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## Article

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# Comparative analysis of design/build and design/bid/build project delivery systems in Lebanon

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## Abstract

Design/bid/build and design/build are two principal project delivery systems used worldwide. The performance of each project may differ with the type of procurement system used. This study has two aims: firstly, to assess and compare the performance of design/bid/build and design/build projects in Lebanon; secondly, to compare the results with the performance of equivalent systems in the Far East and the USA, in order to identify the similarities between Lebanon and these countries. Seven performance indicators were identified in terms of cost, time, quality, communication, risk and safety to evaluate the performance of 102 residential buildings and tower projects completed in Lebanon. Means and medians of these performance indicators were compared to identify which delivery system performs better regarding each indicator. The results presented in this study show some agreements between different performance indicators when applied to principal project delivery systems in the selected countries.

**Keywords** Construction management · Project management · Procurement systems · Project delivery systems · Design/bid/build · Design/build

## Introduction

The entire construction process, from the planning of a project through its design and construction, is referred to as the project delivery system. Project delivery systems define the roles and responsibilities of the parties involved in a project and also form an execution framework in terms of the sequencing of design, procurement and construction (Liu et al. 2016). There are various project delivery systems, such as design/bid/build, design/build, construction management agency and construction management at risk. However, a current review of procurement systems used in the construction industry of Lebanon reveals that the traditional DBB and DB are the most commonly used systems.

In the DBB system, client appoints an independent team of consultants on a fee basis, who completely designs the project and prepares tender documentation upon which competitive bids are obtained from the contractors. The

successful tenderer enters into a direct agreement with the client and carries out the work in accordance with the design and specifications under the supervision of the consultants. These systems offer minimal input of contractors to the design process (Ratnasabapathy and Rameezdeen 2006).

The DB project delivery system is the one where the client makes contract with a single entity to perform both design and construction under a single DB contract. Contractually, DB offers the client a single point of responsibility for both design and construction services. The design and construction, either partly or fully, may be performed by a single DB contractor or may be subcontracted to other contractors. In DB, designers work under contractors as one team, and therefore, there is an absence of adversarial relationship between contractors and consultants which is found commonly in DBB projects (Ratnasabapathy and Rameezdeen 2006; Konchar and Sanvido 1998; Ling 2004).

This study was carried out to assess and compare the performance of building projects procured through DBB and DB delivery systems in Lebanon, and find out which system performs better concerning each performance indicator. Moreover, in order to identify the similarities between Lebanon and other countries, the outcomes of this study were compared with the results of other studies conducted in

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Sri Lanka, Singapore, China and the USA that also evaluated the performance of DBB and DB project delivery systems. It is important to compare the performance of projects using these two systems because the strengths and weaknesses of each system may be revealed. With the results at hand, clients and consultants can then decide which procurement system is more suitable for their projects.

## Literature review

The design/bid/build (DBB) and design/build (DB) are the most commonly used procurement methods in many countries. Hence, it will be informative to know what each delivery system constitutes of in order to have a more complete understanding of how to measure the impacts of the delivery system on project performance.

With the development of new technologies and innovative systems in addition to the increasing complexity in buildings, the construction sector required specialization in the design and construction services. Consequently, designers and constructors started to concentrate on the design and construction of specific building systems. This generated the traditional DBB delivery system, which provided clients a sequential ‘design, bid, then build’ approach (Konchar and Sanvido 1998).

However what resulted from the increasing specialization in the design and construction services is that the interaction between the design and construction parties became extremely low and the information was only shared at the end of design and during the construction phase. This led to ineffective designs, increased errors and disputes, higher costs and longer schedules. In the 1970s and 1980s, many clients were unhappy with this traditional approach and they introduced the construction manager to provide information to the designer in order to improve the constructability of designs and reduce schedule durations. After that, substantial efforts by owners to downsize in-house project management manpower, costly disputes between design and construction parties and various levels of owner experience have forced several owners toward single source DB contracting (Konchar, and Sanvido 1998).

