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Impact of project procurement systems on performance of Rwandan building construction projects

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Abstract: Delivering a construction project successfully is associated with the procurement system used. In other words, the selection of the appropriate system can guarantee the success of the construction project. Therefore, this paper evaluated and compared the effects of the most-utilised project procurement systems on the key performance criteria in the Rwandan building construction projects such as time, cost, quality and scope. A questionnaire survey was conducted among contractors, consultants and clients, and a total of 73 questionnaires were used for the analysis. The survey results, analysed by using statistic method, discovered that the traditional procurement system of design-bid-build (DBB) is the most-employed system in Rwanda. Also, it was revealed that in the Rwandan building construction industry, the construction management (CM) system was identified as a system that performs better for more objectives than others. Specifically, the results showed that owner direct force (ODF) is suitable for cost effectiveness, design and build (DB) system is better for time performance, and CM performs better for both scope and quality achievement. This study will facilitate Rwandan construction practitioners to be able to choose the appropriate option that suits the main objectives of their projects in order to reduce risks resulting from the use of unrelated procurement systems.

Keywords: procurement systems, performance, building construction projects, project objectives, Rwanda

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1 Introduction

Construction industry is a complex and dynamic field that encompasses a plethora of activities such as planning, designing and construction (Mohd et al. 2014). In this context, project procurement systems are very much concerned since they are regarded as the organisational structure needed to organise and manage those activities required to achieve a successful outcome of a construction project with necessary guidance and support (Chandrasekhar and Mahaboobali 2017). Furthermore, the project procurement systems should be related to the project objectives and constraints, and also to the scope or the portion of the project tasks such as design, construction and finance assigned to the contractor in order to deliver a successful project (Tarek 2002).

There are several systems that can be used in the procurement of construction works, and they can be summarised under three broad sections based on the relationship and interaction between design and construction responsibilities (Masterman 2002; Tarek 2002). The first is the separated system, which uses a traditional approach. This system separates the designing and construction responsibilities, whereby the works are carried by different firms of designers and contractors (Abdul Rashid et al. 2006). Owner direct force (ODF) and general contractors mostly known as design-bid-build (DBB) belong to this category. The second is the integrated system known as design and build (DB), which can be divided into package deal, turnkey and develop and construct. This method is a parallel or single responsibility procurement system, which combines the responsibilities of designing and constructing the project, as its name implies (Ashworth 2001). The third is the management oriented system, which is comprised of management contracting and construction management (CM). This method integrates management with the design and construction of the project, and accordingly, the management of both design and construction is

contracted out to a contractor who acts as a management consultant on behalf of the client (Rosli et al. 2006).

The construction industry in Rwanda was initially developed using the models of French and Belgian systems as a basis, when Belgium was the ruling colonial power. After the Tutsi genocide of 1994, the industry began to incorporate styles of various other countries, such as the UK and East African countries. The traditional system has remained a popular procurement method used to deliver Rwandan construction projects till now and it is expected that it would probably continue to be the most dominant (Musoni et al. 2020).

Similar to the other developing countries, Rwanda, an eastern African country, despite its construction industry boom, faces several inadequacies or shortcomings so far as the companies operating within this industry are concerned, and these mostly fall under one or more of the following categories: failure to deliver projects on time, failure to fulfil the project within the framework of the budget outlined prior to the time of the project's commencement (i.e. exceeding initial cost estimations), failure to meet the required or expected quality standards, or otherwise failing to meet client requirements for ensuring successful project performance. It has been observed that these failures, to a large extent, arise from a lack of knowledge about: (i) the effects that choosing different procurement systems have on the timely and effective accomplishment of various objectives; and (ii) the means that can be used for ascertaining which procurement system should be chosen, given a set of objectives. A lack of knowledge on these factors is associated with multiple risks (Musoni et al. 2020). According to the findings of Musirikare and Kure (2016), 65.7% of public construction projects was concentrated in only one district of the capital city of Rwanda, while 5.2% of these projects encountered cost overruns during 2012–2015. The Rwandan annual report of 2018 revealed that building construction projects were among the two types of projects that experienced significant delays, attendant with the associated effects. Furthermore, the use of inappropriate procurement systems has also been recently reported as one of the causes of delays and scope creep occurrence in building construction projects in Rwanda (Umuhoza and An 2019; Umuhoza et al. 2021). However, there is insufficient information about how various procurement systems influence the key performance criteria of building construction projects in Rwanda, namely, time, cost, quality and scope.

