

Lai, J.H.K. (2011), Comparative evaluation of facility management services for housing estates, *Habitat International*, Vol. 35, No. 2, pp. 391-397

Comparative Evaluation of Facility Management Services for Housing Estates

Abstract:

Urbanised areas are increasingly developed with housing estates. Further to their design and construction, the services provided for managing the estates' facilities are crucial to the living quality of numerous habitants there. Holistic study findings on the importance, performance and cost-effectiveness of such facility management (FM) services, especially those between like estates, have yet to be seen. For bridging this knowledge gap, a study was conducted, under which the main aspects of the typical services namely security, cleaning, repair & maintenance, leisure & landscape, and general management were identified in the first stage. In the second stage, the costs of FM services in two comparable estates and the users' perceived importance and performance of the services were collected. The responses drawn from their consistent judgments, after processing by an analytical hierarchy process, were examined against a performance-importance evaluation matrix. Statistical tests were applied to identify the services with different qualities, and a set of weighted performance indicators was computed for representing the cost-effectiveness of the services. Comparisons made between these indicators informed which service or aspect was provided in a more, or less, cost-effective way. Wider adoption of this evaluation approach would facilitate performance benchmarking across estates, which is conducive to attaining quality and cost-effective services.

Keywords: Comparative study; cost-effectiveness; facility management; Hong Kong; housing estate; service performance.

Introduction

In parallel to modernisation of livelihood, urbanisation has become increasingly evident in both developed and developing cities. With growing population yet limited land supply in these areas, the demand for housing estates as settlements for people in the middle- and low-income classes has continued to rise.

Buildings in housing estates are typically medium- to high-rises, with multiple residential flats on each floor. The numerous flats in an estate are usually developed according to some standardized designs. The habitants in the same estate are entitled to use and enjoy the communal facilities, which include building works (e.g. flooring, walling, etc.) and electrical and mechanical systems provided in common areas such as lobbies, corridors and podiums, and also installations like outdoor lighting, road drainage, and leisure and landscape facilities provided in the open space of the estate. Satisfaction of the users with these facilities is dependent on their performance, which hinges on their design provision, constructed quality as well as the quality of services provided for managing the facilities throughout the occupancy stage.

Over the years, a significant volume of research effort had been made on studying design and construction for housing estates. For instance, [Sullivan & Chen \(1997\)](#) examined the changes of space allocation and use patterns in Hong Kong's small public housing flats. In 2002, [Chan et al.](#) reported a study on the density control and quality of living space based on a private housing development. About the same time, [Maloney \(2002\)](#), in the US, analysed the determinants of construction service quality and reviewed the factors involved in contractor selection. Not long ago, [Yang & Peng \(2008\)](#) developed a model for evaluating the satisfaction of project clients with construction project management service in Taiwan.

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Recently, [Ng et al. \(2011\)](#) examined the residents' satisfaction with the quality of constructed facilities in some public housing estates in Hong Kong.

Another group of studies recognises the need of identifying the satisfaction perceived by users in housing estates. Examples of such works include [Awotona \(1988\)](#), who studied the perception of users with housing conditions and later, [Ukoha & Beamish \(1997\)](#) attempted to assess the residents' satisfaction with public housing and the relationship of satisfaction with specific housing features to overall housing satisfaction. In Thailand, [Savasdisara et al. \(1989\)](#) reported their attempts in identifying the factors which contribute to overall satisfaction of dwellers in private low-cost housing estates. In Hong Kong, [Liu \(1999\)](#) conducted a study on the physical and social factors which influence residential satisfaction in housing estates and analysed the perceived factors of dissatisfaction among the public and private housing occupants. Lately, [Hui and Zheng \(2010\)](#) analysed the variables which are crucial to the customer satisfaction with the facility management service in a housing estate in Hong Kong, and [Mohit et al. \(2010\)](#) assessed the satisfaction of residents with newly designed public low-cost housing units in Malaysia.

On the other hand, financial resources used for providing facility management (FM) services for housing estates, which are influential to the performance of the services and hence the users' satisfaction, were seldom studied. Published findings on the cost-effectiveness of these services are limited. But in reality, owners and managers of housing estates are charged with the duty to make effective use of the available resources, failing which deficits would arise and the provision of quality services would become questionable.

