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Study the Affecting Delay Factors on Road Construction Projects in Libya

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Abstract—**The road construction industry significantly contributes to the socio-economic development of a country. However, road construction industries all over the world, including Libya, are facing serious problems related to construction delays, which result in higher costs for the Department of Transportation and contractors as well as cause great inconvenience to the public. The challenges faced by road construction projects in Northwest Libya have resulted in the late delivery of road construction supplies and increased the number of problematic and abandoned projects. Consequently, these delays will result in cost overruns and quality degradation. This study also develops a structural model of road construction delay and determines those groups that greatly contribute to road construction delay through a questionnaire survey. A total of 256 questionnaires were returned for the main study, thereby yielding a 71% response rate. The structural model of road construction delay was developed by using structural equation modelling. This model is deemed fit as the coefficient of determination (R^2) of road construction delay was 0.48 ($R2 \geq 0.26$ = substantial). The model shows that all eleven groups are significant with p-value>0.05, thereby suggesting that all fit indices satisfy the proposed value range assumed for the model development. The model also shows that the contractors group and effects of financial activities, specifically 'time and cost overrun as well as poor quality', have the highest effects on road construction delay. The findings of this study contributed to understand clearly the cause effect factors of construction delay in Libya.**

Index Terms: **Delay Factors on Road Construction Projects, Structural Equation Modelling (SEM), Confirmatory Factor Analysis [CFA]; Libya.**

I. INTRODUCTION

The delays in the completion of construction projects have become a global phenomenon. In Lagos, Ibironke et al. [1] found that the delays in project completion are common problems in the construction industry that not only impose immeasurable costs to the society but also affect the contracting parties, including owners, contractors and consultants, by promoting adversarial relationships, distrust, litigation, arbitration, cash flow problems and apprehension. These delays are almost invariably accompanied by cost and time overruns. Meanwhile, Shaikh et al. [2] found that delays have the most important influence on the overall performance of any construction project by increasing the project costs. Completing a project on time is beneficial for all the parties involved.

[3] Found that one of the major problems being faced by construction projects is falling behind schedule or delays in submission. A delay can be defined as the postponement of the project completion time due to predicted and unpredicted causes. Completion time is very essential in construction because 'time is money' [4]. Delay factors result in high overhead costs by extending the construction period as well as increase the costs of construction materials due to inflation. For the clients, especially the investors, a delay can lead to the loss of profits that they are expecting to earn back after starting the investment at the scheduled time.

The construction industry plays a very important role in the economies of most countries. However, this industry is well-known for facing time and cost overruns in its projects. Construction delays differ amongst countries and even amongst projects that are being conducted within the same geographic location. Accordingly, many studies have attempted to define the factors that influence construction delay in different countries [5-7].

Transportation infrastructure, specifically roads, serves as the backbone of the economic and social development of many countries as well as plays a significant role in local and international communication and trade exchanges. Successful road infrastructure projects are delivered at low cost, on time and in accordance with the technical specifications to guarantee an optimal economic return. Unfortunately, many road infrastructure projects, such as highways and bridges, do not meet the cost and time performance requirements specified in [8]. Time delays have become a well-known phenomenon that is detrimental to both economic development and the taxpayers. Most government-initiated infrastructure projects are delayed and are only

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finished years after their scheduled completion.

The road construction delay in Libya can affect the time and cost of these construction projects. Government authorities in Libya, who are the main owners of all large construction projects, consider the delays in public projects as a major problem. These delays will typically incur unanticipated additional costs for both the clients and contractors, thereby limiting the opportunities for governments (owners) to invest their funds for other purposes and reducing the benefits that these services offer to the Libyan people. According to [9], road construction delays can be minimised and controlled if their factors are accurately identified. Identifying these factors will help owners, consultants and contractors effectively plan and minimise the impacts of delay on their projects. Therefore, road construction delays must be carefully analysed to identify their sources and to devise plans for their mitigation.

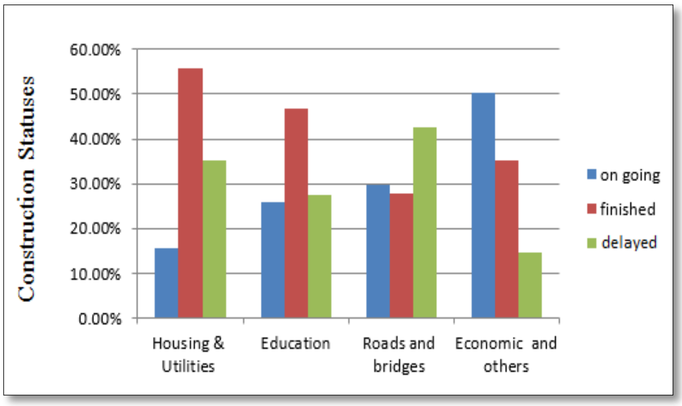
Although some studies have examined the factors of building construction delays, no extant study has investigated the reasons for the road and infrastructure construction delays in Libya. Meanwhile, given the differences in the physical conditions of countries and the differences in the laws and regulations of their governments, the reasons for road construction delays widely differ from one country to another.

In fact, many researchers have addressed the issue of identifying the causes and/or effects of delays in the construction industry in different countries for example, [10-12]. Few researchers have analyzed the relationships between the causes and effects of delays using simple correlation and regression for example, [13] these simple approaches fall short of revealing the complete relationships between the causes and effects of delays and interrelationships within the effects of delays. Unfortunately, only few researchers have studied the construction delays in Libya, whilst no study has specifically focused on road construction delays. These studies have also largely ignored the relationships between the factors and effects of road construction delays. Therefore, the developing structural model for the Libyan construction industry is formulated and focuses on the relationships between the factors and effects of road construction delays as well as integrates such linkages to provide a complete understanding of the factors and effects integrated in this model. This model is addressing a gap in road construction delay for Libyan construction industry.

In this research, the use of a more sophisticated tool, namely, Structural Equation Modelling (SEM) to analyze the complex relationships is demonstrated. The possibility of handling complex dependencies is regarded as one of the main advantages of using SEM [14]. SEM is not new to research related to project management. However, the current study is one of the initial studies that use SEM to study the relationships between factors and effects of delays in the construction industry. However, most of these studies less attention are given on developing relationships model for factors and effects of construction delay. Therefore, this study focuses on identifying the major factors that cause road construction delays, determining the effects of road construction delays and developing a structural model that represent the factors that affect the delays in the Libyan construction industry.

