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An analytical method to evaluate facility management services for residential buildings

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Abstract:

Besides constructed quality and environmental quality, the quality of facilities in residential buildings is influential to the living quality of numerous residents there. The functional quality of the facilities, in turn, is dependent on the quality of their operation and management. A review of the relevant literature and a focus group discussion with facility management (FM) practitioners, which were parts of the study reported here, unveiled that prior performance evaluation studies focussed on assessing the outcome of FM services whereas an analytical method suitable for holistic evaluation of the services is lacking. An interview survey with 297 users of a typical residential estate in Hong Kong was carried out to solicit their perceived levels of importance and performance of FM services. The responses were tested using the analytical hierarchy process (AHP) to isolate those with inconsistent judgments, followed by computing the weightings for various aspects of FM services based on the consistent responses. The calculation of a weighted performance score for benchmarking purposes and a critical evaluation of the cost-effectiveness of FM services, which are crucial for achieving a quality and sustainable built environment, are illustrated.

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1.0 Introduction

Urban cities are typically crowded with high-rise buildings, many of which are residential buildings. Apart from the constructed quality of these buildings and their surrounding environmental quality, the quality of facility management (FM) services such as cleaning, repair & maintenance and so on is critical to the operation of the facilities including building fabric, ventilation systems, electrical installations, leisure & landscape facilities, etc. The performance of these facilities, in effect, is influential to the health, safety and enjoyment of the residents.

A lot of research efforts had been devoted to studying user satisfaction with construction services and products. For instance, Ahmed and Kangari [1] attempted to identify the factors important to construction client satisfaction. Maloney [2] examined the relationship between construction product/service and customer satisfaction. On the satisfaction of home buyers, Torbica and Stroh [3] proposed a model for assessing the design, quality and service dimensions of houses. More recently, Yang and Peng [4] reported on the development of a customer satisfaction evaluation model for construction project management.

Realizing the huge impacts that buildings can incur to the environment, numerous assessment tools have been developed for evaluating environmental performance of buildings [5,6]. The well-known ones include, *inter alia*, the Leadership in Energy and Environmental Design

(LEED) assessment scheme in the US, the Building Research Establishment's Environmental Assessment Method (BREEAM) in the UK, the Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) in Japan, and the Building Environmental Assessment Method (BEAM) in Hong Kong.

As to tools for assessing performance of FM services, the leading post occupancy evaluation (POE) tools for measuring building performance, according to an earlier review [7], include the building quality assessment (BQA) in New Zealand, the serviceability tools and methods (STM) in Canada, and the post-occupancy review of buildings and their engineering (PROBE) in the UK. In the US, a web-based occupant survey has been developed for quantifying building performance, which focuses on employee's satisfaction with their workplace environment [8]. Asian examples include the Yeh's Index Number of Satisfaction [9] used in Singapore for investigating users' satisfaction on the management of public housing and a Korean model developed for evaluating the environment, function and comfort of residential buildings [10].

In Hong Kong, multi-storey residential buildings account for the majority of the building stock. The amount of residential flats has reached 2,486,000 units, accommodating over 6.9 million people, i.e. over 95% of the population [11]. Given the increasing significance of FM services for these buildings, studies in this area have grown. For example, Liu [12] identified the major factors which influence residential satisfaction in housing estates. Li and Siu [13] studied satisfaction of tenants and management staff with the services provided in subsidised housing estates. In another study [14], a scheme for assessing health and hygiene performance of apartment buildings was developed.

The above studies all share a common focus, which is on assessing the quality of the delivered service. Studies investigating also the amount of input resources, which affects the service quality, are yet to be seen. As experienced in a prior study [15], collection of empirical cost data of FM services for existing buildings is really difficult. But the aggregate amount of FM costs expended over the life cycle of buildings is substantial [16]. Without a proper evaluation of the effectiveness of such input resources, assessing solely the outcome performance of FM services would render the evaluation to remain partial.

In order to address this gap, a research study was initiated with an aim to developing an analytical method that can evaluate the cost and performance of FM services in a holistic manner. Reported in this paper includes the steps taken to understand the industry practice in assessing quality of FM services, which informed the design of the data collection tool for the study, and the surveys carried out for collection of the required data. After identifying the various aspects that need to be embraced by an adequate assessment of FM service quality, the analyses on perceived importance and perceived performance of the major FM aspects are reported. Finally, a method developed for calculating a weighted score for representing the overall performance of FM services is elaborated, and its application is exemplified.

2.0 Material and Methods

Prior to devising an appropriate method for data collection, the study started with enquiring into the common practices of assessing FM services quality by inviting five experienced professionals from different leading FM companies in Hong Kong to take part in a focus group discussion [17]. The discussion revealed that for private residential buildings, satisfaction of residents with the FM services they received is typically obtained through

annual surveys, which involve dropping a questionnaire into the letter box of each building flat. Flat occupiers are requested to use a 5-point scale to indicate their level of satisfaction with the performance of various items of FM services, and to return the completed questionnaires to the management office for analysis.

In public housing estates managed by the Housing Department, a scoring system called Property Services Agent Performance Assessment System (PSAPAS) is used for assessing the performance of property services agents in managing the estates [18]. This assessment comprises three components contributed respectively by the Housing Department, the Estate Management Advisory Committee (EMAC) of the estate, and the estate's tenants. However, background details about the considerations taken in formulating the assessment scheme and how the weightings of the assessed components were determined are unknown.

Both the above methods assess only the perceived satisfaction with the performance of different aspects of FM services, without identifying their levels of importance as perceived by the users. Without the latter, and when the users' responses are corrupted with the halo effect where the perceived judgment of a particular attribute is influenced by the perception of the former attributes in a sequence of judgments [19,20], the assessment results could lead to adoption of some cost ineffective measures for raising performance.

To overcome this deficiency, the users may be asked to also indicate their perceived relative importance between pairs of the FM aspects, followed by analyzing such responses using the analytical hierarchy process (AHP) [21]. This approach has been successfully applied in earlier studies, e.g. on performance features of residential buildings [10] and on indoor environmental quality attributes of commercial buildings [22].

The focus group participants were requested to provide sample questionnaires used by their companies for soliciting residential users' responses on their satisfaction with FM services. A content analysis [23] on these sample questionnaires showed that while the questions contained therein are not entirely identical, they generally fall into five main aspects of FM services: security (SEC), cleaning (CLN), repair and maintenance (R&M), landscape and leisure (L&L), and general management (GEN). The major attributes of these aspects include: i) SEC - performance of security staff, passage control, security patrol; ii) CLN – performance of cleaners, cleanliness of common areas, waste collection and removal; iii) R&M – performance of technicians, condition of building fabric and functioning of engineering services; iv) L&L – performance of gardeners, pest control, condition of recreational facilities; and v) GEN – performance of management staff, arrangement of estate activities, etc. This part of the findings, as described below, underpinned the subsequent questionnaire design.

With an objective to analyze the users' perceptions on both the importance and the performance of the FM services they are receiving, a survey was devised and implemented in a typical residential estate that was 8 years old. The estate comprises 12 high-rise residential blocks and a 7-storey car park building. Characteristic information about this estate was sourced from the Buildings Department, from whom a set of record drawings showing the site plan, building layout plans and schedules of gross floor area calculations was obtained. The key characteristics extracted from these drawings are summarised in Table 1.

For ensuring the collection of quality data, the survey method chosen was to conduct personal interviews with users of the residential buildings. The questionnaire designed for use in the

survey comprised three sections. The questions in the first section ask about the personal particulars of the interviewees, including their genders, ages, education levels and monthly incomes. The second section is sub-divided into two parts: the questions in part one request the interviewees to indicate, using a 5-point scale (1: no; 2: little; 3: moderate; 4: great; 5: extreme), their perceived importance of each of the five FM aspects and of all the aspects as a whole; those in part two ask them to indicate, also based on a 5-point scale (1: very poor; 2: poor; 3: fair; 4: good; 5: excellent), their perception about the performance level of each of the five aspects and of all the aspects as a whole. In the final section, the questions ask the interviewees to indicate their perceived relative importance between pairs of the five FM aspects (i.e. totally 10 pair-wise comparisons) using a 9-point scale (1: equal importance; 3: moderate importance of one over another; 5: strong importance; 7: very strong importance; 9: extreme importance; 2, 4, 6 & 8: intermediate values between the two adjacent judgments), which is widely used in surveys for obtaining data for evaluation of weightings among the attributes of a complex issue through the use of AHP (e.g. in the study of Lai and Yik [24]).