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Take Hong Kong, a typical metropolis developed with many housing estates, as an example. Its public housing stock, according to the Housing Authority's record (HA, 2009), has accumulated to 389 estates (Table 1). They consist of 1,139,894 flats, accommodating a population of 1,990,790. Between 2004 and 2009, the annual operating expenditure on rental housing ranged between \$10,636M to \$12,287M, with an average annual amount being \$11,224M (HA, 2010). Nevertheless, an operating deficit arose since the financial year 2006/07. It has been estimated that the deficit for 2010/11 would be as high as \$2,244M. Confronted with these undesirable figures, it is imperative to ensure that the services procured for managing the housing estates and the facilities there are value-for-money. Even better, feasible ways should be sought for improving the cost-effectiveness of the services.

In fact, a scoring system called PSAPAS has been used by the Housing Department (HD), the executive arm of HA, to evaluate the performance of property services agents in managing its estates (HD, 2004). Under this system, a quarterly estate score, which represents the overall performance of a property service agent in a specific estate for a 3-month period, is made up of three components: the Housing Department Assessment Score (weighting: 50%) given by HD staff who manage the service agent; the Estate Management Advisory Committee (EMAC) Score (weighting: 20%) given by EMAC members of the estate; and the Tenant Assessment Score (weighting: 30%) given by randomly selected tenants of the estate. The basis upon which these weightings were set and the assessment results of PSAPAS, however, could not be found in the public domain. For effective monitoring of the management services of a large portfolio of housing estates, as in the case of HD, a reasonably rigorous method that can pragmatically assess the performance of the services is needed.

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It is well accepted that the performance and importance of a service or its attributes are interrelated. The application of a performance-importance analysis, for example, has proved useful for examining the perception of services in the hotel industry (Martin, 1995). Recently, Lai & Yik (2009) has extended its use by incorporating Saaty's (1980) analytical hierarchy process (AHP) to examine the gaps between the performance and importance of environmental qualities perceived by residential users. While these studies were able to identify performance, importance, and their interrelationships, they were unable to tell whether the use of the input resources, which would affect the perceived performance and importance of the services, was effective or not.

Being aware of the above deficiency and in order to investigate how FM services for housing estates can be properly assessed, the study reported in the following made use of an analytical method to evaluate the perceived importance and performance of the services as well as the costs for providing the services. For illustrating how the services in different estates can be evaluated in a comparative manner, empirical data of two estates with comparable characteristics were collected for analysis.

Method and Materials

The housing estates selected for study are of the same age and similar scale (Table 2). The types of their building blocks are also comparable, implying that the design, constructed quality and provisions of the facilities there are alike. Another determining factor behind their selection is that the relevant management personnel were willing to provide information about the estates' expenditures, without which the cost-effectiveness of the FM services could not be evaluated.

Before designing a suitable data collection tool, a focus group discussion among a group of experienced FM practitioners was convened in the first stage of the study. The discussion together with a thematic content analysis (Krippendorff, 2004) on samples of questionnaires used by the leading management companies for soliciting users' satisfaction with FM services, as reported earlier in Lai (2010), enabled the identification of five main aspects, i.e. security (SEC), cleaning (CLN), repair & maintenance (R&M), leisure and landscape (L&L), and general management (GEN), which cover a wide range of attributes associated with the FM services typically provided for housing estates (Figure 1).

Based on the above findings, a questionnaire, to be used in an interview survey with the users in the two estates, was designed in the second stage of the study. The questionnaire comprises three sections, with the first section inquiring about the personal particulars of the interviewees. The second section asks the interviewees to indicate, using a 5-point scale (1: no; 2: little; 3: moderate; 4: great; 5: extreme), their perceived performance of each of the five FM aspects and of all the aspects as a whole. The final section requests the interviewees to indicate their perceived relative importance between pairs of the five aspects 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. This part demands each interviewee to make 10 pair-wise comparisons between the aspects.

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In order to avoid discrepancies in conveying the meanings of the questions to the interviewees, all interviewers in the research team attended the same training before conduction of the interviews. The survey was carried out in the estates' open areas and the interviewees were invited to participate on a voluntary basis. With a success rate of about 10%, totally 508 interviews were completed, embracing 298 users in Estate A and 210 in Estate B.

[Table 3](#) summarises the demography of the interviewees. In both estates, the proportion of female samples was more than double of the males. Over four-fifth of the interviewees were adults, which included a small number of elderly residents. With over one-third possessing a tertiary qualification, the proportions of the interviewees' education levels were comparable across the estates. The distributions of income levels were highly similar; in particular the majority were those belonging to the low-income class or those who were unemployed or not working.

