DEA includes a variety of different modes, including CCR [9] and BCC (Banker et al., 1984). When accounting for multiple input and output decision-making units, traditional DEA cannot be used to discuss production processes and the influence of internal management activities [10]. Therefore, this study uses Network DEA.

Tone and Tsutsui [11] initially explored three interrelated divisions (Fig. 1), thus dividing an organization into three components. Links 1.2, 1.3 and 2.3 are production activities linking the three divisions. Link 1.2 is the partial output of Division 1, which is also the input of Division 2. Link 1.3 is the partial output of Division 1, which is also the input of Division 3. Link 2.3 is the partial output of Division 2, which is the input of Division 3. Traditional DEA requires each activity to be clearly classified as inputs or outputs, leaving it unable to handle intermediate production activities. In contrast, Network DEA does not put an organization's internal production processes in a black box, thus providing a transparent view of the efficiency of each division and insight into their various issues.

3 Data Analysis

Currently, Network DEA has no basic criteria for selecting DMUs. The traditional DEA approach which requires DMU homogeneity, where nonhomogeneous DMUs are deleted to ensure assessment accuracy [12]. This study uses the following criteria to select 26 homogenous cases in central Taiwan: (1) residential properties, (2) provide management services with general cleaning, security and logistical support without customized services, and (3) case inputs and outputs are roughly the same.

Network DEA input items can be used as outputs, while outputs can also be used as inputs. The process of establishing inputs and outputs via Network DEA is summarized as follows.

Step 1: This study uses KMP indicators from the Ministry of Economic Affairs' "Property Management Services Performance Indicators" to generate the 20 initial items.

Step 2: Interviews were conducted for each of the initial items to understand the ease of data acquisition and screening. Data items which were difficult to quantify or to obtain were deleted, to produce a list of 13 items.

Step 3: An expert-constructed questionnaire was established to assess the 13 inputs and outputs and to determine item suitability. The final list, including six inputs and six outputs, is shown in Table 1.

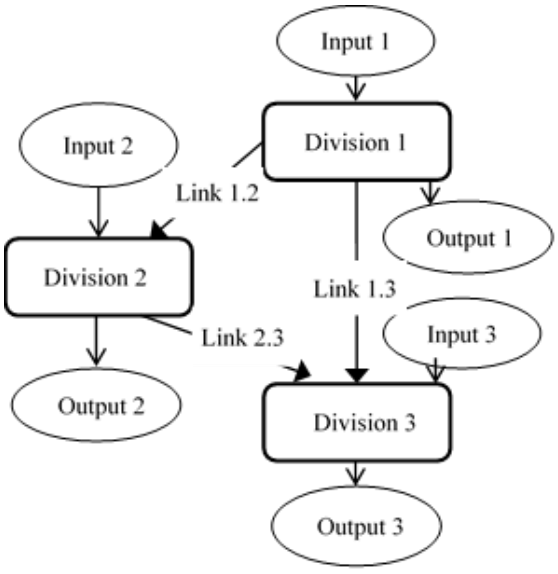

Figure 1: Connectivity division

The study uses case data, where "Management Committee Satisfaction" was based on a satisfaction questionnaire ranging from 5 (very satisfied) to 1 (very unsatisfied) and maximum score of 50. For each case, five management committee satisfaction questionnaires were distributed (for a total of 130 questionnaires), with the average value of all cases. Questionnaire content focused on overall satisfaction with management staff and other items related to service satisfaction. This

study invited 13 experts in the field of property management to measure the degree of interaction between dimensions and to weight each dimension. The resulting weightings were staff quality (0.24), customer satisfaction (0.36) and operation performance (0.40).