Selecting an appropriate delivery system is crucial to the success of any kind of project in construction. Performance of a construction project may differ with the type of delivery system used. Selection of any of the procurement systems to use may depend on how well the project could perform under each system (Ratnasabapathy and Rameezdeen 2006).

Several studies have conducted quantitative analysis to compare the performance of DBB and DB project delivery systems in different countries. Ratnasabapathy and Rameezdeen assessed the performance of DBB and DB projects in Sri Lanka (Ratnasabapathy and Rameezdeen 2006). They

used ‘Analysis of Variance’ (ANOVA) to find out the major differences between the performance of both DBB and DB systems. The indicators considered for comparison are the ones with a statistical significance of  $< 0.05$  (Mendenhall et al. 2013). The outcome of their study showed that the DB projects perform better in certain measures such as cost growth, which is the increase of total project cost based on the initial contract sum. Also, it showed better performance in the schedule growth, which is the increase of total time duration of the project based on the planned time and performance specification followed by the contractor. On the other hand, DBB projects perform better in certain other measures such as interior space, architectural finishes and client’s involvement. The results indicate that in Sri Lanka, DB projects show best performance in terms of cost and time, while quality is better achieved in DBB projects (Ratnasabapathy and Rameezdeen 2006).

Ling and Kerh studied the performance of projects that used the DBB and DB delivery systems in Singapore (Ling and Kerh 2004). Their outcomes show clearly that DB projects performed significantly better than DBB projects in the area delivery speed. In the areas cost and quality, they reported that DBB performed better.

In the USA, Konchar and Sanvido conducted an empirical study that examined explanatory and interacting variables to predict the performance of DB, DBB and construction management at risk projects (Konchar, and Sanvido 1998). That research found that projects using DB delivery could achieve significantly improved cost and schedule advantages, and produce equal and sometimes more desirable quality performance than DBB projects. Park and Kwak investigated DBB and DB projects in the US public transportation (Park and Kwak 2017). They reported that DB seems advantageous to schedule control, while cost advantages of one method over the other are still inconclusive.

Yongqiang and his coworkers investigated DBB and DB projects in Mainland China and analyzed the differences between their project objectives and the differences between the factors that influence the selection of DBB and DB (Yongqiang et al. 2009). The authors indicated that the owner demands higher project quality and less risks in DBB project than in DB project. On the other hand, the weights of meeting or exceeding schedule performance measures and cost performance measures in DB project are higher than in DBB project. Moreover, the requirements for safety in the sites in DB project are also higher than in DBB project.

Chakra and his co-researchers carried out a study to validate the integration among project management knowledge areas in Lebanon (Chakra et al. 2017). This study investigated the degree to which the eight project management knowledge areas of time, cost, quality, scope, human resources, communication, procurement and risk are cross-linked in practice (PMBOK Guide 2013). They reported

that project managers when developing the project management plan for construction projects executed in Lebanon are partially integrating all these areas. Assessing the project management knowledge areas also has an essential role in measuring the performance of project delivery systems in terms of time, cost, quality, communication, safety and risk management. Hence, the results of the study were used as a reference to assess the performance of DBB and DB systems in Lebanon.

## Research methodology

The questionnaire used in the survey conducted by Chakra et al. included 24 questions (Chakra et al. 2017). However, not all those questions are needed in this study. Therefore, the list of questions was filtered in order to limit it to questions that include indicators, which are equivalent to the performance indicators of the four studies mentioned in the literature review. It was found that there are common indicators that measure the performance of construction projects. Table 1 reveals the equivalent eight performance indicators, which are common between the five studies done in Sri Lanka, Singapore, USA, China and Lebanon in terms of time, cost, quality, communication, risk and safety.

## Data collection

The questionnaire survey conducted by Chakra et al. was distributed among 102 projects in different cities in Lebanon (Chakra et al. 2017). However, the projects were selected without specifying the delivery system under which they were procured. Therefore, further analysis was required to define which projects were procured through DB or DBB project delivery system. It was found that among the 102 projects, 60 projects were procured through DBB project delivery system and 42 DB projects. As such, the mean of every performance indicator was calculated from the respondents' perceptions and then used to compare their functioning in DBB and DB project delivery systems in Lebanon. The means of the eight performance indicators listed in Table 1 are presented in Table 2.

