ANALYTICAL ASSESSMENT AND COMPARISON OF FACILITIES MANAGEMENT SERVICES FOR RESIDENTIAL ESTATES

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ABSTRACT. Populous places are particularly in need of high-rise residential buildings, which are increasingly built as estates. The facilities in these estates entail proper management in order to serve the numerous residents there. Aimed at evaluating the facilities management (FM) services for three major kinds of residential estates ('public', 'semi-public' and 'private'), a study was conducted based on a performance-importance-cost (PIC) evaluation model. The end-users' perceived importance and performance levels and the cost data of the FM services for a public estate, a semi-public estate and a private estate were analyzed using the analytical hierarchy process (AHP), analysis of variance (ANOVA) and Fisher's least significant difference (LSD) procedure. The importance and performance levels of the services and their differences between the estates were revealed. The highest service performance and cost levels were found with the private estate, followed by the semi-public estate and the public estate, while the orders of their cost-effectiveness reversed. Rather than assessing merely the cost or performance of services, using the approach of this study to examine their cost-effectiveness can enable more holistic evaluations towards strategic property management.

KEYWORDS: Cost-effectiveness; Facilities management; Housing estate; Performance evaluation; Residential building

1. INTRODUCTION

High-density cities are in need of more residential buildings to accommodate their growing populations. Increasingly, these buildings are grouped for development as residential estates, in which the communal facilities such as electrical and mechanical installations, recreational equipments, seating benches, horticulture and so on are essential for the common areas like garden, playground, podium, lobby, and corridor. While requiring substantial resources for their operation and upkeep in the long run (Evans et al., 1998), the facilities entail cost-effective management services in order to perform to the satisfaction of their end-users.

In many cities, the residential building stock is huge, which covers residential estates built by the government, those constructed with government subvention and those developed by private organizations. Hong Kong serves as an example. With over 2.2 million residential flats, there are 694,099 public rental units, 427,402 semi-public flats (including those under the Home Ownership Scheme, Private Sector Participation Scheme and Tenants Purchase Scheme) and 1,090,600 flats in the private sector (Hong Kong Housing Authority, 2009; Rating and Valuation Department,

2010). The performance of these buildings is influential to the quality of life of the numerous residents there.

In the past, a significant volume of effort had been made to develop some assessment methods for evaluating building performance. Apart from those tailored for assessing the design or construction of buildings (e.g. Yang and Peng, 2008), a range of post-occupancy evaluation (POE) tools were established (McDougall et al., 2002). These tools, in general, were intended for enabling building end-users' feedback to be communicated to the designers of buildings. But they are not often taken up (Eley, 2001). Even though it has been well recognised that facilities managers should proactively assess the performance of facilities management (FM) services and act on the information obtained, renewed attempts in making POE routine were still underway (Bordass and Leaman, 2005).

In fact, the FM discipline has continued to grow globally (British Institute of Facilities Management, 2007; International Facility Management Association, 2007). The provision of quality FM services is well-recognized as critical to the strategic management of built assets in the property sector (Then, 2005; Ventovuori, 2006). For evaluating customer perception of service delivery in the FM sector, for example, Shaw and Haynes (2004) advocated to use a gaps model. Similar to the SERVQUAL model developed by Parasuraman et al. (1985) for studying quality issues in services marketing, the gaps model was proposed based on the theory that measuring the quality of a service involves a comparison between the expected and perceived levels of the service.

In order to enhance the maturity of the FM discipline, more empirical studies involving rigorous hypothesis testing and robust data analysis are needed (Ventovuori et al., 2007). For instance, the study of Tucker and Pitt (2009) was conducted based on two customer surveys to develop a measurement system for

establishing national benchmarks of satisfaction in FM. Using a structural equation model approach, Hui and Zheng (2010) investigated the crucial variables of customer satisfaction towards FM services in the housing sector. In a recent study (Lai and Yik, 2011), an analytical method incorporating the Saaty's (1980) analytical hierarchy process (AHP) has been developed for evaluating the perceived performance level as well as the cost of residential FM services. While the adapted use of this method has proved to be useful in comparing the performance of the FM services provided for two public estates with comparable characteristics (Lai, 2011), empirical evaluations that can inform the comparative quality and cost-effectiveness of the services for different kinds of estates remain unavailable.

The aspiration for the above knowledge has led to a study which aimed to identify the levels of importance, performance and cost-effectiveness of FM services for three major kinds of estates (i.e. 'public', 'semi-public' and 'private') and investigate any difference between the levels. In the following, the evaluation model based on which the study was formulated, the characteristics of the studied estates, the data collection process, the questionnaire design and the types of data collected will be described. Then, the analysis of the end-users' perceived importance and performance levels of the FM services and the cost-effectiveness of the services will be explained and discussed. The final part will cover the conclusions drawn from the study and the suggested future work.

2. METHOD AND DATA

As part of the groundwork for the present study, samples of the customer satisfaction survey forms used by the leading FM companies in Hong Kong were gathered. A content analysis of these forms, as reported earlier in Lai (2010), found that the survey elements contained in the forms typically fall within

five main aspects of services (Table 1), namely general management (GEN), security (SEC), cleaning (CLN), repair & maintenance (R&M), and leisure & landscape (L&L). While there are numerous definitions of FM (Mohd Noor and Pitt, 2009) and the scope of FM may vary from one environment to another, the above five service aspects, which cover the common FM services in the residential context, were the focus of this study.

The common way of surveying end-users' satisfaction with the residential FM services, however, does not take into account the importance levels of the services they perceived. To address this shortcoming, and to enable prioritization of the often-constrained FM resources for allocation, the performance of the services (P) should be assessed with due consideration of their importance levels (I) and the costs for their provision (C). This 'PIC' evaluation model is depicted in Figure 1.

The I-P and C-P planes in Figure 1 correspond to the two evaluation matrices in Figure 2, i.e. the importance-performance (IP) matrix and the cost-performance (CP) matrix.

