Factors Influencing the Construction Cost of Industrialised Building System (IBS) Projects

Nor Azmi Ahmad Bari\textsuperscript{a}\textsuperscript{*}, Rosnah Yusuff\textsuperscript{b}, Napsiah Ismail\textsuperscript{b}, Aini Jaapar\textsuperscript{a} & Norizan Ahmad\textsuperscript{a}

\textsuperscript{a} Department of Quantity Surveying, Faculty of Architecture, Planning & Surveying, Universiti Teknologi MARA, Shah Alam, Malaysia
\textsuperscript{b} Department of Mechanical Engineering and Manufacturing, Faculty of Engineering, Universiti Putra Malaysia, Serdang, Malaysia

Abstract

This paper presents the results of a survey of factors influencing the construction costs of Industrialised Building System (IBS) projects in Malaysia. The aim of the study was to evaluate and rank a range of factors that Malaysian IBS stakeholders regard as important, with the key identified factors being those associated with the main project characteristics, contract procedures and procurement methods, contractors' and consultants' attributes and design parameters besides external market conditions. Remarkably, factors grouped under the consultants and design parameters, external factors and government/authority requirements indicate low RII index while project/IBS characteristics, contractor attributes, external market conditions denote high RII index.

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\textsuperscript{*} Corresponding author. Tel.: +6019-389 0260; fax: +6 03-55444353.
E-mail address: norazmi103@salam.uitm.edu.my
1. Introduction

Increasing awareness in environmental pollution, natural resources depletion, sustainable development and sustainable construction indicate that issues of sustainability are serious concerns throughout the world. In concrete buildings, conventional on-site construction methods have long been criticised for long construction time, low productivity, poor safety records, and large quantities of waste (Egan, 1998; Eastman, 2008). The alternative, more innovative construction method, i.e. Industrialised Building System (IBS) can offer significant advantages, such as shortened construction time, lower project cost, improved quality, enhanced occupational health and safety, less construction site waste, less environmental emissions, and reduction of energy and water consumption.

Cost is undoubtedly the most important concern in any business endeavour, not least in the construction industry. Poor cost performance in construction projects has become a major concern for both contractors and clients (Xiao and Proverbs, 2002; Memon et al. 2010). In order to control costs, it is important to exercise foresight of the various project-related determinants and address the magnitude of their effects. Elhag et al. (2005) agreed that realizing and understanding cost-determinants will enrich the cost estimator’s competence, hence, adequately delivering a more sustainable and reliable cost modelling and estimating technique.

A clearer understanding of the cost determinants is vital to achieve the desired level of accuracy of anticipated labour costs, material costs etc. in total cost estimation. The estimator is able to examine these factors and subsequently estimate, plan for, and mitigate the adverse effects of these factors on the project cost. This paper assesses and ranks the cost-influencing factors of IBS projects in the Malaysian construction industry. The overall aim of the paper is to determine the factors influencing construction costs from the IBS contractors’ and manufacturers’ perspectives. A questionnaire survey was conducted to extract the views of randomly-selected Malaysian IBS contractors and manufacturers who were chosen for their direct involvement in the IBS construction industry. This study suggests that cost estimation inevitably involves an experience-based process requiring industry players to take into full account the uncertainty, incompleteness and other enigmatic circumstances so as to be proficient with the costing rigours.

2. Past Research

Research suggests that various factors, ranging from project estimation to completion, will significantly influence costs. The literature thus far on the factors affecting the overall cost of construction projects include studies by Memon et al. (2010), Stoy and Schalcher, (2007), Chan and Park, (2005) Elhag et al. 2005, Bubshait and Al-Juwaish (2002, all of which identified the factors that significantly influence construction costs in different countries. They assert that these factors are directly related to the construction organizations’ responsibilities for managing the cost, socio-cultural, economic and external conditions as well as the technological and political environments within which they operate which in turn, affect the construction costs.