## Data analysis

Findings from the five studies are arranged in Table 3. These results were used to compare the performance of DBB and DB delivery systems in the five considered countries in terms of time, cost, quality, communication, risk and safety.

**Table 1** Performance indicators in the Lebanese study with their equivalent performance indicators in other countries

Performance indicators in the Lebanese study		Equivalent performance indicators in other countries
Time	I1: The project execution meets schedule dates as planned (Q1)	Sri Lanka, Singapore, USA: Schedule growth China: Meet or exceed schedule performance measures
Cost	I2: It is common fact that the project expenditure always exceeds the estimated budget (Q5)	Sri Lanka, Singapore, USA: Cost growth China: Meet or exceed cost performance measures
Quality	I3: Regular inspection of work activities is essential in achieving the required quality of the work (Q6)	Sri Lanka: Performance specification followed by the contractor
Quality	I4: Proper storage of materials and equipment has a vital role in project execution (Q12)	Sri Lanka, Singapore: Performance of interior space USA: Interior space and layout
Communication	I5: Project management cares about communicating with project stakeholders (Q14)	Sri Lanka: Efficiency of communication
Risk	I6: The project uncertainties and complexities are clarified in the project scope (Q16)	China: Minimize risk
Safety	I7: Safety standards are taken into consideration to minimize project risks and casualties (Q24)	China: Emphasizing safety in construction

*I* stands for indicator, *Q* stands for the question number (Chakra et al. 2017)

**Table 2** Corresponding mean scores of the performance indicators

Project delivery system	Mean							
	I1	I2	I3	I4	I5	I6	I7	
DBB	3.82	3.37	4.72	3.65	3.87	3.45	4.37	
DB	3.29	3.84	4.09	4.26	4.69	3.88	3.58	

**Table 3** Better performance between DBB and DB project delivery system of the five studies

Indicator		Sri Lanka	Singapore	USA	China	Lebanon
Time	I1	DB	DB	DB	DB	DBB
Cost	I2	DB	DBB	DB	DB	DB
Quality	I3	DB				DBB
Quality	I4	DBB	DBB	DB		DB
Communication	I5	DB				DB
Risk	I6				DBB	DB
Safety	I7				DB	DBB

## Time

The results of the time indicator (I1) show that in Sri Lanka, Singapore, USA and China, DB projects have lower schedule growth; on the other hand, in Lebanon, DBB projects have lower schedule growth. This is because in DBB projects conducted in Lebanon, especially the public projects, professional teams are enrolled in the planning stage to highly define the scope of work. This stage provides a high scope definition when tenders are invited which helps the contractor to get on the job quickly knowing well in advance what is expected. In addition, in DB projects, there are no penalties for late delivery, thus finishing the project on time is not the contractor's priority. As a result, many contractors on DB projects in Lebanon rent their construction equipment during the high season. This practice results in a short supply of equipment and causes the construction process to be delayed. In comparison, the norm in DBB projects is for an agreement containing penalty clauses to be struck with the suppliers at the early stages of the project; therefore, contractors care to finish the project at the specified duration to avoid the penalties for late delivery stated in the contractual agreements.

## Cost

The results presented in Table 3 concerning I2 show that DB projects have lower cost growth in Lebanon just as Sri Lanka, USA and China. This is due to a lower tendency for design changes in DB projects compared to DBB projects. It is believed that the aim of the owners procuring their projects through DB delivery systems is to construct their projects with the lowest cost. In DBB, the owner may request more changes throughout the project; however in DB, the contractor aims to avoid or minimize design changes during construction in order to avoid reworks and additional costs. Additionally, since the DB contractors have control over the design, this allows them to use familiar construction methods and processes, leading to a much more effective construction and better savings.

## Quality

Two indicators were used for the assessment of performance in terms of quality.