The aim of this study is therefore to assess the usage of three types of procurement systems that are commonly used in Rwanda: the traditional system, which is comprised of ODF and DBB, and the DB and CM systems. Afterwards, it compares how these procurement systems affect the key project constraints of Rwandan building construction projects' performance, namely, time, cost, quality and scope. To our knowledge, especially as far as the Rwandan building construction industry is concerned, such a comparison has not been carried out in previous studies of project procurement systems. Therefore, this study will increase the ability of construction practitioners to determine the appropriate procurement system for their project in Rwanda and in other countries with the same conditions.

2 Literature review

2.1 The key project performance criteria with their indicators, and the effects of certain project procurement methods

This section presents a review of the previous studies that have dealt with the influence of project procurement systems on the key project constraints and their indicators in various countries.

It is widely accepted view that, at a minimum, key constraints of construction project performance are time, cost and quality (Barkley and Saylor 1994). However, Yates and Eskander (2002) remarked that four key criteria must be used in measuring project performance; and according to the view expounded in their study, a successful project has to be completed within the scheduled time, within budget and within scope, and should satisfy the relevant quality requirements. Since these requirements are needed to be simultaneously satisfied, with the effort made towards the fulfilment of one of these not impeding the achievement of any of the others, they constitute the primary paradox of project management (Caccamese and Bragantini 2012). Therefore, based on the previous studies, this study also adopted four attributes – namely, time, cost, quality and scope – as the project performance criteria.

Oladinrin et al. (2013) assessed the effects of selected procurement systems – namely, CM, DB, management contracting and traditional procurement system – on the project's cost and quality in 76 building projects in Nigeria. The measurement indicators used for cost were delay costs, claims costs, contingencies costs, cost related to environmental issues, cost related to insurance, legal costs, managerial cost, variation between contract sum

and final account, variation in design/change orders, retention and rework; and the indicators used for quality were adherence and compliance with specification, competence of contractor and his team, inconsistency of variation and change orders, insistence on specification, major variation between original design and the actual completed work, material test, number of rework, number of variation, and supervision of works. The results revealed that the traditional procurement system was the most-employed option in executing projects in Nigeria. Thus, the DB system performed better in terms of cost, while the CM system was identified as the most suitable system whenever quality was the most prioritised objective. Based on these results, it was discovered that none of the selected procurement systems is the best for all the performance assessment criteria; instead, one can be better than the other against a specific performance criteria. This is in agreement with Abdul Rashid et al. (2016), who stated that each procurement system possesses its own peculiarity that will provide a different impact on the critical parameters of project performance, i.e. time, cost and quality.

A study by Ling et al. (2001) compared the performance of DB and DBB procurement systems in Singapore and Australia. The criteria to gauge the performance were: aesthetic quality, workmanship quality, physical construction time, total development time, timeliness of completion, and costs. The results of the Analysis of variance (ANOVA) showed that DB project time and cost performance in the two countries were not significantly different. Also, Singapore and Australian architects revealed the aesthetic quality and workmanship quality of DB projects to be lower than those of DBB projects. This is consistent with the studies of Hogg and Morledge (1995) and Smith et al. (1992), which revealed that the nature of DB projects resulted in a failure to achieve high quality. Therefore, the DB system is used to simultaneously meet the owner's requirements and reduce the contractor's cost. Under this system, since they are motivated to submit the lowest bid, the contractors are incentivised to lower quality, which would enable them to achieve more savings in costs together with completion of the defined scope of the work. Thus, financial pressure would take the precedence over the project's quality standards.

Through a survey research, Sanvido et al. (1997) evaluated the cost, schedule and quality performance of US building projects that used CM at risk, DB and DBB project delivery systems. The metrics used for schedule performance were construction speed, delivery speed and schedule growth, while cost metrics were cost unit, cost growth and intensity; and quality metrics were start up; call backs; operation and maintenance; envelope, roof, structure and foundation; interior space and layout environment; and process equipment and layout. According to the results, the DB project delivery system achieved significantly improved cost and schedule advantages. Also, it was indicated that usage of this system yielded a better-quality performance than DBB projects and CM at risk.

Alhazmi and McCaffer (2000) conducted a survey on the performance of a project procurement system selection model in Saudi Arabia and it was revealed that Saudi public clients selected DB as the most appropriate procurement system for their project with an overall priority of 0.496. The model assisted in choosing the procurement system that would ideally fulfil their needs, and it consisted of various key criteria including cost, time and quality. Metrics used to measure cost were capital cost, maintenance cost, prequalification cost, cost overrun and reduction of financial risk. Metrics used to measure time were construction time, the early start of construction activity, planning and designing time, rapid response to new client needs, minimisation of activities interference, speed of construction, and time overruns. Metrics used to measure quality were design reliability and durability, design innovation, building systems guarantees, suitability of the intended uses, flexibility, and aesthetic appearance of the building.