Memon et al. (2010) identified significant factors affecting construction costs in the Malaysian government agencies’ large construction projects. The data gathered using the questionnaire survey was analysed with statistical tools to determine the ranking of factors. The study concluded that cash flow and financial difficulties faced by contractors, contractor’s poor site management and supervision, inadequate contractor experience, shortage of site workers, incorrect planning and scheduling by contractors are the most severe factors while changes in scope of the project as well as changes in design are the least influential factors on construction costs.
Chan and Park (2005) investigation of factors that contribute to project costs in the Singapore construction industry involved a random sample survey of the country’s building projects valued at more than US$5 million that were completed after 1992. The study identified three main groupings which are the project, contractor and owner/consultant, and dissimilates their characteristics into variables. The findings show that special project requirements such as degree of high-technology, contractor’s specialized skills, and public-administered contracts have significant effects on costs. Other factors include the contractor’s technical expertise and financial management ability, as well as the owner’s level of construction familiarity.

Elhag et al. (2005) conducted a questionnaire survey on 218 randomly selected quantity surveyors to look into critical determinants of construction tendering costs at the pre-tender stage for building projects in the United Kingdom (UK). Sixty-seven (67) factors, including external factors and market conditions, were selected and grouped into six different categories, i.e. client characteristics, consultant and design parameters, contractor attributes, project characteristics, contract procedures and procurement methods. The study employed statistical analyses using the severity index and Kendall’s concordance test and illustrated strong agreement amongst the quantity surveyors in ranking of cost-influencing factors.

Similarly, Bubshait and Al-Juwairah (2002) measured and evaluated 42 main factors influencing the construction cost in Saudi Arabia. In identifying their degree of importance by using the severity index for contractors, consultants, owners and a combination of respondents, the study concluded that material cost, incorrect planning, inexperience in managing contracts, and poor financial control on-site are factors that contribute to high construction costs.

Despite the varied literature on cost influencing factors, to date, there is no literature available to identify the factors influencing construction costs of IBS projects in the Malaysian construction industry as prior research focused on the general aspects of construction projects involving conventional methods. The studies by these researches, however, can be used to define the theoretically relevant causal relationships.

3. The Survey

The questionnaire survey was conducted to determine the opinions of IBS contractors and manufacturers on factors affecting IBS construction costs in the Malaysian construction industry. The questionnaire was developed based on a combination of an extensive review of literature and a series of discussions/interviews involving the quantity surveyors, engineers and contractors. Discussions, as part of a pilot study, in order to adjust and modify the questionnaire were also held. A six-page questionnaire, accompanied by a cover letter indicating the research objectives, was sent via post to the respondents randomly-selected from the sampling frame. The majority, comprising 44 respondents, were from the top management of their organizations followed by middle management, professional, and technical staff. Almost 65 percent were from top and middle management including general managers, managing directors and directors. The analysis proved the respondents exercised high decision-making powers in their organizations due to their considerable experience and knowledge.

Fifty-four (54) factors were developed for the survey and grouped into seven categories, i.e. project characteristics/IBS characteristics, contract procedure and procurement method, consultant and design parameters, contractors’ attributes, economic and market conditions, external factors and government’s requirements.

4. Data Analysis
The procedure used in analyzing the results was aimed at determining and prioritizing the factors that influence IBS construction costs. The score for each factor was calculated by summing up the scores assigned to it by the respondents. Therefore, the level of significance as indicated by the IBS contractors and manufacturers were used to measure the relative importance of each factor. Chan and Kumaraswamy (1997) assert that the mean and standard deviation of each individual factor are not statistically suitable to assess the overall rankings as they do not reflect any relationships. Accordingly, Chan and Kumaraswamy (1997) used the ‘relative importance index’ (RII) method to determine the relative ranking of the factors. RII was computed using the following equation (1):

$$RII = \frac{\sum w}{(A \times N)} \quad (0 \leq \text{index} \leq 1)$$

Where: $w$ is the weight given by the respondents to each factor ranging from 1 to 5, $A$ is the highest weight (i.e. in this case is 5), and $N$ is the total number of respondents. The factors were then arranged according to their descending order of RII values and were duly ranked. The highest RII indicates the most critical and important factor with rank 1 and the next indicates the second-most critical factor with rank 2, and so forth.

5. Survey Result and Analyses

The questionnaire was analyzed from the contractors’ and manufacturers’ viewpoints to identify the important factors that may influence IBS construction costs. The ranking of these factors according to various groups facilitated the process.