Table 1 Step 3 final selection results

Dimensions	Inputs	Outputs
Staff quality	Staff training hours	Direct personnel costs
	Staff retention rate	CMC satisfaction
Customer satisfaction	CMC satisfaction	Contract price
	Staffing	Direct personnel costs
Operation performance	Direct personnel costs	CMC satisfaction
	Contract price	Staff retention rate

4 Empirical Analysis

4.1 Constructing a Network DEA model

Network DEA is divided into three modes: basic, vertical integration and segregated. However, the segregated model is more suitable for this present research. Figure 2 shows the Network DEA model developed according to the input and output characteristics.

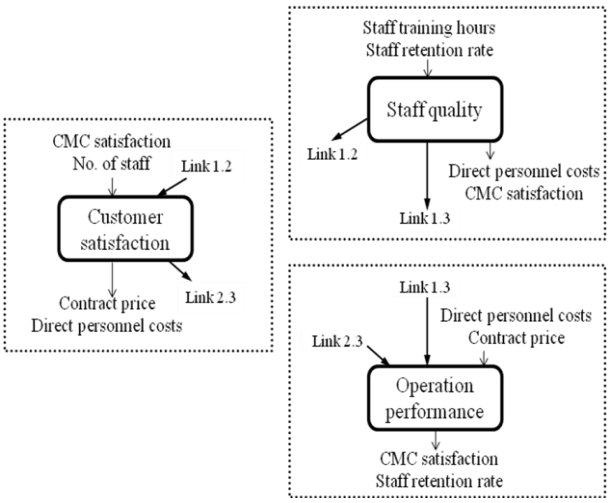

Figure 2: Segregated model

This study uses DEA-Solver Pro 7 to analyse Network DEA and assess the performance for each dimension (staff quality, customer satisfaction and operation performance) for each case, with a higher performance value corresponding to increased input and output values. After collecting the relevant expert opinions from the questionnaire, we calculated the structural weights for staff quality (0.24), customer satisfaction (0.36), and operation performance (0.40).

4.2 Total Efficiency Analysis

Comprehensive evaluation is based on the performance values of staff quality, customer satisfaction and operation performance (Table 2). The results are as follows:

1. Most total DMU efficiency values fell between 0.75 and 0.90, with only one DMU is equipped with 1.
2. DMU_2 was ranked first in terms of staff quality and customer service, but overall performance value was ranked 26th due to its operation performance dimensioin being only 0.3746.
3. DMU_6 is ranked first, with performance values for each dimension of 1.

Aside from the staff quality dimension (0.8134), the other two dimensions (customer satisfaction and operation performance) for DMU_{10} are both below 0.78, indicating this DMU is most in need of improvement.

4.3 Sensitivity Analysis

Sensitivity analysis was conducted to observe the variability for each dimension, and the sensitivity is examined for each case. Analysis was conducted each time an input or output item was deleted to provide insight into the variability for overall performance and each dimension. The variability and difference in variability is calculated by using Eqs. 1 and 2.

Rate of Change
= | Original efficiency value ÷ Original efficiency value after deleting the item − 1 | (1)

Variance of Change
= | Original efficiency value - The original efficiency value after deleting the item | (2)

Taking the total efficiency as an example to explain how the sensitivity analysis was performed. Each time an input or output was deleted to observe changes. Table 3 shows the CMC satisfaction had a considerable impact on overall performance and each of the three dimensions. Staff quality was highly sensitive to overall performance and customer satisfaction. Staff quality was highly sensitive to overall performance and customer satisfaction. Staff retention rate was found to be highly sensitive to overall performance, staff quality and operation performance. Contract price was sensitive to customer satisfaction and operation performance.

