

# Designing a framework for Sudanese Construction Industry

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## Abstract

This paper investigates interdependencies between a construction organization's "resources", "project management capabilities", "strategic decisions", "strength of relationships with other parties" and "external factors" with "project performance" and "organization performance" from a resource based perspective which puts forward intangible assets of the organization. A structural equation model was set up to measure the seven latent variables through their constituent variables and to see if the hypothesized relationships exist. Based on the findings of this study, it can be concluded that, this paper has introduced a method to measure performance both in qualitative and the quantitative terms.

**Keywords:** Project management capabilities; Project performance ; organization performance

## 1. Introduction

Almost every industry is dynamic in nature and the construction industry is no exception. Its environment has become more dynamic due to the increasing uncertainties in technology, budgets, and development processes.

Advancements on performance measurement mainly rely on seven reasons which were mentioned by Neely. The changing nature of work, increasing competition, specific improvement initiatives, national and international quality awards, changing organizational roles, changing external demands, and the power of information technology can be listed as the main reasons responding to why performance measurement is now on the management agenda [1].

Gaining competitive advantage became one of the major targets for organizations recently. Accordingly, organizations made several attempts to gain and sustain competitive advantage in the relevant industry all over the world [2]. This often resulted in the adoption of new philosophies such as concurrent engineering, lean

production and many others such as just-in-time (JIT), total quality management (TQM), benchmarking, business process reengineering (BPR) in manufacturing and service sectors [3]. The main driver behind those philosophies was the optimization of an organization's performance within its market and also rethinking of performance management systems through effective performance measurement as well as gaining competitive advantage [2]. Performance of an organization should be managed in line with its corporate and functional strategies and objectives [4]. This is the main stream of performance management system process. The main objective of this process is to provide a "proactive closed-loop control system" where the corporate and functional strategies are deployed to all business processes, activities and tasks. Finally, the feedback is obtained through a performance measurement system. Therefore, this process supports and coordinates the process of systematic management, decision making and taking action throughout the organization [5].

The performance measurement process determines how successfully organizations or individuals have been attaining their objectives and strategies. In this process the outputs of organizational strategies and operational strategies are measured in quantifiable form to monitor the qualitative signs of an organization [2]. Thus as suggested, it can be said that the performance measurement system is the information system which is at the heart of the performance management process and it is of critical importance to the effective and efficient functioning of the performance management system [6]. In today's business environment, where organizations compete on the basis of non-financial factors, they need information on how well they are performing across a broader spectrum of dimensions, not only financial but also operational [7].

Traditionally the construction industry was focused mainly on project performance [8]. Moreover, the performance of projects and contractors were assessed to the extent of the client's objectives such as cost, time and quality achieved on those projects [9]. Although these three measures provide an indication of the success or failure of a project they do not, in isolation, provide a balanced view of the project's performance, and their implementation in construction projects is apparent only at the end of the project.

Therefore as suggested, these three measures can only be classified as "lagging" rather than "leading" indicators of performance [6]. International research also supports this argument, which indicates that performance relative to cost, quality and schedule is influenced by other factors like health and safety, productivity, performance relative to the environment, and employee satisfaction [10].

It is mentioned that the evaluation of projects, contractors, professionals or procurement methods solely according to the client's objectives is problematic. Essentially because they mention the parameters associated with client's objectives as unreliable [8]. The bias of the client, flawed attitudes in measuring intangibles and invisible aspects, establishing priorities among objectives, effects of procurement processes that are needed to accomplish those objectives, effects due to external factors, and ultimately the question of whether the goals set were at an appropriate level, are the problems that were mentioned. Additionally, they pointed out the importance of good relationship management in construction, in addition to cost, time and quality, enriched by the special features of harmony, trust and goodwill, to be successful in the market.

## **2. Materials and methods**

A questionnaire survey was used to elicit the attitudes of contractors towards the factors affecting the performance of construction projects and organizations in the Sudanese construction industry. The target populations of contractors were those registered with the Sudanese Contractors Association as well as with the Organizing Council of Engineering Works Contractors.

114 questionnaires were distributed to contractors. 93 questionnaire were returned (response rate of 82.1%). The questionnaire has been validated by the criterion-related reliability test which measures the correlation coefficient between the factors affecting the performance of construction projects and structure validity test.

The respondents were experienced construction project managers and organizations managers. 42 factors believed to affect project and organization performance were considered in this study and were listed under seven groups based on the literature reviewed. The performance factors were summarized and collected according to previous studies and others as recommended by local experts. The main groups considered in this paper are: resources, project management capabilities, strength of relationships with other parties, strategic decisions, external factors, project performance, and organization performance. A computer software called EQS 6.2 was used for analysis the questionnaire data.