5.1 Project Characteristics/IBS Characteristics

There are sixteen (16) items grouped in the ‘Project Characteristics/IBS Characteristics’-related group. It was found that the item ‘Repeatability and standardisation’ (of a given project) was perceived by the respondents as the most important influencing factor (RII = 0.8818). Additionally, all respondents, ranked ‘Repeat use of design, moulds or construction technique from previous projects’ as the second-most important factor (RII = 0.8591), ‘fast track job/speed of construction/urgency for completion’ (RII = 0.8545) as the third-most important and ‘Economies of scale’ (RII = 0.8318) as the fourth-most important factor. The high coefficient index of RII between respondents indicates that the factors contained within the category have strong effects on the construction cost estimates and costs of IBS project.

5.2 Factors related to Contract Procedures and Procurement Methods

This group factor reveals a low coefficient index of RII between respondents. Two factors were perceived as having influence in the construction costs in this group, i.e. ‘Accuracy and consistency of design’ (RII = 0.7768), and ‘Completeness and timeliness of project information’ (RII = 0.7591).

5.3 Factors related to Consultant and Design Parameters

This group factor also reveals a low coefficient index of RII between respondents. The RII index ranges between 58% and 75%. ‘Experience and proficiency of the design team’ (RII = 0.7500) was perceived as having influence on the construction costs. The rest of the factors listed had low coefficient index of RII due to their lesser influence.

5.4 Factors related to Contractor Attributes
There are nine (9) items grouped in ‘Contractors attributes’-related factors. Four (4) factors achieved RII ranging between 76% and 82%. This indicates that these variables have a relatively higher degree of influence on construction costs. The remaining factors in this group obtained RII ranging between 60% and 70%, which indicates their moderate significance. The top ranked factors include ‘Contractors’ construction planning and control’ (RII = 0.8273), ‘Availability/adequacy of contractor’s staff and workers’ (RII = 0.7909) and ‘Contractors’ management team’ (RII = 0.7818).

5.5 Factors Related to Economics and Market Conditions

There are seven (7) items for ‘Economics and market conditions’-related factors. The RII obtained by this category ranges between 60% and 80%. Two factors in this group are amongst the most significant variables in the overall ranking. The top ranking variables are ‘Price stability of building materials’ (RII = 0.8045), and ‘Supply stability of building materials’ (RII = 0.7955), indicating their high influence in the preparation of construction cost estimates and costs of IBS project.

5.6 Factors Related to External Factors

There are seven (7) items for ‘External’-related factors that reveal a moderate coefficient index of RII between respondents. The RII index ranges between 65% and 75%. The top ranking variables are ‘Usage of plant, equipment and machinery during site installation’ (RII = 0.7500) and ‘Quality and reliability of jointing, coupling, grouting, waterproofing’ (RII = 0.7455).

5.7 Factors Related to Government/Authority Requirements

There are four (4) items for ‘Government/Authority requirements’-related factors. This group maintained RII ranges between 62% and 65%. Evidence shows that the respondents regarded the factors contained within the category as having little effect upon the construction cost estimates.

6. Significant Factors Ranked by All Groups of Respondents

The results present several underlying factors that can affect an IBS project’s construction costs. They should be deemed as significant since the data was gathered from the personnel directly and intimately involved in the execution of IBS building projects. As depicted in Table 1, the study establishes the ten (10) most significant factors influencing the IBS project construction costs in Malaysia, and with some fine-tuning, these can be replicated in many other developing countries of comparable socio-economic traits.
Table 1: Overall Top 10 Ranking.

<table>
<thead>
<tr>
<th>Item</th>
<th>Factors</th>
<th>Factor group</th>
<th>RII</th>
<th>Percentage</th>
<th>Overall Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Repeatability and standardization (e.g. repeated units in a terrace housing or typical floor plans in a multi-storey building project)</td>
<td>Project/IBS Characteristics</td>
<td>0.8818</td>
<td>88.18</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Repeat use of design, moulds or construction techniques from previous projects</td>
<td>Project/IBS Characteristics</td>
<td>0.8591</td>
<td>85.91</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Fast track job / Speed of construction / Urgency for completion</td>
<td>Project/IBS Characteristics</td>
<td>0.8545</td>
<td>85.45</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Economies of scales / Quantity of components ordered</td>
<td>Project/IBS Characteristics</td>
<td>0.8318</td>
<td>83.18</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Contractor’s construction planning and control</td>
<td>Contractors’ Attributes</td>
<td>0.8273</td>
<td>82.73</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Price stability of building materials</td>
<td>Economics &amp; Market Conditions</td>
<td>0.8045</td>
<td>80.45</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Supply stability of building materials</td>
<td>Economics &amp; Market Conditions</td>
<td>0.8045</td>
<td>79.55</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Contractor’s staff and workers</td>
<td>Contractors’ Attributes</td>
<td>0.7909</td>
<td>79.09</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Contractor’s management team</td>
<td>Contractors’ Attributes</td>
<td>0.7818</td>
<td>78.18</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Comprehensiveness of IBS principles in the design</td>
<td>Project/IBS Characteristics</td>
<td>0.7727</td>
<td>77.27</td>
<td>10</td>
</tr>
</tbody>
</table>

