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Research paper

A Study of Identifying Significant Variables of Delays in Road Construction Via Structural Equation Modelling (SEM)

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Abstract

Delays have always been a major concern in road construction projects throughout the world, with significant financial and social impacts for stakeholders, and the occurrence of schedule delays has a serious impact on project investment, efficiency, cost, and reputation. Libya is one of the countries faces all these delay issues. This study explored variables of delays in road construction via Structural Equation modelling SEM. Drawing upon an earlier studies, combined with interviews of road experts. Confirmatory factor analysis CFA was applied to extract significant variables based on the questionnaire results to verify the relationships between the significant variables [8 Factors and 3 Effects] identified in road construction. Eleven variables were found to have significant impacts on delays in road construction. The results of the goodness of fit [GOF] showed that chi square is significant at 0.000 levels. Overall, Based on the CFI, TLI, and IFI indices with values more than the cut off value of 0.9 the model had good fit of data. Further. The root-mean-square error of approximation [RMSEA] was 0.033 which was within the perfect fit range. Additionally. The Relative CMIN/df [1.276] was less than 5 showed the good fit of the model and it was found that the unstandardized regression weights were all significant by the critical ratio test [> ±1.96, P < 0.001]. So the study has shown that CFA can quantify comprehensive relationships among a broad range of variables and contribute to resolving problems commonly experienced in the road construction industry.

Keywords*: road projects; delay variables; Structural Equation Model [SEM];* Confirmatory Factor Analysis *[CFA]; Libya.*

1 Introduction

Delays in Libya mainly occur at the construction stage [1], when work is executed in accordance with the contractual agreement. The general rule in Libya is that, in line with the project stages, the owner draws up three contracts for the project. These contracts are between the owner and, respectively:

- The consultant who carries out design stage.
- The contractor who implements the project.
- The supervisor [or consultant's office], that monitors the contractor's performance during the construction stage, following the terms of the agreed contract. The supervision contract may be made with the design consultant, or a separate body. Occasionally, supervision is carried out by a team of engineers who are employed in the owner's organization.

The construction industry is subject to risk due to its complexities and technological advancements in this field. The construction industry requires huge amount of capital, it is large in scale, and it is subject to volatility in project implementation [2]. Due to nature of the industry and its complexity, construction projects are subject to delays. The delays are caused by different factors that differ from project to project and from country to country [3].

The project management team therefore faces a wide range of different problems in attempting to complete the project on time[4]. The on-time completion of the project is one of the most important factors of project success, although a number of factors contribute to project success [5-8] In order to complete construction projects on time and within the limits, proper management is required in terms of project schedules, project costing, project estimation, project management, and minimization of delays. A number of parties are involved in this process ranging from consultants, project managers and project team, and owners or clients of the project [9]. These parties dislike delays in construction projects and aim to complete projects within the required time and estimated cost. This problem is commonly present in traditional types of contracts and in projects that lack an efficient strategic distribution of resources or managerial skills on the part of the project manager. The problem of delay is also more likely to occur in developing countries due to less advanced technology and strategy implementation [10]. The on-time completion of projects and appropriate project management depends upon number of factors and usually depends upon a suitable methodology and engineering of the projects [11] Delays in projects occur in the form of time over-runs or exceeding budgeted or estimated costs which are identified at the time of drafting the project [12].

In reality, delays are a common element in every project, but the level of delays and factors contributing to delays vary in different project contexts, and between developed countries and developing countries.

2. Delays in Construction Projects: A Literature Review

Construction delay can be defined as the time overrun either beyond the contracted date or beyond the date that the parties have agreed upon for the delivery of the project [13]. Delays, and related cost over-runs, are ubiquitous in construction projects: they occur throughout the world, in developed and developing countries, regardless of project size, and they detrimentally affect all parties involved in a project - owners, clients, contractors, and consultants. The effects may vary in scale and severity, but they include stalling, or even halting, progress of the project, financial costs, communication breakdown and disputes among the various parties, that may even develop into legal battles [14, 15]. Construction delays are a common phenomenon in most countries, particularly in the developing ones. Many studies have shown that construction delays have negative effects on clients, contractors, and consultants [13, 16]. The causes and effects of these delay factors in the road construction industry vary from country to country, due to different environments and the techniques applied in the construction processes. In Sudan for instance, where government is the sole client for road construction projects, the set of factors are bound to influence delays are different to delay factors common for developed countries where the responsibility for road construction works rests more on the private sector [17].

