COLLABORATION IN CONSTRUCTION PROJECTS AND EFFECTS ON PROJECT PERFORMANCE

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Abstract
In recent years collaboration amongst project players has drawn much attention within the field of construction management. Several case studies support the argument that collaboration has positive effects on project performance. There is however, a need for quantitative studies investigating statistical relationships between collaboration and project performance, The purpose of this study is to investigate how collaborative tools affect collaboration and further collaboration's effect on project performance. The empirical data was collected through a survey responded to by 106 construction professionals within FCT Abuja. Results from hierarchical regression analyses show a positive relationship between collaborative tools and collaboration suggesting that joint activities are crucial for collaboration to emerge. A positive relationship was also found between collaboration and project performance. The statistical results support previous case study findings where collaboration is positively affected by joint activities and project performance is enhanced by collaboration.
Keywords: Collaboration, Collaborative Toots, Construction Management and Project Performance

Introduction

Construction is a project-intensive industry (Morris, as cited in Papadonikolaki, Oel, & Kagioglou, 2019). Project-intensive industries rely upon temporary or semi-permanent project teams (Turner, as cited in Papadonikolaki et al., 2019), and thus managing information, communication and knowledge is highly significant. The integration of management, communications management and stakeholder management is known as collaboration and are key knowledge areas of the discipline, all of which are related to collaboration of these temporary teams. (Project Management Institute. 2017) asserted that construction projects are temporary endeavours with a definite start and end to create an end product satisfactory to the client. Project Management Institute (2017) asserted that these projects are initiated due to some consideration such as market demand, client's needs and the projects are established with a specific aim of accomplishing a complex task. Collaboration in construction projects takes different dimension, as different projects have different ingredients, it continues to be ambiguous (Bjorvatn & Wald, 2018; Yan & Wagner, 2017) . It could come as a result of technical skills required, size of project and can be measured base on the level of complex nature (Hobday as cited in Zaib, 2019). Streams of literature have been established by different authors relating impact of collaboration on project performance (Nguyen, Le-Hoai, Tran, Dang, &Nguyen, 2019; Zaib, 2019; Bjorvatn & Wald, 2018; Cristóbal, 2017; Dao, Kermanshachi, Shane, & Anderson, 2016; Dao, Kermanshachi, Shane, Anderson, & Hare, 2016; Floricel, Michela, & Piperca, 2016; He, Luo, Hu, & Chan, 2015).

Achieving Project Goals through Collaboration

Collaboration and cooperation are interchangeable terms which are defined as a recursive process where people or organisations work together in an intersection of common goals by sharing knowledge, learning and building consensus (Dietrich et al., 2010). Mattessich & Monsey (as cited in Papadonikolaki et al., 2019)defined collaboration as a dynamic and mutually beneficial and well-defined relationship entered into by two or more organisations to achieve common goals. There is a broad consensus among scholars and practitioners that collaboration in teams generates positive work outcomes, especially in the context of innovative projects (Walker et al.; Kotlarsky and Oshri as in cited in Caniëls, Chiocchio, & van Loon, 2019). Effective collaboration among team members is viewed as the key success factor in projects (Gransberg et al.,; Vaaland, as cited in Caniëls et al., 2019). Collaboration is associated with effective coordinate on and communication that come forward from a shared understanding of the context and assumptions inherent to an innovation project (Chiocchio et al., as cited in Caniëls et al., 2019).

Construction is a highly project-based industry (Gann andSalter; Morris as cited in Oraee et al., 2019) in which various organisations must couple with each other through project-specific collaborative relationships (Cao et al., as cited in Oraee et al., 2019)). Construction activities are therefore inherently contingent upon collaboration among team members (Greenwood and Wu; Papadonikolaki et al., as cited in Oraee et al., 2019). Conversely, the lack of collaboration in construction project teams results in misunderstandings,

misinterpretations of data, poor communication and, consequently, increased rework(Greenwood and Wu; Hosseini et al; Kalay; Nikas et al., as cited in Oraee et al., 2019). Thereby, collaboration is seen as "the mainstay" for improving efficiency, integrating processes and resources, increasing profit and enhancing the quality of products on construction projects (Ey et al.; Fulford and Standing; Greenwood and Wu; Kalay as cited in Oraee et al., 2019).With BIM's advent, its technical capabilities in facilitating a collaborative environment have been a major motivator for construction projects in their move towards BIM's implementation (Alreshidi et al., 2016a; Bassanino et al., 2014; Cao et al.,2016; Hosseini et al., 2016).

