Statistical analysis of large building contractors’ awareness on cost-significant elements of high-rise condominium projects

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Abstract. Emphasis is laid on the importance of identifying cost-significant elements (CSEs) and non-CSEs (NCSEs) in the recent building cost planning’s evolution. Building contractors’ understanding on CSEs of high-rise condominium projects (HRCPs) is imperative as a result of the proliferation of high-rise residential multi-unit projects in urban areas due to limited land availability. This study aims at ascertaining the levels of awareness among the Klang Valley Malaysian large building contractors on CSEs of HRCPs in Klang Valley, Malaysia. It is found that the respondents’ understanding on CSEs has not achieved to a satisfactory level. Both the managerial staff and executive staff have quite similar levels of awareness on CSEs of HRCPs. The ways to improve this situation are recommended. Further analysis using a factor analysis technique groups the variables into four components, namely, understanding of external doors, stairs, and roof as NCSEs; understanding of frame, finishes, internal subdivision, and envelope as CSEs; understanding of substructure, external works, and preliminaries as NCSEs; and understanding of services and fittings as CSEs.

1. Introduction
Nowadays, building contractors must equip themselves with the knowledge of cost significance so that they could be able to identify the CSEs for different construction projects. Identification of CSEs will facilitate building contractors in recognising areas for cost checking when preparing cost estimates for tendering purposes. More often than not, the contractors if being requested by the clients to tender for projects would need to rush through the whole estimating process due to the short timeframe given [1]. In actual fact, there are many elements to be priced for construction works and so it is not possible for the bidders to perform cost checking on every single element in detail within the tender period. Hence, to ensure that the cost estimates reflect the scope of the work, the estimated prices for the CSEs should be counterchecked since these elements contribute to a larger portion of the total costs. Nevertheless, it is apparent that different buildings have different CSEs. Up to now, only Smith et al. [2] could provide a comprehensive theory on CSEs and their effects for high-density multi-unit residential projects.

Because land areas are becoming limited, housing developments are moving towards constructing vertically rather than horizontally. Thus, the number of HRCPs has been increased exponentially in the urban areas in Malaysia. The large building contractors should be aware of the CSEs of HRCPs as this knowledge offers a guide to the areas to concentrate on when monitoring the cost estimating process to ensure that the estimated prices for the construction works are free from mistakes and errors. The CSEs in HRCPs are: frame (columns, upper floors), envelope (external walls and windows), internal subdivision (internal walls, screens and doors), finishes (wall, ceiling and floor), fittings, services, and preliminaries while the NCSEs are: substructure, stairs, roof, external doors, and external works [2].
Although the studies on CSEs are not new, this area should receive more attention from the academics and practitioners worldwide to enhance our understanding on cost significance. Hence, this study aims to ascertain the levels of awareness among the Klang Valley Malaysian large building contractors on CSEs of HRCPs in Klang Valley, Malaysia. Klang Valley has been chosen as the place to conduct this study because it is where the capital of the country is located.

2. Literature review

In the past, researchers worldwide have applied cost significance theory in selecting CSEs for different construction projects and subsequently used the CSEs identified as parameters to estimate the costs for the entire projects. Poh and Horner [3] elucidate the way they employ the cost significance principle to derive a simplified method of measurement that can be easily understandable and adequately accurate. As an example, the development of a cost-significant model for student accommodations in Singapore is shown. Based on a cost-significant technique, Tas and Yaman [4] develop a generic computer aided building cost estimation model for Turkish construction sector public projects in their detailed design stage. Wang and Horner [5] develop two easy-to-use cost models, namely, the double mean model and the trend line model based on the cost-significance method to estimate the costs for major asphalt road maintenance projects. Despite the availability of an easy method for identifying CSEs, the contractors’ awareness on CSEs has not been assessed thoroughly. This research gap is filled by the present study.

3. Methods

Questionnaire survey methodology, one of the quantitative research methods, is used to ascertain the levels of awareness among large building contractors on CSEs of HRCPs. Based on the Likert scale (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree), the respondents are asked to answer as to what extent they agree or disagree with the total of twelve statements on whether the specific element mentioned in each statement is a CSE. The respondents are required to respond to all of the statements and choose only one answer for each statement. Besides, the respondents are requested to indicate their company names and their positions in the companies.