Disagreements involving construction works are no longer restricted to local firms and by-laws as globalization means multinational organizations are involved in large scale construction projects, funded by governments and international finance organizations. Foreign firms and investors will withdraw their investments if there are serious disagreements and legal proceedings. Hence it will hinder the country's economic growth and infrastructure development.

Delays in construction projects have serious repercussions. Thus, it has drawn the attention of many researchers and various studies have been done to ascertain the cause factors and the different context it occurs. [18-22] have examined delays which occur in general construction projects. [23-25] have investigated delays in large projects. Others like [26-30] have examined specifically at delays that occurs in road construction projects. Even though, several research have dealt with the role of specific groups such as consultant, owner or contractor who are involved in projects, there are many researchers who have utilised a broader perspective by including and comparing the involvements of the parties involved. The number of previous studies done on the subject of delays in construction projects indicate its importance to the industry and the exclusive situations under which different countries carry out construction projects. Hence, this shows that the topic is pertinent.

Delays can be caused by several reasons. The contractor plays a major role as the initiator of the project. Any internal problem that occurs within the contractor's organization for example the contractor is responsible for the technical problems or mismanagement in executing the project. Delays can also occur due to any element outside the influence of the execution process of the project. Besides, delays can be caused by factors outside the control of the contractor's firm such as the designer, consultant, other contractor's involved in the project or the owner [31].

Each group has its own opinion about the factors which caused delays and they are interested in protecting their own interest. This is proven by a study carried out by [28], who discovered that the contractors perspective about the most important factor that caused delay is different from the consultants opinion. Their research showed that inept planning, unforeseen underground utilities, attributes and reliability of the design, delays in getting approvals from authorities and delays in expropriations are the five most significant risks involving highway projects in the United Arab Emirates [UAE].

[30] has conducted a research on a road construction project in Palestine. They discovered significant discrepancies between how the contractors, consultants and other groups involved ranked the delay factors. Their study has identified two main factors which caused delay namely political condition and partitioning of the West Bank that hinders the movement of goods, services and people. Other factors which have been identified are [1] awarding projects to the lowers bidder [2] delays in progressive payments by the owners and [3] shortage of equipment.

Literature review showed that if the factors that causes delay can be identified more accurately then delays and their impact can be reduced.

3. Construction of the Model

The steps involved in constructing the model in SEM software included the following: construction of the model based on a hypothetical model; assigning names of the constructs or variables; connecting the independent variables to the dependent variable; and assigning indicators to the respective independent variables. The constructed model consisted of 11 categories or constructs [8 Factors and 3 Effects]. Defining a measurement model seemed necessary prior to assessing the fit of the structural path model in order to substantiate that all the 49 identified measurement causes for reflecting the unobserved constructs can in fact stand reliable and do whatever they are supposed to do. To this end, the measurement model for the Factors-Effects of Delay entailed the Measurement Model by regarding the previous studies and results as well as having logic into account [Figure 1].