A team of four research personnel was trained before they were dispatched to conduct the interview survey, to ensure there would be no discrepancies in their explanations about the meaning of the questions to the interviewees. The survey was carried out at the open area near the entrances to the buildings where the interviewers could easily find residential users and seek their voluntary participation in the interviews. On average, only 1 out of 10 persons approached accepted the request for interview. Among the 297 interviews conducted, three questionnaires containing incomplete information were discarded. The remaining data, provided by 174 female and 120 male interviewees, were taken for analysis. Of this sample, the majority (82.0%) were adults, including 14 elders who were aged over 60. With 70.4% who received education up to the primary or secondary level and 28.2% possessing

qualifications at the tertiary education level, most of the interviewees (84.7%) had a monthly income of less than HK$20,000.

Apart from the survey results, a summary of the annual expenditure of the estate was collected from the estate manager (the willingness of the estate manager in supplying this information was a key reason for basing the study on that estate). This allowed the various cost items under the five FM aspects to be identified. These data, as will be discussed later, are useful in evaluating the cost-effectiveness of the services.

3.0 Analysis and Discussion

3.1 Perceived importance of FM services

For each of the FM aspects, a mean value of the importance ratings given by individual respondents with reference to the 5-point scale, referred to here as the mean importance rating, was calculated. The mean importance rating of the five aspects as a whole was likewise computed based on the corresponding importance ratings given by individual respondents. The margin of error (E) of each mean importance rating was also computed based on the 95% confidence level under the Student's t-distribution. These calculation results together with the associated maximum, minimum and standard deviation (S.D.) values pertaining to the entire sample are summarised in Table 2. According to their mean importance ratings, the importance ranks of the five aspects were determined, with security (4.5068) being the highest, followed by cleaning (4.3912), repair & maintenance (4.2007), landscape & leisure (3.7959), and general management (3.7653). The mean importance

rating of repair & maintenance, which was ranked at the middle of the five aspects, is close to the mean rating of the five aspects as a whole (4.2075).

Closer examination of the mean values reveals that there are just minor differences between these mean values. The respondents generally considered all the aspects as important, which suggests that the halo effect might exist in their perceived judgments. As such, further analysis using the AHP method was carried out to check the consistency of the judgments given by the respondents and to evaluate the importance weights of the FM aspects.

A computer program that utilizes the EVCRG standard subroutine (available from the well-established International Mathematical and Statistical Library) for eigenvalue and eigenvector calculations was used to evaluate the importance weights, based on the pair-wise relative importance ratings given by the respondents as their answers to the questions in the final section of the questionnaire. The steps taken for this part of calculation are as follows:

- *Step 1:* Each set of the collected ratings of perceived relative importance was organised to form a 5x5 comparison matrix.

- *Step 2:* The matrix data were input to the computer program for: (a) evaluating the principal eigenvalue and eigenvector; (b) computing the consistency ratio (*CR*) (as defined in Equation (1)); and (c) normalizing the elements in the principal eigenvector to yield the importance weights (such that their sum equals 1).

- *Step 3:* The *CR* of each data set was checked against the limit for a 5x5 matrix; it would be retained and its normalized eigenvector elements taken as the importance weights if it passed the consistency test but would be screened out if it failed the test.

$$CR = \frac{\lambda_{max} - N}{N - 1} \times \frac{1}{RC} \quad (1)$$

In Equation (1), λ_{max} is the principal eigenvalue; N is the number of aspects being rated (i.e. 5 for this study); and RC is the random consistency. According to Saaty [25], for pair-wise comparison of 5 items involving the use of a 5×5 comparison matrix, the value of RC is 1.11 and the CR limit is 10%. Data sets with calculated CR values exceeding this limit were treated as involving inconsistent judgments.

As summarised in Table 3, 211 out of the 294 responses in the collected sample failed in the consistency test, with a mean consistency ratio (CR) of 0.3478; only 83 (28.2%) were found by the test to be consistent judgments. The CR value of this "consistent" group, on average, is 0.0418 and the standard deviation is 0.0358, which is about just one tenth of that of the "inconsistent" group. The difference between their range values is even greater.

Table 4 summarises the statistics of the importance ratings calculated based on the responses given by the 211 respondents in the inconsistent group. The mean values of the five FM aspects and for the five as a whole, as shown in this table, are comparable with those shown in Table 2 for the entire sample. The importance ranks of the FM aspects in these two sets of results are even identical. These observations are not unexpected given the dominance (72.8%) of the inconsistent group in the sample.

With the inconsistent group ignored, the importance weights of the five FM aspects were calculated using the AHP method based on the responses given by the 83 respondents in the consistent group. The results, including the mean, margin of error, rank, maximum, minimum and standard deviation, are shown in Table 5. Since this calculation was based on the respondents' answers for the pair-wise comparisons, the perception of the importance of the five FM aspects as a whole is not applicable. The results show that the security aspect (0.2905) was ranked as the most important by this group of respondents. The remaining aspects, in descending order of their importance, are: cleaning (0.2142), repair & maintenance (0.1962), general management (0.1644), and landscape & leisure (0.1347). When compared to the results in Tables 2 and 4, an obvious distinction is that the landscape & leisure aspect instead of the general management aspect was regarded as the least important.

Given that the calculated importance weights were normalized such that their sum equals one, with five aspects being rated in this study, their importance weights would each be one-fifth (i.e. 0.2) if all of them were regarded as of equal importance. Yet, the current results show that the mean importance weights of the five aspects are differentiated: the weights for security and cleaning aspects are above 0.2; that of repair & maintenance is close to 0.2; and those associated with the remaining two aspects, namely general management and landscape and leisure, are well below 0.2.

Since the mean importance weights in Table 5 were computed using the AHP method, they could not be directly compared with the mean importance ratings pertaining to the whole sample (Table 2) and the inconsistent group in the sample (Table 4), which were simply

averages of the ratings given by the respondents. For comparison purpose, the mean importance ratings of the consistent group were also calculated, and the statistics of the results are summarised in Table 6. Akin to the results in Tables 2 and 4, the mean importance ratings of the five FM aspects and of the five as a whole belong to moderately or highly important. Nevertheless, the importance ranks of the five aspects, determined according to the mean scores, are same as those identified based on the calculated AHP weights (Table 5).

3.2 Perceived performance and its relation with perceived importance

From the responses to the questions in section 2 of the questionnaire, the mean performance ratings of the five FM aspects were calculated by averaging the ratings given by individual respondents. The statistics of these calculation results pertaining to the whole sample, the inconsistent group and the consistent group are shown in Tables 7, 8 and 9 respectively. Cross inspection of the mean values in these tables does not give any apparent observations, except that they lie between 3.5301 and 3.7299, which is a rather narrow range. This also indicates that the respondents generally perceived the performances of the FM aspects as between "fair" and "good".

Despite the small variations in these mean performance ratings, the orders of performance ranks of the FM aspects are apparently different between the consistent group (Table 9) and the inconsistent group as well as the whole sample (Tables 7 and 8). Referring to the results of the consistent group, the performances of both the security and cleaning aspects top the table, followed by that associated with general management, repair & maintenance, and landscape & leisure. On the other hand, the performance of general management is the highest in the results of all in the sample and of the inconsistent group.

With the aid of the evaluation matrix shown in Figure 1, the perceived performance and the perceived importance of the FM aspects can be analysed in a collective manner. When the performance and importance of an aspect are both perceived as low, rather than a desperate change, its current state should be closely monitored. When an aspect is perceived as having a low importance yet a high performance, it is desirable to maintain its current state. But, in case the perceived performance of an important aspect is low, it is necessary to find ways for improvement. If both the importance and performance of an aspect are perceived as high, it should be capitalised to become a competitive advantage. In this scenario, for example, the way in which the FM services are organized and managed could be set as a good practice model for reference by FM teams looking after other estates.

The mean performance ratings and importance ratings calculated based on the responses given by all respondents in the sample are plotted in Figure 2. Comparing these results with the matrix in Figure 1 shows that the rated aspects cluster in the upper-right quadrant, which implies that all of them should be capitalised.