A total of 488 fully completed survey questionnaires are collected through personal interviews. The data collection through personal interviews conducted in this study has allowed all of the respondents to understand the statements clearly and thus able to answer accurately. When screening and cleaning the data [6], 24 survey questionnaires are removed from the data set due to straight lining [7] (11 cases) and outliers detected [8] in one of the twelve statements (13 cases). The remaining analysable 464 survey questionnaires are subsequently divided into two equal sets of 232 each. The first set is used for data analysis and the second set is used for validation purposes. Nevertheless, this paper only presents the results of the data analysis on the first set of the data.

Large building contractors in this study are referred to as contractors officially endorsed by the Construction Industry Development Board (CIDB) Malaysia as grade G7 building contractors that can undertake construction projects exceeding the value of Ringgit Malaysia 10 million. The respondents in this study are comprised of the managing directors, directors, senior managers, managers, quantity surveyors, estimators, and others from the Klang Valley Malaysian large building contractors. In order to ease the interpretation of the results, the respondents are subsequently categorised into two groups: managerial staff (that comprises the managing directors, directors, senior managers, and managers) and executive staff (that comprises the quantity surveyors, estimators, and others).

Four levels of awareness based on the calculated mean for every statement: (1 – 2 = slightly aware, 2.01 – 3 = somewhat aware, 3.01 – 4 = moderately aware, and 4.01 – 5 = extremely aware) are derived to define the levels of awareness precisely. Furthermore, it is also interesting to discover whether there is a difference in terms of the levels of awareness on CSEs between the managerial staff and executive staff. Therefore, the null hypothesis: there is no difference in terms of the levels of awareness on CSEs between the managerial staff and executive staff; and that the alternative hypothesis: there is a significant difference in terms of the levels of awareness on CSEs between the managerial staff and executive staff would be tested [6].
Additionally, a factor analysis approach which is an advanced statistical technique has been used to examine the underlying relationships among the measured variables (statements). Factor analysis can summarise and reduce a large number of measured variables into a smaller number of latent variables by investigating the underlying patterns or relationships for the measured variables and decide if the extensive list of some measured variables can be consolidated into a smaller set of explainable factors. Factor analysis deals with the problems of analysing the structure of the correlations among a large number of measured variables by defining a group of common underlying dimensions (factors). Data reduction can be attained by calculating scores for every underlying dimension and replacing them for the measured variables [9]. However, prior to conducting the factor analysis, both Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett’s test of sphericity are performed to investigate if the original data are suitable for factor analysis [10].

4. Results
Out of the total of 232 respondents, 2 are managing directors, 5 are directors, 3 are senior managers, 91 are managers, 108 are quantity surveyors, 2 are estimators, and 21 are others. This means that 101 are managerial staff and 131 are executive staff. The responses from these 232 respondents have been analysed statistically. Table 1 shows the ranking of overall respondents’ levels of awareness on CSEs of HRCPs in Klang Valley, Malaysia. ‘Frame (columns, upper floors)’ that achieves a mean of 3.79 is ranked first. ‘Finishes (wall, ceiling and floor)’ that achieves a mean of 3.66 is ranked second. ‘Envelope (external walls and windows)’ that achieves a mean of 3.54 is ranked third. ‘Services’ that achieves a mean of 3.44 is ranked fourth. ‘Internal subdivision (internal walls, screens and doors)’ that achieves a mean of 3.42 is ranked fifth. ‘Preliminaries’ that achieves a mean of 3.41 is ranked sixth. ‘External doors’ that achieves a mean of 3.39 is ranked seventh. ‘Fittings’ that achieves a mean of 3.26 is ranked eighth. ‘Stairs’ that achieves a mean of 3.24 is ranked ninth. ‘Roof’ that achieves a mean of 2.95 is ranked tenth. ‘External works’ that achieves a mean of 2.84 is ranked eleventh. ‘Substructure’ that achieves a mean of 2.50 is ranked last.