By plotting the measured importance and performance levels of FM services on the IP matrix, one can ascertain whether the services need to be maintained, monitored, improved or capitalized. With the aid of the CP matrix, tracking the changes of the measured cost and performance levels can distinguish if the services are value-for-money; the use of resources is ineffective; there are factors other than cost that give rise to high performance; or more resources are needed for performance improvement.

The three estates of which the importance, performance and cost of FM services were studied each belonged to one of the three major types ('public', 'semi-pubic' and 'private') in Hong Kong. The criteria for their selection include: they had been occupied for a considerable period; the record drawings showing their characteristics could be retrieved from the archive kept by the Buildings Department; interviews with the end-users could be carried out in their open spaces; and the annual accounts recording their FM expenses could be collected.

Table 1. Main aspects of residential FM services

Aspect	Elements
General management	Uniform and appearance of management staff; Attitude and manner of management staff; Professional knowledge of management staff; Efficiency of handling complaints; Communication with residents; Ability of handling emergency situation; Response to resident requests; Arrangement of recreational activities
Security	Uniform and appearance of security staff; Attitude and manner of security staff; Professional knowledge of security staff; Communication ability of security staff; Initiative of providing assistance; Handling the register of visitors; Security facilities (e.g. CCTV); Security control and patrol
Cleaning	Uniform and appearance of cleaners; Attitude and manner of cleaners; Cleanliness of lobbies and corridors; Cleanliness of lift interiors; Cleanliness of washrooms; Cleanliness of staircases; Cleanliness of grounds; Arrangement of waste collection
Repair and maintenance	Uniform and appearance of technicians; Attitude and manner of technicians; Professional knowledge of technicians; Electricity supply system; Potable water supply system; Flushing water supply system; Elevator system; Intercom system and TV reception; Ventilation / air conditioning system; Fire services system; Grounds and building fabric
Landscape and leisure	Aesthetics and tidiness of plants; Pest control; Environmental protection measures; Recreational facilities (e.g. play equipment); Leisure amenities (e.g. seating bench)
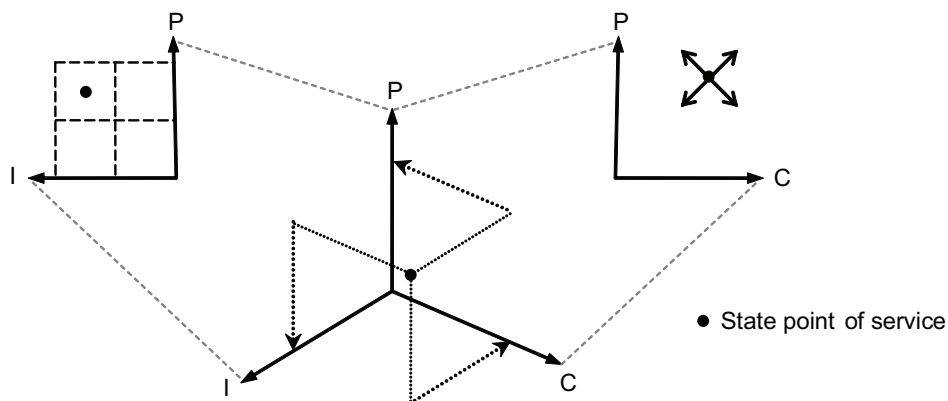
Figure 1. The performance-importance-cost (PIC) evaluation model
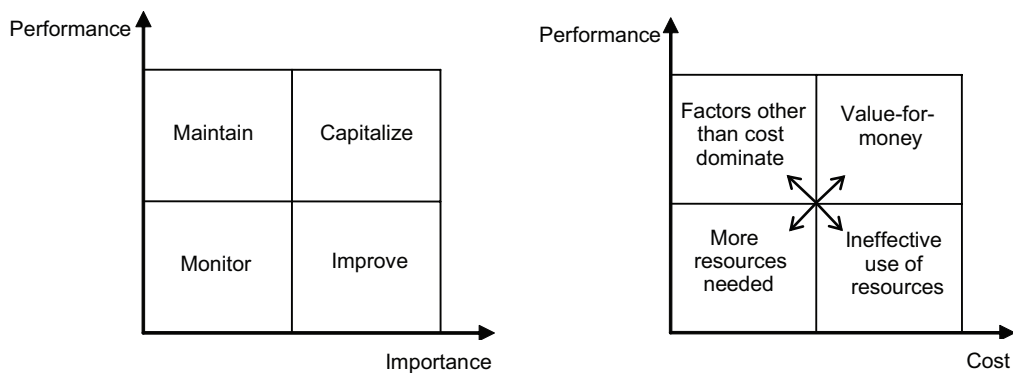
Figure 2. Importance-performance matrix (a); Cost-performance matrix (b)

As summarised in Table 2, the public estate was much older than the other two estates. While the public estate contained the smallest number of building blocks, the total number of flats in this estate was the largest as its number of flats per block was significantly more than the counterparts of the semi-public and private estates. The numbers of floors per block in the three estates, with all of them being high-rise buildings, ranged between 21 and 36. Different from the semi-public and private estates in which the number of flats per typical floor and the size per flat were comparable, the public estate, with a wider range of flat size, accommodated up to 40 flats in each typical floor. In aggregate, there were 9,226 flats in the three estates.

From the collected FM expenditure accounts, it was found that their formats largely follow the recommended cost classifications (Independent Commission against Corruption et al., 2003). But since the three estates and the variety of their facilities were different, some cost breakdowns in the accounts were not identical. In order to allow cross comparisons between the services for the estates, discussions were made with the managers of the estates to identify the meanings and coverage of the cost items before mapping them with the five main aspects of FM services.

Table 2. Characteristics of the estates and key information about the samples

	Public	Semi–public	Private
Age (years)	20	8	8
Building blocks (No.)	7	12	8
Floors per block (No.)	21–35	22–30	35–36
Flats per block (No.)	612–800	220–300	280–288
Flats per typical floor (No.)	18–40	10	8
Flat size (m^2)	42.64–75.02	46–64	46–68
Total flats (No.)	4,794	3,000	1,432
All samples			
Samples no.	210	294	204
CR (mean)	0.2196	0.2614	0.2824
CR (S.D.)	0.2724	0.3468	0.3921
Usable samples			
Samples no.	79 (37.6%)[a]	83 (28.2%)[a]	68 (33.3%)[a]
CR (mean)	0.0338	0.0418	0.0445
CR (S.D.)	0.0344	0.0358	0.0379

[a] Proportions of usable samples within each estate are shown in the parentheses.