As pointed out in the foregoing analysis on perceived importance, the existence of the halo effect might give rise to the comparable mean importance ratings given to the five FM aspects. To enable proper differentiation between their perceived importance levels, the AHP weights of the consistent group were calculated. These results together with their corresponding performance ratings are plotted in Figure 3. It shows that the security and cleaning aspects lie in the upper-right quadrant (i.e. the capitalisation region) whereas the aspects of repair & maintenance, general management, and landscape and leisure, which fall within the upper left quadrant, should be maintained (see Figure 1).

The perceived importance and performance ratings given by individual respondents of the consistent group were scrutinised further. As shown in Figures 4 and 5, the perceived responses of the majority of respondents on the security and cleaning aspects belong to the capitalisation region, i.e. with their performance ratings and importance weights above 3 and 0.2 respectively. Whereas the distribution of individual responses with respect to the repair & maintenance aspect, as can be seen from Figure 6, appears to be rather even between the upper two quadrants, the majority of the respondents perceived the landscape & leisure aspect (Figure 7) and the general management aspect (Figure 8) as below the nominal importance weight value (0.2).

3.3 Weighted performance of FM services

The responses given by the consistent group were used to calculate the importance weighted performance scores for the five rated FM aspects and for the estate as a whole. Firstly, the weighted performance scores given by individual respondents for a particular aspect were calculated using Equation (2). The proportion distributions of these performance scores are shown in Figure 9, from which the following observations are noted.

$$\hat{S}_{i,a} = S_{i,a} \times W_{i,a} \tag{2}$$

$$\hat{S}_i = \sum_{a=1}^{N} \hat{S}_{i,a} \tag{3}$$

$$\hat{S}_{i(\%)} = \frac{\hat{S}_i}{\max\left(\hat{S}_i\right)} \times 100\% \tag{4}$$

$$\max\left(\hat{S}_i\right) = \max\left(\sum_{a=1}^{N} S_{i,a} \times W_{i,a}\right) \tag{5}$$

$$\max\left(S_{i,a}\right) = 5 \quad (6)$$

$$\max\left(\sum_{a=1}^{N} W_{i,a}\right) = 1 \quad (7)$$

$$\hat{S}_{(\%)} = \frac{\sum_{i=1}^{n} \hat{S}_{i(\%)}}{n} \quad (8)$$

a = 1, 2, 3, 4, or 5 assigned to the a^{th} aspect being rated

n = total number of respondents

N = total number of the rated aspects

$S_{i,a}$ = performance rating given by the i^{th} respondent for the a^{th} aspect

$\hat{S}_{i,a}$ = weighted performance score of the i^{th} respondent for the a^{th} aspect

$\hat{S}_i$ = weighted performance score of the i^{th} respondent for all the rated aspects

$\hat{S}_{i(\%)}$ = weighted performance score (in percentage) of the i^{th} respondent for all the rated aspect

$\hat{S}_{(\%)}$ = overall FM performance score (i.e. FMP score) for the estate

$W_{i,a}$ = importance (AHP) weight given by the i^{th} respondent for the a^{th} aspect

First, the ranges of the weighted scores of the security and cleaning aspects, which are 2.5 and 2.1 respectively, are much wider than those of the repair & maintenance (1.3), landscape & leisure (1.2), and general management (1.4) aspects. Second, while the minimum weighted scores of the five aspects are comparable (between 0.1 and 0.3), the maximum weighted scores of the security and cleaning aspects (2.8 and 2.2, respectively) are significantly higher than the counterparts of the remaining three aspects (between 1.3 and 1.5). Third, the maximum proportions of weighted scores (current subdivisions being 0.1) in the five aspects

are all slightly above 20%; no particular domination is found in any of the five distribution spectrums.

Equation (3) was used for summing up the weighted performance scores for the five rated aspects, which were obtained by Equation (2) before, to generate the weighted performance score given by individual respondents for the five aspects as a whole. The distribution of these calculated results, as graphed in Figure 10, is skewed towards the low side. With the minimum score being above 2.3 and a maximum score of 5.0 (i.e. full score), the average score is 3.6443 (i.e. between "fair" and "good"). Around one-third of the respondents gave a weighted performance score between 3.9 and 4.1, meaning that the performance of FM services was rated by this group as "good". Furthermore, the proportions of share between the weighted scores of individual aspects contributing to the overall weighted performance score were found to be: 29.5% (security); 21.6% (cleaning); 19.5% (repair & maintenance); 13.1% (landscape & leisure); and 16.3% (general management).

To enable comparisons of performance scores on a general scale with maximum score of 100, the weighted performance scores obtained from Equation (3) were processed using Equation (4) to yield the weighted performance scores (in %) of the consistent group of samples. Note that the maximum weighted performance scores per respondent can be represented by Equation (5) where the maximum score given for any of the rated aspects is 5 (Equation (6)) and the maximum sum of importance (AHP) weights is unity (Equation (7)).

Besides, the raw scores pertaining to different sample groups, namely the whole sample, the consistent group and the inconsistent group, were computed by multiplying the respondents' perceived performance ratings on the overall FM services by 20 (i.e. conversion of a 5-point

scale into a full scale of 100). Due to this conversion, the distributions of these three groups of raw scores, as shown in Figure 11, are discrete at 40, 60, 80, and 100. Their distribution patterns are highly similar, and the lowest score is 40, which corresponds to a perceived performance rating of 2 (i.e. "poor") under the 5-point scale. The raw scores given by the majority (between 66.3% and 68.3%) in these groups, all being 80, are identical.

Also shown in Figure 11 is the distribution of the weighted scores of the consistent group, which was worked out by subdividing the full score of 100 into ten equal intervals: for example, the class of score 50 embraces the scores exceeding 50 but not greater than 60, so on and so forth. The weighted scores of this group, unlike the discrete distributions of the above raw scores, spread between 40 and 100. The score given by the majority (55.4%) is 80, which is identical to that of the preceding three groups.

Based on the weighted performance scores of individual respondents belonging to the consistent group, Equation (8) was used to compute the overall FM performance score (denoted as "FMP score") for the estate. Statistics of the computed results, including the scores distribution and their cumulative percentage, are depicted in Figure 12. With a lowest score of 47.6 and a highest score of 100, the mean score is 72.9. The cumulative percentage curve can also be used for internal or external benchmarking purposes, e.g. when the FM performance data of the same estate at different times or the same types of data of similar estates are available.

3.4 Costs of FM services

Assessing merely the performances of FM services provided for a residential estate would only inform the outcome of the services. Without examining the level of input resources for the services, the performance assessment results might not be meaningful: e.g. a high performance level could be obtained by inputting an excessive amount of resources; and a low performance level could be a result of an inadequate input of resources. To have a holistic evaluation of the FM services, therefore, it is essential that the costs spent on the services are also examined.

As noted from the collected expenditure account of the estate, the expenses on FM services are grouped under four different portions of the estate: residential; car park; shop; and estate common. Among these expenses, the residential and estate common portions essentially affect all users of the estate, including those who are owners, non-owner residents as well as visitors. Since not all the expenditure items in the account were shown with breakdowns pertaining to different portions of the areas, apportionment of the costs, as explained in the following, was carried out.

The land law system in Hong Kong provides that, by the principle of unity of possession, individual unit owners of the estate co-own the common area [26] and thus bear the responsibility of sharing the cost for its FM services. The amount of shares assigned to each unit owner, typically specified in a deed of mutual covenant (DMC), is the basis on which the apportionment of management fees is determined [27]. In practice, the commonly used method for this determination is to apportion the management fees to each unit according to its area [28]. Thus, the portion of estate expenses on the FM services that should be shouldered by the residential unit owners can be calculated by Equation (9).

$$\widetilde{E}_r = E_e \times \left(\frac{A_r}{A_c + A_r + A_s} \right) \quad (9)$$

$$E'_r = E_r + \widetilde{E}_r \quad (10)$$

$$\overline{E}_r = \frac{E'_r}{A_r} \quad (11)$$

Where

A_c = gross floor area of car park (m^2)

A_r = gross floor area of residential units (m^2)

A_s = gross floor area of shops (m^2)

E_e = expenses on estate common area (HK$)

E_r = expenses on residential portion (HK$)

$\widetilde{E}_r$ = expenses on estate common area apportioned to the residential portion (HK$)

E'_r = total expenses borne by the residential owners (HK$)

$\overline{E}_r$ = normalised total expenses borne by the residential owners (HK$/$m^2$)

Using Equation (10) to sum up the apportioned estate expenses and the residential expenses gives the total expenses borne by the residential owners. This was done for each of the five FM aspects and the results are shown in Table 10. These results were further normalised by the total residential gross floor area using Equation (11) to give the normalised expenses (in HK$/$m^2$).