A. Delays In Road Construction Projects In Libya

Although many studies have examined the causes of construction delays in developing countries, most of them have focused on the entire construction sector or on the building sub-sector. For instance [13] found that Human factor is major contributor towards delays in construction industry of Libya there is need to overcome these factor in order to complete projects on time without any additional cost, time and reputational loss. The human factors include client specialization, client's perception regarding cost reduction and high quality, and project team leader. Many projects have also demonstrated a poor performance because of client-related obstacles, the unavailability of materials, the closure of roads, the amendment of designs and drawings and the implementation of additional works in [14]. Figure 1 shows the percentage of ongoing projects, finished projects and delayed projects for each project type in Libya from 2005 to 2014. As shown in the figure, Libya has a high percentage of delayed projects, especially for roads and bridges (more than 40%).



Fiureg 1. Construction Statuses, by Category (Percentages)
Source: Report of Managing the implementation of housing projects and facilities 2015

The scale of road construction projects in Libya continuously increases and their rational process management becomes increasingly complex. These projects are constantly delayed due to uncertainty factors related to engineering, management, exterior delays, resources and weather. Many studies show that time, cost and quality are the basic factors that contribute to the success of a construction project. These factors form a parallel relationship with project success as the occurrence of delays usually leads to cost overruns. Therefore, the factors that contribute to road project delays and the effects of delays from the pre-construction stage to the handover stage must be identified to mitigate their occurrence.

II. RESEARCH METHODOLOGY

A research is a process of answering professional questions by adopting a proper and systematic approach or by following a plan that guides the questions being investigated. In this study, a quantitative approach (structured questionnaire survey) was applied to understand the perceptions of the players in the Libyan construction industry towards the factors that contribute to construction delays and their effects on road construction projects. The target participants for this study included the owners, consultants and contractors who are involved in road construction projects. The sample included those projects that have been completed between 2005 and 2014.

A Questionnaire Design

Given that a survey questionnaire was employed as the main instrument for empirically testing the hypothesised relationships, the recommended variables in the research framework should be defined and measured. As suggested in many studies, designing a questionnaire is a difficult task that requires artistic and scientific skills. The first phase of the data analysis (which mainly includes statistical analysis) was performed after screening the data by using SPSS 21.0 for Windows. Data screening is an essential part of any analysis process in which the presence of outliers as well as the normality, reliability and validity of the data are assessed. This phase also involved the Exploratory Factor Analysis (EFA) and the assessment of the correlations amongst the scales. The second phase of the data analysis involved SEM and Confirmatory Factor Analysis (CFA), which aimed to examine the factors of delays and their effects on road construction projects and to study the relationship between these factors and effects. The questionnaire development technique employed in this study was related to the analysis of construction delays and was adapted from [15-16].

The questionnaire items were validated before the survey. An eight-page list of questions associated with the delay factors was produced. The questions in this document were formulated based on the results of the literature review and the informal discussions with experts in road construction and questionnaire design. The questionnaire was also submitted to experts at the Bridges Department of the Ministry of Transportation in Libya. The experts also clarified the research objectives and variables that were supposed to be measured by the questionnaire. They were also asked to share their opinions and recommendations for improving these objectives and variables. These opinions and recommendations were considered in the questionnaire design to ascertain that the measurements are meaningful and are in line with the research objectives. The questionnaire was also pretested amongst several experts who were asked to appraise the length and complexity of the questionnaire. The survey tool was later modified based on the feedback shared by these experts, who perceived that the questionnaire had reasonable length and complexity.

B Pilot and Main Study

A pilot study involves pre-testing the designed questionnaire. In this study, the questionnaire was pre-tested by eliciting the opinions of a small number of experienced practitioners in the road construction industry. The findings from a pre-study can be used to correct any fault found in the questionnaire before conducting the main research as well as to check or improve the design of the research instruments to be used in the actual survey [17]. Thus, conducting a pilot study is crucial in the questionnaire design stage. In this work, a pilot study was performed by distributing the structured questionnaire to selected contractors, consultants and owners who are involved in road construction projects in Libya. The pilot survey was carried out from the 2^{nd} of April 2015 to the 28th of May 2015. The respondents were asked to indicate the level of relevance of the causative factors and the level of the effect factors on a five-point Likert scale as well as to verify whether the factors assigned in the group are accurate based on the actual scenarios in the construction industry. According to [18], the usable response rate usually ranges from 25% to 35%. For similar reasons, [19] suggested 10 to 30 participants for pilots in survey research. The questionnaires were distributed by hand and email. A total distribution of questionnaires was about 53 for the pilot survey and a total of 46 questionnaires were returned, however 31 questionnaires were completed. Thereby yielding a 58% of total complete questionnaires returned. Thus, the response rate obtained in the pilot study meets the requirements for running a preliminary analysis. All aspects of the questionnaire, including the wording and order of questions, response categories, reliability checks, physical layout and length of time for answering and reading the questionnaire, were carefully analysed. Five factors and two effects were deleted after the analysis, thereby yielding a final set of 54 questions (factors) and 10 questions (effects). Notes were also placed in some questions. For the main study the road construction project participants in west Libya include approximately 593 engineers and according to [20-21] recommended having a minimum sample size of 200 for any SEM analysis. The questionnaires were distributed to 360 individuals comprising of owners, consultants and contractors. Were 256 questionnaires were valid for the main study, thereby yielding a 71% of total questionnaires.

C Sampling Statistics

A sample was drawn from the study population by using a probability formula. Using random sampling to select the subjects can help make valid generalisations from the responses of engineers (owners, contractor and consultants). According to [22], sampling is the process of selecting a sufficient number of elements from the engineers. Therefore, studying the sample, its properties or characteristics allows us to generalise the properties or characteristics of such elements. [22] Proposed that sample sizes larger than 30 and less than 500 are appropriate for any type of research. Also according to [21- 36] recommended having a minimum sample size of 200 for any SEM analysis. The questionnaires were distributed to 360 individuals comprising of owners, consultants and contractors. After following up with these individuals in a period of four months, 282 of the distributed questionnaires were returned, amongst which 26 had incomplete answers and were thus considered invalid and 256 were considered valid for further analysis, thereby yielding a 71% usable response rate.