Similar to the questionnaire design in an earlier study (Lai and Yik, 2011), the questionnaire used for interviewing the end-users of the estates consisted of three sections (Appendix A). The questions in the first section asked the respondents about their personal particulars. Those in the second section requested them to base on a 5-point scale to indicate their perceived performances of the five aspects of FM services. Under the final section, the respondents were asked to rate, using a 9-point scale, the relative importance they perceived between pairs of the aspects.

A team of trained interviewers approached the end-users at the open spaces of the three estates, and altogether 708 accepted to be interviewed. The proportions of female samples (public: 73.3%; semi-public: 59.2%; private: 71.1%) outweighed the male group. Ranging between 82.0% and 84.8%, the proportions of adult samples were similar across the estates. As to their education backgrounds, the majority were up to secondary or tertiary level.

The main groups of respondents of the public (93.3%) and semi-public (84.7%) estates belonged to the low-income class, earning not more than $20,000 a month. The monthly incomes of 21.6% of the 'private' group lied between $20,000 and $50,000.

The responses to the final section of the questionnaire, i.e. the pair-wise relative importance ratings, were processed following the screening procedure of Lai and Yik (2011) to detect any of them were drawn from inconsistent judgments. This involved: i) organizing the ratings in the form of a 5 x 5 comparison matrix; ii) entering the matrix data into a computer program for calculating the principal eigenvalue and eigenvector; and iii) computing the consistency ratio (*CR*) of each data set.

Based on all the collected samples, the mean consistency ratio of the public group was the lowest, followed by the semi-public group and the private group (Table 2). The same trend is noted from the values of their standard deviation (S.D.). But the detection results show

that only 230 samples, with their *CR* values not exceeding 0.1, were drawn from consistent judgments (Saaty, 1995). The smallest mean and S.D. values of the 'public' samples indicate that relatively more consistent responses were given by this group.

The highest and the lowest proportions of usable sample were found with the public estate and the semi-public estate, respectively. On average, 67.5% of the total samples which failed the consistency test were discarded. This ensured processing only the remaining quality data in the subsequent analysis.

3. DATA ANALYSIS AND DISCUSSION

3.1. Importance of FM aspects

The procedures used in the earlier studies (Lai and Yik, 2011; Lai, 2011) for determining the levels of importance, performance and cost-effectiveness of residential FM services

were integrated for adoption in this study, and the relevant equations were consolidated as shown in Appendix B. Equation (1) was used for processing the end-user response to yield the importance weights of the five FM aspects for each of the three estates. Table 3 summarises the calculation results as well as the ranks of the aspects determined according to their importance weight values.

Given that the total AHP weight of the rated aspects is unity, each of the five aspects would have a nominal weight value of 0.2 if they were all rated as of equal importance. From the results, an importance weight exceeding this nominal value was found with the security and cleaning aspects of both the public and semi-public estates. For the private estate, the security aspect was also rated as above the nominal weight. But instead of 'cleaning', 'repair & maintenance' was perceived as above the nominal importance.

Table 3. Importance and performance of the FM aspects

	Public			Semi-public			Private		
Importance	Weight	Rank [a]	Rank [b]	Weight	Rank [a]	Rank [b]	Weight	Rank [a]	Rank [b]
General management	0.1713	4	1	0.1644	4	2	0.1558	4	3
Security	0.2750	1	3	0.2905	1	2	0.3298	1	1
Cleaning	0.2367	2	1	0.2142	2	2	0.1972	3	3
Repair & maintenance	0.1968	3	2	0.1962	3	3	0.2033	2	1
Leisure & landscape	0.1203	5	2	0.1347	5	1	0.1140	5	3
Performance	Rating	Rank [a]	Rank [b]	Rating	Rank [a]	Rank [b]	Rating	Rank [a]	Rank [b]
General management	3.2658	3	3	3.6506	3	2	3.8676	4	1
Security	3.5823	1	3	3.7108	1.5	2	4.1471	1	1
Cleaning	3.3544	2	3	3.7108	1.5	2	4.0441	2	1
Repair & maintenance	3.0886	5	3	3.6024	4	2	3.9559	3	1
Leisure & landscape	3.1392	4	3	3.5301	5	2	3.8382	5	1

[a] Ranks within an estate. [b] Ranks between estates.

The rank orders of the weights were the same within the public group and the semi-public group, with the security aspect being the most important and the leisure & landscape aspect the least. The importance weights of the rated aspects for the private estate exhibit almost the same rank orders except that the ranks of the cleaning and repair & maintenance aspects reverse.

The ranks of the rated aspects between the estates show that those pertaining to the private estate are extreme values. Both of its security and repair & maintenance aspects rank top whereas the perceived importance of its remaining three aspects, i.e. general management, cleaning and leisure & landscape, are the lowest. On the other hand, the ranks of the general management and cleaning aspects of the public estate and the rank of the leisure & landscape aspect of the semi-public estate are the highest.

3.2. Performance of the services

Based on the performance ratings given by the end-users, the mean performance rating for each aspect of the services was calculated using Equation (2). As can be seen from the calculation results (Table 3), across the three estates the security and cleaning services outperformed the other services. The respondents of the private estate, in particular, were greatly satisfied (ratings > 4.0) with these two aspects of services.

In the public and semi-public estates, the services for repair & maintenance and leisure & landscape facilities recorded the lowest performance levels. Comparing the ratings between the estates finds a consistent pattern – the performance levels of the rated aspects all descended from the private group through the semi-public group to the public group.