Among the five aspects, repair & maintenance incurred the largest proportion (36.3%) of the overall expenses. The amounts of expenses on general management (29.2%) and security (24.3%) are comparable. The proportions spent on the remaining two aspects, namely

cleaning (9.1%) and landscape & leisure (1.1%), are relatively low. Making comparisons based on these proportions, however, could only inform the arithmetic differences or relative magnitudes between them. More meaningful evaluations would be available if the expenditure on various FM aspects are analysed together with their performance levels.

Figure 13 shows the proportions of weighted performance scores of the FM aspects plotted against the corresponding proportions of costs. This kind of cost-performance plot is useful especially when the FM budget is limited. It can show, for certain shares of the budget allocated to the various aspects, their relative contributions to the overall performance score. Consider, for instance, the two aspects (L&L and R&M) with extreme cost inputs. L&L accounted for a significant share (13.1%) of the overall weighted performance score while incurring only a minimal cost (1.1%). In contrast, 36.3% of the total cost was spent on R&M, which contributed to 19.5% of the overall score. These observations imply that the cost-performance efficiency of L&L is higher than that of R&M. Nevertheless, it does not necessarily mean that L&L outperformed R&M because these two aspects are basically different. Their difference in design provision and as-built condition may also render different volume and complexity of services required for their ongoing use and upkeep, leading to different levels of cost input.

Rather than making direct comparisons between different aspects of services, a scatter plot of the performance ratings and costs of different FM aspects can be used for gauging the sensitivity of performance level perceived by the users against incremental change in cost input for the FM services. Figure 14 is plotted in this way and it represents a snapshot of the cost-performance states of the FM aspects at the time of the study.

In interpreting the results shown in Figure 14, reference can be made to the evaluation matrix in Figure 15. If an additional cost input to an aspect results in a rise in its performance level rated by the users (i.e. the current state point shifts in the upper-right direction), it indicates that the increase in cost is value-for-money. But if the users perceive a lowered performance even after an increase in cost input, the additional resources should have been used ineffectively. When the state point shifts in the opposite direction, there should be some other factors (e.g. change in user expectation) that override the effect of cost reduction. A shift of the state point in the lower-left direction, obviously, would imply that more input resources are needed to uplift the performance.

4.0 Conclusions

Based on an interview survey on a typical estate of high-rise residential buildings in Hong Kong, an analytical method has been developed to examine the importance levels that the building users perceived about the five aspects of FM services, which include security, cleaning, repair & maintenance, landscape & leisure, and general management. It has been shown that regardless of the cautions taken to avoid discrepancies in the interviewing process, respondents giving inconsistent judgments are common. The AHP method is useful for isolating the inconsistent responses as well as differentiating the perceived importance levels based on the consistent responses.

Instead of assessing only the raw performance ratings of the FM services perceived by the users, it has been illustrated how a weighted facility management performance score (FMP score) can be computed. This score, taking into account the consistent judgments of the users on the importance of the five aspects, is a useful indicator for representing the overall

performance of FM services. A benchmarking curve constructed according to the cumulative proportions of the FMP scores can help in gauging the future performance of the same building estate or comparing the performances between peer estates.

A holistic evaluation of FM services requires assessing not only their performance levels but also the levels of their input resources. Elaboration has been given on how a snapshot of the current state of cost-performance may be recorded. It serves as a footprint against which changes in cost-effectiveness of expenses on different aspects of FM services can be measured. This kind of information, in addition to constructed quality and environmental quality of buildings, is essential in the pursuit of quality FM services for realisation of sustainable buildings in the long run.

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Lai, J.H.K. and Yik, F.W.H. (2011), An analytical method to evaluate facility management services for residential buildings, Building and Environment, Vol. 46, No. 1, pp. 165-175.

References

[1] Ahmed SM, Kangari R. Analysis of client-satisfaction factors in construction industry. Journal of Management in Engineering 1995;11(2):36-44.

[2] Maloney WF. Construction Product/Service and Customer Satisfaction. Journal of Construction Engineering and Management 2002;128(6):522-529.

[3] Torbica ZM, Stroh RC. Customer satisfaction in home building. Journal of Construction Engineering and Management 2001;127(1):82-86.

[4] Yang JB, Peng SC. Development of a customer satisfaction evaluation model for construction project management. Building and Environment 2008;43(4): 458-468.

[5] Cole RJ. Emerging trends in building environmental assessment methods. Building Research and Information 1998;26(1):30-16.

[6] Forsberg A, von Malmborg F. Tools for environmental assessment of the built environment. Building and Environment 2004;39(2):223-228.

[7] McDougall G., Kelly JR, Hinks J, Bititci US. A review of the leading performance measurement tools for assessing buildings. Journal of Facilities Management 2002;1(2):142-153.

[8] Huizenga C, Laeser K, Arens E. A Web-Based Occupant Satisfaction Survey for Benchmarking Building Quality. Proceedings of Indoor Air 2002, Monterey, CA.

[9] Yeh SHK. Public Housing in Singapore: A Multidisciplinary Study. University Press for Housing and Development Board, Singapore; 1975.

[10] Kim SS, Yang IH, Yeo MS, Kim KW. Development of a housing performance evaluation model for multi-family residential buildings in Korea. Building and Environment 2005;40(8):1103-1116.

[11] Housing Authority. Housing in Figures 2008, Hong Kong, 2009. (http://www.housingauthority.gov.hk/)

[12] Liu AMM. Residential satisfaction in housing estates: a Hong Kong perspective. Automation in Construction 1999;8(4):511-524.

[13] Li LH, Siu A. Privatising management services in subsidised housing in Hong Kong. Property Management 2001;19(1):37-49.

[14] Ho DCW, Leung HF, Wong SK, Cheung AKC, Lau SSY, Wong WS, Lung DPY, Chau KW. Assessing the health and hygiene performance of apartment buildings. Facilities 2004;22(3/4):58-69.

[15] Lai JHK, Yik FWH, Jones P. Expenditure on Operation and Maintenance Service and Rental Income of Commercial Buildings. Facilities 2008;26(5/6): 242-265.

Lai, J.H.K. and Yik, F.W.H. (2011), An analytical method to evaluate facility management services for residential buildings, Building and Environment, Vol. 46, No. 1, pp. 165-175.

[16] Evans R, Haryott R, Haste N, Jones A. The Long Term Costs of Owning and Using Buildings. Royal Academy of Engineering, London; 1998.

[17] Edmunds H. The focus group research handbook. NTC Business Books; 1999.

[18] HD. PSA Performance Assessment System (PSAPAS). Housing Department, Hong Kong; 2004.

[19] Thorndike EL. A constant error on psychological rating. Journal of Applied Psychology 1920;IV:25-29

[20] Nisbett RE, Wilson TD. The halo effect: Evidence for unconscious alteration of judgments. Journal of Personality and Social Psychology 1977;35(4):250-256.

[21] Saaty TL. The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. McGraw-Hill; 1980.

[22] Lai JHK, Yik FWH. Perceived Importance of the Quality of the Indoor Environment in Commercial Buildings. Indoor and Built Environment 2007;16(4):311-321.

[23] Zikmund WG. Business Research Methods. Thomson Learning, US; 2003.

[24] Lai JHK, Yik FWH. Perception of Importance and Performance of the Indoor Environmental Quality of High-Rise Residential Buildings. Building and Environment 2009;44(22):352-360.

[25] Saaty TL. Decision Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World. RWS Publications; 1995.

[26] Srivastava DK. Business Law in Hong Kong, Sweet & Maxwell Asia, 2002.

[27] HAD. Building Management. Home Affairs Department, Hong Kong; 2003.