Analysis and Discussion

Perceived importance and performance of FM services

To detect if the sample contains any response with inconsistent judgment, the pair-wise relative importance ratings given by the respondents were processed by the AHP method, and the procedures of which were similar to that used in [Lai & Yik \(2009\)](#) for finding out the importance weights of different environmental quality attributes. First, each set of ratings of the attributes was organised to form a 5x5 pair-wise comparison matrix. Second, the matrix data was input to a program that utilises the EVCRG standard subroutine (available from the

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International Mathematical and Statistical Library) for eigenvalue and eigenvector calculations. Third, the principal eigenvalue and eigenvector were extracted from the EVCRG outputs, followed by computing the consistency ratio (CR) and normalising the elements in the principal eigenvector. Fourth, the CR value of each data set was checked against the allowable limit, which, for computations involving the use of 5x5 comparison matrix, is 10% (Saaty, 1995). Data sets with CR value exceeding this limit were treated as corrupted with inconsistent judgments.

350 of the samples, with a mean CR value (\bar{x}_{CR}) of 0.3722 and a standard deviation (s_{CR}) of 0.3631, were found to fail the consistency test (i.e. $CR > 0.1$). 158 samples ($\bar{x}_{CR} = 0.0373$, $s_{CR} = 0.0360$), which include 79 from Estate A ($\bar{x}_{CR} = 0.0409$, $s_{CR} = 0.0374$) and coincidentally the same amount from Estate B ($\bar{x}_{CR} = 0.0338$, $s_{CR} = 0.0344$), were able to pass the test, meaning that the overall proportion of usable samples was 31.1%. Although a large portion of the samples corrupted with inconsistent judgments was discarded in this way, it ensured only quality data obtained from users giving consistent judgments were used in the ensuing analysis.

Based on all of the usable samples, the mean importance weights of the five FM aspects were calculated using Equation (1) [see Table 4 for meanings of the symbols]. In descending order, they are: 0.2718 (SEC), 0.2273 (CLN), 0.2099 (R&M), 0.1691 (GEN), and 0.1218 (L&L). Given that the sum of AHP weights is unity and thus an aspect would carry a weight of 0.2 if all aspects are regarded as of equal importance, the R&M aspect, with its importance weight being close to 0.2, was perceived as of nominal importance. On the other hand, the

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importance weight given to the SEC aspect was more than double of that given to the L&L aspect.

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

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

$$\hat{P}_{i,a} = P_{i,a} \times W_{i,a} \quad (3)$$

$$\hat{P}_a = \bar{W}_a \times \bar{P}_a \quad (4)$$

$$PI_a = \frac{\hat{P}_a}{\bar{C}_a} \times 10^3 \quad (5)$$

$$RPI_{X-Y} = \frac{PI_X - PI_Y}{PI_Y} \times 100\% \quad (6)$$

$$\hat{P} = \sum_{a=1}^N \bar{W}_a \times \bar{P}_a \quad (7)$$

$$\bar{P} = \frac{1}{N} \hat{P} \quad (8)$$

$$PI = \frac{\bar{P}}{\bar{C}} \times 10^3 \quad (9)$$

The mean performance ratings of the FM aspects were calculated by [Equation \(2\)](#). With all of them recording a performance level between moderate and great, the SEC aspect was rated as the highest (3.544), followed by CLN (3.430), GEN (3.367), L&L (3.342), and R&M (3.203).

Further analysis was carried out by grouping the importance and performance ratings according to the estate where the samples were collected. These ratings and their rank orders are summarised in [Table 5](#). Without substantial differences between the mean importance

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weights of the estates, their rank orders were highly similar, with security and general management being at the top and the bottom respectively. Yet, the rank orders of the cleaning and repair & maintenance aspects reversed between the estates.

Unlike the results of importance ratings, the rank orders of performance ratings between the estates were obviously different. Whereas the general management aspect was considered as the best performer in Estate A, its performance was the second last among the rated aspects in Estate B. Common to the two estates, repair & maintenance was rated as the lowest performer.

The above perceived importance and performance results were scrutinised further with the aid of an evaluation matrix (Figure 2). Both aspects, namely general management and leisure & landscape in Estates A and B, and the repair & maintenance aspect of the latter fall into the first quadrant (Q1), showing that they had a higher-than-medium performance but a relatively low importance. Hence, their performance levels should be maintained. The repair & maintenance aspect in Estate A, with both its performance and importance being rated at a higher-than-medium level, should be capitalised as a competitive edge. Likewise, the remaining two aspects, security and cleaning, also recorded high-importance-high-performance ratings, supporting that they should be capitalised for enhancing the services.