So far, the analyses could not tell if any changes to the existing services are needed in order to strive for better performance. The answer to this uncertainty, as illustrated in the pilot work (Lai, 2010), can be determined by plotting the importance and performance levels of the rated aspects on an IP matrix. In Figure 3 where the importance and performance levels of the FM services are shown, it is clear that the highest and the lowest performance levels correspond to the private estate
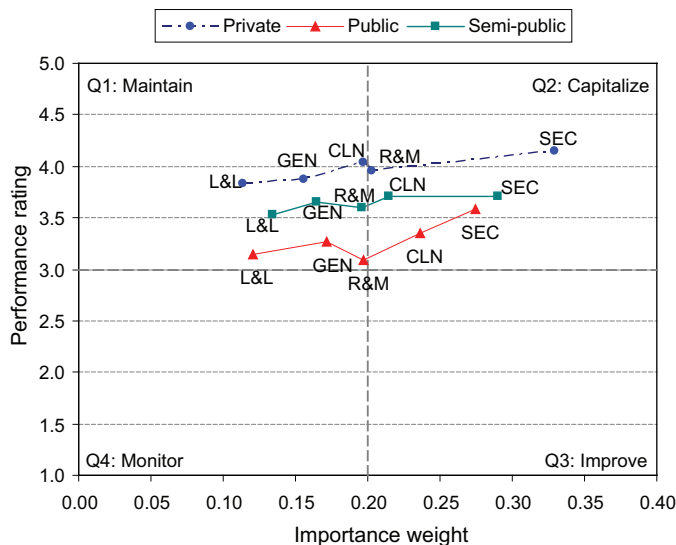

Figure 3. Importance and performance levels of the services

and the public estate, respectively. With all the services performing above the moderate level (rating = 3.0), none of them falls in the third and fourth quadrants. The services of which the performance levels need to be maintained include: the leisure & landscape and general management services for the three estates; the repair & maintenance service for the public and semi-public estates; and the cleaning service for the private estate. The remaining services, all falling within quadrant 2, should be capitalized as a competitive edge of the providers serving the respective estates.

Taking into account the importance levels that the end-users perceived, the weighted performance ratings given by individual respondents for each aspect were calculated using Equation (3). Summing these ratings for each respondent by Equation (4) gives a weighted performance rating for the five aspects as a whole, and the results with respect to the three estates are graphed in Figure 4. The ratings accounting for the highest proportion, which were found with the private estate, were between 3.9 and 4.0. Though with a smaller proportion, this band of ratings was also the peak for the semi-private estate. For the public estate, however, the distribution peaked at a much lower band (2.9 to 3.0).

For comparisons on a general scale of 0 - 100, the weighted performance ratings were converted into weighted performance scores using Equations (5) to (8). The scores so obtained for all respondents of each estate were averaged to yield an overall facility management performance (FMP) score for the estate (Equation (9)). The cumulative proportions of the weighted performance scores of individual respondents were grouped by the three estates, as depicted in Figure 5.
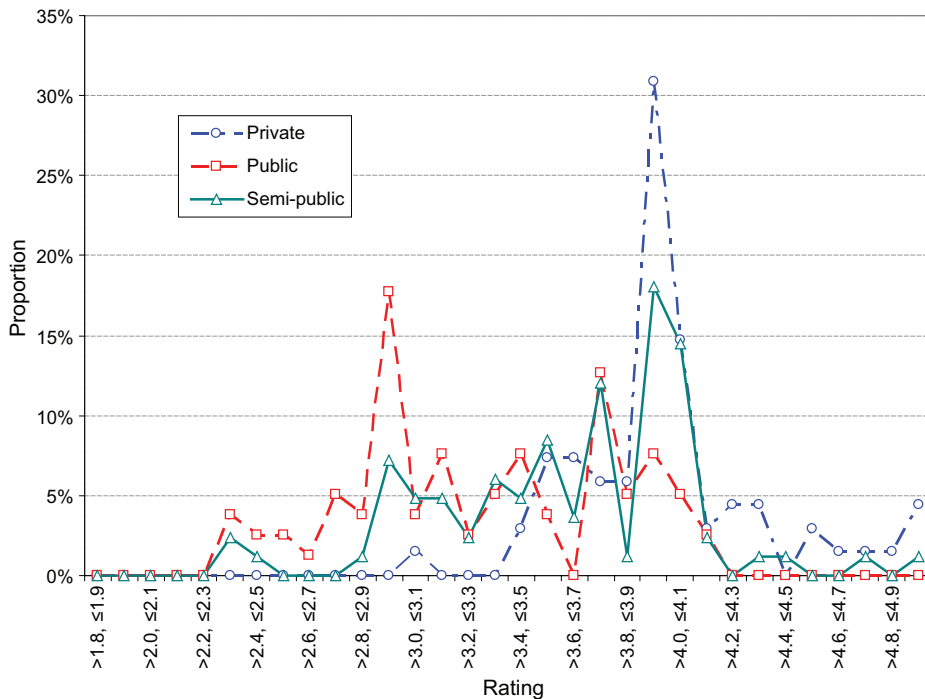

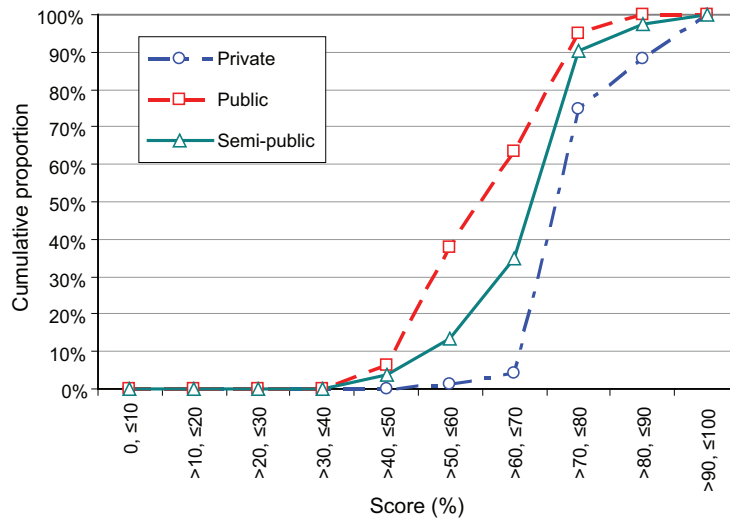**Figure 4.** Distributions of weighted performance ratings of the estates

Figure 5. Cumulative proportions of the FMP scores

From left to right, the three curves correspond to the public, semi-public and private estates, indicating that their overall FM performances were in ascending order. This observation echoes with the FMP scores, which were found to be: 66.5 (public), 73.1 (semi-public) and 80.2 (private).