III. DESCRIPTIVE STATISTICS SECTION ONE: EXPERIENCE OF THE RESPONDENTS

A frequency analysis is conducted for questions related to experience of the respondents. This information includes the Type of Business, Type of Organisation, Years of Experience, Level of Education and Value of Project. The majority of the respondents 103 (40.23%) are working in the public sector, 65 (25.39%) are working in the private sector and 88 (34.37%) are working in both the public and private sectors. Fortunately, the majority of the participants have more than 15 years of experience in road construction projects, thereby highlighting the reliability of the collected data. Amongst the 256 respondents, 75 (29.29%) had 15 years of experience, 68 (26.56%) had 11 to 15 years of experience, 78 (30.46%) had 5 to 10 years of experience and 35 (13.67%) had less than 5 years of experience. The knowledge of the respondents was measured based on their academic qualification and work experience in the construction industry. Academic qualification and work experience are essential indicators that play important roles in understanding the problems occurring at construction sites. The result shows that, 2.7% of the respondents are graduates from institutes, 37.1% are diploma holders, 42.2% have a bachelor’s degree, 12.1% have a master’s degree and 5.9% have a doctorate degree. Most of the respondents have a bachelor’s degree.

Value of Project: Contract amount is an important criterion considered in this survey that classifies a construction project as either large scale or small scale. The result shows that amongst the 256 respondents, 100 (39.1%) are working in small-scale construction projects (valued under 5 million D.L), 64 (25%) were working in medium-scale projects (valued from 5 to 15 million D.L), 33 (12.9%) were working in large-scale projects (valued from 16 to 30 million D.L) and 59 (23%) were working in very large-scale projects (valued over 30 million D.L). In sum, most of the respondents are experienced in large-scale projects.

IV. DESCRIPTIVE STATISTICS SECTION TWO: PERFORMANCE OF PROJECTS

Descriptive statistics is conducted for questions related to performance of project; this information includes the number of projects, number of delayed projects, and percentage of delay time of the delayed projects and responsible parties for the delays.

The participants have been involved in over 2986 projects. Therefore, most of them have a very broad background in road construction projects, which suggests that the most important factors and effects of construction delays can be accurately identified based on their shared knowledge. Since the number of projects that a respondent has participated in has a high impact when analysing delay impacts and factors, ensuring that a breadth of experience was represented within the sample improves the reliability of the survey results.

The result shows that 1,463 of the 2,986 surveyed projects have been delayed. Conversely, 1523 of these projects were successfully delivered as scheduled. The result shows that the delayed projects comprise 48.99 % of the total projects.

The percentage of delay time was classified into five categories and the respondents were asked to select more than one of these categories to indicate the average time of delay in their projects. The result shows that most of the projects have been delayed by 10%–30% or 31%–50%. Amongst the 256 respondents, 40 (15.6%), 88 (34.4%), 67 (26.2%), 42 (16.4%) and 19 (7.4%) participated in projects with less than 10%, 10%–30%, 31%–50%, 51%–100% and more than 100% delay time, respectively. Most of the projects under investigation were delayed by 10%–30% and 31%–50%, thereby highlighting project delays as a major problem in the Libyan road construction industry.

The result shows that amongst the 256 respondents, 127 (49.6%), 92 (35.9%), 27 (10.5%) and 10 respondents (3.9%) identified contractors, owners, consultants and others as the most responsible party for road construction delays, respectively. The next sections break down the survey results according to group opinions.

V. STRUCTURAL MODELLING OF THE FACTORS AND EFFECTS OF ROAD CONSTRUCTION DELAYS

The structural model aims to evaluate how factors influences on construction delay. This model also attempts to examine the relationships amongst the degradation effects of construction delays. The quality of the sample data was assessed, the presence of missing values or outliers was checked and the normality of the data distribution was evaluated before performing the CFA and SEM.

A Confirmatory Factor Analysis (CFA)

The literature outlines the various purposes for conducting CFA. Hair et al. [23] stated that CFA aims to evaluate how well the specifications of the conceptual model match the reality. The validity of the models was assessed based on the model fit indices established in the SEM literature. CFA was performed to determine the degree of model fit, the explained variances, the standardised residual for the measurement variables and the adequacy of the factor loadings. Based on the CFA results for each latent variable, those items with a low factor loading (at least 0.60) were dropped from the analysis [24].

- *Measurement Model One: CFA for Delay Factors*

After conducting EFA, the factors of delay were identified for the CFA. Eight goodness-of-fit indices were used in this study. A CFA model was then generated to reduce the number of modification indices after formulating the specified models. The CFA model was developed by classifying the delay factors into relevant categories. The CFA model for this study included 39 items that measured eight constructs for the antecedents and consequences of project delays, namely, contractors (CO), owners (OW), consultants (CN), utility services (US), government regulations (GR), projects (PR), external (EX) and equipment and materials (E&M). Figure 2 illustrates the initial CFA model.

A total of 39 factors were extracted from the EFA results, Eight of these factors were classified under contractor delay, six were classified under owner delay, five were classified under consultant delay, four were classified under utility services delay, five were classified under government regulations delay, four were classified under project delay, four were classified under external delay and three were classified under equipment and materials delay. The relationships amongst these delay factors were examined based on the covariance of the components. Table 1 shows the results of the preliminary analysis of model fitness.

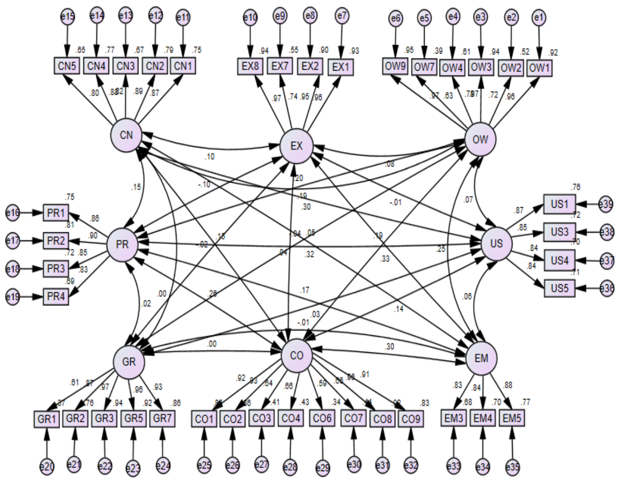


Figure 2. Measurement model one-CFA for delay factors

Standardised Loadings of the Model Items: The CFA model was developed for the constructs and their relative measurement items. The standardised loadings of these items were assessed. One item (CO6) had a factor loading below the cut-off value of 0.60. However, [24] argued that the factor loading for every item should not go below 0.6. Therefore, CO6 was removed from its relative constructs. The revised model with 38 items was used to check the stability of the factor structure. The standardised factor loadings for all items in this revised model were all greater than 0.6 and ranged from 0.606 to 0.974. There is no agreement among researchers which fitness indexes to use. Holmes-Smith [25] recommend the use of at least one fitness index from each category of model fit. There are three model fit categories namely Absolute Fit, Incremental Fit, and Parsimonious Fit. According to Table 1 presents the acceptable fit index values. Based on the AMOS output, Figure 3 shows that the proposed structural model has an acceptable fit because its indices satisfy the model fit requirements.