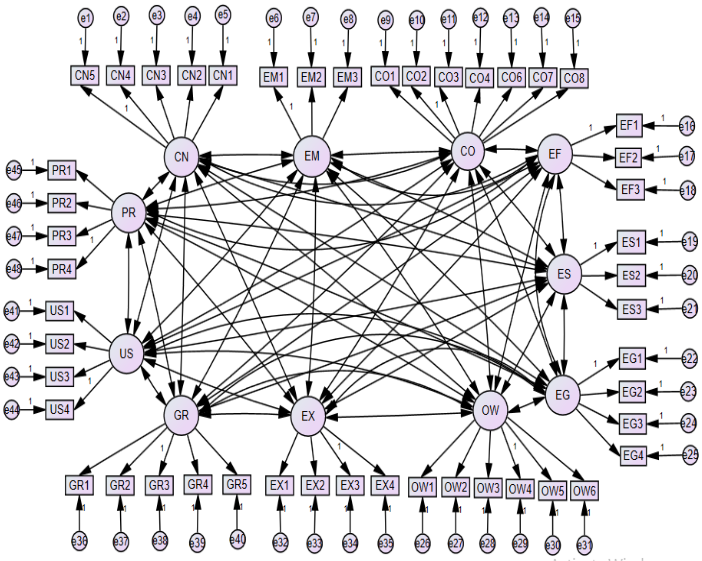

Fig. 1: The developed CFA model

Each of the 11 independent variables [8 Delay Factors and 3 Delay Effects] includes a number of separate indicators or sub-variables which are as listed below:

3.1. Delay Factors:

- CO is the variable for the group of contractor-related factors, which consist of the following sub-variables: CO1 for Rework due to errors during construction; CO2 for Poor site management and supervision by contractor; CO3 for Improper planning and scheduling of project by contractor; CO4 for Inexperienced manpower employed by contractor; CO5 for Poor qualification of the contractor's technical staff; CO6 for Difficulties in project financing by contractor; CO7 for Shortage of manpower; and CO8 for Poor communication between contractor and other project parties.
- OW is the variable for the group of owner-related factors, which consist of the following sub-variables: OW1 for Difficulty in Budget availability for the project; OW2 for Delay in decision making by the owner; OW3 for Interference by the owner during construction operations; OW4 for Delay in progress payments by the owner; OW5 for

Poor communication between owner and other project parties; and OW6 for Change of project scope by the owner during construction.

- CN is the variable for the group of consultant-related factors group which consist of the following sub-variables: CN1 is Delay in performing testing and inspection by consultant; CN2 is Delay in approving major changes in the scope of work by consultant; CN3 is Lack of flexibility by consultant; CN4 is Delay in reviewing and approving design documents by consultant; and CN5 is Insufficient experience of consultant.
- US is the variable for the group of Utility Services-related factors which consist of the following sub-variables: US1 is Delays in the conversion and transfer of utility services by the competent authorities [such as power lines, water, etc.]; US2 is Long time for response from utilities agencies; US3 is Effects of subsurface [underground] conditions; and US4 is Smaller utilities are restrained by funding limitation.
- GR is the variable for the group of Government Regulation-related factors which consist of the following sub-variables: GR1 for Complexity and delays in administrative and financial procedures of project; GR2 for Tendering system requirement of selecting the lowest bidder; GR3 for Non-activation of punitive deterrent measures for delays; GR4 for Change in government regulations and rules; and GR5 for Delay in obtaining permits from different government offices.
- PR is the variable for the group of project related factors which consist of the following sub-variables: PR1 for Original contract duration is too short; PR2 for some designs are not suitable for implementation; PR3 for Non-provision of bonus for early completion; and PR4 for Lack of financial liquidity of the project.
- EX is the variable for the group of external related factors which consist of the following sub-variables: EX1 is Delays in construction activities due to weather changes; EX2 is Delays in acquiring land from citizens; EX3 is Economic problems; and EX4 is Poor political situation and security, especially after revolution in Libya.
- EM is the variable for the group of Equipment and Material-related factors which consist of the following sub-variables: EM1 is Shortage of equipment; EM2 is Re-work because of poor quality materials; and EM3 is change in prices of materials.

3.2. Delay Effects:

- EF is the variable for of Effects related to Financial which consist of the following sub-variables: EF1 is Time overrun; EF2 is Cost overrun and EF3 is Poor quality.
- *ES is the variable for of Effects related to Site which consist of the following sub-variables: ES1 is Disruption of traffic movement, ES2 is Obstruction of economical and ES3 is development Delay of other projects related to the main one.*
- *EG is the variable for of Effects related to Government which consist of the following sub-variables: EG1 is Litigation, EG2 is Arbitration, EG3 is Breach of contract and EG4 is Disputes.*

4. Questionnaire Design and Data Collection

Schedule delays of construction projects not only cause time delays and opportunity costs, but also delay project completion and hand-over, which will increase the contractor's cost, reduce investment profit, and credibility [32, 33]. Therefore, in the current research, time delay, cost increase and reduced credibility are used to measure the variable of schedule delay.