To further investigate the existence of any statistical difference in the quality of each service aspect across the estates, performance rating, which represents the quality of service perceived by the end-users, was used as a testing parameter in an analysis of variance (ANOVA). Because the eventual performance of the services hinges on their importance levels that the end-users perceived, the weighted performance rating was also included as a testing parameter. The population means of the parameters are defined as:

- μ_1 = mean rating for all end-users in the public estate
- μ_2 = mean rating for all end-users in the semi-public estate
- μ_3 = mean rating for all end-users in the private estate

The null hypothesis (H_0) and alternative hypothesis (H_a) that no difference existed in the quality of the services for the estates can be written as:

$$H_0 : \mu_1 = \mu_2 = \mu_3$$

H_a: not all population means are equal

The results of a series of ANOVA, including the values of average, variance, F and p-value, are summarised in Table 4. At a level of significance (α) of 0.05, the critical F value ($F_{0.05}$) is 3.0356. Since the F values drawn from the performance ratings of each aspect are all greater than the critical F value, the null hypothesis is rejected. This means that the population mean performance ratings of the three estates are not all equal.

When the effect of perceived importance of the rated aspects was factored in, i.e. performing ANOVA based on the weighted performance ratings, the F values of the general management, cleaning, and leisure & landscape aspects were found to be smaller than the critical F value. Therefore, their null hypotheses are not rejected. With the F values of the security and repair & maintenance aspects both exceeding the critical value, it can be concluded

Table 4. ANOVA results for sample means of performance and weighted performance

	Performance			Weighted performance		
	Public	Semi-public	Private	Public	Semi-public	Private
General management						
Average	3.2658	3.6506	3.8676	0.5511	0.5928	0.5998
Variance	0.4028	0.3520	0.2957	0.0746	0.0974	0.0884
F	19.6074[a]			0.6099		
p-value	0.0000			0.5443		
Security						
Average	3.5823	3.7108	4.1471	0.9910	1.0762	1.3712
Variance	0.3233	0.3788	0.2169	0.1684	0.2413	0.2945
F	20.1830[a]			12.3267[a]		
p-value	0.0000			0.0000		
Cleaning						
Average	3.3544	3.7108	4.0441	0.7949	0.7875	0.7972
Variance	0.4369	0.3300	0.1622	0.1166	0.1165	0.0879
F	27.5176[a]			0.0183		
p-value	0.0000			0.9818		
Repair & maintenance						
Average	3.0886	3.6024	3.9559	0.5970	0.7116	0.7997
Variance	0.5433	0.2912	0.2219	0.0454	0.0746	0.0649
F	39.3971[a]			12.3491[a]		
p-value	0.0000			0.0000		
Leisure & landscape						
Average	3.1392	3.5301	3.8382	0.3868	0.4761	0.4470
Variance	0.4547	0.4716	0.3167	0.0597	0.0641	0.0730
F	21.5390[a]			2.5521		
p-value	0.0000			0.0801		

[a] F value $> F_{0.05}$

that not all their population means are equal, meaning that the qualities of the services for the estates were particularly different in these two aspects.

The above analysis has shown the existence of quality difference among the services provided for the three estates. To further determine between which estates the difference occurred, the Fisher's least significant difference (LSD) procedure was used to make pair-wise comparisons of the population means. Under this procedure (see Table 5 for nomenclature of symbols), the null hypothesis (H_0) and alternative hypothesis (H_a) are:

$$H_0 : \mu_1 = \mu_j$$

$$H_a : \mu_i \neq \mu_j$$

The test statistic t is computed by:

$$t = \frac{\overline{x}_i - \overline{x}_j}{\sqrt{MSE\left(\dfrac{1}{n_i} + \dfrac{1}{n_j}\right)}}$$

where:

$$MSE = \frac{SSE}{n_T - k}$$

$$SSE = \sum_{j=1}^{k}(n_j - 1)s_j^2$$

$$n_T = n_1 + n_2 + ... + n_k$$

Table 5. Nomenclature of symbols for Fisher's LSD procedure

Symbol	Representation
k	number of populations
MSE	mean square due to error
n_i	number of observations for treatment i
n_j	number of observations for treatment j
n_T	total number of observations
s_j^2	sample variance for treatment j
SSE	sum of squares due to error
μ_i	mean of the ith population
μ_i	mean of the jth population
$\overline{x}_i$	sample mean for treatment i
$\overline{x}_j$	sample mean for treatment j

Based on the computed t-values and the degree of freedom (n_T - k) of a 2-tailed test, the p-values were determined. The results obtained from the Fisher's LSD procedure, including the values of SSE, MSE, t test statistic and p-value pertaining to the performance and weighted performance of the services, are shown in Table 6.

Referring to the results drawn from the performance ratings, all the p-values, with the exception of that corresponding to the comparison between the security services provided for the public and semi-public estates, are smaller than $\alpha = 0.05$. Therefore, their respective null hypotheses are rejected. Yet, the LSD results obtained based on the weighted performance ratings show that p-value < α was found when making comparison of: i) the leisure & landscape services between the public and semi-public estates; ii) the security services between the private and public estates and those between the private and semi-public estates; and iii) the repair & maintenance services between all pairs of the estates.

3.3. Cost effectiveness of the services

The annual total costs of FM services provided for the three estates were: $17.7 million (public), $18.1 million (semi-public) and $14.7 million (private). To enable making comparisons on the same normalised basis, these costs were divided by the total number of residential flats of the respective estates. Thus, the estates' FM costs (in $/unit/year) were: 857.7 (private), 502.3 (semi-public) and 308.0 (public). This descending order of costs matches with the expected order of service qualities for the three estates.