The industry is a complex and high-risk multi-actor business that over a long period of time has received criticism for its relationship between client and contractor, where poor collaboration, ineffective communication, unbalanced risk allocation provisions, limited trust and lack of customer focus are cited amongst its shortcomings. Projects are becoming more complex due to unexpected emergent behaviour, characteristics and technology involved (Bakhshi, Ireland, & Gorod, 2016). Kermanshachi et al., (2016) presented that complexity is widely used in the construction but the construct is perceived as different interpretation by industry experts but ultimately it is believed that complexity has impact on a number of industry practices such as project delivery, management practices and project performance. Complexity affects project management including expertise & experience requirements of project managers; also it affects the evaluation, control of project and objective such as time, cost, quality and safety. Hence, Managers needs to share information, collaborate to increase the chances of project success.

Types of Collaborative Tools

Collaboration or partnering overhauls the traditional adversarial relationships between contracted parties with a shift towards more collaborative and caring environments. To facilitate effective partnering a range of collaborative methods and joint activities with the purpose to enhance the collaborative spirit among contracted parties, collectively named collaborative tools, are required Kermanshachi et al., (2016). Examples of collaborative tools are: joint objectives, follow-up workshops, dispute resolution techniques, joint IT-database, joint project office, team building activities, partnering facilitator, and joint risk management (Alreshidi et al., 2016a; Bassanino et al., 2014; Cao et al., 2016; Hosseini et al., 2016). A joint IT-database, designed to reflect the projects strategic vision and environmental factors, is an effective tool to increase collaboration and information sharing among construction companies.

Hypotheses

Hypothesis 1: The higher the usage of collaborative tools, the better the collaboration among contracted parties in a construction project.

Hypothesis 2: The better the collaboration among contracted parties in a construction project, the better the project performance.

Figure 1 below shows the proposed model in which collaboration works as a mediator between collaborative tools and project performance. A full mediating effect hypothesize that there is no direct relationship between collaborative tools and project performance.

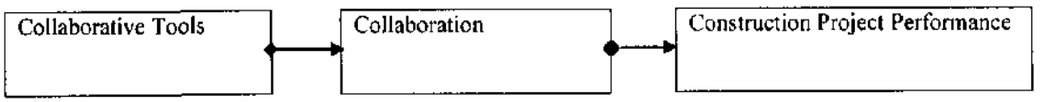


Figure 1.The proposed project performance model.

Methodology

The empirical data were collected through a questionnaire administered purposefully to selected registered construction professionals practicing in Abuja. The population consists of Architects, Builders, Quantity surveyors and Civil Engineers. The organizations were initially approached for the investigation and then subsequently registered contact persons were telephoned, in order to inquire about theirs or other more suitable person's willingness to participate in the study; given that the survey involved procurement, project management processes and project performance. Six respondents declined participation due to lack of time. In a third stage, questionnaires were posted to the 134 potential respondents that had agreed to participate in the investigation. After two reminders a total of 111 responses were received. In a fourth stage respondents who had not answered all questions were telephoned and asked to respond to such questions. This resulted in minimization of the amount of missing values. Nevertheless, in five responses there were a lot of missing

values, for which reason they were discarded. Accordingly, from the population of 140 professionals, 106 usable responses were received, resulting in a response rate of 76%. In the questionnaire the respondents were asked to what extent they use different collaborative tools in their construction projects, and how satisfied they are with various aspects of project performance, including collaboration among project actors. The questions were measured using seven-point Likert scales anchored by 1 = very seldom/very dissatisfied and 7 = very often/very satisfied. The questions did not measure these aspects in a particular project but involved firm-level behaviour and project performances in the firms' portfolios of procured and finished projects. Furthermore, three control variables were measured through a nominal scale: if the organization follows public procurement regulations or not, if the construction collaboration affects performance activities involving new construction/rebuilding projects or continuous maintenance work, and if the firm is active on a local/regional or national/international market.

Data Presentation and Analysis

Usage of collaborative tools: The most commonly used collaborative tool is joint objectives (4.35) followed by joint IT-database (4.26). The least common used collaborative tools are partnering facilitator (2.46) and joint project office (2.46). The eight items of collaborative tools (joint objectives, follow-up workshops, arena for relationship discussion and dispute resolution, joint IT-database, joint project office, teambuilding activities, partnering facilitator, and joint risk management) were subjected to principal component analysis (PCA) with Oblimin rotation using the Statistical Package for the Social Sciences (SPSS) version 16. Oblimin rotation is justified when it is reasonable to expect correlation between perceptual dimensions (Hair et al., 2006). The Kaiser-Meyer-Oklin (KMO) value was 0.87, exceeding the recommended value of 0.6 and the Bartlett Test of Sphericity reached statistical significance (0.00). The analysis on collaborative tools resulted in a one-dimensional factor with factor loadings between 0.39 and 0.80. Hence, collaborative tools was computed into a single factor in later analysis. The computed factor of collaborative tools have Cronbach alpha CA = 0.84 and factor mean value MV = 3.24. The relatively low mean value indicates that collaborative tools are not used to a high extent by construction companies in Abuja.