Table 1. Ranking of overall respondents’ levels of awareness on CSEs of HRCPs in Klang Valley, Malaysia.

| Statement                                                                 | Mean  | Standard Deviation | Rank |
|---------------------------------------------------------------------------|-------|--------------------|------|
| S02 – Frame (columns, upper floors) is a CSE.                             | 3.79  | 0.727              | 1    |
| S08 – Finishes (wall, ceiling and floor) are a CSE.                       | 3.66  | 0.852              | 2    |
| S04 – Envelope (external walls and windows) is a CSE.                     | 3.54  | 0.836              | 3    |
| S10 – Services are a CSE.                                                 | 3.44  | 1.009              | 4    |
| S07 – Internal subdivision (internal walls, screens and doors) is a CSE.  | 3.42  | 0.932              | 5    |
| S12 – Preliminaries are a CSE.                                            | 3.41  | 1.057              | 6    |
| S06 – External doors are not a CSE.                                       | 3.39  | 1.017              | 7    |
| S09 – Fittings are a CSE.                                                 | 3.26  | 0.950              | 8    |
| S03 – Stairs are not a CSE.                                               | 3.24  | 0.995              | 9    |
| S05 – Roof is not a CSE.                                                  | 2.95  | 1.110              | 10   |
| S11 – External works are not a CSE.                                       | 2.84  | 1.073              | 11   |
| S01 – Substructure is not a CSE.                                          | 2.50  | 1.097              | 12   |

Table 2 shows the respondents’ levels of awareness on CSEs of HRCPs in Klang Valley, Malaysia based on position (managerial staff and executive staff). Despite the differences in the ranking of the statements, both the managerial staff and executive staff respondents are aware that ‘frame (columns, upper floors)’ is the most significant element in affecting the costs of HRCPs and the respondents have misunderstood that ‘roof’, ‘external works’, and ‘substructure’ are the CSEs of HRCPs. Table 3 shows the result of the Mann-Whitney U test comparing the managerial staff and executive staff respondents’ levels of awareness on CSEs of HRCPs in Klang Valley, Malaysia. The probability (p-value) for each of the 11 out of the total of 12 statements, specifically, S01 to S09, S11, and S12, is more than 0.05;
indicating that the result is not significant. For statement S10, its probability (p-value) is less than 0.05, indicating that the result is significant. Thus, except for statement S10, the null hypothesis is accepted at a 95% confidence level and that the alternative hypothesis is rejected (p-value > 0.05). It is concluded that, on the whole, the levels of awareness on CSEs of HRCPs between the managerial staff and executive staff are quite similar.

Afterwards, the 12 statements of CSEs are subjected to principal components analysis (PCA) using PASW Statistics 18 [11]. The suitability of data for factor analysis is assessed before conducting PCA. Inspection of the correlation matrix reveals the presence of numerous coefficients of ≥ 0.3. The KMO value is 0.65, exceeding the recommended value of 0.6 [12,13] and Bartlett’s test of sphericity [14] reaches statistical significance (p < 0.001 which fulfills the requirement that the significance value should be < 0.05), supporting the factorability of the correlation matrix. PCA reveals the presence of four components with eigenvalues > 1, that explain 57.514% of the variance (20.195%, 15.759%, 12.290%, and 9.270% of the variance for each component respectively), as shown in Table 4. Table 5 shows the rotated component matrix using the principal components extraction method and varimax rotation with Kaiser normalisation. By referring to the statements in each of the components, the four components can be renamed as: component 1 – understanding of external doors, stairs, and roof as NCSEs; component 2 – understanding of frame, finishes, internal subdivision, and envelope as CSEs; component 3 – understanding of substructure, external works, and preliminaries as NCSEs; and component 4 – understanding of services and fittings as CSEs.

Table 2. Respondents’ levels of awareness on CSEs of HRCPs in Klang Valley, Malaysia based on position (managerial staff and executive staff).

| Statement | Managerial Staff | Executive Staff | Total |
|-----------|-----------------|----------------|-------|
|           | Mean            | Standard Deviation | Mean | Standard Deviation | Mean | Standard Deviation |
| S01       | 2.52            | 1.110            | 2.48 | 1.091 | 2.50 | 1.097 |
| S02       | 3.81            | 0.731            | 3.78 | 0.726 | 3.79 | 0.727 |
| S03       | 3.25            | 1.033            | 3.24 | 0.967 | 3.24 | 0.995 |
| S04       | 3.65            | 0.805            | 3.46 | 0.853 | 3.54 | 0.836 |
| S05       | 2.98            | 1.113            | 2.93 | 1.111 | 2.95 | 1.110 |
| S06       | 3.46            | 1.063            | 3.34 | 0.981 | 3.39 | 1.017 |
| S07       | 3.37            | 0.924            | 3.47 | 0.939 | 3.42 | 0.932 |
| S08       | 3.69            | 0.845            | 3.64 | 0.860 | 3.66 | 0.852 |
| S09       | 3.30            | 0.985            | 3.23 | 0.925 | 3.26 | 0.950 |
| S10       | 3.62            | 1.008            | 3.30 | 0.990 | 3.44 | 1.009 |
| S11       | 2.93            | 1.042            | 2.76 | 1.094 | 2.84 | 1.073 |
| S12       | 3.28            | 1.078            | 3.50 | 1.033 | 3.41 | 1.057 |