Table 7 shows a summary of the monthly cost breakdowns and proportions of the five aspects of services provided for the estates. While some expenses of the general management and security services could not be segregated for comparison, the magnitudes of the costs incurred for the remaining three aspects were in the same order except that the cost of leisure & landscape service for the public estate was particularly low. It is also noted that among these three aspects, the repair & maintenance cost dominated.

Hitherto the question of whether the FM services were cost-effective remains. For answering this question, firstly, the weighted mean performance rating of each aspect was determined by Equation (10). This rating, in turn, was divided by its normalised monthly cost to give a performance index (Equation (11)).

Table 6. Fisher's LSD results between pairs of the estates

			Private : Public	Public : Semi	Private : Semi
General management [a]	*SSE*	80.0940			
	MSE	0.3528			
	|t|		6.1248	4.1212	2.2339
	p-value		0.0000**	0.0001**	0.0265**
Security [a]	*SSE*	70.8048			
	MSE	0.3119			
	|t|		6.1132	1.4645	4.7752
	p-value		0.0000**	0.1444	0.0000**
Cleaning [a]	*SSE*	72.0038			
	MSE	0.3172			
	|t|		7.4028	4.0261	3.6178
	p-value		0.0000**	0.0001**	0.0004**
Repair & maintenance [a]	*SSE*	81.1269			
	MSE	0.3574			
	|t|		8.7699	5.4679	3.6149
	p-value		0.0000**	0.0000**	0.0004**
Leisure & landscape [a]	*SSE*	95.3636			
	MSE	0.4201			
	|t|		6.5194	3.8367	2.9063
	p-value		0.0000**	0.0002**	0.0040**
General management [b]	*SSE*	19.7313			
	MSE	0.0869			
	|t|		0.9977	0.8996	0.1445
	p-value		0.3195	0.3693	0.8853
Security [b]	*SSE*	52.6578			
	MSE	0.2320			
	|t|		4.7722	1.1256	3.7446
	p-value		0.0000**	0.2615	0.0002**
Cleaning [b]	*SSE*	24.5313			
	MSE	0.1081			
	|t|		0.0408	0.1435	0.1792
	p-value		0.9675	0.8860	0.8580
Repair & maintenance [b]	*SSE*	14.0063			
	MSE	0.0617			
	|t|		4.9320	2.9352	2.1672
	p-value		0.0000**	0.0037**	0.0313**
Leisure & landscape [b]	*SSE*	14.8064			
	MSE	0.0652			
	|t|		1.4269	2.2247	0.6948
	p-value		0.1550	0.0271**	0.4879

[a] Based on performance ratings. [b] Based on weighted performance ratings. ** *p*-value < α = 0.05.

Performance indices of the same aspect were then processed using Equation (12) to yield a relative performance index between each pair of the estates. For assessing the cost-effectiveness of the five aspects as a whole, the weighted mean performance ratings were inputted to Equation (13) to find out the sum total of weighted performance ratings. Processing this sum by Equation (14) gives an overall weighted mean performance rating of the FM services for an estate. Finally, dividing this rating by the normalised total FM cost yields a performance index for representing the five aspects of services (Equation (15)). The overall cost-effectiveness of an estate's FM services as compared to that of another, akin to the comparisons for individual aspects, was evaluated by referring to their relative performance indices obtained from Equation (12).

The weighted mean performance ratings calculated from the above procedures and their ranks between the estates are summarized in Table 8. Concurring with the performance ranks shown in Table 3, the highest weighted mean performance rating of each aspect was generally found with the private estate, followed by the semi-public estate and the public estate. The only exception was associated with the leisure & landscape aspect of which the weighted performance of the semi-public estate was higher than that of the private estate. Overall, the FM services for the private estate outperformed those for the other two estates.

While the above analysis has identified the differences between the performance levels of the services, their cost-effectiveness should be judged in accordance with their performance indices, which measure the ratio between the levels of outcome performance and cost input. From Table 9 where the calculated performance indices (*PIs*) and relative performance indices (*RPIs*) for the three analyzable aspects and the FM services as a whole are shown, the performance indices of the public estate, in contrast to the results of weighted mean performance ratings (Table 8), all rank above the

Table 7. Monthly expenses on the FM services

	Public		Semi–public		Private	
	$/unit	%	$/unit	%	$/unit	%
General management	127.7 [a]	41.5 [a]	146.7	29.2	500.7 [b]	58.4 [b]
Security	– [a]	– [a]	122.0	24.3	19.7 [c]	2.3 [c]
Cleaning	41.9	13.6	46.0	9.1	69.0	8.1
Repair & maintenance	137.6	44.7	182.3	36.3	257.0	30.0
Leisure & landscape	0.8	0.2	5.3	1.1	11.3	1.3

[a] Embraced all expenses on security. [b] Embraced the cost for hiring security guards. [c] Indicated only the maintenance cost of the security installations.

Table 8. Weighted mean performance ratings and their ranks

	Public		Semi-public		Private	
	Rating	Rank	Rating	Rank	Rating	Rank
General management	0.5593	3	0.6002	2	0.6025	1
Security	0.9850	3	1.0779	2	1.3678	1
Cleaning	0.7939	3	0.7950	2	0.7973	1
Repair & maintenance	0.6079	3	0.7068	2	0.8041	1
Leisure & landscape	0.3776	3	0.4754	1	0.4375	2
Overall	0.6647	3	0.7311	2	0.8018	1

counterparts of the semi-public and private estates. The particularly high performance index of the leisure & landscape aspect of the public estate was due to the low cost needed for managing the minimal provision of this aspect of facilities there.

Based on the relative performance indices, comparisons can be made between the performance indices of the estates. Take the performance index for the overall FM services as an example. The performance index of the public estate is 48.3% higher than that of the semi-public estate. Likewise, the latter exceeds the performance index of the private estate by 55.7%. The values of the relative performance indices are all positive. This indicates that the performance indices and hence the cost-effectiveness of the public, semi-public and private estates are in descending order, which is in contrast to the order of performance levels identified earlier.