## **3. Results and discussion**

### ***3.1 Validity of the performance measures and indicators***

The data obtained from the 93 construction organizations and 325 projects were analyzed by using SEM software package called EQS 6.2. In this part of the paper, after testing the validity of the measurement model, the analysis results of the structural model will be presented.

#### ***3.1.1 Content validity testing of performance measures***

Content validity tests rate the extent to which a constituent variable belongs to its corresponding construct. Since content validity cannot be tested by using statistical tools, an in-depth literature survey is necessary to keep the researcher's judgment on the right track [11]. An extensive literature survey was conducted to specify the variables that define latent variables.

#### ***3.1.2. Scale reliability testing of performance measures***

The scale reliability is the internal consistency of a latent variable and is measured most commonly with a coefficient called Cronbach's alpha. The purpose of testing the reliability of a construct is to understand how each observed indicator represents its correspondent latent variable. According to the EQS 6.2 analysis results, Cronbach's alpha values were 0.943 for "resources", 0.787 for "project management capabilities", 0.923 for "external factors", 0.927 for "strategic decisions", 0.852 for "strength of relationships with other parties", 0.716

for “projects performance” and 0.846 for “organization performance”. These reliability values are satisfactory since the Cronbach’s alpha coefficients are all above 0.70, the minimum value [12].

### **3.1.3 Convergent validity testing of performance measures**

Convergent validity is the extent to which the latent variable correlates to corresponding items designed to measure the same latent variable. Ideally, convergent validity is tested by determining whether the items in a scale converge or load together on a single construct in the measurement model.

It is stated that if the factor loadings are statistically significant, then convergent validity exists [11]. Since sample size and statistical power have a substantial effect on the significance test, this statement needs expanding. To assess convergent validity, the researcher should also assess the overall fit of the measurement model, and the magnitude, direction, and statistical significance of the estimated parameters between latent variables and their indicators. The model parameters were assessed and all factor loadings were found to be significant at  $\alpha = 0.05$ .

### **3.1.4 Discriminant validity testing of performance measures**

The discriminant validity is the extent to which the items representing a latent variable discriminates that construct from other items representing other latent variables. Low correlations between variables indicate the presence of discriminant validity. The correlation metrics calculated for all constructs shows that all intercorrelations are below 0.90, suggesting that there is no multicollinearity [13], but indicating that the constructs have discriminant validity & these correlations provide evidence that they are complementary.

## **3.2 Structural model analysis**

Steps of Structural Equation Modeling:

- Specification of the model,
- Estimation and identification of the model,
- Evaluation of the model fit.

### **3.2.1 Specification of the proposed model**

This model is specified by the following direct path equations:

$$OP = \mu_1 * PP + \mu_2 * R + \mu_3 * SD + \alpha_1. \quad (1)$$

$$PP = \mu_4 * R + \alpha_2. \quad (2)$$

$$SD = \mu_5 * PMC + \alpha_3. \quad (3)$$

$$R = \mu_6 * SR + \mu_7 * PMC + \alpha_4. \quad (4)$$

$$SR = \mu_8 * EF + \alpha_5. \quad (5)$$

$$PMC = \mu_9 * EF + \alpha_6. \quad (6)$$

Where; *OP* is organization performance, *PP* is project performance, *R* is resources, *SD* is strategic decisions, *PMC* is project management capabilities, *SR* is strength of relationship with other parties, *EF* is external factors,  $\mu$  is a path coefficient and  $\alpha$  is an error term.

### 3.2.2 Estimation and identification of the proposed model

There are several methods of model estimation. Some frequently utilized methods include maximum likelihood (ML), generalized least squares (GLS), asymptotically distribution free (ADF) estimator, and robust statistics. The robust model fit indices such as NNFI, CFI, RMSEA and the ratio of  $\chi^2$  per degree of freedom are provided in the analysis report.

### 3.2.3 Evaluation of the model fit

It means to determine how well the model as a whole explains the data. Once it is determined that the fit of a structural equation model to the data is adequate, the performance measurement model is completed. It seems that the concern for overall model fit is sometimes so great that little attention is paid to whether estimates of its parameters are actually meaningful.

According to the analysis of the model fit indices for the constructs of the model, it is certified that all variables fit to its latent variable well beyond the recommended values. Reliability values of the constructs were also calculated and presented in the previous parts of the analysis results. Having obtained reliable constructs and constituent variables with significant factor loadings and goodness of fit indices within the allowable ranges for each construct, the structural model will be as below in Figure (1).

The overall model fit indices listed in table (1) interpreted a relatively good fit of the data since all findings were within the allowable ranges. In figure (1), the path coefficients marked on the arrows can be interpreted similar to regression coefficients that describe the linear relationship between two latent variables.