[28] Hong Kong Institute of Real Estate. Professional Practice of Property Management. Commercial Press (Hong Kong); 2005.

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Table 1 Key information about the building estate

Characteristics	Key figures
Total site area	35,129 m^2
No. of residential blocks	12
Total no. of residential flats	3,000
Total gross floor area of residential flats	177,559 m^2
No. of floors per residential block	22 – 30
No. of flats per residential block	220 – 300
Size of typical floor	592 m^2
No. of flats per typical floor	10
Size of residential flats	46 – 64 m^2

Table 2 Statistics of importance ratings of the whole sample

Aspect	Mean	*E*	Rank	Max	Min	S.D.
Security	4.5068	0.0708	1	5.0000	1.0000	0.6168
Cleaning	4.3912	0.0684	2	5.0000	2.0000	0.5958
Repair & maintenance	4.2007	0.0797	3	5.0000	1.0000	0.6941
Landscape & leisure	3.7959	0.0874	4	5.0000	1.0000	0.7612
General management	3.7653	0.0950	5	5.0000	1.0000	0.8279
Five aspects as a whole	4.2075	0.0658	-	5.0000	1.0000	0.5734

Table 3 Consistency ratios (*CR*s) of the inconsistent and consistent sample groups

Sample group	Mean	S.D.	Range
Inconsistent (n = 211)	0.3478	0.3751	2.4267
Consistent (n = 83)	0.0418	0.0358	0.0993

Table 4 Statistics of importance ratings of the inconsistent group

Aspect	Mean	*E*	Rank	Max	Min	S.D.
Security	4.5308	0.0861	1	5.0000	1.0000	0.6345
Cleaning	4.3744	0.0824	2	5.0000	2.0000	0.6072
Repair & maintenance	4.2133	0.0988	3	5.0000	1.0000	0.7283
Landscape & leisure	3.8152	0.1083	4	5.0000	1.0000	0.7982
General management	3.7393	0.1231	5	5.0000	1.0000	0.9068
Five aspects as a whole	4.1991	0.0804	-	5.0000	1.0000	0.5922

Table 5 Statistics of AHP importance weights of the consistent group

Aspect	Mean	*E*	Rank	Max	Min	S.D.
Security	0.2905	0.0273	1	0.6820	0.0840	0.1251
Cleaning	0.2142	0.0197	2	0.5348	0.0566	0.0901
Repair & maintenance	0.1962	0.0143	3	0.3641	0.0771	0.0656
Landscape & leisure	0.1347	0.0140	5	0.2699	0.0345	0.0640
General management	0.1644	0.0184	4	0.4947	0.0338	0.0844

Table 6 Statistics of importance ratings of the consistent group

Aspect	Mean	*E*	Rank	Max	Min	S.D.
Security	4.4458	0.1241	1	5.0000	3.0000	0.5685
Cleaning	4.4337	0.1239	2	5.0000	3.0000	0.5673
Repair & maintenance	4.1687	0.1313	3	5.0000	3.0000	0.6012
Landscape & leisure	3.7470	0.1440	5	5.0000	1.0000	0.6597
General management	3.8313	0.1268	4	5.0000	3.0000	0.5806
Five aspects as a whole	4.2289	0.1148	-	5.0000	3.0000	0.5256

Table 7 Statistics of performance ratings of the whole sample

Aspect	Mean	*E*	Rank	Max	Min	S.D.
Security	3.6769	0.0754	3	5.0000	2.0000	0.6566
Cleaning	3.6871	0.0732	1.5	5.0000	1.0000	0.6379
Repair & maintenance	3.5544	0.0679	5	5.0000	2.0000	0.5918
Landscape & leisure	3.6122	0.0770	4	5.0000	2.0000	0.6707
General management	3.6871	0.0661	1.5	5.0000	2.0000	0.5760
Overall	3.7211	0.0604	-	5.0000	2.0000	0.5262

Table 8 Statistics of performance ratings of the inconsistent group

Aspect	Mean	*E*	Rank	Max	Min	S.D.
Security	3.6635	0.0913	3	5.0000	2.0000	0.6730
Cleaning	3.6777	0.0899	2	5.0000	1.0000	0.6622
Repair & maintenance	3.5355	0.0830	5	5.0000	2.0000	0.6113
Landscape & leisure	3.6445	0.0900	4	5.0000	2.0000	0.6631
General management	3.7014	0.0773	1	5.0000	2.0000	0.5698
Overall	3.7299	0.0711	-	5.0000	2.0000	0.5237

Table 9 Statistics of performance ratings of the consistent group

Aspect	Mean	*E*	Rank	Max	Min	S.D.
Security	3.7108	0.1344	1.5	5.0000	2.0000	0.6155
Cleaning	3.7108	0.1254	1.5	5.0000	2.0000	0.5745
Repair & maintenance	3.6024	0.1178	4	5.0000	3.0000	0.5396
Landscape & leisure	3.5301	0.1500	5	5.0000	2.0000	0.6868
General management	3.6506	0.1296	3	5.0000	2.0000	0.5933
Overall	3.6988	0.1168	-	5.0000	2.0000	0.5350

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Table 10 Annual expenses on the five FM aspects

Aspect	HK$	HK$/m^2	%
Security (security guard services)	4,393,361	24.7	24.3
Cleaning (cleaning services)	1,654,433	9.3	9.1
Repair & maintenance (repair and maintenance works for grounds, building structure and fabric, and building services installations; special projects; electricity charges; water charges)	6,562,423	37.0	36.3
Landscape & leisure (landscaping services)	192,191	1.1	1.1
General management (staff salaries, wages and benefits; accounting fee; audit fee; insurance premium; manager's remuneration; miscellaneous management expenses)	5,281,540	29.8	29.2
Overall	18,083,949	101.9	100.0

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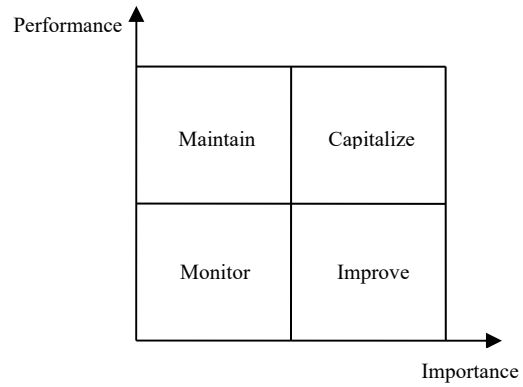

Figure 1 Importance-performance evaluation matrix

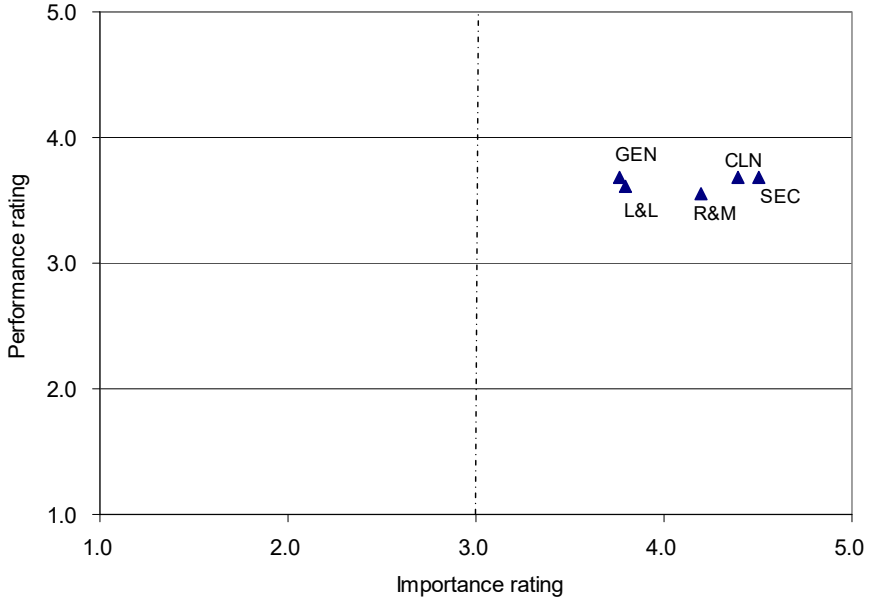

Figure 2 Perceived performance and importance of the FM aspects (whole sample)