4. CONCLUSIONS

In densely populated places, residential buildings are increasingly built in the form of estates. The facilities in these estates need to be properly managed in order to provide a quality built environment for the end-users. The above study, grounded on the PIC evaluation model, has demonstrated how a holistic evaluation of the FM services for the three types of estates

(public, semi-public and private) can be carried out in a comparative manner by considering the importance and performance levels of the services that the end-users perceived and the costs for providing the services.

With the aid of an IP matrix, it has been shown how the perceived importance and performance levels of the services can be evaluated to determine which aspect of the services requires improvement. Application of the ANOVA and the Fisher's LSD procedure can further identify whether difference in the quality of the services exists and, if so, between which estates the difference exists.

As the evaluations of this study revealed, the highest performance and cost levels of the services were found with the private estate, followed by the semi-public estate and the public estate, while the orders of their cost-effectiveness reversed. Therefore, it is necessary to assess not merely the outcome performance of the services and the cost input to the services, but also the cost-effectiveness of the FM services, which can be identified by referring to their performance indices. Being useful for measuring the ratio between the levels of outcome performance and cost input, these indices can be used for determining the relative performance indices, based on which the comparative cost-effectiveness of the services can be evaluated.

Table 9. Performance indices and relative performance indices

	Performance index						Relative performance index	
	PI_{PU}	$Rank_{PU}$	PI_{SP}	$Rank_{SP}$	PI_{PR}	$Rank_{PR}$	$RPI_{PU\text{-}SP}$	$RPI_{SP\text{-}PR}$
Cleaning	18.96	1	17.30	2	11.55	3	9.6%	49.8%
Repair & maintenance	4.42	1	3.88	2	3.13	3	13.9%	23.9%
Leisure & landscape	500.05	1	89.05	2	38.87	3	461.6%	129.1%
Overall	2.16	1	1.46	2	0.93	3	48.3%	55.7%

PU: Public; SP: Semi-public; PR: Private.

Worldwide many populous cities, similar to Hong Kong, are in need of more residential buildings provided with quality FM services. Wider adoption of the approach of this study to evaluate the services in such places would enable more comprehensive benchmarking. Regular review and sharing of such evaluation results among the stakeholders, including property managers, service providers and end-users, are conducive to identifying areas for improvement and hence the provision of value-for-money FM services for achieving strategic property management.

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REFERENCES

Bordass, B. and Leaman, A. (2005) Making feedback and post-occupancy evaluation routine 1: a portfolio of feedback techniques, *Building Research & Information*, 33(4), pp. 347–352. http://dx.doi.org/10.1080/09613210500162016

British Institute of Facilities Management (2007) *FM 2007: Challenges and opportunities in the facilities management sector*. London: Redactive Publishing Ltd.

Eley, J. (2001) How do post-occupancy evaluation and the facilities manager meet?, *Building Research & Information*, 29(2), pp. 164–167. http://dx.doi.org/10.1080/09613210010016848

Evans, R., Haryott, R., Haste, N. and Jones, A. (1998) *The long term costs of owning and using buildings*. London: The Royal Academy of Engineering.

Hong Kong Housing Authority (2009) Hong Kong housing authority annual report 2008/09. Hong Kong: Housing Authority.

Hui, E. C. M. and Zheng, X. (2010) Measuring customer satisfaction of FM service in housing sector: a structural equation model approach, *Facilities*, 28(5/6), pp. 306–320. http://dx.doi.org/10.1108/02632771011031538

Independent Commission against Corruption, Home Affairs Department and Hong Kong Society of Accountants (2003) Clean and effective building management: a guide on financial management for owners' corporations. Hong Kong: Independent Commission against Corruption, Home Affairs Department and Hong Kong Society of Accountants.

International Facility Management Association (2007) Facility management forecast 2007: exploring the current trends and future outlook for facility management professionals. Houston TX, US: International Facility Management Association.

Lai, J. H. K. (2010) Investigating the quality of FM services in residential buildings. In: *Proceedings of W070 - Special Track, 18th CIB World Building Congress (CIB Publication 343)*, Salford, UK, 10–13 May 2010. Salford: International Council for Research and Innovation in Building and Construction, pp. 13–25.

Lai, J. H. K. (2011) Comparative evaluation of facility management services for housing estates, *Habitat International*, 35(2), pp. 391–397. http://dx.doi.org/10.1016/j.habitatint.2010.11.009

Lai, J. H. K. and Yik, F. W. H. (2011) An analytical method to evaluate facility management services for residential buildings, *Building and Environment*, 46(1), pp. 165–175. http://dx.doi.org/10.1016/j.buildenv.2010.07.012

McDougall, G., Kelly, J. R., Hinks, J. and Bititci, U. S. (2002) A review of the leading performance measurement tools for assessing buildings, *Journal of Facilities Management*, 1(2), pp.142–153. http://dx.doi.org/10.1108/14725960310807881

Mohd Noor, M. N. and Pitt, M. (2009) A critical review on innovation in facilities management service delivery, *Facilities*, 27(5/6), pp. 211–228. http://dx.doi.org/10.1108/02632770910944943

Parasuraman, A., Zeithaml, V. A. and Berry, L. L. (1985) A conceptual model of service quality and its implications for future research, *Journal of Marketing*, 49(Fall), pp. 41–50. http://dx.doi.org/10.2307/1251430

Rating and Valuation Department (2010) Hong Kong property review 2010. Hong Kong: Rating and Valuation Department.

Saaty, T. L. (1980) *The analytic hierarchy process: planning, priority setting, resource allocation*, New York, London: McGraw-Hill International Book Co.

Saaty, T. L. (1995) *Decision making for leaders: the analytic hierarchy process for decisions in a complex world*, Pittsburgh, Pa.: RWS Publications.