Table 1 Goodness of fit indices of measurement model one

Fit index	Modified Model	Recommended
Chisq/df	1329.245/674= 1.972	< 3
P-value	0.000	< 0.05
GFI	0.785	> 0.80
AGFI	0.751	> 0.80
CFI	0.932	> 0.90
TLI	0.926	> 0.90
IFI	0.933	> 0.90
RMSEA	0.062	< 0.08

- *Measurement Model Two: CFA for Delay Effects*

Similar to the measurement of the model discussed in the previous section, the effects of delay were subjected to a CFA after performing the EFA as shown in Figure 3. The dataset was analysed in view of the findings presented in Table 2. This measurement model was also hypothesised to encompass three factors, namely, 'effects related to financial', 'effects related to site' and 'effects related to government'. The CFA model of effects with 10 items and Table 2 presents the Goodness of Fit Indices of Measurement Model two.

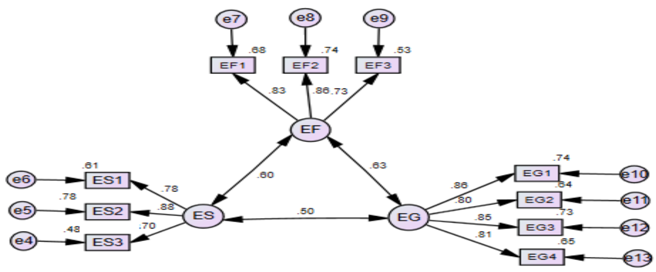


Figure 3. Measurement model two- CFA for delay effects

Table 2. Goodness of fit indices of measurement model two

Fit index	Modified Model	Recommended
Chisq/df	79.887/32= 2.49	< 3
P-value	0.000	< 0.05
GFI	0.937	> 0.80
AGFI	0.892	> 0.80
CFI	0.967	> 0.90
TLI	0.954	> 0.90
IFI	0.967	> 0.90
RMSEA	0.077	< .08

The standardised factor loadings for all items in this revised model were all greater than 0.6 and ranged from 0.696 to 0.881 and were significant at $P < 0.05$, thereby highlighting the convergent validity of the employed research instrument.

- *Measurement Model Three: CFA for the Factors and Effects of Delay*

A measurement model must be defined before assessing the fit of the structural path model to prove that all of the 48 identified measurement variables for reflecting the unobserved constructs are reliable and can achieve their intended purpose. To this end, the measurement model for the factors and effects of construction delays followed measurement model three by referring to logic and the findings of previous studies (Figure 4).

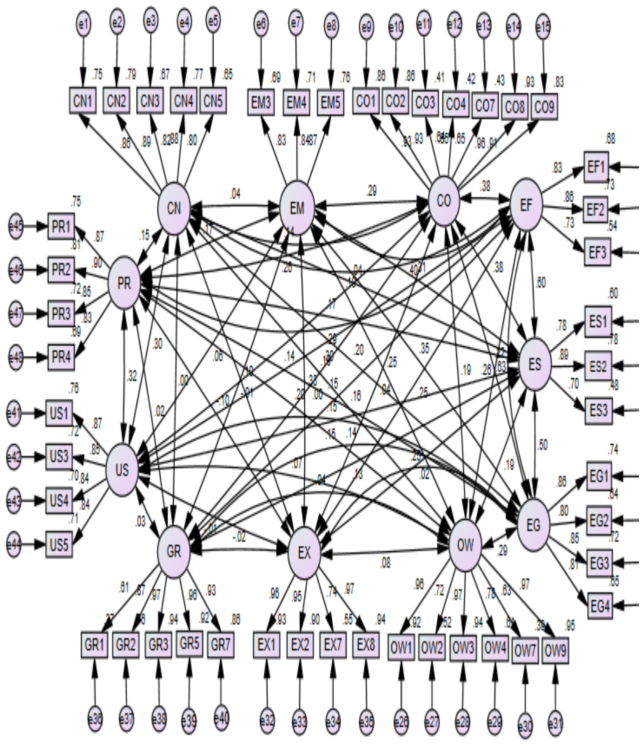


Figure 5. Measurement model 3: CFA for factors-effects of delay

CFA was conducted to establish the degree of model fit and the adequacy of the factor loadings. Based on the fitness values shown in Table 3, the measurement model for the factors and effects of delay has an acceptable fit.

Table 3. Goodness of Fit Indices of Measurement Model three

Fit index	Modified Model	Recommended
Chisq/df	1719.104/1025= 1.677	< 3
P-value	0.000	< 0.05
GFI	0.783	> 0.80
AGFI	0.751	> 0.80
CFI	0.938	> 0.90
TLI	0.931	> 0.90
IFI	0.938	> 0.90
RMSEA	0.052	< .08

The unstandardised regression weights were all significant according to the results of the critical ratio test (CR > 1.96, p < 0.05). The standardised regression weights (factor loadings) varied from 0.607 to 0.974 thereby proving that the 48 measurement variables were significantly represented by their corresponding latent constructs.

GFI Indices**:** Measurement model 3, which included 48 items, obtained a significant chi-square value (X^2 = 1719.104, df = 1025 and p-value = 0.000), a GFI of 0.783 (below the 0.8 cut-off value) and an AGFI of 0.751 (below the 0.8 cut-off value). In sum, this model has a poor fit because of its failure to meet the model fit requirements listed in Table 16. As discussed, model modification aims to improve the model fitness. In the first round, the model achieved the required fitness by meeting the TLI and CFI requirements. TLI, CFI and AGFI are all categorised under incremental fit. Therefore, the modification indices and standardised residual covariance were further analysed.