Although, model fit indices of the structural model were within allowable ranges, it was observed that one of the path coefficients was not significant at  $\alpha=0.05$ . Moreover, the insignificant path coefficient was surprisingly between the constructs, “project performance” and “organization performance” which is actually considered as an undeniable significant relationship both in theory and practice.

Nevertheless, this finding required the investigation of different relationships between the constructs of the model. Perhaps more often, researchers' initial models do not fit the data very well.

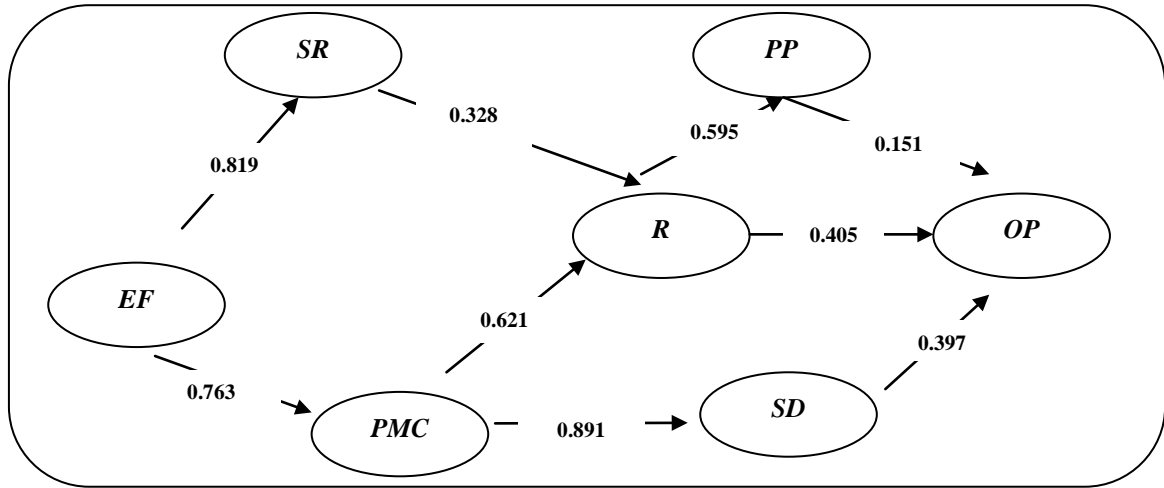


Figure (1) The initial (proposed) model

Table (1) Model fit indices for "initial model"

Fit indices	Allowable range	Overall
NNI	0 (no fit)-1 (perfect fit)	0.727
CFI	0 (no fit)-1 (perfect fit)	0.742
RMSEA	< 0.1	0.082
$\chi^2/ dof$	< 3	1.500

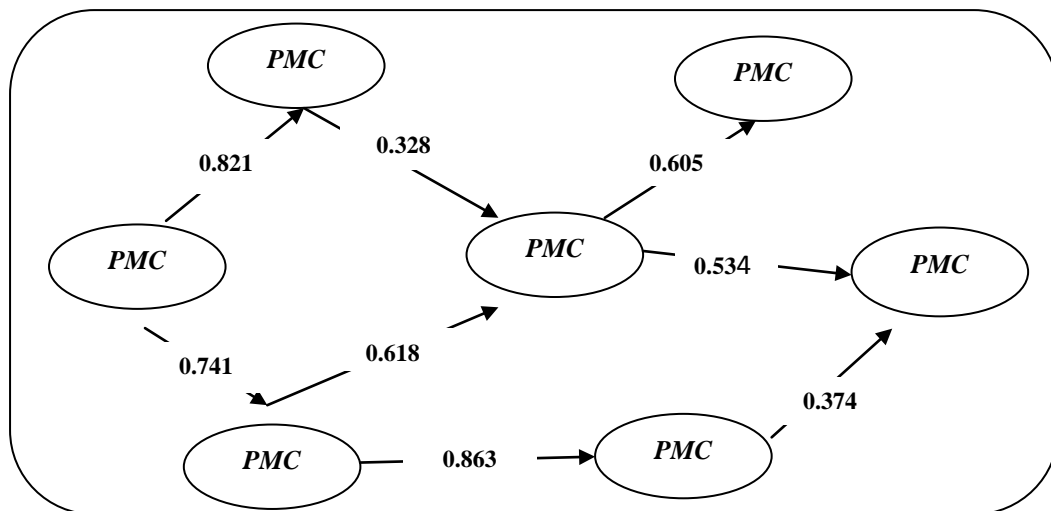


Figure (2) The respecified model

Table (2) Model fit indices for "respecified model"

Fit indices	Allowable range	Overall
NNI	0 (no fit)-1 (perfect fit)	0.787
CFI	0 (no fit)-1 (perfect fit)	0.783
RMSEA	< 0.1	0.082
$\chi^2/ dof$	< 3	1.500

When this happens, the model should be respecified. Hence, the model was respecified and the fit of the model was reevaluated. An equivalent respecified model explains the data just as well as the researcher’s preferred model but does so with a different configuration of hypothesized relations.