Shaw, D. and Haynes, B. (2004) An evaluation of customer perception of FM service delivery, *Facilities*, 22(7/8), pp. 170–177. http://dx.doi.org/10.1108/02632770410547534

Then, D. S. S. (2005) A proactive property management model that integrates real estate provision and facilities services management, *International Journal of Strategic Property Management*, 9(1), pp. 33–42. http://dx.doi.org/10.1080/1648715X.2005.9637524

Tucker, M. and Pitt, M. (2009) National standards of customer satisfaction in facilities management, *Facilities*, 27(13/14), pp. 497–514. http://dx.doi.org/10.1108/02632770910996342

Ventovuori, T. (2006) Elements of sourcing strategies in FM services – a multiple case study, *International Journal of Strategic Property Management*, 10(4), pp. 249–267. http://dx.doi.org/10.1080/1648715X.2006.9637556

Ventovuori, T., Lehtonen, T., Salonen, A. and Nenonen, S. (2007) A review and classification of academic research in facilities management, *Facilities*, 25(5/6), pp. 227–237. http://dx.doi.org/10.1108/02632770710742192

Yang, J. B. and Peng, S. C. (2008) Development of a customer satisfaction evaluation model for construction project management, *Building and Environment*, 43(4), pp. 458–468. http://dx.doi.org/10.1016/j.buildenv.2006.07.044

APPENDIX A. Summary list of the questions in the questionnaire

A1	Gender:	a) Male	b) Female		
A2	Age:	a) <31	b) 31–40	c) 41–50	d) >50
A3	Education:	a) Nil	b) Primary	c) Secondary	d) Tertiary
A4	Monthly income:	a) Nil	b) up to $20,000	c) $20,001–$50,000	d) > $50,000

Performance of the following facilities management aspects:

		Very poor	Poor	Fair	Good	Excellent
B1	General management	1	2	3	4	5
B2	Security	1	2	3	4	5
B3	Cleaning	1	2	3	4	5
B4	Repair & maintenance	1	2	3	4	5
B5	Landscape & leisure	1	2	3	4	5

Please circle below your judgment of the relative importance between each pair of aspects:

C1	General management	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Security
C2	General management	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Cleaning
C3	General management	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Repair & maintenance
C4	General management	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Leisure & landscape

(Continued)

(Continued)

		9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	
C5	Security	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Cleaning
C6	Security	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Repair & maintenance
C7	Security	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Leisure & landscape
C8	Cleaning	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Repair & maintenance
C9	Cleaning	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Leisure & landscape
C10	Repair & maintenance	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	Leisure & landscape

Representation for the above 9-point scale:

Point	Description
1	Equally important
2	Intermediate level between the two adjacent levels
3	Moderately more important
4	Intermediate level between the two adjacent levels
5	Strongly more important
6	Intermediate level between the two adjacent levels
7	Very strongly more important
8	Intermediate level between the two adjacent levels
9	Most important; no compromise acceptable

APPENDIX B. Equations for calculating importance weights, performance ratings, performance scores and performance indices

$$\bar{W}_a = \frac{\sum_{i=1}^{n} W_{i,a}}{n} \tag{1}$$

$$\hat{P}_{i(\%)} = \frac{\hat{P}_i}{\max(\hat{P}_i)} \times 100\% \tag{5}$$

$$\bar{P}_a = \frac{\sum_{i=1}^{n} P_{i,a}}{n} \tag{2}$$

$$\max(\hat{P}_i) = \max\left(\sum_{a=1}^{N} P_{i,a} \times W_{i,a}\right) \tag{6}$$

$$\hat{P}_{i,a} = P_{i,a} \times W_{i,a} \tag{3}$$

$$\max(P_{i,a}) = 5 \tag{7}$$

$$\hat{P}_i = \sum_{a=1}^{N} \hat{P}_{i,a} \tag{4}$$

$$\max\left(\sum_{a=1}^{N} W_{i,a}\right) = 1 \tag{8}$$

$$\hat{P}_{(\%)} = \frac{\sum_{i=1}^{n} \hat{P}_{i(\%)}}{n} \qquad (9)$$

$$\hat{P} = \sum_{a=1}^{N} \bar{W}_a \times \bar{P}_a \qquad (13)$$

$$\hat{P}_a = \bar{W}_a \times \bar{P}_a \qquad (10)$$

$$\bar{P} = \frac{1}{N} \hat{P} \qquad (14)$$

$$PI_a = \frac{\hat{P}_a}{\tilde{C}_a} \times 10^3 \qquad (11)$$

$$PI = \frac{\bar{P}}{\tilde{C}} \times 10^3 \qquad (15)$$

$$RPI_{X-Y} = \frac{PI_X - PI_Y}{PI_Y} \times 100\% \qquad (12)$$

Nomenclature of symbols (for Appendix B)

Symbol	Representation
a	assigned to the ath aspect of the FM services
$\tilde{C}$	total cost of all aspects per month normalised by number of residential units (\$/month/unit)
$\tilde{C}_a$	cost of the ath aspect per month normalised by number of residential units (\$/month/unit)
n	total number of respondents
N	total number of rated aspects
$\hat{P}$	sum total of weighted mean performance ratings of the rated aspects
$\bar{P}$	overall weighted mean performance rating of the FM services
$\bar{P}_a$	mean performance rating of the ath aspect
$P_{i,a}$	performance rating given by the ith respondent for the ath aspect
$\hat{P}_a$	weighted mean performance rating of the ath aspect
$\hat{P}_{i,a}$	weighted performance rating of the ith respondent for the ath aspect
$\hat{P}_i$	weighted performance rating of the ith respondent for all the rated aspects
$\hat{P}_{i(\%)}$	weighted performance score (in percentage) of the ith respondent for all the rated aspect
$\hat{P}_{(\%)}$	overall FM performance score (i.e. FMP score) for the estate
PI	performance index of all aspects as a whole
PI_a	performance index of the ath aspect
RPI_{X-Y}	relative performance index for comparing X against Y
$\bar{W}_a$	mean importance weight of the ath aspect
$W_{i,a}$	importance weight given by the ith respondent for the ath aspect