Fortunately, none of the rated aspects was found to fall within the quadrants with lower-than-medium performance. If, for instance, an aspect was given a higher-than-medium importance rating while showing a relatively low performance (quadrant Q3), improvement should be made to elevate its performance level. If it was regarded as not important and its

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performance level was relatively low, i.e. in quadrant Q4, raising its performance is not desperate but ongoing monitoring of its performance is necessary.

Quality difference between FM services

The perceived performance ratings and importance weights given by the users are essential parameters that can be used for testing if quality difference exists between the FM services provided for the estates. Since the eventual performance of services perceived by the users may be affected by the importance of the services they perceived, the weighted performance ratings given by individual users on the rated aspects, which were calculated using [Equation \(3\)](#), were also included as testing parameters. The population means of such parameters, i.e. performance, importance, and weighted performance, are defined as follows:

μ_1 = the mean rating (or weight) for all users in Estate A

μ_2 = the mean rating (or weight) for all users in Estate B

Assuming that no difference exists in the quality of FM services provided for the estates, the null hypothesis (H_0) and alternative hypothesis (H_1) can be written as:

$$H_0 : \mu_1 - \mu_2 = 0$$

$$H_1 : \mu_1 - \mu_2 \neq 0$$

The above hypotheses were tested by a 2-tailed z -test. For a 95% confidence interval estimate of the difference between two population means (i.e. $\alpha = 0.05$), the critical value

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($z_{\alpha/2}$) is 1.96. Based on the responses on overall performance of the FM services (i.e. five rated aspects as a whole) provided for the estates, the sample mean (\bar{x}) and variance (s^2) for Estate A ($\bar{x} = 3.544$; $s^2 = 0.405$) and Estate B ($\bar{x} = 3.316$; $s^2 = 0.296$) were calculated. The z value was found to be 2.419, which exceeds the critical value and thus H_0 is rejected. In other words, it can be concluded that μ_1 and μ_2 are not equal and that the estates differed in terms of the quality of FM services they received.

A closer examination was made by performing the z -test on each of the rated aspects. As can be seen from the results in [Table 6](#), the z values across the parameters on the security and cleaning aspects are all smaller than the critical value, indicating that they are not in the rejection region. Therefore, it can be concluded that the population means are equal, and so the qualities of security and cleaning services provided for the estates were not different.

The population means of the importance weights and weighted performance ratings pertaining to the general management and leisure & landscape aspects are also equal as the corresponding z values are less than the critical value. The z values of the performance of these two aspects, however, exceed the critical value. This indicates that the population means are not equal. As to the repair and maintenance aspect, the z values in respect of performance, importance and weighted performance are all larger than the critical value. This implies that there is sufficient statistical evidence to reject the null hypothesis, meaning that the population means are not equal. These results show that the estates differed specifically in the qualities of repair and maintenance, general management, and leisure and landscape services they received.

Cost-effectiveness of FM services

As shown in the collected expenditure accounts of the estates, the titles of the itemized costs were not entirely identical but they essentially followed the standard format as recommended by the Home Affairs Department (HAD, 2003). In order to examine if resources were effectively used for providing the FM services, the cost items were grouped together with reference to the attributes under each of the five main aspects depicted in Figure 1. However, it was found that the expenditure on leisure & landscape in Estate A was covered by the costs spent on general management matters. In Estate B, the expenditure on security was included in the general management expenses and thus could not be singled out.

The annual expenditures, the monthly expenditures normalised by number of residential units in the corresponding estate, and the proportions of expenditure on each FM aspect are summarised in Table 7. The annual total expenditure of Estate A and that of Estate B exceeded \$22M and \$17M, respectively. The monthly sums, \$302.9 and \$308.0, which represent the average amount of management fee to be borne by each unit for disbursing the costs of the services, are comparable between the estates.

While the expenditure on leisure and landscape facilities in Estate A could not be identified, the counterpart in Estate B was minimal, at only 0.2% of the total expenditure. In contrast, the expenditures due to repair & maintenance, being 39.2% in Estate A and 44.7% in Estate B, accounted for the largest portion of the FM costs. Despite these dominant expenditures, the performance of repair & maintenance was rated as the lowest in both estates (see Table 5). But this observation does not necessarily mean that the R&M aspect was the least cost-effective among the studied aspects. Because different aspects are intrinsically different in

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their nature, complexity and so on, making direct comparison between their cost-performance efficiencies may lead to unfair results. For instance, the performance of the L&L aspect may depend largely on the quality of play equipment, seating benches, etc. installed in the first place while the cost for their ongoing upkeep may be small as compared to the substantial cost required for hiring management staff, whose quality is critical to the performance of the GEN aspect.