An equivalent model thus offers a competing account of the data. For a given structural equation model, there may be many and in some cases infinitely many equivalent variations; thus, it is necessary for the researcher to explain why his preferred model should not be rejected in favor of statistically equivalent ones.

In the respecified model, an insignificant path coefficient between “project performance” and “organization performance” constructs was eliminated (figure 2). However, as mentioned before, the relation between the “project performance” and “organization performance” is inevitable. Thus, it was decided to consider this strong relationship in an additional structural model which will be presented later.

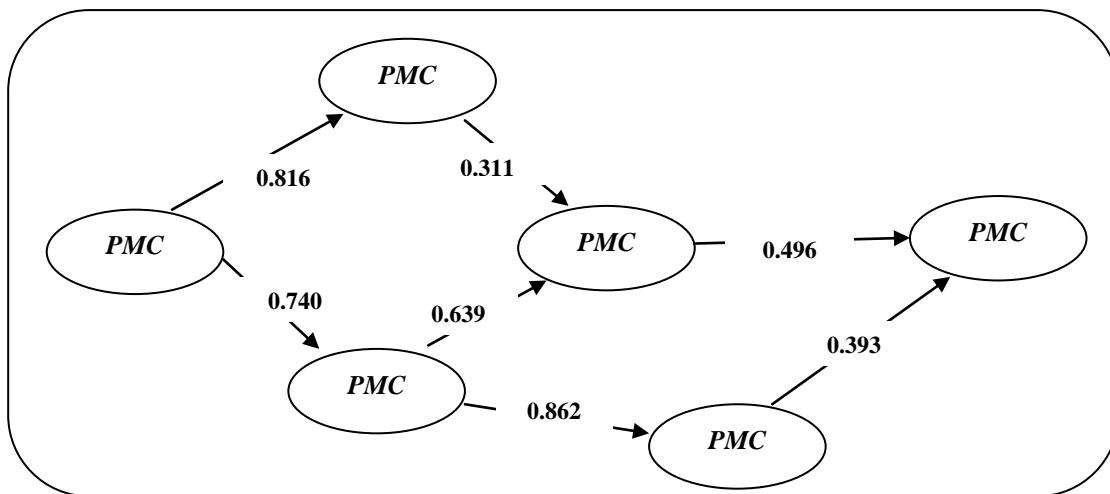


Figure (3) The final model

Table (3) Model fit indices for "final model"

Fit indices	Allowable range	Overall
NNI	0 (no fit)-1 (perfect fit)	0.868
CFI	0 (no fit)-1 (perfect fit)	0.860
RMSEA	< 0.1	0.067
$\chi^2/ dof$	< 3	1.480

#### **4. Conclusion**

Data was collected from 93 Sudanese construction organizations and 325 projects held by those 93 organizations participated in the survey and were analyzed in order to determine the key performance measures and the indicators of performance in construction industry both from the project and the organization perspectives. The main objective was to design an integrated framework to demonstrate all relationships between determined measures and indicators. In order to set the goals, structural equation modeling technique was used to assess the validity of the measurement model and the structural model in a single test. An structural equation modeling program package called EQS 6.2 was used for the statistical analysis. According to the analysis results, all Cronbach's alpha values. were well beyond 0.7 which was the threshold. All factor loadings for the indicators of latent variables were found to be significant at  $\alpha=0.05$ . Moreover, goodness of fit indices for each construct was in the recommended ranges [14].

Having obtained reliable latent variables and indicators, hypothetical structural relationships between the latent variables were specified. The structural model was assessed in order to eliminate the relationship with the insignificant path coefficients and improve it with new hypothetical relations. Accordingly, the initial model (Figure 1) was rejected due to the insignificance in some paths. In order to improve the model fit with significant path coefficients, the model was respecified eliminating some of the constructs.

Finally, three models were obtained which have the ability to measure performance from different perspectives. In the first model, effects of determined measures of performance were shown on both projects performance and organization performance which makes it a single tool to measure project performance and organization performance in a single measurement model (figure 1). In the second model, neglecting the effects of performance measures on projects performance, their effects on organization performance only was considered (Figure 2). In the last and the final partial model, the effects of projects performance on organization performance were investigated (Figure 3). This very well known relationship was evaluated from the measures of projects performance to the indicators of organization performance which were taken as the perspectives of balanced scorecard. The effects of each variable on each perspective of organization performance were demonstrated in mathematical equations. Goodness of fit indices for all three models was found to be quite satisfactory as mentioned in tables (1, 2 & 3). Acquisition of three different models with valid variables and significant paths, which have the potential to be used in the construction industry in order to measure the performance of construction organizations and projects performance as well.

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