Project performance: The respondents are satisfied with project performance: customer satisfaction (5.90) receives the highest score and time schedule minimized (4.70) the lowest (Table 1). The ten items of project performance are theoretically related to the four aspects of cost, time, quality and collaboration. In order to investigate if the empirical data supports such a grouping of performances the ten items were subjected to a PCFA with Oblimin rotation, which was forced into four solutions. The Kaiser-Meyer-Oklin (KMO) value was 0.76 and the Bartlett Test of Sphericity reached statistical significance (0.00), supporting the expected four factor solution, explaining 42.2%, 14.8%, 9.7% and 8.7% of the variance respectively. The identified factors are; 1) Quality (CA = 0.87, MV = 5.76), 2) Time (CA = 0.60, MV = 5.17), 3) Cost (CA = 0.73, MV = 5.09) and 4) Collaboration (CA = 0.59, MV = 5.73). To be able to address H2 the collaboration factor is used as an independent variable potentially affecting the performance factors quality, time and cost.

Table 1: Principal component factor analysis of project performance

	Item Mean	Factor 1 Quality	Factor 2 Time	Factor 3 Cost	Factor 4 Collaboration
Function according to specification	5.75	0.91	0.04	0.13	-0.14
Expected quality is achieved	5.70	0.90	0.01	-0.03	0.03
High customer satisfaction	5.90	0.77	-0.04	-0.06	0.20
Time schedule is minimized	4.70	-0.09	0.92	-0.02	0.07
Within time schedule	5.61	0.25	0.60	0.30	-0.06
Within project budget	5.51	0.01	0.05	0.94	-0.07
Project cost is minimized	4.95	-0.06	0,14	0.77	0.16
Life cycle costs are minimized	4.87	0.32	-0,24	0.48	0.20
Negotiations don't end up in disputes	5.18	-0.10	-0,05	0.18	0.87
Good cooperation among project actors	5.41	0.30	0.19	-0.12	0.67
Percentage of variance		42.16	14.76	9.70	8.56
Crombach alpha (CA)		0.87	0.60	0.73	0.59
Factor mean value (MV)		5.76	5.17	5.09	5.73

Collaborative tools' effect on collaboration

Hierarchical multiple regression analysis was used to assess the ability of collaborative tools to predict levels of collaboration, after controlling for the influence of three control variables (if the organization follows public procurement regulations or not, new construction/rebuilding projects or maintenance work, and local/regional or national/international market). Model 1 in Table 2 only consists of the control variables, explaining 2.4% of the variance in collaboration. In Model 2 collaborative tools were entered and the model as a whole explained 11.6% of the variance in collaboration. Hence, collaborative tools explained an additional 9.2% of the variance, which is a small but definite correlation (Hair et al., 2006). The control variables are not statistically significant ($p > 0.05$) and can be rejected whereas Model 2 was statistically significant ($p < 0.05$). H1 is therefore confirmed with a small but definite positive relationship between the usage of collaborative tools and collaboration among project actors (R^2 change = 0.092).

Table 2: Hierarchical regression analysis testing Hypothesis 1

	Model	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig.F Change
1	0.15	0.024	-0.01	1.07	0.024	0.83	3	102	0.48
2	0.34	0.116	0.08	0.98	0.092	10.49	1	101	0.02

Collaboration's effect on project performance

Project performance is divided into three dependent variables; quality, cost and time and the collaboration construct functions as an independent variable. A hierarchical multiple regression analysis was used to assess the ability of collaboration to affect the three factors of project performance, after controlling for the influence of four control factors (if the organization follows public procurement regulations or not, new construction/rebuilding projects or maintenance work, local/regional or national/international market, and collaborative tools). Model 1 for each performance factor represents the results only from the control variables whereas Model 2 represents the results from control variables and collaboration (Table 3). The results from the three regression analyses show that none of the Model 1 solutions are statistically significant ($p > 0.05$). This indicates that the three original control variables together with collaborative tools do not affect project performance. To further verify this result bivariate regression analyses with collaborative tools as independent variable and the three performance factors as dependent variables were conducted. These analyses verify that there is no statistically significant relationship between collaborative tools and any of the three aspects of project outcome ($p > 0.05$). Collaboration's effects are statistically significant ($p < 0.05$) on all three aspects of project performance. Collaboration accounts for 23.7 % of the variance in quality, 22.1 % of the variance in cost and 4.5% of the variance in time. For quality and cost collaboration accounts for significantly more than the control variables which is not the case for time where control variables accounts for 7.9% compared to collaboration 4.5%. The effects collaboration has on quality and cost are moderately strong and its effect on time is small but definite (Hair et al., 2006). H2 is thus confirmed with a positive relationship between collaboration and all three aspects of project performance.