It can be concluded that factors related under ‘Project/IBS Characteristics’, ‘Economics and Market Conditions’ and ‘Contractors’ attributes’ are common factors that can influence the construction costs of IBS project. This concurs with Elhag et al.’s (2005) findings that project characteristics-related factors also influence the construction costs followed by contractors’ attributes, and consultant and design parameters. Again, this agrees with other literature where project characteristics-related factors such as project size/ gross floor area is one of the highest determinant factors influencing project costs and is widely used in the construction of cost models (Stoy and Schalcher, 2007; Sonmez, 2004; Seeley, 1996; Ashworth, 1995; Karshenas, 1984).

It can be observed that most of the factors grouped in ‘Project/IBS characteristics’-related factors are regarded as important, illustrating a higher degree of RII index in the IBS construction costs. They are ‘repeatability and standardization’, ‘repeat use of design, mould and construction techniques’, ‘fast track job/speed of construction’, ‘economies of scales’, and ‘comprehensiveness of IBS principles in the design’. Again, this reflects Abd Shukor et al.’s (2011) study of supply chain integration in IBS projects which found that continuous demand and repetition and standardization of works is vital to ensure the sustainability of IBS players in the Malaysian construction industry. Furthermore, ‘Repeatability and standardisation’, ‘repeat use of design and construction techniques’ and ‘comprehensiveness of IBS principles’ are interrelated factors since repeated units in a terrace housing or typical floor plans in a multi-storey building project will apply repeated designs and construction units. Thus, comprehensive principles such as measuring convention, standardization, buildability score, open system etc. must be adhered to in IBS design. This finding also parallels the learning curve theory which suggests that each time the number of repetition doubles, the cumulative production rate (man-hours per unit) declines by a consistent fixed percentage of the previous rate. Meanwhile, economies of scale are defined as the increase in efficiency of production as the number of goods being produced increases. Typically, a company that achieves economies of scale lowers the average cost per unit through increased production
since fixed costs are shared over an increased number of goods. Construction time (fast track job/speed of construction) is also regarded an important influence as it was found significant in ensuring that time and cost performance meet the organisations’ objectives (Kaming et al., 1997).

7. Conclusion

In order to lay the groundwork for cost estimation accuracy, this study sought to discover the major variables affecting construction costs of IBS project and via ranking, to examine the relationship between them. The results reinforce that costs are impacted by ‘Project/IBS characteristics’ and ‘Economics and Market conditions’ and ‘Contractors’ attributes’, above all others.

Of the seven broad categories identified, statistical analyses revealed that there is strong agreement between contractors and manufacturers in the ranking of the cost factor groups; ‘Project/IBS characteristics’, ‘Economics and Market Conditions’, ‘Contractors’ attributes’. Conversely, factors which were grouped under ‘Contract procedures and procurement methods’, ‘Consultants and Design parameters’, ‘External factors’ and ‘Government/Authority requirements’ were proven to have low agreement between the respondents as indicated by a low RII index.

Thus, a major implication of the study is the need for estimators to consider these factors to augment efficacy and accuracy in cost estimation. More fundamentally, the challenge for the estimator is to prioritise various competing factors in addressing the problem of potential cost overruns.

This paper is among the first in Malaysia to suggest that it is the responsibility of entrepreneurs, contractors and estimators to take into account ‘Project/IBS characteristics’-related factors such as repeatability and standardisation, repeat use of design, and ‘Economics and market conditions’-related factors such as the price and supply stability of materials when making costing and strategic decisions at the initial project phase. Besides providing valuable insight into the factors influencing construction costs, specifically from the Malaysian contractors’ perspectives, it seeks to develop a robust conceptual costing mechanism for the construction industry.

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