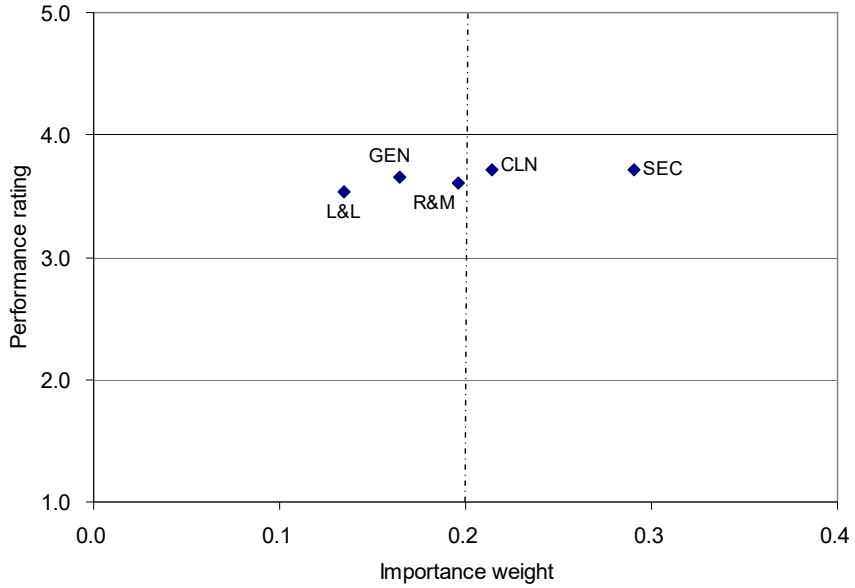

Figure 3 Perceived performance and importance (AHP weights) of the FM aspects (consistent group)