Table 3: Hierarchical regression analysis testing Hypothesis 2

	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
						R Square Change	F Change	df1	df2	Sig.F Change
Quality	1	0.17	0.029	-0.01	0.92	0.029	0.74	4	101	0.56
	2	0.52	0.265	0.23	0.80	0.237	32.20	1	100	0.00
Cost	1	0.25	0.061	0.02	1.09	0.061	1.65	4	101	0.17
	2	0.53	0.283	0.25	0.95	0.221	30.85	1	100	0.00
Time	1	0.28	0.079	0.04	0.91	0.079	2.15	4	101	0.08
	2	0.35	0.124	0.08	0.89	0.045	5.18	1	100	0.03

Discussion

Based on the notion that the nature of collaborative tools is to encourage, foster and maintain a collaborative spirit among project actors (Bayliss et al., 2004), the study show only a small but definite relationship between the usage of collaborative tools and the achievement of collaboration (R^2 0.092). Even if H1 is confirmed it is not entirely in line with previous research which argues for a strong relationship between them. The difference in results could be explained by the difficulties in effective implementation of collaborative tools in a construction project. This study only investigates to what extent construction professionals use collaborative tools and does not address questions of implementation, time of

implementation nor which actors that participated in the joint activities. The difference in results could also be explained by the criticism previous research received arguing that the studies in some extent is limited in scope and based on evidence from successful projects in which strong collaboration was achieved. Hence, the effect of collaborative tools on collaboration may be exaggerated if the relationship is not investigated on an industry level, including both successful and failed partnering relationships.

References

Adebisi, E. O., Ojo, S. O., &Alao, O. O. (2018). Assessment of factors influencing the failure and abandonment of multi-storey building projects in Nigeria. *International Journal of Building Pathology and Adaptation*, *36*(2), 210–231. https://doi.org/10.1108/IJBPA-10-2017-0048

Assaf, S. A., & Al-Hejji, S. (2006). Causes of delay in large construction projects. *International Journal of Project Management*, *24*(4), 349–357. https://doi.org/10.1016/j.ijproman.2005.11.010

Baccarini, D. (1996). The concept of project complexity a review, *14*(4), 201–204.

Bakker, R. M., DeFillippi, R. J., Schwab, A., & Sydow, J. (2016). Temporary Organizing: Promises, Processes, Problems. *Organization Studies*, *37*(12), 1703–1719. https://doi.org/10.1177/0170840616655982

Bjorvatn, T., & Wald, A. (2018). Project complexity and team-level absorptive capacity as drivers of project management performance. *International Journal of Project Management*, *36*(6), 876–888.

Burke, C. M., & Morley, M. J. (2016). On temporary organizations: A review, synthesis and research agenda. *Human Relations*, *69*(6), 1235–1258. https://doi.org/10.1177/0018726715610809

Caniëls, M. C. J., Chiocchio, F., & van Loon, N. P. A. A. (2019). Collaboration in project teams: The role of mastery and performance climates. *International Journal of Project Management*, *37*(1), 1–13.

Chiocchio, F., Grenier, S., O'Neill, T. A., Savaria, K., & Willms, J. D. (2012). The effects of collaboration on performance: a multilevel validation in project teams. *International Journal of Project Organisation and Management*, *4*(1):1–37. https://doi.org/10.1504/IJPOM.2012.045362

Cristóbal, J. R. S. (2017). Complexity in Project Management. In *Procedia Computer Science*; 121:762–766. Elsevier B.V. https://doi.org/10.1016/j.procs.2017.11.098

Daniel, P. A., & Daniel, C. (2018). Complexity, uncertainty and mental models: From a paradigm of regulation to a paradigm of emergence in project management. *International Journal of Project Management*, *36*(1): 184–197.

Dao, B., Kermanshachi, S., Shane, J., & Anderson, S. (2016). Project Complexity Assessment and Management Tool. *Procedia Engineering*, *145:* 491–496. https://doi.org/10.1016/j.proeng.2016.04.026

Dao, B., Kermanshachi, S., Shane, J., Anderson, S., & Hare, E. (2016). Identifying and Measuring Project Complexity. In *Procedia Engineering;* 145:476–482.