Alaeddin and Nuhu (2016) assess the impact of DBB procurement methods on project performance in Libya and revealed that 11 out of its 12 common selection criteria exhibit a significant contribution to one or more project performance criteria, namely, time, cost and quality. The criteria highlighted as a best measure for one or more criteria were high price completion, clarity of scope definition, complexity of design, high quality level, clear definition for project parties' responsibilities, client involvement, controllable project variations, cost certainty, organising and reviewing, project planning and project functionality.

Ghulam and Noel (2015) compared the performance evaluations of DB and traditional procurement systems for highway projects in Afghanistan and ascertained that DB was a superior option in terms of time performance, while it performed poorly in cost saving compared to the traditional procurement system. However, both the systems were identified as suitable in terms of quality performance. The quality variables used were in conformity with the applicable standards and specifications, and using these, it was possible to ensure compliance with warranty provisions as well as expectations as to the aesthetic quality of the workmanship, and thereby achieve

overall client satisfaction. Cost saving and cost overrun were used as the main measurement metrics for cost, while, similarly, time saving and time overrun were used as the key measurements for time.

Luis et al. (1999) evaluated the improvement of the procurement process used in construction projects, where the potential performance indicators for the procurement process were identified as cycle times, event indicators, management indicators, cost indicators and referential values. For cost indicators, these were number of drops to ground and month, number of days in warehouse and in delivery, number of rules and of possible fiscal credits, number of repairs, number of special transport and time until release of container. The results indicated that the main problem of procurement is related to schedule delays and lack of specified quality for the project.

The study of Ameyaw (2009) evaluated the performance of the traditional DBB and DB procurement methods in Ghana and the findings indicated that, while a sizeable portion of DB projects are completed within their respective estimated durations and budgets, a greater number of DBB projects do incur time and cost overruns due to variation and price fluctuations. On the other hand, there is significant difference between the qualities of completed projects executed under the two project delivery methods.

Ron (2012) studied the changing of construction procurement culture to improve project outcomes and highlighted that construction projects need to be delivered on time, within the budget and in adherence with the applicable quality standard, but also need to meet the client requirement or agreed scope of work. Project Management Institute (2013) revealed the key components of scope management as defined project scope, set manageable requirements, control scope related risks such as scope change and scope creep, and a detailed identification of the scope involved using the trifurcation of scope into flexible, fixed and interfered scope.

Several previous studies have evaluated the influence of project procurement systems on the three key project constrains/performance criteria of time, cost and quality. However, the criteria have to be adjusted to reflect the most current attributes while executing projects in different countries. Accordingly, in this paper, the four project performance criteria of time, cost, quality and scope are utilised, since these have been extensively reported as the key factors determining the success or failure of construction projects (Yates and Eskander 2002). In addition, based on the above literature review, we are able to ascertain that the respective various effects that the choice of procurement system have on the different criteria vary from country to country, probably due to the disparity in the environment of their construction projects. Therefore, a gap emerges in the literature dealing with Rwandan construction projects, calling for the need to evaluate the influence of the various procurement systems on the mentioned key performance criteria: Finally, given the fact that there is a paucity in studies dealing with the evaluation of procurement systems' effects on the measurement indicators associated with the mentioned key performance criteria, in formulating the list of the indicators corresponding to each criterion (for which an evaluation is proposed to be made), some indicators that are particularly compatible with the Rwandan construction industry were selected from several studies, adequately having the required type of content, that were identified based on a review of the literature and on experts' opinions, as shown in Table 1.

3 Methodology

This study was carried out through a survey questionnaire to identify the views of key construction professionals about the influence of the most-utilised procurement systems – namely, ODF, DBB, DB and CM – on the building construction project performance in Rwanda. The measures of performance used were time, cost, quality and scope. A total of four performance criteria, including time, cost and quality and together with their 35 performance indicators, were highlighted based on the results gleaned from the literature review undertaken.

3.1 Sample size

The sample size was ascertained by employing formula of Taro Yamane (1973), which is utilised in reckoning the sample size when the number of a target population is known.

According to Yamane (1973):

$$n = \frac{N}{[1+(Ne^2)]} \tag{1}$$

where n = sample size, N = target population, e = error limit, and the error limit of 0.05 was used based on a 95% confidence level.

Therefore, $n = 90/[1 + 90(0.05)^2]$, and thus, $n = 73.4$.