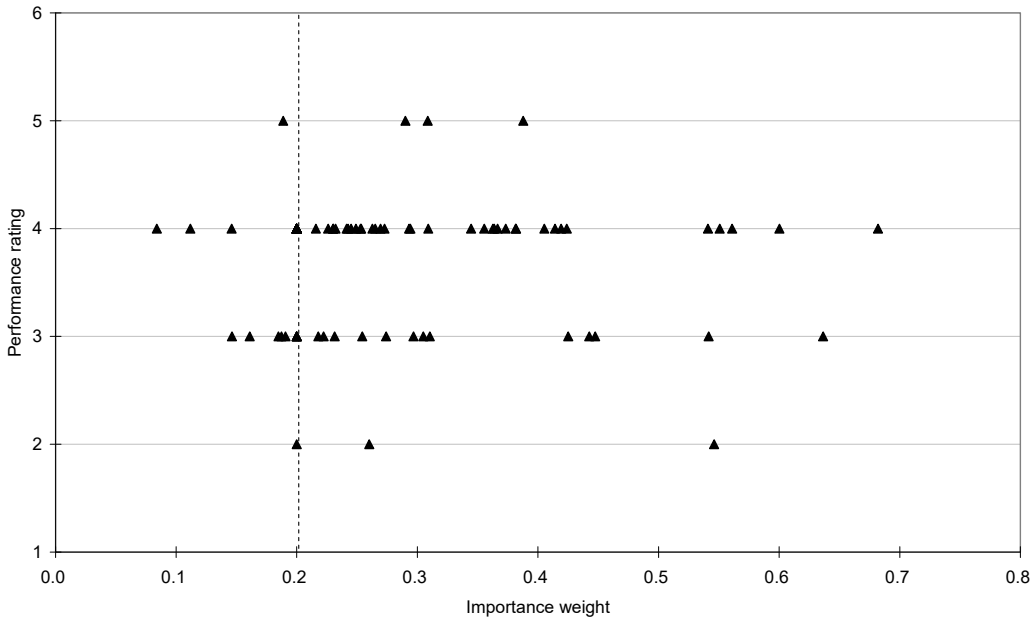

Figure 4 Individual responses on the security aspect

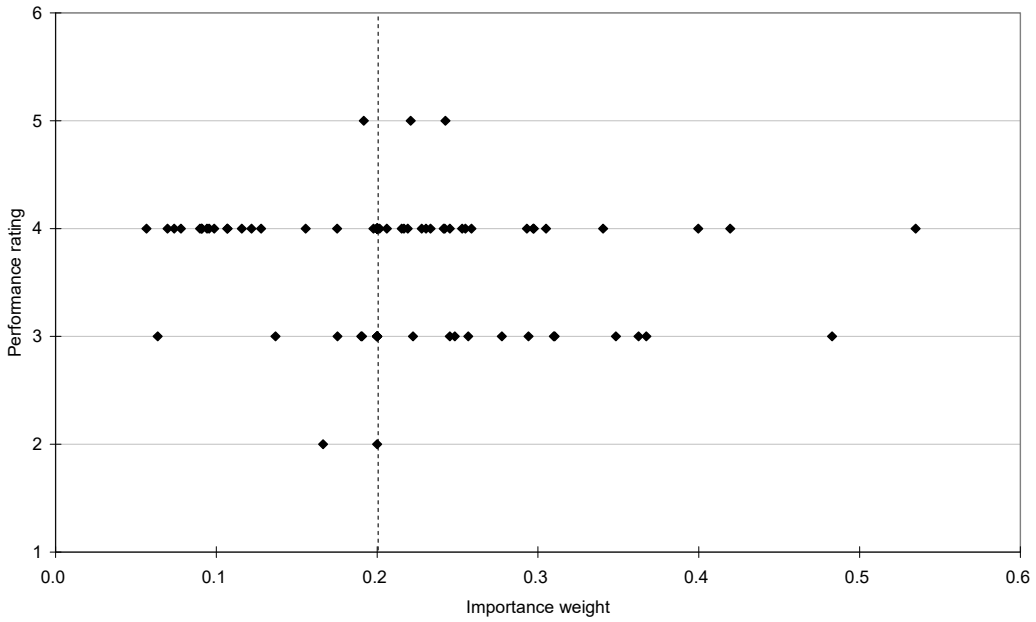

Figure 5 Individual responses on the cleaning aspect

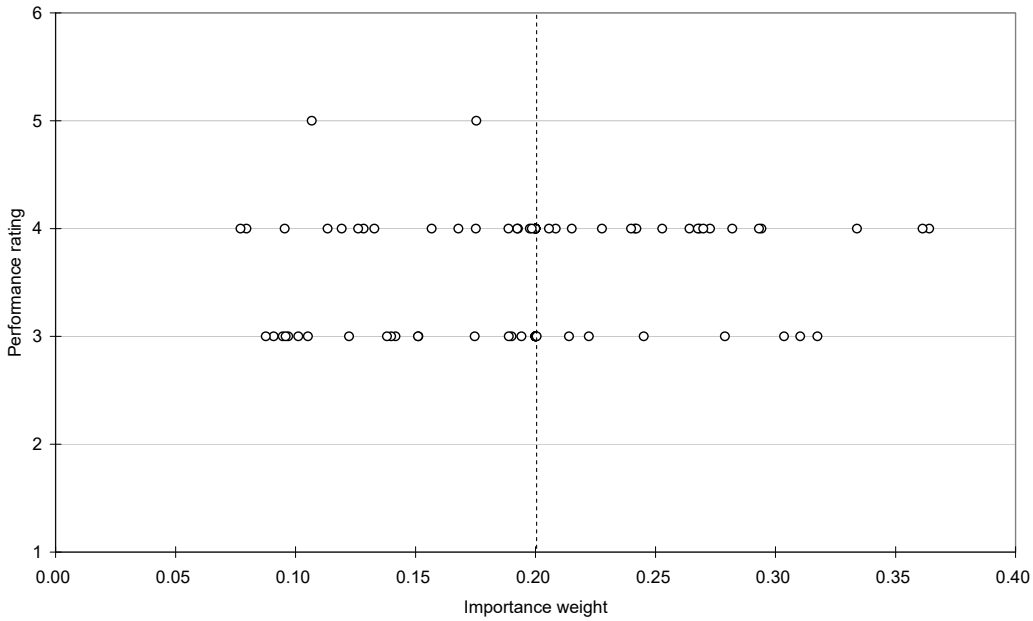

Figure 6 Individual responses on the repair & maintenance aspect

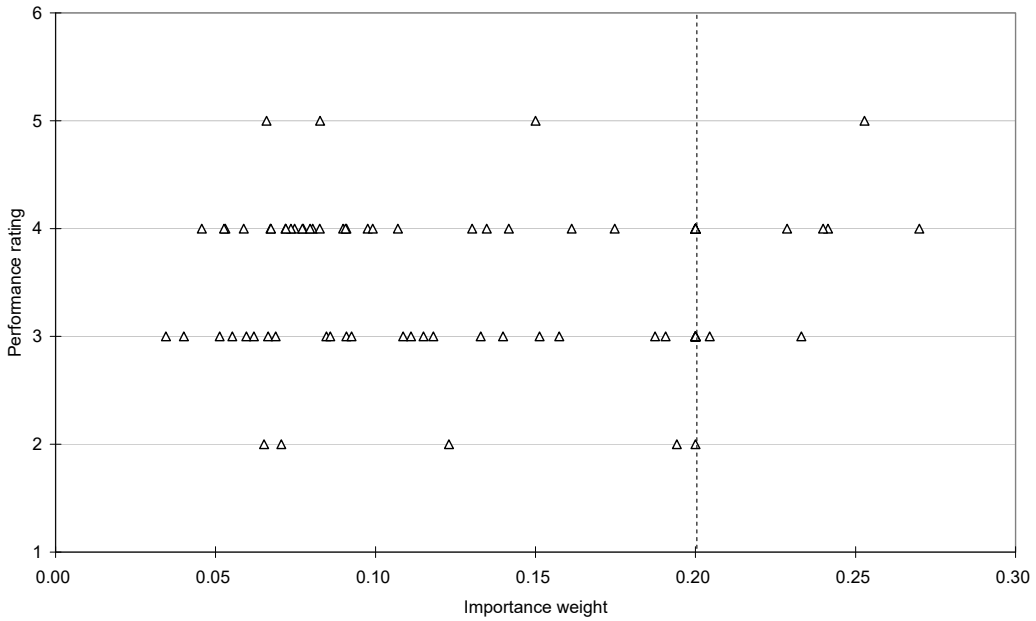

Figure 7 Individual responses on the landscape & leisure aspect

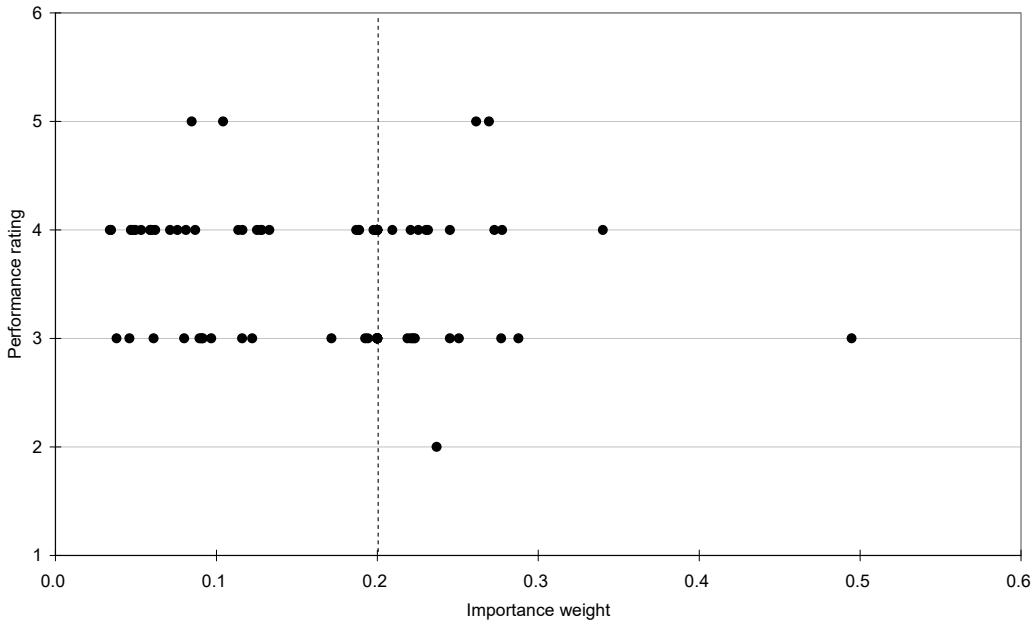

Figure 8 Individual responses on the general management aspect

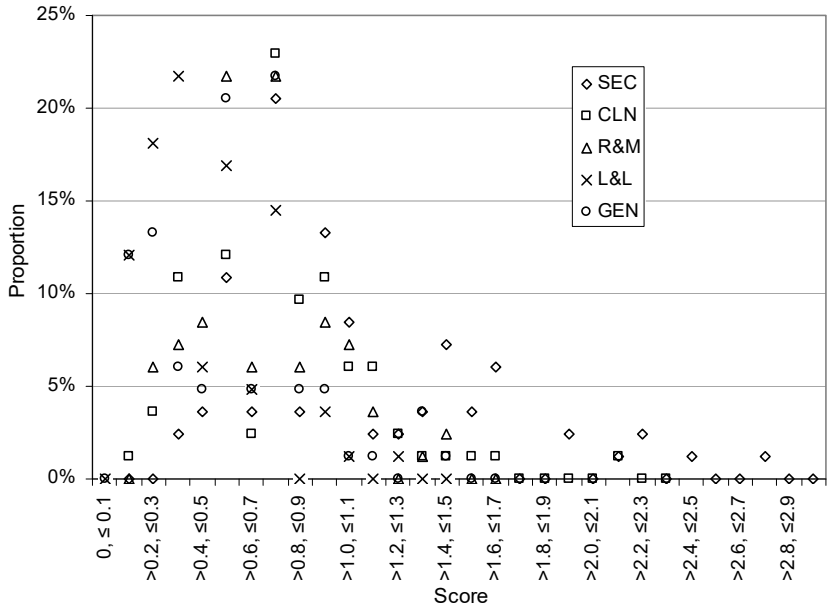

Figure 9 Distribution of weighted performance scores for individual aspects

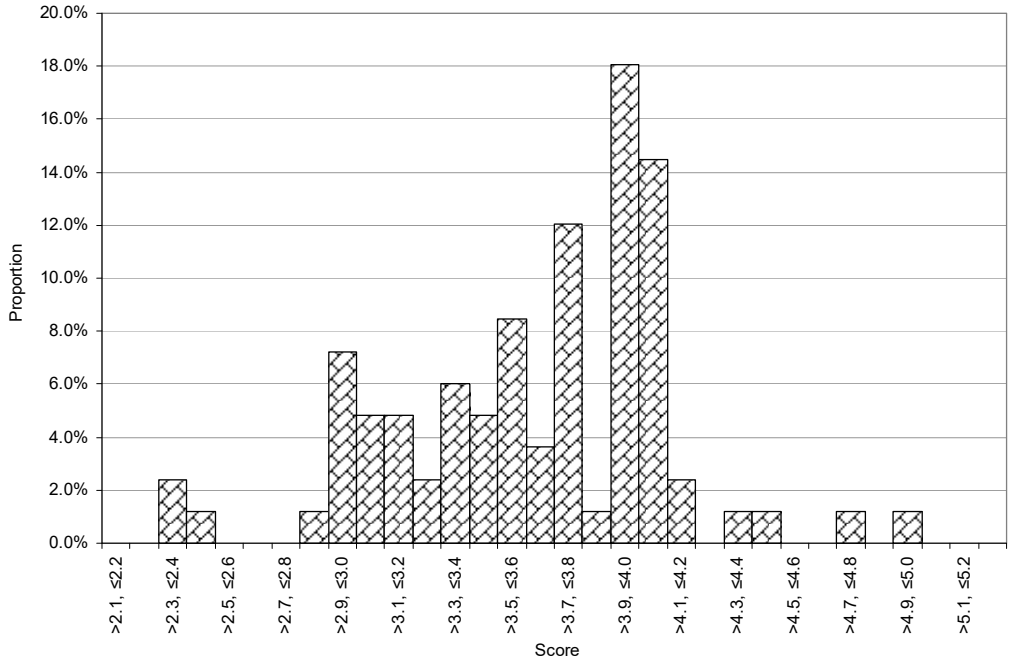

Figure 10 Distribution of weighted performance scores for the five aspects as a whole