Table 2. Overall and dimensional efficiency for each DMU

DMU	Total operational efficiency	Ranking	Weighted average	Ranking	Staff quality (SQ)	Customer satisfaction (CS)	Operation performance (OP)
DMU_1	0.8856	7	0.9012	6	0.9633	0.7500	1.0000
DMU_2	0.5996	26	0.7498	22	1.0000	1.0000	0.3746
DMU_3	0.8255	11	0.8295	13	0.8425	0.7574	0.8866
DMU_4	0.7021	24	0.7431	23	0.8459	0.9001	0.5401
DMU_5	0.9545	2	0.9574	2	1.0000	1.0000	0.8936
DMU_6	1.0000	1	1.0000	1	1.0000	1.0000	1.0000
DMU_7	0.7924	15	0.8033	15	0.8448	0.6840	0.8857
DMU_8	0.8572	9	0.8754	9	0.9020	0.7192	1.0000
DMU_9	0.9311	3	0.9372	3	0.9792	0.8394	1.0000
DMU_{10}	0.7140	22	0.7236	25	0.8134	0.7726	0.6255
DMU_{11}	0.7719	17	0.7763	17	0.8555	0.7053	0.7927
DMU_{12}	0.7866	16	0.7930	16	0.9046	0.8012	0.7186
DMU_{13}	0.7108	23	0.7299	24	0.8228	0.8235	0.5900
DMU_{14}	0.8081	13	0.8359	11	0.8339	0.6549	1.0000
DMU_{15}	0.6889	25	0.7207	26	0.8488	0.8325	0.5432
DMU_{16}	0.8049	14	0.8243	14	0.8422	0.6695	0.9530
DMU_{17}	0.9123	5	0.9184	5	0.9167	0.8288	1.0000
DMU_{18}	0.8203	12	0.8351	12	0.9698	0.8890	0.7058
DMU_{19}	0.7192	21	0.7598	19	0.8718	0.9126	0.5550
DMU_{20}	0.8653	8	0.8781	8	0.8569	0.7569	1.0000
DMU_{21}	0.9262	4	0.9337	4	0.9850	0.8257	1.0000
DMU_{22}	0.7602	18	0.7731	18	0.8947	0.8201	0.6577
DMU_{23}	0.7441	20	0.7533	21	0.8675	0.7812	0.6596
DMU_{24}	0.7457	19	0.7570	20	0.8815	0.7910	0.6518
DMU_{25}	0.8398	10	0.8486	10	0.9255	0.7366	0.9033
DMU_{26}	0.8875	6	0.8996	7	0.9903	0.7652	0.9662
Maximum	1.0000		1.0000		1.0000	1.0000	1.0000
Minimum	0.5996		0.7207		0.8134	0.6549	0.3746
Means	0.8098		0.8291		0.9023	0.8083	0.8040
S.D.	0.0949		0.0804		0.0634	0.0966	0.1930

In order to investigate potential issues of DMU operation, the study invited five experienced practitioners of property management to analyze DMU from the perspectives of staff quality, customer satisfaction and operation performance. These practitioners were also asked to provide suggestions for the improvement of mentioned drawbacks. Table 4 summarizes the proposals for improvements to business strategy as a reference to enhance overall business performance of investigated DMUs.

Table 3. Sensitivity of Input and Output

Sensitivity / Item	High ⟹ Low 1st	2nd	3rd
Total effiency	Staffing	Staff retention rate	CMC satisfaction
Staff quality	CMC satisfaction	Direct personnel costs	Staff retention rate
Customer satisfaction	Staffing	CMC satisfaction	Contract price
Operation performance	Staff retention rate	CMC satisfaction	Contract price

5 Conclusions

Property management companies face significant challenges in effectively managing different properties. The Network DEA model is used to evaluate the performance of 26 cases and can provide useful reference for apartment building management firms.

Staff quality, customer satisfaction and operation performance all impact resigential management operation performance. Residential building management is service-oriented, thus we must fully consider the customer experience based on quality of service. Good staff quality can improve customer satisfaction and thus improve DMU performance. According to the researh results, most of the total DMU efficiency values fell between 0.75 and 0.90. DMU_6 (1.0000) is ranked first, with performance values for each dimension of 1. Aside from the staff quality dimension (0.8134), the other two dimensions (customer satisfaction and operation performance) for DMU_{10} are both below 0.78, indicating this DMU is most in need of improvement, especially for the operation performance dimension. Additionally, Sensitivity analysis can show the impact of inputs and outputs on case performance. Thus decision-makers should focus on relatively sensitive items when formulating operational strategy.