### I3: Regular inspection of work activities

Table 3 shows that DBB projects perform better than DB projects in Lebanon. This outcome does not agree with the Sri Lanka study. It is believed that in Lebanese DB projects, direct supervision is conducted by the owner who is generally not an expert in construction. This lack of professional supervision results in a decrease in the quality performance. On the other hand, there is efficient supervision given by the consultants from the initiation to completion of the project when procuring through DBB systems. These consultants are appointed by owners to supervise and monitor contractor's work, and their checks enable these projects to have better quality and fewer defects and problems.

### I4: Proper storage of materials and equipment

With respect to the performance of the interior space, there was an observed agreement between the Lebanese and the US data. However, the data from these 2 countries did not agree with those from Sri Lanka and Singapore. This is due to the fact that, in DB projects, the contractors have sole control over the entire construction site, and hence, the ability to manage the interior space. This enables them to use the whole place to store their materials and equipment more adequately and in a functional way, as they want them.

## Communication

Data from both Lebanon and Sri Lanka support the observation that DB projects perform better in communication. In DBB, there is a complex hierarchy between the various parties involved in the project, which tends to negatively impact the efficiency of communication between these parties. In contrast, communication in DB projects tends to be efficient



and clear. This is because there are fewer parties involved, and hence, direct contact exists between the contractor and the owner.

### Risk

Lebanese DB projects show better performance than DBB projects. However, in China, the results show that DBB projects perform better. In DB projects, the contractors have the responsibility for both construction and design. Hence, all risks of design, management and time slippage or error are borne by the DB contractor. So, they are obliged to clarify the project uncertainties and complexities in the project scope in order to avoid the extra-costs of the risks when they happen. There were no indications why DBB performed better in China. One potential explanation is that most construction projects in China are driven by the government and as such failure to deliver on time could disqualify the contractor from future bids.

### Safety

With respect to safety, DBB projects in Lebanon adhere to the relevant safety regulations more than DB projects. This is because most projects procured through the DBB delivery system do stress on regular inspections during execution to ensure the safety of the construction. In other words, in a DBB system, the contractors are obliged to apply safety rules. However, for DB projects in Lebanon, cost is the main driving factor and as such attention to safety details tends to be compromised in order to meet budgetary constraints.

## Results and discussion

This study was carried out to assess and compare the performance of building projects in Lebanon procured through DBB and DB delivery systems, and to compare the performance of both systems with Sri Lanka, Singapore, China and the US projects procured through a similar route. Seven common performance indicators related to time, cost, quality, communication, risk and safety were identified between the Lebanese study and the other four studies. These indicators were used to assess the performance of the different project delivery systems.

The outcomes of this study clearly show that the Lebanese DBB projects perform better in terms of time, regular inspection of work activities and safety. However, DB projects have better performance in terms of cost, proper storage of materials and equipment, communication and risk.

## Conclusions

The findings presented in this study are important in a way that they provide valuable references for the Lebanese owners in choosing the appropriate project delivery system. It is recommended that in Lebanon, for projects to be completed and delivered at a specific time, the owner should select the DBB project delivery system. This system involves a comprehensive planning at the beginning of the construction period in order to achieve the specified completion time. In addition, there will be more focus on the completion time from the contractor to avoid the penalties for late delivery stated in the contractual agreements.

Clients aiming to construct projects with a lower cost growth, they must go to DB delivery system. In this system, the owner makes an agreement with the contractor on a fixed price and any other extra-costs. Furthermore, when owners need to construct projects that may face a lot of risks, it is recommended to select the DB delivery system since most of the risks in this system are borne by the contractor.

The second part of this study was to compare the results from Lebanon with the results from the USA and the Far East in order to identify the similarities between Lebanon and these countries. It can be concluded that the performance of procurement methods in terms of cost and quality between Lebanon and these countries is fairly consistent. This gives a chance for Lebanese investors to invest in such countries using the same delivery system they are familiar with as they achieve the same results, since these countries use equivalent methods and specifications for their projects. Similarly, contractors from these countries can have the opportunity to procure projects in Lebanon following the same delivery systems they use in their countries and with the same outcome.

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