- *Modified Measurement Model for the Factors and Effects of Delay*

Some items showed a high discrepancy of covariance between their related errors, thereby indicating the presence of redundant items in the model [26] as shown in Table 4. For instance, if the error terms of e34 (EX7) to e32 (associated to EX1) are allowed to correlate, then the fit of the model can be enhanced substantially by exploring the modification indices (Table 4).

Table 4 Modification indices (covariance), measurement model factors-effects

	M.I	Par Change
e34 ⟷ e32	35.236	. 105
e9 ⟷ e10	18.848	-.047
e22 ⟷ e23	17.818	.074

If the error terms of e9 (associated with CO1) and e10 (associated with CO2) are allowed to correlate, then the error terms of e22 (associated with EG1) and e23 (associated with EG2) are also allowed to correlate. In this case, the fit of the model can be substantially enhanced by exploring the modification indices listed in Table 4. Allowing these two error terms to correlate can also decrease the chi-square value of the modified model. According to [27], given the small possible improvement in the fit of the hypothesised model, improving such fit has little practical significance and lacks any theoretical justification. However, the correlated errors were still included in the model because the measurement variables of CO1 resembled those of CO2 (i.e., they are above or beyond the latent constructs that they were supposed to represent). Three within-constructs error covariance terms were found between EG1 and EG2, between EX7 and EX1 and between CO1 and CO2. These terms can negatively affect construct validity [27]. Therefore, in the model modification, a correlation path was drawn between the errors of the items to be estimated to reduce the X^2 and to improve the model fit [23].

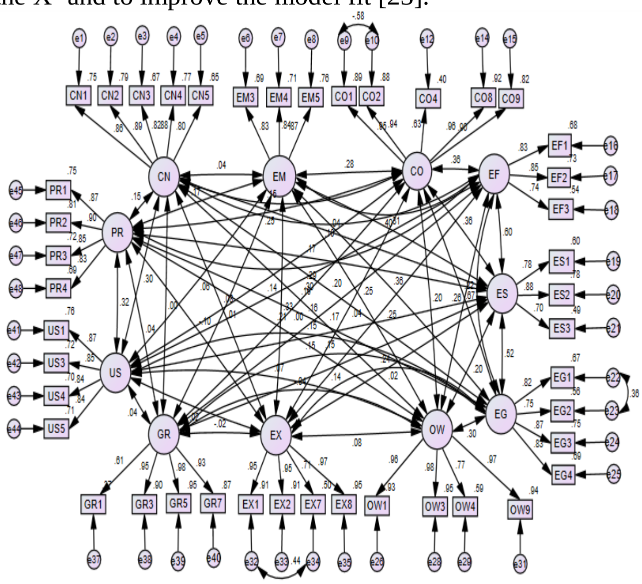


Figure 6. Modification measurement model for factors-effects of construction delay

The model also revealed a covariance between the error terms of the indicator variables loading on different constructs. The high MI covariance between the error terms of CO3, CO7, GR2, OW2 and OW7 and those of other constructs indicates a between-construct error covariance, which suggests that those items associated with a specific error term are more highly related to one another than what was predicted by the original measurement model. Such phenomenon suggests that a significant cross-loading exists in the model, which can lead to the absence of discriminant validity. According to Awang, [26] High value of MI (above 15) indicates there are redundant items in the model (The MI indicate a pair of items which is redundant in the model) To solve the redundant items, the researcher could choose one of the following: Delete one of the items (choose the lower factor loading) or Set the pair of redundant item as "free parameter estimate". Therefore, in the model modification, five items were removed from the model instead of drawing correlation paths between the errors of these items. After iteratively removing these items, the model with the remaining 43 items was subjected to another CFA. Given that the modified measurement model fits the data adequately, no further adjustments are required. The modified measurement model shown in Figure 6 was re-estimated accordingly. As shown in Table 5, the fit indices in the original and modified measurement model can improve the latter model.

The Goodness of Fit (GOF) results show that the chi-square is significant at the 0.000 level. However, the absolute fit index of the chi-square with minimum discrepancy can be ignored if the sample size exceeds 200 [23]. The GFI was 0.853, which was slightly lower than the cut-off value of 0.9 suggested by Hoyle [28]. The GFI is greatly affected by a relatively small sample size (below 200) and [29] added that using CFI is more appropriate than GFI when the sample size is small. Meanwhile, [30] suggested that the GFI value must lie between 0.85 and 0.9. Therefore, the obtained GFI was deemed satisfactory. After adjusting the df relative to the number of variables, the adjusted GFI (AGFI) was equal to 0.820, which was above the 0.80 cut-off value suggested by [31]. Even though the values for GFI and AGFI do not exceed 0.9 (the threshold value), they still met the requirement suggested by [32], [33] the value is acceptable if above 0.8. The CFI, TLI and IFI with values exceeding the 0.9 cut-off value all highlight the good fit of the model. The RMSEA was 0.033, which was within the acceptable fit range recommended by [23-27]. The relative CMIN/df (1.276) was less than 3, thereby indicating the good fit of the model. The unstandardised regression weights were all significant according to the critical ratio test (> ±1.96, $P < 0.05$).

Table 5 Goodness of fit indices of measurement model three

Goodness of Fit (GOF)	Original Model Measurement	Modified Model	Improved (Yes/No)
Chi-square (X^2)	1719.104	1023.543	Yes
P-value	.000	.000	Yes
df	1025	802	Yes
X^2/df	1.677	1.276	Yes
GFI	.783	.853	Yes
AGFI	.751	.820	Yes
NFI	.860	.905	Yes
CFI	.938	.978	Yes
TLI	.931	.975	Yes
IFI	.938	.978	Yes
RMSEA	.052	0.033	Yes

B Reliability and Convergent Validity

After establishing their unidimensionality, the constructs were assessed for their reliability and convergent/discriminant validity. Reliability was assessed by using Cronbach's alpha, CR and AVE. AVE reflects the amount of variance in the indicators that is accounted for by the latent construct. All constructs obtained AVE values ranging from 0.623 to 0.853, which exceeded the 0.5 cut-off value suggested by) [34]. Meanwhile, CR depicts the degree to which the construct indicators indicate the latent construct. All constructs obtained CR values ranging from 0.831 to 0.958, which exceeded the 0.6 cut-off value suggested by) Bagozzi and Yi 1988). The result shows that the reliability and validity of the SEM data reach the threshold requirements. As the most popular test of inter-item consistency and reliability, Cronbach's alpha indicates how well the items in a set are positively correlated to one another. This measurement not only reflects the homogeneity of the measured scale but also assesses the internal consistency and reliability amongst a group of items that comprise such scale. In social science, a reliability coefficient equal to or greater than 0.60 is considered good [35]. The Cronbach's alpha values, which describe the degree to which a measure is free from errors, ranged from 0.744 to 0.929 and far exceeded the 0.7 threshold recommended by [43]. Therefore, all constructs were sufficiently error free.