For comparisons on a like-with-like basis, the cost-effectiveness of an aspect in a particular estate should be evaluated by benchmarking against that of the same aspect in another estate of the same kind. Firstly, the weighted mean performance rating of an aspect was calculated by multiplying its mean importance weight by its mean performance rating (Equation 4). Such a performance rating, in turn, was divided by the normalised monthly cost of that aspect to yield a performance index (Equation 5), which equals the ratio between its outcome performance and cost input. The performance index of an aspect was then compared with that of the same aspect in another estate by referring to their relative performance indices, which were obtained by Equation (6).

For assessing the overall cost-effectiveness of the FM services, the weighted mean performance ratings of all aspects were processed by Equation (7) to give a sum total of weighted performance ratings of the rated aspects, followed by dividing it by the number of rated aspects to generate an overall weighted mean performance rating of the services (Equation 8). A performance index representing the ratio between overall outcome performance and total input cost of the services was computed using Equation (9), where the overall weighted mean performance rating was divided by the normalised monthly total cost of the services. Similar to the comparisons for individual aspects, the overall cost-

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effectiveness of FM services in an estate relative to that in another was evaluated according to their relative performance indices calculated by [Equation \(6\)](#).

The cost figures that could be analyzed in a comparative manner between the estates are those covering: i) the cleaning aspect; ii) the repair & maintenance aspect; and iii) as a whole (overall) of the five studied aspects. Their weighted mean performance ratings, performance indices, and the relative performance indices between the estates, which were obtained by following the above calculation procedures, are shown in [Table 8](#).

Inspection across the results reveals that the magnitudes of performance indices of the cleaning aspect were one order higher than the counterparts of the repair & maintenance aspect. This was attributed to the fact that with the magnitudes of their performance ratings being equal, the repair & maintenance cost was much higher than the expenditure on cleaning (see [Table 7](#)). Whereas the overall performance indices of the estates were very close, the performance index of the cleaning aspect in Estate B was apparently higher than that in Estate A, and the reverse was observed on the repair & maintenance aspect.

Referring to the relative performance indices obtained by comparing the performance index of Estate A against that of Estate B (denoted as RPI_{A-B}) and those obtained from a reversed comparison (i.e. RPI_{B-A}), the differences in respect of the overall services were subtle. With obvious differences between the relative performance indices of the cleaning aspect, the differences on the repair & maintenance aspect were far more substantial. In summary, the overall cost-effectiveness of FM services provided for the estates were comparable but the comparative cost-effectiveness of repair & maintenance in Estate A outperformed that of the cleaning aspect in Estate B.

The weighted mean performance ratings and performance indices were further plotted on [Figure 3](#), which enables a direct visualisation of their variations. If the expenditure on the leisure & landscape aspect in Estate A and that on the security aspect in Estate B could be singled out, the performance ratings and indices corresponding to the outstanding aspects could be found in the same way as described above. Their variations, if also plotted, would make the evaluation more complete.

Conclusion

Prior studies on housing estates tended to focus on assessing their design and construction, or customer satisfaction with the provisions and constructed quality of housing units. Despite the growing attention on performance of existing habitats, research studies which holistically examined the cost and performance of services provided for managing facilities in housing estates have been rare.

The study, as reported, had identified five main aspects of FM services, i.e. security, cleaning, repair & maintenance, leisure & landscape, and general management, which are typically provided for housing estates in Hong Kong. Based on two housing estates with comparable characteristics, information about the expenditures on the FM services and the levels of importance and performance that the users perceived about the services were also collected. It has been illustrated that processing the responses by the AHP method can enable detection and removal of those corrupted with inconsistent judgments. Examining the group of quality data remained can reveal the levels and rank orders of importance and performance of the rated aspects. With the aid of a performance-importance matrix, which among the aspects

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should be maintained, capitalised, improved or monitored can be determined. Performing statistical analysis on the sample means of performance, importance and weighted performance ratings between the estates can identify whether the services or which aspect of the services are different in quality.

Rather than investigating only the performance or weighted performance of the services, the deployed resources should also be examined in order to assess the cost-effectiveness of the services. On top of raw expenditures on the services and their normalised values with respect to scale of services, the computed performance indices can reflect the efficiency between service performance and cost input. Comparing the difference between these indices and that between the associated relative performance indices can show which service or aspect between the estates performs in a more, or less, cost-effective way.