5. Discussion
The results indicate that both the managerial staff and executive staff have almost the same levels of awareness on CSEs of HRCPs in Klang Valley, Malaysia. This is quite a surprising outcome, because it is anticipated that the managerial staff would have higher levels of awareness on the CSEs than the executive staff would have seeing that they are the individuals with higher positions in the companies probably due to stronger educational backgrounds and extensive working experiences. Evidently, the knowledge of CSEs among the managerial staff has to be enhanced since that knowledge is important to the managerial staff in monitoring the cost estimates prepared by the executive staff.

The respondents are only moderately aware that frame (columns, upper floors) is a CSE although it is clear that frame, usually made of reinforced concrete for HRCPs in Klang Valley, Malaysia, is the building element that forms the building’s skeleton [15], which would contribute to a larger portion of the building costs. Because the respondents are not extremely aware that frame is a CSE, it is believed
that some respondents are still not very sure about the cost significance of this building element on the total costs of the building.

Besides frame, finishes (wall, ceiling and floor) are another building element that is recognised as a CSE by the respondents. This may be due to the fact that condominiums are luxurious residential units which would use large quantities of high quality of finishes such as costly façade for the external wall finishes, low volatile organic compound (VOC) paint for the wall finishes, timber panel ceilings for the ceiling finishes, and homogeneous tiles or natural stones for the wall and floor finishes. Because of this very reason, it has been expected that the respondents would be extremely aware that finishes are a CSE. Nonetheless, this result also indicates that some of the respondents have failed to appreciate the cost significance of this building element.

In contrast, external doors are not a CSE because they are usually relatively less costly compared to other building elements such as frame and finishes. The quantities of external doors needed for HRCPs are relatively small too. However, the respondents are only moderately aware of the cost significance of this building element. In actual fact, this is the only NCSE that most respondents could understand well seeing that it has achieved a mean of 3.39 that is higher than the grand mean of 3.29. On the other hand, most respondents could not really understand that stairs, roof, external works, and substructure are indeed not CSEs for HRCPs seeing that their achieved means are lower than the grand mean.

Table 3. Result of the Mann-Whitney U test comparing the managerial staff and executive staff respondents’ levels of awareness on CSEs of HRCPs in Klang Valley, Malaysia.

| Statement | Mann-Whitney U | Wilcoxon W | Z | Asymptotic Significance (2-tailed) |
|-----------|----------------|------------|---|----------------------------------|
| S01       | 6484.500       | 15130.500  | -0.268 | 0.789                           |
| S02       | 6418.000       | 15064.000  | -0.443 | 0.657                           |
| S03       | 6507.000       | 15153.000  | -0.225 | 0.822                           |
| S04       | 5894.500       | 14540.500  | -1.534 | 0.125                           |
| S05       | 6426.500       | 15072.500  | -0.386 | 0.700                           |
| S06       | 6147.500       | 14793.500  | -0.962 | 0.336                           |
| S07       | 6137.500       | 11288.500  | -1.002 | 0.316                           |
| S08       | 6399.000       | 15045.000  | -0.460 | 0.646                           |
| S09       | 6442.000       | 15088.000  | -0.359 | 0.720                           |
| S10       | 5413.000       | 14059.000  | -2.491 | 0.013 *                         |
| S11       | 5951.500       | 14597.500  | -1.358 | 0.175                           |
| S12       | 5775.000       | 10926.000  | -1.726 | 0.084                           |

Grouping variable: position.
*Significant as p-value < 0.05.