A sample size of 74 respondents was adopted within an error limit of 5%. Only those participants who had been attending a university with ≥5 years of experience, who are familiar with the construction industry in Rwanda and

Tab. 1: Summary of previous studies on the key performance criteria and their indicators that have been used for evaluating the effects of procurement systems on project performance

Performance criteria and their indicators	Previous studies														
	Smith et al. (1992)	Barkley and Saylor (1994)	Hogg and Morledge (1995)	Sanvido et al. (1997)	Luis et al. (1999)	Alhazmi and McCaffer (2000)	Ling et al. (2001)	Yates and Eskander (2002)	Ameyaw (2009)	Oladinrin et al.(2013)	Caccames and Bragantini (2012)	Project management institute (2013)	Ghulam and Noel (2015)	Abdul Rashid et al.(2016)	Alaeddin &Nuhu (2016)
Criteria															
A. Time		✓	✓	✓	✓	✓		✓	✓		✓		✓	✓	✓
B. Cost		✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓
C. Quality		✓		✓		✓	✓			✓	✓		✓	✓	✓
D. Scope	✓		✓									✓			✓
A. Time related indicators															
1. Less compensable time of delays				✓							✓				
2. Time overruns control during construction						✓								✓	
3. Time saving						✓									
4. Rapid response to new order change				✓		✓									✓
5. Fast track construction															
6. Early start of construction						✓			✓						
7. Meeting scheduled time															
B. Cost related indicators															
1. Compensable costs										✓					
2. Contingency costs										✓					
3. Legal costs										✓					
4. Dispute and claim costs										✓					
5. Cost of insurance															
6. Cost of environmental issue										✓					
7. Managerial costs						✓				✓					
8. Reworks costs						✓				✓					
9. Maintenance costs						✓									
10. Change orders costs										✓					
11. Cost saving	✓		✓									✓			
12. Reduction of financial risks						✓	✓							✓	✓
C. Quality related indicators															
1. Compliance with specification									✓					✓	
2. Competence of project team									✓						
3. Change control									✓						
4. Material tests									✓						
5. Training and incentives for labour personnel						✓			✓						
6. Supervision of work									✓						
7. Flexibility for innovation and new systems									✓						
8. Construction durability								✓	✓						
9. Appearance of the building								✓	✓	✓					
D. Scope related indicators															
1. Meeting defined project scope	✓		✓									✓			✓
2. Scope change control												✓			✓
3. Scope creep and gold-plating control												✓			
4. Set manageable requirement												✓			
5. Flexible scope of work												✓			
6. Fixed scope of work												✓			
7. Activities interference minimisation												✓			

who are considered reputable professionals were chosen. The participants comprising this study were clients, consultants and contractors having experience concerning various procurement systems, especially in the four most-utilised systems in Rwanda. They were chosen through purposive sampling technique in order to gather the data needed for the study. In order to obtain an appropriate sample size, 100 questionnaires were forwarded to the respondents. Out of the 100 questionnaires that were administered and sent through email, 73 questionnaires were received back as suitable for the analysis, signifying a response rate of 73%.

3.2 Questionnaire structure

In order to ensure the reliability of the responses obtained for the questionnaire, and to verify the degree up to which these responses are in compliance with the research aim, the survey questionnaire was divided into two main sections. The first section of the questionnaire shows the background information of the respondents (organisation category, respondents' position and years of experience), the type and size of the projects that are mostly executed, and the level of awareness concerning project procurement systems and their utility. The second section, firstly, dealt with rating the usage of the project procurement system using a 5-point Likert scale (1 – never, 2 – rare, 3 – sometimes, 4 – very often and 5 – always); and secondly, the effect of each procurement system on performance criteria and indicators was evaluated, likewise, using a 5-point Likert scale as follows: 1 – very low effect, 2 – low effect, 3 – medium effect, 4 – high effect and 5 – very high effect.

3.3 Reliability and validity of the data

Cronbach's α is one of the most-utilised methods for evaluating the inter-correlations among test items, which is known as an internal consistency estimate of the reliability of the test scores. If the Cronbach's α is >0.9, the internal consistency is considered excellent, while $0.8 < \alpha > 0.9$ is good, and $0.7 < \alpha > 0.8$ is still acceptable (Tavakol and Dennich 2011). In this study, the Cronbach's α coefficients of 0.880, 0.928, 0.910, 0.968 and 0.960 were obtained from the data concerning the usage levels of the four most-utilised delivery methods in Rwanda, the effect of ODF on performance criteria and indicators, the effect of DBB on performance criteria and indicators, the effect of DB on performance criteria and indicators, and the effect of CM on performance criteria and indicators, respectively. Therefore, the acceptable reliability was obtained as shown in Table 2. Additionally, a research methodology appropriate to the research aim and objectives was employed in order to achieve valid and reliable results.