Ineffective measurement and monitoring of the services provided for housing estates, besides leading to operating deficits, would have adverse impact on the living quality of numerous habitants there. The above comparative evaluation is useful for assessing the cost-effectiveness of the services in housing estates, which are not only ubiquitous in Hong Kong and other major cities in Asia, but are also common in populous cities across the world including those in Africa and America. When more assessment results are made available through wider adoption of this evaluation approach, performance benchmarking across the estates would be facilitated, which is conducive to providing quality and cost-effective FM services.

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Table 1 Stocks of housing estates and flats

	Estates (Nos.)	Flats (Nos.)
Public Rental Housing	153	694,099
Interim Housing	1	5,455
Home Ownership Scheme	141	211,678
Private Sector Participation Scheme	48	99,508
Buy or Rent Option Scheme ^a	6	7,472
Tenants Purchase Scheme	39	116,216
Surplus stock ^b	1	5,466
Total	389	1,139,894

^aThe Mortgage Subsidy Scheme is included. ^bSurplus stock include buyback / rescinded cases, individual unsold flats and flats in unsold blocks / courts, but excludes those Home Ownership Scheme flats transferred to other uses.

Table 2 Key information of the studied estates

	Estate A	Estate B
Age	21 years	20 years
Residential buildings	7 blocks	7 blocks
Block types	^a New Slab (1), Trident-3 (6)	New Slab (1), Trident-3 (2), Trident-4 (4)
Total amount of flats	6,076 units	4,794 units

^a 'New Slab' is 19-storey high with 42.64 m² per flat. 'Trident-3' is 35-storey high with flat sizes between 47.82 and 66.54 m². 'Trident-4' is 35-storey high with flat sizes between 47.96 and 75.02 m². Figures in parentheses represent the number of blocks.

Table 3 Demography of the sampled users

		Estate A	Estate B
Gender:	Female	67.1%	73.3%
	Male	32.9%	26.7%
Age (years):	<18	17.8%	15.7%
	18-60	81.2%	83.8%
	>60	1.0%	0.5%
Education:	Nil	0.0%	1.9%
	Primary	12.4%	10.0%
	Secondary	51.7%	54.8%
	Tertiary	35.9%	33.3%
Monthly income (HK\$):	Nil	41.3%	40.0%
	1-20,000	51.3%	53.3%
	20,001-50,000	6.7%	6.2%
	>50,000	0.7%	0.5%

Table 4 Nomenclature of symbols

Symbol	Representation
a	assigned to the a^{th} aspect; equals 1: SEC, 2: CLN, 3: R&M, 4: L&L, or 5: GEN
\tilde{C}	total cost of all aspects per month normalised by number of residential units (\$/month/unit)
\tilde{C}_a	cost of the a^{th} 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 a^{th} aspect
$P_{i,a}$	performance rating given by the i^{th} respondent for the a^{th} aspect
\hat{P}_a	weighted mean performance rating of the a^{th} aspect
$\hat{P}_{i,a}$	weighted performance rating of the i^{th} respondent for the a^{th} aspect
\hat{P}_i	weighted performance rating of the i^{th} respondent for all the rated aspects
PI	performance index of all aspects as a whole
PI_a	performance index of the a^{th} aspect
RPI_{X-Y}	relative performance index for comparing X against Y
\bar{W}_a	mean importance weight of the a^{th} aspect
$W_{i,a}$	importance weight given by the i^{th} respondent for the a^{th} aspect

Table 5 Importance and performance ratings of the FM services

Aspect	Importance				Performance			
	Estate A		Estate B		Estate A		Estate B	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Security	0.269	1	0.275	1	3.506	2.5	3.582	1
Cleaning	0.218	3	0.237	2	3.506	2.5	3.354	2
Repair & maintenance	0.223	2	0.197	3	3.316	5	3.089	5
Leisure & landscape	0.167	4	0.171	4	3.468	4	3.266	3
General management	0.123	5	0.120	5	3.544	1	3.139	4