The research reported in this paper analyzes the influence of factors and effects contributing to construction schedule delays during the road construction phase. A questionnaire was designed incorporating elements from [34-37] and suggestions given by five Libyan experts who have extensive experience in road engineering construction. Data were collected from parties involved in road projects carried out in Libya through the Ministry of Roads and Transport in 2015.

After eliminating incomplete questionnaires with missing data, 256 valid questionnaire responses were received.

The questions required responses in a 5-point Likert scale format. The proportions of responses received from owners, contractors and consultants were 42.0%, 26.9%, and 30.1% respectively. The question regarding length of time respondents have been involved in construction yielded the following: 13.7% of respondents have less than 5 years' experience; 30.5% have between 5 and 10 years' experience; 26.5% have between 11 and 15 years' experience; and 29.3% have more than 15 years' experience.

5. Research Approach

To achieve the research objective, the following methodologies were developed. First, then metrics were developed to measure attributes among project delay variables. The SPSS 21.0 software package was used for statistical analysis of the data collected from the questionnaires, and the results were presented by frequency, percentage and cross analysis. The statistics application software AMOS 21.0 was used for the confirmatory analysis.

6. Confirmatory Factor Analysis [CFA]

Structural equation models are able to incorporate several independent and dependent variables and to display hypothetical latent constructs that may represent observed variables. Ordinary regression models, in comparison, do not have the capacity to display as much information in their results. Additional advantages of CFA are that the models make it possible to examine relationships between observed and hidden variables and to test theories and models when it is not feasible to perform a physical experiment. SEM researchers will first test a pure measurement underlying a full structural equation model [Kline, 1998]. The researchers will proceed to the second step if the measurement model fit is acceptable. The second step is testing the structural model by comparing the model's fit with the fit from different structural models.

This study used AMOS 21.0 to test a measurement model, and subsequently to test a number of structural models. Two different models including the causes and effects of delay were designed using the AMOS software, and incorporating eight variables of delay factors [i.e. Contractor, Owner, Consultant, Utility Service, Government Regulation, Project, External Factors, and Equipment and Material] and three variables of delay effects [Financial, Site and Government]. The AMOS 21 system was applied to construct the relations amongst the variables. Once the Exploratory Factor Analysis [EFA] process was conductedthe factors and effects of delay were presented for Confirmatory Factor Analysis [CFA]. Nine goodness-of-fit indices derived from previous SEM-based research and the SEM references [Arbuckle, 2003; J. F. Hair et al., 2006] were applied. Table 1 displays the acceptable value of fit indices. Figure 2 shows that based on the AMOS output this model satisfies the requirements for acceptable model fit.

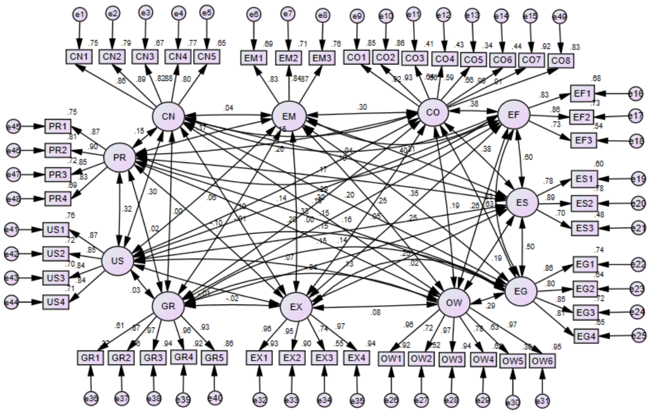

Fig. 2: Initial First Measurement CFA model with all 49 items

Table 1: displays the Initial value of fit indices

Absolute Fit Index [AFI]	Incremental Fit Index [IFI]	Parsimonious Fit Index [PFI]
df = 1025	CFI= .938	CMIN/DF= 1.677
Chi-square = 1719.104	TLI= .931	
P- Value = .000	IFI= .938	
GFI = .783		
AGFI = .751		
RMSEA = .052		