C Discriminant Validity

The discriminant validity was examined to assess how truly distinct a construct is from the other constructs. The correlations between the factors in the measurement model should not exceed the 0.85 cut-off value suggested by [36]. The discriminant validity was checked by comparing the correlations between constructs with the square root of the AVE for a construct [37]. Table 6 shows the discriminant validity of the modified measurement model.

As shown in Table 6, the inter-correlations amongst the constructs ranged from –0.041 to 0.665, which were below the 0.85 threshold. The squared correlations were also less than the square root of the AVE for the factors, thereby highlighting the good discriminant validity of these factors [36].

Table 6 Discriminant validity index summary for the construct

Construct	GR	CN	PR	CO	EF	ES	EG	US	EM	OW	EX
Government Regulation	**0.880**										
Consultant	0.000	**0.851**									
Project	0.037	0.154	**0.862**								
Contractor	0.000	0.151	0.245	**0.885**							
Effects of Financial	0.170	0.104	0.293	0.361	**0.807**						
Effects of Site	0.136	0.044	0.166	0.361	0.597	**0.789**					
Effects of Government	0.153	0.200	0.155	0.223	0.665	0.522	**0.816**				
Utility Service	0.042	0.303	0.324	0.136	0.304	0.151	0.154	**0.852**			
Equipment & material	0.005	0.045	0.174	0.284	0.404	0.306	0.359	0.056	**0.848**		
Owner	-0.041	0.191	0.206	0.197	0.257	0.195	0.304	0.070	0.251	**0.923**	
External	-0.019	0.083	-0.103	0.039	0.251	0.021	0.244	-0.017	0.328	0.080	**0.904**

*Note: Diagonals represent the square root of the average variance extracted while the other entries represent the correlations.

VI. TEST OF HYPOTHESES

A Hypothesised Relationships between the Identified Factors and Road Construction Delay:

The significant relationship for each path of the developed model is presented in Table 7.

Table 7 Hypothesis Results of the Model

Relationship in the model	C.R	P-value	Hypothesis results
CO → Construction Delay	3.753	0.000	Accepted
OW → Construction Delay	3.074	0.002	Accepted
CN → Construction Delay	2.009	0.045	Accepted
US → Construction Delay	3.602	0.000	Accepted
GR → Construction Delay	2.714	0.007	Accepted
PR → Construction Delay	2.291	0.022	Accepted
EX → Construction Delay	2.184	0.029	Accepted
EM → Construction Delay	2.275	0.023	Accepted
Construction Delay → EG	7.766	0.000	Accepted
Construction Delay → ES	7.397	0.000	Accepted
Construction Delay → EF	8.643	0.000	Accepted

The objective of the study is to explore the possible factors of delay in road construction industry located in Libya. Province of northwest Libya which is achieved successfully. The results of the study reveal that the factors related to contractors, owner, consultant, material and equipment, government regulation, project, external and utility services have a significant impact on delay in road construction projects. However, consultant related and external factors do not explain significant variance in project delay. According to [38], investigated to identify the final conceptual model and the results of the six extracted factors affecting the project completion had a significant impact on delay in road construction projects: (factor 1) competence, finance, and the approval procedure of the owner, (factor 2) external elements, (factor 3) extraneous nature and internal interaction of the project, (factor 4) competence of the consultant, (factor 5) competence, finance, and productive forces of the contractor, and (factor 6) contract terms. By using multiple regression technique, the analysis indicated that the factors relating to contractor and owners have the strongest impact on the project completion in the conceptual model. Also, the objective of the study is to explore the possible effects of delay in road construction industry located in Libya. The results of the study reveal that the effects related to government, financial and site have a significant impact on delay in road construction projects. According to the previous study [39] conducted to measure the effects of project delay like cost-overrun, time-overrun, litigation and project abandonment. The objective of his study, the effects of delay in construction projects has been achieved successfully as the study found delay in construction projects leading significantly to the cost-overrun, time-overrun, litigation and abandonment that is highly unfavourable for the construction firms. Apart from that, the level of delay in construction projects has also been measured in various construction firms. The study has concluded that there are significant relationships of the factor and effect of construction delay. Therefore, the relationship model is giving a clear understanding of the construction delay for Libyan construction industry.

H1: Contractor VS Construction Delay:

H1 analysed the impacts of contractor-related factors on construction delay based on the output of the SEM for the factors and effects of construction delay. Figure 7 and Table 8 show a positive correlation between CO and construction delay. CO had a critical ratio of 3.753, which exceeds the recommended value of 1.96 [28]. The standardised estimate of Beta was $\beta = 0.249$, thereby confirming the positive relationship between CO and construction delay. In other words, when the standard deviation of CO goes up by 1, the standard deviation of construction delay also goes up by 0.249. Previous studies [16, 40, 41] confirmed that the contractor-related factors of construction delay, such as 'inexperienced manpower recruited by the contractor' and 'difficulties faced by the contractor in financing the project', have effects on construction projects. Therefore, H1 is significant.

Table 8 Results of examining hypotheses in the developed structural model

H	Dependent variable	path	Latent variable	Value of path coefficients (β)	C.R	P-value	Significance Yes / No
H1	Construction Delay	←	CO	0.249	3.753	0.000	Yes
H2	Construction Delay	←	OW	0.229	3.074	0.002	Yes
H3	Construction Delay	←	CN	0.132	2.009	0.045	Yes
H4	Construction Delay	←	US	0.218	3.602	0.000	Yes
H5	Construction Delay	←	GR	0.175	2.714	0.007	Yes
H6	Construction Delay	←	PR	0.159	2.291	0.022	Yes
H7	Construction Delay	←	EX	0.139	2.184	0.029	Yes
H8	Construction Delay	←	EM	0.157	2.275	0.023	Yes
H9	EG	←	Construction Delay	0.764	7.766	0.000	Yes
H10	ES	←	Construction Delay	0. 670	7.397	0.000	Yes
H11	EF	←	Construction Delay	0. 880	8.643	0.000	Yes