3.4 Data analysis

Data obtained from the respondents were analysed using Statistical package for the social sciences (SPSS) IBM SPSS Statistics 22 (manufactured by HYPERLINK "https://en.wikipedia.org/wiki/Norman_H._Nie" Norman H. Nie, Dale H. Bent, C. Hadlai Hull, Stanford, USA) after screening for data entry errors in Microsoft Excel. After verifying the reliability of the data, the mean scores (MS) based on the 5-point Likert scale and ranks (R) were calculated to determine the level of influence that the choice of project procurement systems exerted on the project performance. scores (MS).

The first section of the demographic information presented in Table 3 shows the frequency of survey responses from participants according to the years of experience, qualification of the respondents, organisation category, position, the type and size details corresponding to the most-performed project, and awareness of project delivery methods. Only those with >5 years of experience were selected as respondents for the survey, in order to ensure that the chosen individuals would have

Tab. 2: Reliability of the data

Characteristic	Cronbach's α	Reliability
(1) Level of usage of four most-utilised procurement systems in Rwanda	0.880	Good
(2) Effect of ODF on performance indicators	0.928	Excellent
(3) Effect of DBB on performance indicators.	0.910	Excellent
(4) Effect of DB on performance indicators	0.968	Excellent
(5) Effect of CM on performance indicators	0.960	Excellent

CM, construction management; DB, design and build; DBB, design-bid-build; ODF, owner direct force.

Tab. 3: Respondents' backgrounds

Demographic table	No. of respondents	Percentage (%)
Years of experience		
5 years	44	60.3
6–10 years	23	31.5
11–15 years	5	6.8
≥16 years	1	1.4
Qualification		
Undergraduate	60	82.2
Master's	12	16.4
PhD	1	1.4
Organisation category		
Design consultants	29	39.7
General contractors	27	37
Client	17	23.3
Position		
Project manager	10	13.7
Architect	12	16.4
Engineer	20	27.4
Quantity surveyor	9	12.3
Owner	22	30.2
Type of project mostly performed		
Residential construction	29	39.7
Commercial construction	18	24.7
Institutional construction	24	32.9
Industrial construction	2	2.7
Project size		
Small	27	37
Medium	43	58.9
Large	3	4.1
Awareness of project delivery method		
ODF	15	20.5
DBB	24	32.9
DB	12	16.4
Package deal	2	2.7
Turnkey	2	2.7
Develop and construct	1	1.4
CM	13	17.8
Management contracting	2	2.7
Design and manage	2	2.7
Total of questionnaires sent		100
Total of questionnaires received		73
Percentage of respondents		73%

CM, construction management; DB, design

adequate knowledge-sharing capabilities. The respondents were classified as persons with 5 years, 5–11 years, 10–15 years and >16 years of working experience, and their rates were 60.3%, 31.5%, 6.8% and 1.4%, respectively. In addition, the responses have been gleaned from a variety of organisation categories, such as contractors (37%), consultants (39.7%) and owners (23.3%); and the respondents' positions were, variously, project manager (13.7%), architect (16.4%), engineer (27.4), quantity surveyor (12.3%) and owner (13.2%). This ensures that the obtained responses represent diverse views from the key construction participants and that it implies a fair distribution of the questionnaire. Particularly, large groups of the respondents, accounting for 39.7% and 58.9% of the survey size, mostly performed residential construction and medium sized projects, respectively. Subsequently, the respondents revealed that from a total of 12 project procurement systems, only four – namely ODF (20.5%), general contractors (32.9%), DB (16.4%) and CM (17.8%) – were identified as forming part of the most popular method. This implies that these four systems are mostly known in Rwanda because they are probably more patronised than others.

4 Results

This section evaluated the perceptions of project parties, namely, contractors, consultants and clients, on the usage levels of the four most-popular project procurement systems in vogue in building construction projects in Rwanda. Table 4 lists the MS of the four project procurement systems according to their usage levels. Also, Tables 5–8 list and rank the influence level on the project performance, and the analysis incorporates the use of four performance criteria with their 36 indicators. It is important to note that the results obtained pursuant to this analysis are generalisable only to the Rwandan construction industry and the construction industries of other countries having similar conditions.

4.1 Usage level of most known project procurement methods in Rwanda

From Table 4 that assessed the usage levels of project procurement systems in Rwandan building construction projects, it is ascertained that the general contractor system ranked highest, with a mean score of 4.36. This

Tab. 4: Current status concerning the usage level of project procurement systems in building construction projects in Rwanda

Level of usage	ODF	DBB	DB	CM
MS	4.03	4.36	3.22	1.49

CM, construction management; DB, design and build; DBB, design-bid-build; MS, mean scores; ODF, owner direct force.

was followed by the ODF, DB and CM systems, with the MS of 4.03, 3.22 and 1.49, respectively. This means that DBB is the most popular and utilised method, while CM is the least utilised system. This is probably due to the fact that, among the four popular systems for project procurement prevalent in Rwanda, a low awareness level prevails concerning DBB, as can be confirmed from Table 3.