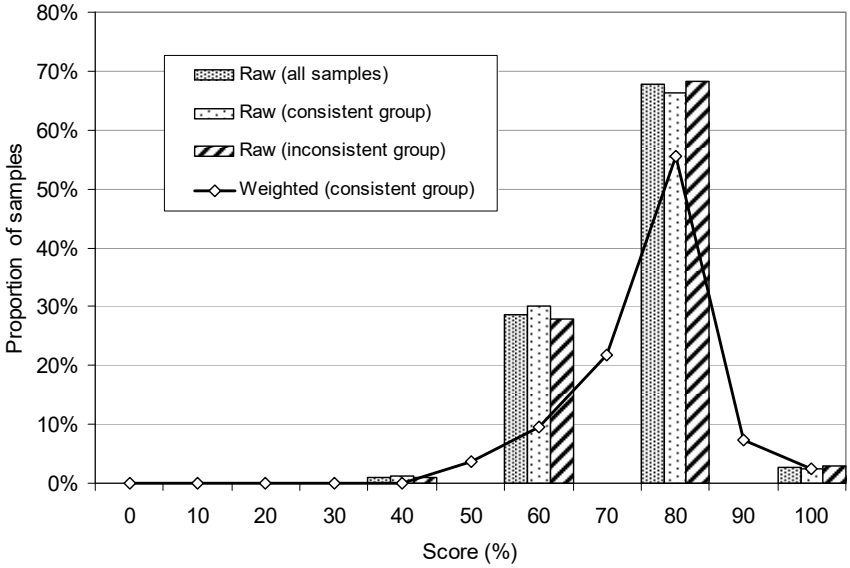

Figure 11 Raw and weighted performance scores of different sample groups

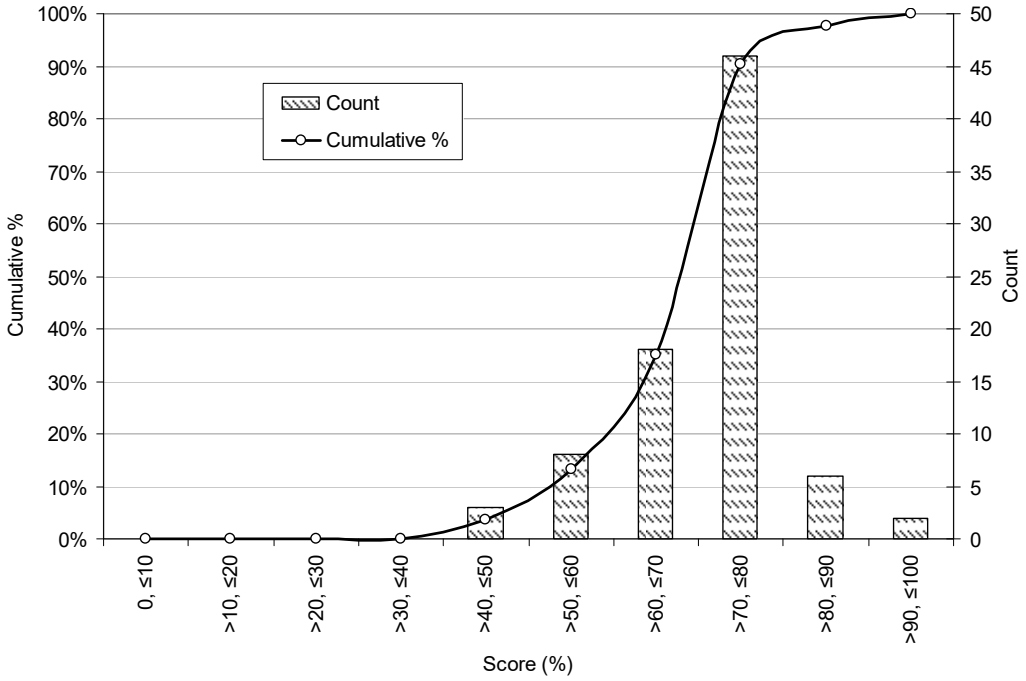

Figure 12 Distribution and cumulative proportion of FMP scores

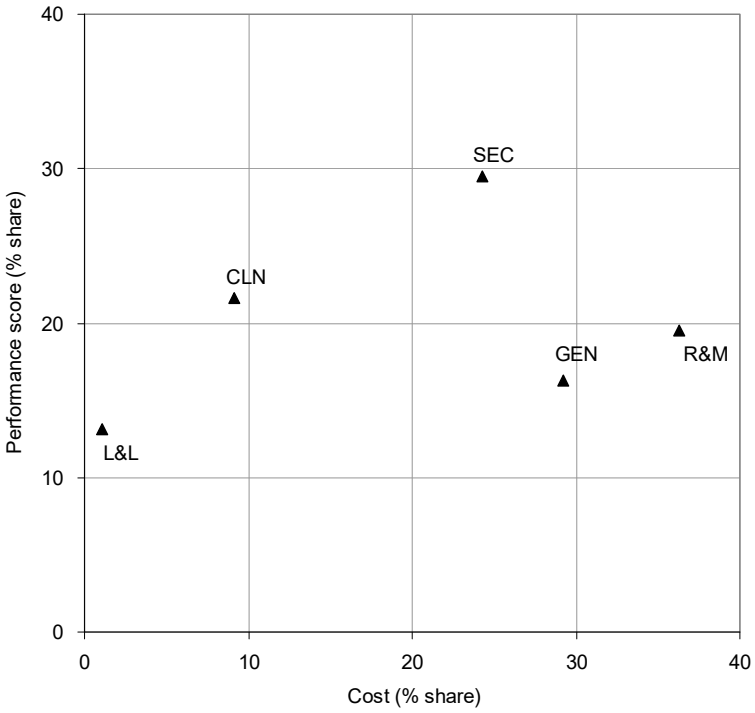

Figure 13 Proportions of performance score and cost of the FM aspects

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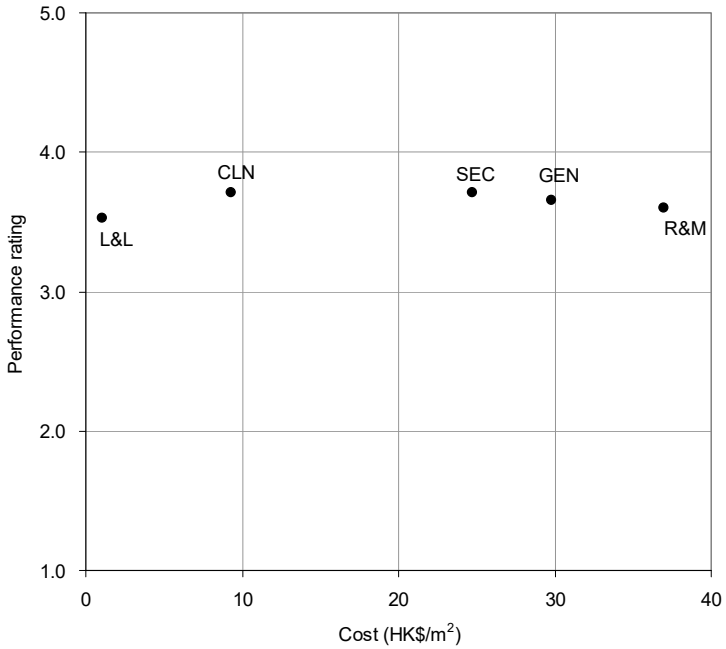

Figure 14 Performance and cost of the FM aspects

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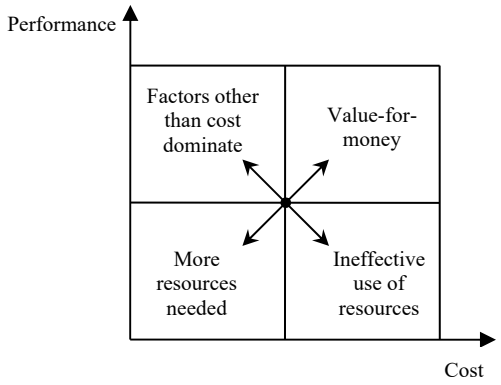

Figure 15 Cost-performance evaluation matrix