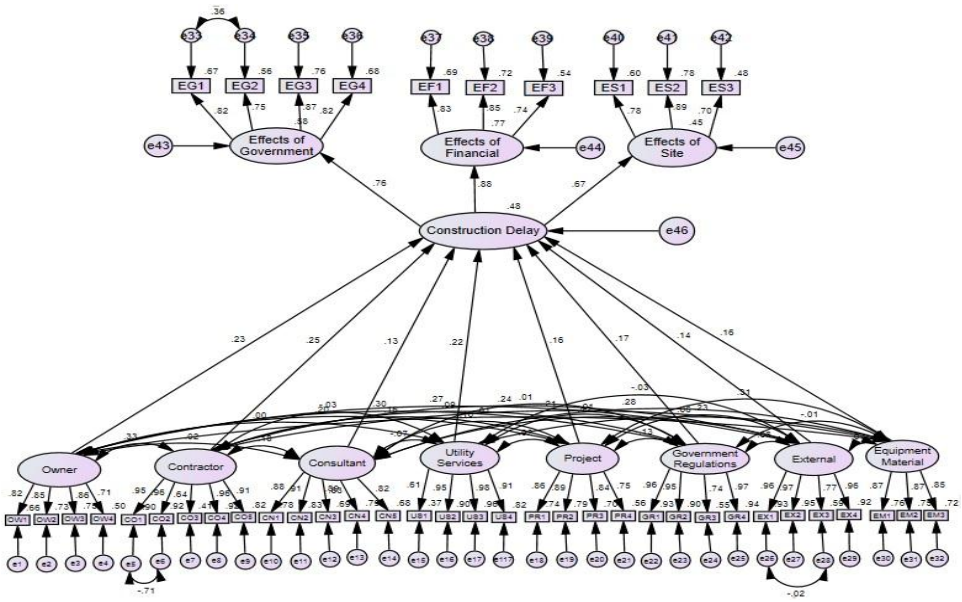


Figure 7. Structural equation model – (factors-effects) of construction delay

H2: Owner VS on Construction Delay

The output of the SEM for the factors and effects of construction delay (Figure 7 and Table 8) revealed a positive relationship between OW and construction delay. OW had a critical ratio of 3.074, which exceeded the recommended value of 1.96 [28]. The standardised estimate of Beta was β = 0.229, thereby confirming the positive relationship between OW and construction delay. In this case, when the standard deviation of OW goes up by 1, the standard deviation of construction delay goes up by 0.229. The previous literature [9, 14,42] confirmed that the owner-related factors of construction delay, such as 'difficulties in securing a budget for the project' and 'delays in progress payments attributable to the owner', have effects on construction projects. Therefore, H2 is significant.

H3: Consultant VS Construction Delay

H3 analysed the impacts of consultant-related factors on construction delay. The output of the SEM for the factors and effects of construction delay (Figure 7 and Table 8) revealed a positive correlation between CN and construction delay. CN had a critical ratio of 2.009, which exceeded the recommended value of 1.96 [28]. Furthermore, the standardised estimate of Beta was β = 0.132, thereby confirming the positive relationship between CN and construction delay. In this case, when the standard deviation of CN goes up by 1, the standard deviation of construction delay goes up by 0.132. The previous literature [16,43] confirmed that the consultant-related factors of construction delay, such as 'delay in approving the major changes proposed by the consultant in the scope of the project' and 'lack of a competent person to monitor the progress on the construction site', have effects on construction projects. Therefore, H3 is significant.

H4: Utility-Services VS Construction Delay

H4 analysed the impacts of utility-services-related factors on construction delay. The output of the SEM for the factors and effects of construction delay (Figure 7 and Table 8) revealed a positive correlation between US and construction delay. US had a critical ratio of 3.602, which exceeded the recommended value of 1.96 [28]. Furthermore, the standardised estimate of Beta was β = 0.218, thereby confirming the positive relationship between US and construction delay. In this case, when the standard deviation of US goes up by 1, the standard deviation of construction delay goes up by 0.218. Previous research [9, 44] confirmed that the utility-service-related factors of construction delay, such as ‘delays in the conversion and transfer of utility services by the competent authorities’ and ‘effects of subsurface or underground conditions’, have effects on construction projects. Therefore, H4 is significant.

H5: Government-Regulations VS Construction Delay

Hypothesis 5 analysed the impacts of government-regulations-related factors on construction delay. The output of the SEM for the factors and effects of construction delay (Figure 7 and Table 8) revealed a positive correlation between GR and construction delay. GR had a critical ratio of 2.714, which exceeded the recommended value of 1.96 [28]. Furthermore, the standardised estimate of Beta was β = 0.175, thereby confirming the positive relationship between GR and construction delay. Therefore, when the standard deviation of GR goes up by 1, the standard deviation of construction delay goes up by 0.175. Previous studies [9, 41 ,45] confirmed that the government-regulations-related factors of construction delay, such as ‘ineffective delay penalties’ and ‘changes in government rules and regulations’, have effects on construction projects. Therefore, H5 is significant.

H6: Project VS Construction Delay

The output of the SEM for the factors and effects of construction delay (Figure 7 and Table 8) revealed a positive correlation between PR and construction delay. PR had a critical ratio of 2.291, which exceeded the recommended value of 1.96 [28]. Furthermore, the standardised estimate of Beta was β = 0.159, thereby confirming the positive relationship between PR and construction delay. In other words, when the standard deviation of PR goes up by 1, the standard deviation of construction delay goes up by 0.159. Previous research [41, 46] confirmed that the project-related factors of construction delay, such as ‘original contract duration is too short’ and ‘unavailability of incentives for the contractor to finish the project ahead of schedule’, have effects on construction projects. Therefore, H6 is significant.

H7: External Factors VS Construction Delay

The output of the SEM for the factors and effects of construction delay (Figure 7 and Table 8) revealed that external factors positively affect construction delay. EX had a critical ratio of 2.184, which exceeded the recommended value of 1.96 [28]. The standardised estimate of Beta was β = 0.139, thereby confirming the positive relationship between EX and construction delay. In this case, when the standard deviation of EX goes up by 1, the standard deviation of construction delay goes up by 0.139. Previous studies [16; 43] confirmed that the external factors related to construction delay, such as ‘delays in construction activities due to weather changes’ and ‘poor political and security situation in Libya especially after the revolution’, have effects on construction projects. Therefore, H7 is significant.