4.2 Influence level of project procurement systems on four building project performance criteria and their indicators

Tables 5–8 show MS and ranks for the influence levels of four selected project procurement systems marked by a higher awareness level than others, namely, ODF, general contractor, DB and CM, on the key project performance criteria such as time, cost, quality and scope and their 36 indicators. Each method was individually assessed under the four performance criteria together with their 36 indicators. The MS were used to measure the influence levels on all four performance criteria and their 36 indicators, and according to the methodology formulated for the analysis, it would be inferred that a system with the highest mean score on a particular criterion or indicator implies that it performs better with respect to that criterion or indicator and vice versa.

4.2.1 Influence level of procurement systems on time performance

From the results shown in Table 5, we infer that the DB system ranked the first according to the influence level on time performance, with a mean score of 3.92. Construction management ranked the second with a mean score of 3.75. DBB ranked the third with a mean score of 2.95. ODF ranked the least in influencing time performance, with a mean score of 2.72. The five time-related indicators where the ODF system performed better are less compensable time of delays (3.14), early start of construction (3.08), time overrun control during construction (3.04), rapid response to new orders and changes (2.99) and time saving (2.45), while the highest effects of the DBB system are found in meeting scheduled time (3.41), early start of construction (3.08), time overrun control during construction (3.08), compensable time of delays (3.00) and fast track construction (2.90). For the DB system, the five major indicators with the highest rankings are compensable time of delays (4.63), meeting scheduled time (4.22), fast track construction (4.18), early start of construction (3.08) and time saving (3.63). For the CM system, the highest influence is found in the indicators of compensable time of delays (4.45), fast track construction (4.01), time overrun control during construction (3.39), time saving (3.63) and meeting scheduled time (4.49).

4.2.2 Influence level of procurement systems on cost performance

As can be observed from Table 6, the analysis concerning the influence level of project procurement systems on the cost performance criterion based on the average of its indicators' MS show that the ODF method has the highest influence with a mean score of 4.18. This is followed by CM, DBB and DB with the MS of 4.12, 4.07 and 3.32, respectively. On the other hand, when considering the top five cost-related indicators with the highest influence level of each of the project delivery methods, ODF showed the highest influence on cost saving, rework cost, managerial cost, legal costs and change order costs with the MS of 4.63, 4.65, 4.59, 4.41 and 4.37, respectively. General contractor

Tab. 5: Influence level of procurement systems on time performance

Performance criteria	MS of project procurement systems' influence level				Rank			
	ODF	DBB	DB	CM	ODF	GC	DB	CM
Time-related	**2.72**	**2.95**	**3.92**	**3.75**	**4**	**3**	**1**	**2**
1. Less compensable time of delays	3.14	3.00	4.63	4.45	1	4	1	1
2. Time overruns control during construction	3.04	3.08	3.34	3.93	3	3	7	3
3. Time saving	2.45	2.37	3.63	3.63	5	7	5	4
4. Rapid response to new order or change	2.99	2.82	3.41	3.38	4	6	6	7
5. Fast track construction	1.97	2.90	4.18	4.01	7	5	3	2
6. Early start of construction	3.08	3.08	4.04	3.38	2	2	4	6
7. Meeting scheduled time	2.37	3.41	4.22	3.49	6	1	2	5

CM, construction management; DB, design and build; DBB, design-bid-build; GC, General contractors; MS, mean scores; ODF, owner direct force.

Tab 6: Influence level of procurement systems on cost performance

Performance criteria	MS of project procurement systems' influence level				Rank			
	ODF	DBB	DB	CM	ODF	GC	DB	CM
Cost-related	**4.18**	**4.07**	**3.32**	**4.12**	**1**	**3**	**4**	**2**
1. Compensable costs	3.92	3.54	3.51	3.53	11	11	5	11
2. Contingency costs	4.15	3.82	3.11	4.63	6	9	8	2
3. Legal costs	4.41	4.00	3.00	4.04	4	6	9	7
4. Dispute and claims costs	4.04	4.00	2.86	4.04	8	7	11	6
5. Costs of insurance	3.37	3.33	3.37	3.37	12	12	7	12
6. Cost of environmental issues	4.00	4.51	2.44	4.59	9	3	12	3
7. Managerial costs (consultancies)	4.59	3.88	3.00	4.00	3	10	10	9
8. Reworks costs	4.65	4.59	4.01	4.64	2	2	1	1
9. Maintenance costs	4.10	4.29	3.41	4.41	7	5	6	4
10. Change orders costs	4.37	4.37	3.58	4.37	5	4	4	5
11. Cost saving	4.63	4.55	3.86	3.78	1	1	2	10
12. Reduction of financial risk	4.00	3.96	3.67	4.00	10	8	3	8

CM, construction management; DB, design and build; DBB, design-bid-build; GC, General contractors; MS, mean scores; ODF, owner direct force.