Table 6 z-test results for the two sample means of the rated aspects

	Performance		Importance		Weighted performance	
	Estate A	Estate B	Estate A	Estate B	Estate A	Estate B
<i>Security</i>						
Mean	3.506	3.582	0.269	0.275	0.943	0.991
Variance	0.535	0.323	0.011	0.009	0.192	0.168
<i>z</i>	-0.729		-0.392		-0.704	
<i>p</i> ($Z \leq z$) two-tail	0.466		0.695		0.482	
<i>Cleaning</i>						
Mean	3.506	3.354	0.218	0.237	0.765	0.795
Variance	0.381	0.437	0.007	0.008	0.120	0.117
<i>z</i>	1.492		-1.373		-0.552	
<i>p</i> ($Z \leq z$) two-tail	0.136		0.170		0.581	
<i>Repair & maintenance</i>						
Mean	3.316	3.089	0.223	0.197	0.746	0.597
Variance	0.322	0.543	0.007	0.005	0.113	0.045
<i>z</i>	2.178		2.122		3.328	
<i>p</i> ($Z \leq z$) two-tail	0.029		0.034		0.001	
<i>General management</i>						
Mean	3.468	3.266	0.167	0.171	0.580	0.551
Variance	0.406	0.403	0.005	0.007	0.069	0.075
<i>z</i>	2.002		-0.357		0.688	
<i>p</i> ($Z \leq z$) two-tail	0.045		0.721		0.492	
<i>Leisure & landscape</i>						
Mean	3.544	3.139	0.123	0.120	0.425	0.387
Variance	0.559	0.455	0.005	0.004	0.058	0.060
<i>z</i>	3.576		0.299		0.995	
<i>p</i> ($Z \leq z$) two-tail	0.000		0.765		0.320	

Table 7 Costs of FM services for the estates

	Estate A			Estate B		
	\$/year	\$/month/unit	%	\$/year	\$/month/unit	%
Security	4,281,462	58.7	19.4	- ^b	- ^b	- ^b
Cleaning	3,611,600	49.5	16.4	2,409,363	41.9	13.6
Repair & maintenance	8,647,708	118.6	39.2	7,918,454	137.6	44.7
Leisure & landscape	- ^a	- ^a	- ^a	43,441	0.8	0.2
General management	5,542,070 ^a	76.0 ^a	25.1 ^a	7,344,892 ^b	127.7 ^b	41.5 ^b
Total (overall)	22,082,840	302.9	100.0	17,716,150	308.0	100.0

^a The expenditure on general management embraced that on leisure & landscape. ^b The expenditure on general management embraced that on security.

Table 8 Weighted mean performance ratings and performance indices

	Estate A		Estate B		Comparison	
	<i>WMPR</i>	<i>PI</i>	<i>WMPR</i>	<i>PI</i>	<i>RPI_{A-B}</i>	<i>RPI_{B-A}</i>
Cleaning	0.764	15.4	0.794	19.0	-18.6%	22.9%
Repair & maintenance	0.740	6.2	0.608	4.4	41.2%	-29.2%
Overall	0.693	2.3	0.665	2.2	5.9%	-5.6%

WMPR: weighted mean performance rating; *PI*: performance index; *RPI*: relative performance index.

Lai, J.H.K. (2011), Comparative evaluation of facility management services for housing estates, *Habitat International*, Vol. 35, No. 2, pp. 391-397

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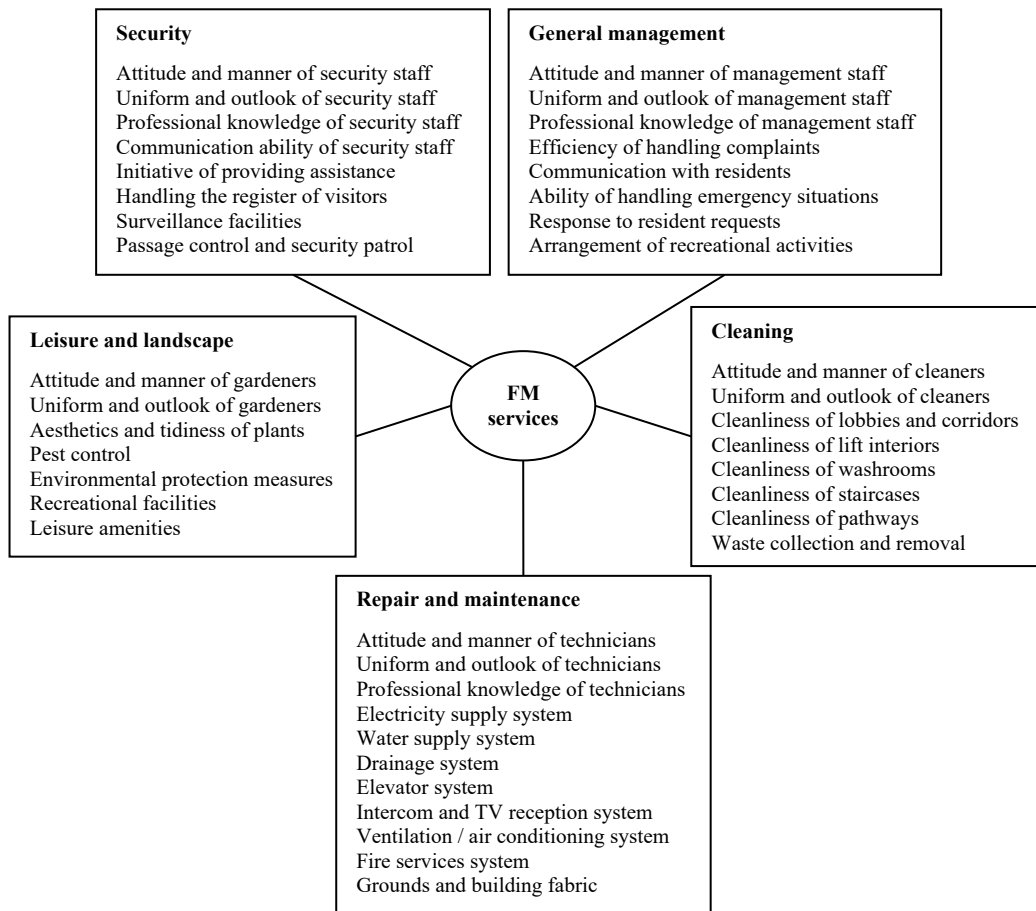