Table 4. Total rotated factor variance explained for respondents’ awareness on CSEs of HRCPs in Klang Valley, Malaysia.

| Component | Initial Eigenvalues | Extraction Sums of Squared Loadings | Rotation Sums of Squared Loadings |
|-----------|---------------------|-------------------------------------|----------------------------------|
|           | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1         | 2.423 | 20.195      | 20.195 | 2.423 | 20.195 | 20.195 | 1.983 | 16.323 | 16.323 |
| 2         | 1.891 | 15.759      | 35.954 | 1.891 | 15.759 | 35.954 | 1.701 | 14.179 | 30.702 |
| 3         | 1.475 | 12.290      | 48.244 | 1.475 | 12.290 | 48.244 | 1.655 | 13.795 | 44.497 |
| 4         | 1.112 | 9.270       | 57.514 | 1.112 | 9.270 | 57.514 | 1.562 | 13.017 | 57.514 |
| 5         | 0.926 | 7.715       | 65.229 | 0.926 | 7.715 | 65.229 | 0.802 | 6.685 | 71.914 |
| 6         | 0.802 | 6.685       | 71.914 | 0.802 | 6.685 | 71.914 | 0.706 | 5.881 | 77.795 |
| 7         | 0.635 | 5.293       | 83.089 | 0.635 | 5.293 | 83.089 | 0.582 | 4.847 | 87.935 |
| 8         | 0.582 | 4.847       | 87.935 | 0.582 | 4.847 | 87.935 | 0.554 | 4.614 | 92.549 |
| 9         | 0.554 | 4.614       | 92.549 | 0.554 | 4.614 | 92.549 | 0.473 | 3.938 | 96.487 |
| 10        | 0.473 | 3.938       | 96.487 | 0.473 | 3.938 | 96.487 | 0.422 | 3.513 | 100.000 |

Extraction method: PCA.
Table 5. Rotated component matrix using the principal components extraction method and varimax rotation with Kaiser normalisation.

| Statement | Component (Factor Grouping) |
|-----------|-----------------------------|
|           | 1 | 2 | 3 | 4 |
| S06       | 0.760 | | | |
| S03       | 0.755 | | | |
| S05       | 0.706 | | | |
| S02       | | 0.706 | | |
| S08       | | 0.690 | | |
| S07       | | 0.682 | | |
| S04       | | 0.401 | | 0.363 |
| S01       | | | 0.824 | |
| S11       | 0.345 | | 0.695 | |
| S12       | 0.310 | | -0.375 | 0.359 |
| S10       | | | | 0.783 |
| S09       | | | | 0.754 |

The grand mean for all of the twelve statements on cost significance of different building elements indicates that in general the respondents are only moderately aware of the CSEs of HRCPs. This result further shows that the large building contractors’ knowledge on CSEs is quite weak and for that reason improvements become necessary in understanding and applying the cost significance theory to prevent submitting a lower bid price as a result of underestimation of costs. The current trend in the Malaysian construction industry that the clients more often than not will enter into contract with the contractors in the form of ‘without quantities’ contract has put the bidders on the losing side as the contractors will not be allowed to claim for reimbursement due to any discrepancy between the quantities measured on plan and the actual quantities measured on site. The cost significance theory is absolutely important to contractors as it substantially reduces the time and effort in cost checking a large number of building elements in HRCPs by means of performing cost checking for a smaller number of building elements that are of cost significance within the short tendering period available.

As long as the construction related courses in higher learning institutions do not explicitly include cost significance theory in their syllabuses, educating students on cost significance remains as a great challenge. Thus, it is recommended that firstly, the information on cost significance theory is properly included in the relevant courses such as construction estimating and construction economics so that the students could gain sufficient theoretical knowledge and be able to apply it when necessary. Secondly, workshops, seminars, and talks on cost significance theory and its applications could also be organised to help increase the levels of awareness on CSEs for various projects among construction stakeholders especially the contractors. The results from the factor analysis done in this study demonstrate that the awareness of cost significance among contractors shall be enhanced by imparting relevant knowledge following the themes identified in the four factor groupings, namely, understanding of external doors, stairs, and roof as NCSEs; understanding of frame, finishes, internal subdivision, and envelope as CSEs; understanding of substructure, external works, and preliminaries as NCSEs; and understanding of services and fittings as CSEs.

6. Conclusions

Contractors should possess some knowledge of cost significance so that they are aware of the building elements that contribute to a larger portion of the building costs. Cost checking the CSEs is imperative in the cost estimating process as inaccurate estimate will have negative impacts on the project success. Clearly, the contractors have to improve their knowledge of CSEs especially on HRCPs to manage the project costs effectively and efficiently. As a starting point, the knowledge of which building elements are of cost significance and which building elements are not of cost significance could be shared with
the contractors in the building industry based on what the contractors currently understand as CSEs and NCSEs in the building project through both formal and informal education systems.

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