Tab. 7: Influence level of procurement systems on quality performance

Performance criteria	MS of project procurement systems' influence level				Rank			
	ODF	DBB	DB	CM	ODF	GC	DB	CM
Quality-related	**2.86**	**3.02**	**4.09**	**4.11**	**4**	**3**	**2**	**1**
1. Compliance with specification	3.63	3.60	4.26	4.34	2	2	5	5
2. Competence of project team	2.16	3.63	4.30	4.95	8	1	4	1
3. Change control	2.68	3.00	3.55	3.38	5	5	9	9
4. Material tests	4.26	3.03	4.32	4.37	1	4	3	4
5. Training and incentives to labours	2.97	2.40	3.93	3.39	4	8	6	8
6. Supervision of wok	2.42	3.55	4.53	4.63	7	3	2	2
7. Flexibility for innovation and new systems	2.00	2.37	4.59	4.63	9	9	1	3
8. Construction durability	2.59	2.63	3.95	4.25	6	7	7	6
9. Appearance of the building	3.00	3.00	3.36	3.41	3	6	8	7

CM, construction management; DB, design and build; DBB, design-bid-build; GC, General contractors; MS, mean scores; ODF, owner direct force.

Tab. 8: Influence level of procurement systems on scope performance

Performance criteria	MS of project procurement systems' influence level				Rank			
	ODF	DBB	DB	CM	ODF	GC	DB	CM
Scope-related	**2.79**	**2.72**	**3.97**	**4.08**	**3**	**4**	**2**	**1**
1. Meeting-defined project scope	2.42	3.05	4.19	4.47	5	3	3	1
2. Scope change control	3.15	3.49	4.25	4.33	3	2	1	2
3. Scope creep and gold plating (adding or altering features) control	2.42	2.00	3.92	4.04	6	7	4	5
4. Set manageable requirements	2.63	2.52	4.00	4.21	4	4	5	3
5. Flexible scope of work	3.45	2.00	3.70	3.79	1	6	6	6
6. Fixed scope of work	2.18	3.63	4.19	4.15	7	1	2	4
7. Activities interference minimisation	3.26	2.37	3.52	3.60	2	5	7	7

CM, construction management; DB, design and build; DBB, design-bid-build; GC, General contractors; MS, mean scores; ODF, owner direct force.

indicated the most significant effects on rework costs, cost saving, cost of environmental issues, change order costs and maintenance costs with the MS of 4.59, 4.55, 4.51, 4.37 and 4.29, respectively. For the DB system, the indicators with peak influence level are rework costs, cost saving, reduction of financial risks, change order costs and compensable costs with the MS of 4.01, 3.82, 3.67, 3.58 and 3.51, respectively. The top five indicators where the CM system performs better are managerial costs, contingency costs, costs of environmental issues, maintenance costs and change order costs with the MS of 4.64, 4.63, 4.59, 4.41 and 4.37, respectively.

4.2.3 Influence level of procurement systems on quality performance

From the results highlighted in Table 7, it is observed that CM showed the highest mean score (4.11). This was followed by DB, DBB and ODF with the MS of 4.09, 3.02 and 2.86, respectively. The major five quality related indicators according to the influence level of the ODF method are material tests (4.26), compliance with specification (3.63), appearance of the building (3.00), training and incentives to labours (2.97) and change control (2.68). According to the influence level of the general contractor method, the arrangement of the factors would be competence of project team (4.30), compliance with specification (3.60), supervision of work (3.55), material tests (3.03) and change control (3.00). For the DB method, the significant influences were found in flexibility for innovation and new systems (4.59), supervision of work (4.53), material tests (4.32), competence of project team (4.30) and compliance with specification (4.26). The highest impacts of the CM system were demonstrated in competence of project team (4.95), supervision of work (4.63), flexibility for innovation and new systems (4.63), material tests (4.37) and compliance with specification (4.34).