At the same time if the error terms of e3 [associated with EX3] to e2 [associated to EX1] are allowed to correlate, the fit of the model can be improved significantly as shown by exploring the modification indices. The model modification includes modifying the projected model by setting parameters. The process of model modification creates Modification Index [MI]. Correlating the two error items can decrease the chi-square value of the modified model minimum 35.236 as shown in Table 2.

Even though [38] has argued that the possibility of improvement being made in fit for the model is slim, and it is not supported by any theory and has very little practical importance, correlated errors has been included in the model used in this study. This is mainly because the C04 measurement variables are similar to the C06 variables above and below the latent constructs that they are suppose to signify. Other examples of within-constructs error covariance are prevalent among the following pairs of items namely EX 3 & 1, EG 1 & 2 and CO 1 & 2. Within-construct error covariance terms are threats to construct validity [38]. On the other hand, drawing correlation paths between these errors and estimating these paths will decrease X2 and enhance the model fit [39]. Thus the model is modified by drawing a correlation path between the error items. Moreover, the model signifies covariance between the error items of indicator variables loading on varies constructs. Hereby, a higher M.I covariance value of the errors CO3, CO6, GR2, OW2 and OW5 compared with the error items of other constructs refer to between-construct error covariance. The importance of construct error covariance revealed that the items related to the error term are more likely to be related to each other than the original measurement model. This scenario shows that cross-loading occurs in the model and can trigger a lack of discriminant validity [40]. Thus, the model is modified by removing these 5 items instead of drawing correlation paths between the error items. After the 5 items are removed the CFA model with the remaining 43 items is tested again. The results obtained for the goodness of fit indices of the modified measurement model are displayed in Table 2.

Table2: Modification Indices

	M.I	Par Change
e34 ←→ e32	35.236	. 105
e9 ←→ e10	18.848	-.047
e22 ←→ e23	13.818	.074

Such a phenomenon indicates that significant cross-loading exists in the model which can cause a lack of discriminant validity [40]. Therefore, it was decided to modify the model by eliminating these 5 items from the model, rather than drawing correlation paths between the items' errors. After iteratively removing these 5 items, the CFA model with the remaining 43 items was performed once again.

7. Results of the CFA

There are two components of structural equation model namely a measurement model and a structural model. The measurement model of a structural equation model incorporates estimates of errors of measurement of exogenous variables and their intended latent variable [Green, 1990]. On the other hand, a structural model deals with modelling the relationship between latent variables. A structural equation model is different from standard regression model that allows explicit modelling of direct effects only. A structural equation model allows modelling of direct, indirect, and correlative effects. Hence, it enables an analyst to report the relationships between latent variables and the mechanisms triggering a process or event. The structural component of structural equation model is compared with a system of simultaneous regression model [Meyers et al., 2006].

[Molenaar et al., 2000] has stated that the initial structural equation model that is based on past empirical findings and theoretical expectations may not be efficient if it cannot fulfil the standard indices of goodness of fit [GOF] such as R-squares and t-statistics for model equations. Hence, SEM analysis requires a model which satisfies both GOF indices and theoretical expectations [Molenaar et al., 2000]. GOF measures are utilised in the present study to refine the model to improve the fit to recommended levels as displayed in Table 2. The final model fit for construction delays has met the GOF standards. The GOF results displayed chi-square is significant at 0.000 level. [J. Hair et al., 1995] stated that the absolute fit index of minimum discrepancy chi-square can be disregarded if the sample size for a research is more than 200 as in the case of the present study. The GFI reading of 0.853 is lower than the cut-off value of 0.9 recommended by [Hoyle, 1995] but meets the standards recommended by [Gefen et al., 2000] whereby the value of GFI must be between 0.85 and 0.9. Thus, the GFI obtained is satisfactory.