Table 4. Potential issues and proposed suggestions

Dimension	Potential issues	Suggestions for improvement
Staff quality	1.Heavy turnover and incomplete training result in inconsistent staff quality	1.Regular education and training
	2.Low quality workers lack "full-service" mentality, making it difficult to achieve overall improvement	2.Property owner selects primary service staff
	3.Large human resource investment requirements make it difficult to maintain comprehensive control	3.Investigate candidate qualifications and work attitudes
Customer satisfaction	1.Difficulty meeting expectations of multiple customer types	1.Focus on needs of majority of households
	2.Inconsistent community cultures	2.Indirect observation of community activities
	3.Contract renewal not assured despite overall household satisfaction	3.Establish a comprehensive response platform
Operation performance	1.Revenue does not reach contract value, and is dependent on the attributes of residential cases.	1.Model communities are less profitable
	2.Staff and management have different views on operational efficiency	2.Regular meetings between head office management and case managers
	3.Many factors affect operational performance including corporate policy, government regulations, industrial structure, consumption patterns and employment platforms	3.Effective integration of left column factors to reduce regulatory impact

References

[1] Chen, W.T. and Wang, C.-W. Project management performance assessment of condominium building — A case study. In *proceedings of the AMME 2015-CTUE 2015*, pages 768–771. Bangkok, Thailand, 2015.

[2] Ramón, S.G., Francesc, H.S., and María M.S. Assessing the efficiency of wastewater treatment plants in an uncertain context: A DEA with tolerances approach. *Environmental Science & Policy*, 18: 34–44, 2012.

[3] Wanke, P.F. Capacity shortfall and efficiency determinants in Brazilian airports: Evidence from bootstrapped DEA estimates. *Socio-Economic Planning Sciences*, 1–4, 2012.

[4] Bayraktar, E., Tatoglu, E., Turkyilmaz, A., Delen, D., and Zaim, S. Measuring the efficiency of customer satisfaction and loyalty for mobile phone. *Expert Systems with Applications*, 39(1): 99–106, 2012.

[5] Sueyoshi, T. and Goto, M. DEA radial measurement for environmental assessment and planning: Desirable procedures to evaluate fossil fuel power plants. *Energy Policy*, 41(1): 422–432, 2012.

[6] Boscá, J.E., Liern, V., Martinez, A., and Sala, R. Ranking decision making units by means of soft computing DEA. *International Journal of Uncertainty Fuzziness and Knowledge-Based Systems*, 19(1): 115–134, 2011.

[7] Yang, C. and Liu, H.M. Managerial efficiency in Taiwan bank branches: A network DEA. *Economic Modelling*. 29(2): 450–461, 2012.

[8] Despotis, D.K., Sotiros, D., and Koronakos, G. A network DEA approach for series multi-stage processes. *Omega*, 61: 35–48, 2016.

[9] Charnes, A., Cooper, W.W., and Rhodes, E. Measuring the efficiency of decision making units. *European Journal of Operational Research*, 12(6): 429–444, 1978.

[10] Chen, C. and Yan, H. Network DEA model or supply chain performance evaluation. *European Journal of Operational Research*. 213(1): 147–155, 2011

[11] Banker, R.D., Charnes, A., and Cooper, W.W. Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*, 30(9): 1078–1092, 1984.

[12] Zhao, Y., Triantis, K., Murray-Tuite, P., and Edara P. Performance measurement of a transportation network with a downtown space reservation system: A network-DEA approach. *Transportation Research Part E: Logistics and Transportation Review*. 47(6): 1140–1159, 2011.

[13] Tone, K. and Tsutsui, M. Network DEA: A slacks-based measure approach. *European Journal of Operational Research*, 197(1): 243–252, 2009.