4.2.4 Influence level of procurement systems on scope performance

From the results indicated in Table 8, we observe that CM has the highest mean score of 4.08, which is followed by DB, ODF and DBB with the MS of 3.97, 3.79 and 3.72, respectively. Also, according to the top five scope related indicators with significant impacts of project procurement systems, flexible scope of work ranked the first as the scope related indicator with respect to the influence level of the ODF system with the mean score of 3.45, followed by activities interference minimisation, scope change control, set manageable requirements and meeting defined project scope with the MS of 3.26, 3.15, 2.63 and 2.42, respectively. Fixed scope of work ranked the first with respect to the influence level of the DBB system with a mean score of 3.63, scope change control ranked the second with a mean score of 3.49, meeting defined project scope ranked the third with a mean score of 3.05, set manageable requirements ranked the fourth with a mean score of 2.52 and activities interference minimisation ranked the fifth with a mean score of 2.37. For the DB system, the peak ranking with high influence was found in scope change control with a mean score of 4.25, followed by fixed scope of work, meeting defined project scope, scope creep and gold plating control, and set manageable requirements with the MS of 4.19, 4.19, 4.00, and 3.92, respectively. According to the influence level of CM, meeting defined project scope, scope change control, set manageable requirements, fixed scope of work, and scope creep and gold plating control were indicated as the scope related indicators, where these were ascertained to be the most suitable systems with the MS of 4.47, 4.33, 4.21, 4.15, and 4.04, respectively.

Based on the above results, it can be seen that ODF and DB are the most suitable procurement systems whenever cost and time become the most prioritised objective, respectively. On the other hand, CM performs better when quality and scope criteria are the main objective of building construction projects in Rwanda.

5 Discussion of the results

The following discussion focusses on the results obtained for the usage level of project delivery methods and indicate whether there are significant impacts of procurement systems on key project performance criteria in Rwanda. Table 3 showed that among the most popular project procurement systems in Rwanda, DBB was selected as the most frequently used system. This is probably attributable to its long existence and a lack of adequate knowledge about alternative systems in the Rwandan construction industry.

Despite that, it is worthwhile to note that the use of the CM system in the Rwandan building construction project shows a positive influence on quality and scope by causing the project to meet the required quality and defined scope as shown in Tables 7 and 8. This is probably due to the fact that this system can utilise advanced management skills, which are needed for attaining a lot of the project's objectives that other systems do not use. Additionally, this

study has discovered that ODF's high level of influence on cost effectiveness by enabling the projects to be completed within the estimated budget results in a favourable situation wherein all the sources of loss and expenses become easily minimised, thereby metamorphosing the possibility for meeting budgets into a concrete, pragmatic development. This is possibly due to the fact that in the Rwandan construction industry, when using this system, all the cost burden is borne by the clients, and since the project's purpose is to maximise profit as much as possible, this method allows room for clients to involve in the project's activities as much as they wish to. Additionally, it was ascertained that, in the Rwandan construction business scenario, the DB method satisfies construction practitioners the most whenever time is the prioritised objective, by giving a chance to complete the project within the estimated time. This may be in the line with the advantage of this method for Rwandan projects, whereby this system can reduce construction time by overlapping some phases such as design and construction. Also, it can facilitate more convenient coordination between design and construction – since all the activities are assigned to one company, changes can be implemented in an easier manner and without any attendant delays.

Based on the above discussion, we may infer that the influence level of procurement systems on key performance criteria may vary from criterion to criterion, and the same may be said for the indicators. It is therefore recommended to check also the influence level of different systems for each criterion's indicators in the results section in order to obtain detailed information about which system would perform better for any criterion and indicator, so that the clients can choose the right system according to their most favourable criteria and indicators – because a certain criteria or indicator can be an important requirement for a particular client. Finally, the result obtained from this study is not capable of being generalised to all construction industries, since the influence level of procurement systems may vary from country to country due to the differences in the environment characterising the various countries' construction industries.

6 Conclusions

This study firstly attempted to examine the awareness of respondents about various types of project procurement systems. Afterwards, the selected systems were also assessed for their usage levels. Finally, the study evaluated the influence levels of the four most-known systems on cost, time, quality, scope performance criteria, and their 36 indicators for building construction projects in Rwanda. A questionnaire survey was distributed among clients, consultants and contractors. A majority of respondents indicated ODF, DBB, DB and CM as the systems with a high level of awareness. Among all the systems, the traditional method of DBB was identified as the most-utilised system.

Based on the general assessment, it was ascertained that in the Rwandan building construction industry, the CM method marked the highest performance level for many criteria and indicators. Besides, based on the results obtained in terms of the influence levels of project procurement systems on four key project performance criteria, the ODF method is identified as the most cost effective, the DB method performs better when time is the main objective, and the CM method is the most suitable for both quality and scope performance as it ranked highest in these results.

This study is among the few attempting to evaluate the effect of project procurement systems on building project performance. Thus, it could be extended to other countries and to other types of construction projects. As a contribution, this study will play a vital role of helping the Rwandan project practitioners to select appropriate the project procurement system that fits their projects' objectives. Additionally, this will reduce some risks, associated with the usage of unsuitable systems, that can be expected to be faced in the absence of a project procurement system chosen based on the objectives specific to the project in question.

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8 Disclosure statement

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