After regulating the degrees of freedom compared to the number of variables, the adjusted GFI [AGFI] is 0.820 that is higher than the cut-off point of 0.80 suggested by [Chau & Hu, 2001]. This signifies that the model forecasts 85% of the variances and covariance in the survey data. The CFI, IFI and TLI indices with a value higher than the cut off value of 0.9 shows that the model has a good fit of data. Moreover, the RMSEA [root-mean-square error of approximation] is 0.033 which is within the ‘perfect’ fit range as suggested by [J. F. Hair et al., 2006; Ho, 2006]. Furthermore, the Relative CMIN/df [1.276] is less than 5 which is a criteria of good fit model. Furthermore, the unstandardized regression weights are all significant as shown by the critical ratio test [> ±1.96, P < 0.001]. The modified measurement model fits the data sufficiently, hence there is no need for further adjustments. The results of the goodness of fit indices of the modified measurement model are presented in Table 3 and Figure 3 shows the modified measurement model.

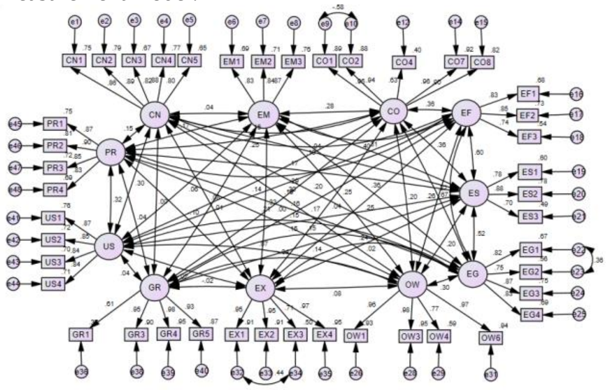

Fig. 3: Modified Measurement model of CFA

Table 3: GOF Indices of Modified Measurement Model

GOF	Initial GOF	Final GOF	Description of test	Source
Chi-square [X^2]	1719.104	1023.543	0.05>	
P-value	0.000	0.000		
df	1025	802	5.00≤	Bagozzi and Yi [1988]
X^2/df	1.677	1.276	2 ≤	Kline, 1998& Ullman, 2001
GFI	0.783	0.853	0.90 ≥	Hoyle [1995]
AGFI	0.751	0.820	08 0.≥	Chau and Hu [2001]
CFI	0.938	0.978	0.90≥	Bagozzi and Yi [1988]; Byrne [1998]
TLI	0.931	0.975	0.90 ≥	Hair et al. [2006]; Ho [2006]
IFI	0.938	0.978	0.90≥	Hair et al. [2006]; Ho [2006]
RMSEA	0.052	0.033	0.10 [.03 to .08] ≤	Schumacker and Lomax [2010]

8. Conclusion

Schedule delays commonly occur in all projects, and identifying the Significant Variables of delays enables relevant stakeholders to take preventive actions. Many earlier studies have focused on identifying the Variables of delay using various indices and although this is a necessary initial step, identification provides limited information for analysts. The present study was concerned with examining the relative impact of different Variables on project delay. The study adopted a novel approach, using CFA to quantify the impacts of different Variables of delay from factors and effects on road construction. The study used questionnaire results as data for CFA analysis to quantify the influence of different Variables of delay on road construction schedules. As an empirical study, it is limited in scope, being concerned only with road construction in Libya. Because of the localized nature of the construction industry and the factors that affect it, further investigation in different countries or areas. The results show signifies that the model forecasts 85% of the variances and covariance in the survey data. The CFI, IFI and TLI indices with a value higher than the cut off value of 0.9 shows that the model has a good fit of data. Moreover, the RMSEA [root-mean-square error of approximation] is 0.033 which is within the 'perfect' fit. Despite its limitations, the study has shown that CFA can quantify comprehensive relationships among a broad range of Variables and contribute to resolving problems commonly experienced in the road construction industry and, more specifically, it provides valuable information for construction professionals in Libya.

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