H8: Equipment- And Material-Related Factors VS Construction Delay

The output of the SEM for the factors and effects of construction delay (Figure 7 and Table 8) revealed a positive relationship between equipment- and material-related factors and construction delay. E&M had a critical ratio of 2.275, which exceeded the recommended value of 1.96 [28]. The standardised estimate of Beta was β = 0.157, thereby confirming the positive relationship between E&M and construction delay. In other words, when the standard deviation of E&M goes up by 1, the standard deviation of construction delay goes up by 0.157. Previous study [46] confirmed that the equipment- and material-related factors of construction delay, such as ‘poor quality of construction materials’ and ‘changes in prices of materials’, have effects on construction delay. Therefore, H8 is significant.

B Hypothesised Relationships between the Identified Effects and Road Construction Delay

H9: Construction Delay VS Government-Related Effects

The output of the SEM for the factors and effects of construction delay (Figure 7 and Table 8) revealed a positive relationship between construction delay and government-related effects, amongst which ‘disputes’ showed the most significant effect. EG obtained a critical ratio of 7.766, which exceeded the recommended value of 1.96 [28]. The standardised estimate of Beta was β = 0.764, thereby confirming the positive relationship between EG and construction delay. In this case, when the standard deviation of construction delay goes up by 1, the standard deviation of EG goes up by 0.764. Previous studies [5, 43] confirmed that Construction delays could lead to disputes, arbitration and litigation. Therefore, H9 is significant.

H10: Construction Delay VS Site-Related Effects

The SEM of the factors and effects of construction delay (Figure 7 and Table 8) revealed a positive relationship between construction delay and site-related effects, amongst which ‘disruption of traffic’ showed the most significant effect. SE obtained a critical ratio of 7.397, which exceeded the recommended value of 1.96 [28]. The standardised estimate of Beta was β = 0.670, thereby confirming the positive relationship between SE and construction delay. Therefore, when the standard deviation of construction delay goes up by 1, the standard deviation of ES goes up by 0.670. Previous studies [9, 16] confirmed that construction delay could lead to the disruption of traffic and the delay of other projects related to the main project. In sum, construction delay has negative site-related effects and H10 is significant.

H11: Construction Delay VS Financial-Related Effects

The output of the SEM for the factors and effects of construction delay (Figure 7 and Table 8) revealed a positive relationship between construction delay and financial-related effects, amongst which 'time overrun' showed the most significant effect. EF obtained a critical ratio of 8.643, which exceeded the recommended value of 1.96 [28]. Meanwhile, the standardised estimate of Beta was $\beta = 0.880$, thereby confirming the strong positive relationship between construction delay and EF. In other words, when the standard deviation of construction delay goes up by 1, the standard deviation of EF goes up by 0.880. Previous works (16, 43] confirmed that construction delay could lead to financial-related effects, such as time overrun, cost overrun and poor quality. Therefore, construction delay has a negative financial-related effect and H11 is significant.

VII. CONCLUSION

The following recommendations for minimising and controlling road construction delays are proposed in consideration of the statistically significant SEM for the factors and effects of construction delay. Firstly, clearly defining the scope and objective of the project would facilitate the identification of variations emerging from the uncertainty in project objectives. Secondly, clearly defining the scope and objective of the project can help define the scope of work for each participant involved in a project. This study offers the following recommendations for the project participants:

- Properly plan and schedule the project to guarantee its continuous progress. They also match the allocation of resources to the schedule requirements to avoid cost and time overruns.
- Manage the financial resources of the project and plan the project cash flow by using progress payment.
- Offer contractors with progress payments according to the project duration, work progress and available budget for the project.
- Aware that any changes proposed in the later stages of the project will significantly increase the cost and/or time required to complete the project. Therefore, a clear agreement regarding the project scope must be reached between the contractor and the client.
- Minimise project delays by responding promptly to issues and conflicts relating to utility relocation that can pose safety risks and lead to traffic congestion.
- Improve the utility relocation coordination process during the construction project. Changing the schedule of utility relocation from what is expected may affect the schedule and costs of the contractors. Conversely, the relocation schedule of a utility company may be affected by the changes in the schedule of the contractor. Therefore, the communications amongst all parties should be improved. Excellent coordination processes are especially crucial for those major projects that require a significant relocation of utility facilities.
- Improve their administrative and financial procedures because such procedures become increasingly complex when the number of projects increases. The lack of consistency amongst different government regulations also contributes to such complexity. Construction companies have become overburdened with overly complex and lengthy administrative procedures.
- Facilitate the issuance of road construction permits because these projects can benefit all citizens and the occurrence of a delay will impose a huge cost for the government.
- Activate punitive and deterrent measures to motivate contractors to complete their projects on time.

VIII. RECOMMENDATIONS AND FUTURE DIRECTIONS

The proposed framework and the findings of this research have a generic structure even though this study specifically focused on road construction projects in Libya. Nevertheless, this research proposes the following suggestions for future research:

- This work is primarily limited by its geographical location (Libya) and restricted focus (road construction projects). Other types of road construction delays may be encountered in different countries due to their respective regulations and practices. The road construction projects being conducted in the other regions of Libya also need to be surveyed. This study is also limited by the fact that it only considers the opinions of key internal stakeholders. Therefore, future research should consider the opinions of a wider range of stakeholders, including the external ones.
- The applied research framework can also be used for examining the road construction projects in other developing countries. This framework is particularly applicable for those countries that have the same environmental factors, weather conditions and working methodologies observed in Libya.
- Although the suitability of the developed model for analysing road construction delays has been validated, this model needs to be investigated further to ensure that it can provide a realistic representation of other construction projects.
- The results of this study can be further investigated qualitatively by conducting case studies. Integrating the factors identified in each phase of a project life cycle can also help quantify the effect of various factors in a road construction project.
- The findings are obtained by conducting questionnaire surveys and by consulting experts. However, questionnaire surveys usually face problems related to the sample size and the attitude of respondents. Although the research has met the minimum requirements for a reliable and valid sampling size, the sample size needs to be increased to obtain more reliable data. Moreover, the occupation and attitudes of the respondents during the questionnaire survey may lead to a social desirability bias. Specifically, some respondents tend to over-agree or over-disagree with some delay factors. The unstable political and security situation in Libya after the 2011 revolution could also affect

the responses of the survey participants. These problems may be remedied by carefully rephrasing the questions and answers, including forced-choice items in the questionnaire, piloting the questionnaire prior to its distribution and validating the findings with project management experts.

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