Floricel, S., Michela, J. L., & Piperca, S. (2016). Complexity, uncertainty-reduction strategies, and project performance. *International Journal of Project Management*, *34*(7):1360–1383.

Geraldi, J., Maylor, H., & Williams, T. (2011). Now, let's make it really complex (complicated): A systematic review of the complexities of projects. *International Journal of Operations and Production Management*. https://doi.org/10.1108/01443571111165848

Hair, J. F., Black, B., Babin, B., Anderson, R. E. & Tatham, R. L. (2006) Multivariate Data Analysis London, Prentice-Hall.

He, Q., Luo, L., Hu, Y., & Chan, A. P. C. (2015). Measuring the complexity of mega construction projects in China-A fuzzy analytic network procelysis. *International Journal of Project Management*, *33*(3), 549–563. https://doi.org/10.1016/j.ijproman.2014.07.009

Kermanshachi, S., Dao, B., Shane, J., & Anderson, S. (2016). Project Complexity Indicators and Management Strategies - A Delphi Study. In *Procedia Engineering* (Vol. 145, pp. 587–594). Elsevier B.V. https://doi.org/10.1016/j.proeng.2016.04.048

Meng, X. (2012). The effect of relationship management on project performance in construction. *JPMA*, *30*(2), 188–198. https://doi.org/10.1016/j.ijproman.2011.04.002

Mirza, E., & Ehsan, N. (2017). Quantification of Project Execution Complexity and its Effect on Performance of Infrastructure Development Projects. *EMJ - Engineering Management Journal*, *29*(2), 108–123. https://doi.org/10.1080/10429247.2017.1309632

Nguyen, L. D., Le-Hoai, L., Tran, D. Q., Dang, C. N., & Nguyen, C. V. (2019). Effect of project complexity on cost and schedule performance in transportation projects. *Construction Management and Economics*, *37*(7), 384–399. https://doi.org/10.1080/01446193.2018.1532592

Oraee, M., Hosseini, M. R., Edwards, D. J., Li, H., Papadonikolaki, E., & Cao, D. (2019). Collaboration barriers in BIM-based construction networks: A conceptual model. *International Journal of Project Management*, *37*(6), 839–854. https://doi.org/10.1016/j.ijproman.2019.05.004

Padalkar, M., & Gopinath, S. (2016). Are complexity and uncertainty distinct concepts in project management? A taxonomical examination from literature. *International Journal of Project Management*, *34*(4), 688–700. https://doi.org/10.1016/j.ijproman.2016.02.009

Papadonikolaki, E., Oel, C. Van, & Kagioglou, M. (2019). Organising and Managing boundaries : A structurational view of collaboration with Building Information Modelling (BIM). *International Journal of Project Management*, *37*(3), 378–394. https://doi.org/10.1016/j.ijproman.2019.01.010

Project Management Institute. (2017). *A Guide to the Project Management Body of Knowledge* (6th ed.). Pennsylvania: Project Management Institute.

San Cristóbal, J. R., Carral, L., Diaz, E., Fraguela, J. A., & Iglesias, G. (2018). Complexity and project management: A general overview. *Complexity*. https://doi.org/10.1155/2018/4891286

Sohi, A. J., Hertogh, M., Bosch-Rekveldt, M., & Blom, R. (2016). Does Lean & Agile Project Management Help Çoping with Project Complexity? *Procedia - Social and Behavioral Sciences*, *226*(October 2015), 252–259. https://doi.org/10.1016/j.sbspro.2016.06.186

Vidal, L. A., Marle, F., & Bocquet, J. C. (2011). Measuring project complexity using the Analytic Hierarchy Process. *International Journal of Project Management*, *29*(6), 718–727. https://doi.org/10.1016/j.ijproman.2010.07.005

Yan, T., & Wagner, S. M. (2017). Do what and with whom? value creation and appropriation in inter-organizational new product development projects. *International Journal of Production Economics*, *191*, 1–14. https://doi.org/10.1016/j.ijpe.2017.05.010

Zaib, A. (2019). *The Combined Effect of Project Complexity and Team Communication on Project Performance ; Mediated by Team Collaboration*. Capital University of Science and Technology.

Zhen, Z. (2012). The research of collaboration management framework for complex construction project. *Applied Mechanics and Materials*, *177*, 3360–3363. https://doi.org/10.4028/www.scientific.net/AMM.174-177.3360