Figure 1 Main aspects of FM services and their attributes

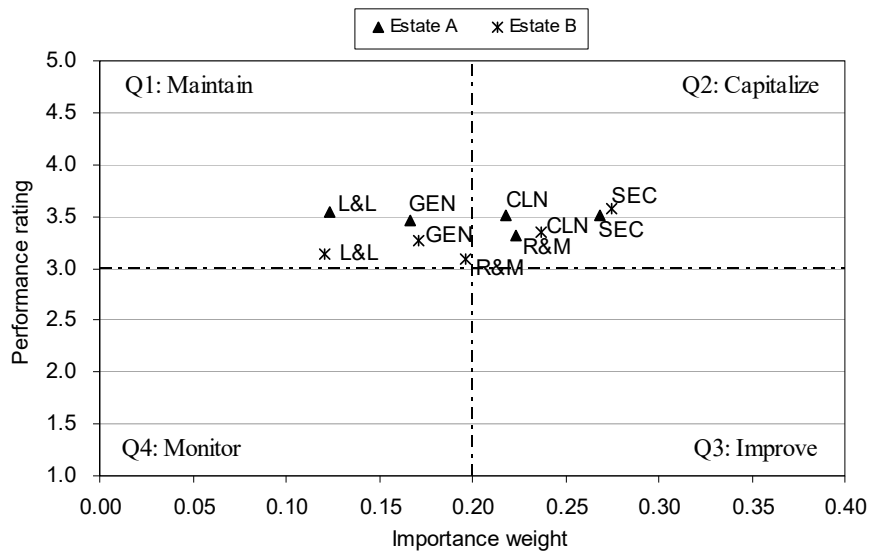


Figure 2 Performance-importance plot of the FM services

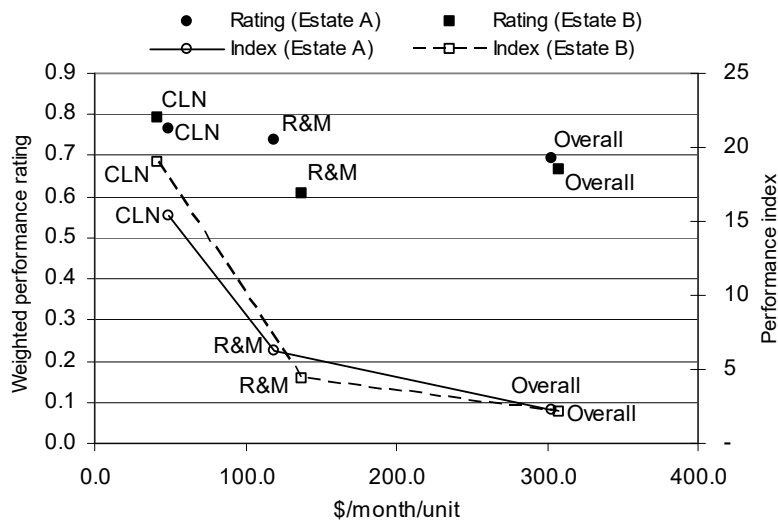


Figure 3 Variations of weighted mean performance ratings and performance indices