Underlying causes and mitigation measures of delays in construction projects

An empirical study

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Abstract

Purpose – The purpose of this study is to contribute to the theory and practice of project management in the construction industry by identifying the primary causes and extracting the underlying causes of construction delays and providing recommendations on delay mitigation measures.

Design/methodology/approach – AA survey was used to identify the importance of 47 causes of delays. The relative importance index was used to rank them, factor analysis was applied to extract the underlying causes and focus group interviews were used for discussion and development of mitigation measures.

Findings – Six of the ten most important causes are in the top ten universal delays in construction projects. Factor analysis revealed six underlying causes: improper planning, poor consultant performance, inefficient site management, owner influence, bureaucracy and sub-standard contracts.

Practical implications – The owner/sponsor/client must have adequate engineering and project management skills to be able to evaluate proposals and contractors more accurately, economically and technically. The bidding and contract award process should focus on the most economically advantageous proposal and contracts should provide for mechanisms for managing risks while executing projects. Contractors should select reliable, high-quality subcontractors and suppliers and should have competent site managers.

Originality/value – This work expands and improves the understanding of the causes of delays in construction projects by providing an empirical study of the causes of delays and respective mitigation measures in Portugal.

Keywords Project management, Construction/project management, Delays in project delivery, Factor analysis, Delay causes, Construction industry, Mitigation

Paper type Research paper

Introduction

Building project delays, regardless of the type of project, are a worldwide problem. A delay in a construction project is defined as a time overrun either beyond the date the contract parties agree on for delivery of a project or beyond the completion date specified in the respective contract (Assaf and Al-Hejji, 2006). A project must be concluded on time and meet the specified cost and quality requirements to be successful. Hence, timely completion of a project is usually regarded as the major parameter for measuring the success of a project.

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With a view to overcoming delays, projects are extended or sped up, thus incurring inevitable added costs (Oyegoke and Al Kiyumi, 2017). The complexity of construction projects often makes it difficult to identify the causes of delays; moreover, these causes are frequently interrelated.

The scenario in the Portuguese construction industry is no different, and delays affect a significant number of construction projects. However, since the beginning of the Portuguese economic crisis in 2009, the industry has suffered enormous losses, resulting not only in a decline in the real estate sector but also in a near 30 per cent reduction in public works projects from 2012 to 2013 (FEPICOP, 2013). According to the most recent data available for the construction sector published by the Bank of Portugal (Banco de Portugal, 2016), the compound annual growth rate in the sector between 2009 and 2015 was almost −10 per cent. This has forced a large number of firms to move their operations abroad or to declare bankruptcy (Kapelko *et al.*, 2014). Accordingly, construction firms must be aware of and understand the origins of delays in their projects. Such delays can lead to late completion of the projects, lost productivity, increased costs and even contract termination, all of which have negative impacts on their ability to compete.

A number of studies have been conducted on this subject. For example, Assaf and Al-Hejji (2006) carried out a study to determine the causes of delay and their importance in different types of construction projects in Saudi Arabia. Fallahnejad (2013) investigated the causes of delays in 24 gas pipeline projects in Iran and Oyegoke and Al Kiyumi (2017) studied the causes and effects of delays in megaprojects in Oman. However, the causes of delays may vary depending on the circumstances, e.g. the environmental context, cultural differences, construction methods, management system, geographical context, entities involved, public policies, economic environment, access to resources and the political climate of the country in which the study was conducted (Zidane and Andersen, 2018). Accordingly, the main objective of this study is to identify the main causes and extract the underlying causes of delays in construction projects in the Portuguese context and offer recommendations on delay mitigation measures for improving construction project management practices in general.

This study is organized as follows. In Section II, a review of the literature on the causes of delays in construction projects is presented. In Section III, the research methods are presented. In Section IV, the results concerning the ranking of the causes and the underlying causes of delays are presented and analysed. In Section V, the mitigations measures are proposed and discussed. Finally, in Section VI, the respective conclusions and implications are drawn.

Studies on causes of delay in construction projects

There are many causes of delays because the development process in construction projects is very complex and requires integrating the concerns and priorities of various stakeholders, thus encompassing multiple works and requiring a long period to reach a conclusion. Various researchers have studied the causes of delays in construction projects (Table I). Odeh and Battaineh (2002) found that the most important causes of delays were inadequate contractor experience, owner interference, delay in progress payments by the owner, slow decision-making by the owner, improper planning, low productivity level of the labour involved and problems with subcontractors. They recommended that all stakeholders in the industry should introduce damage clauses and incentives, improve human resources and adopt a new approach to contract award procedures by giving less weight to price.

Authors	Research method	Sample size
Odeh and Battaineh (2002)	Survey, 28 causes of delay, five-point scale Relative importance index Spearman rank correlation coefficient	82
Assaf and Al-Hejji (2006)	Survey, 73 causes of delay, four-point scale, Importance index. Spearman rank correlation coefficient	57
Doloi et al. (2012)	Survey, 45 causes of delay, five-point scale Relative importance index Factor analysis Regression analysis	77
Doloi et al. (2012)	Survey, 17 causes of delay, five-point scale Relative importance index Focus group interviews Structural equation model	77
Fallahnejad (2013)	Survey, 43 causes of delay, 0 to 100 scale Independent relative importance index Spearman rank correlation coefficient	25
Shehu et al. (2014)	Survey, 84 causes of delay, five-point scale Kruskal Wallis analysis Mann-Whitney test	205
Ruqaishi and Bashir (2015)	Survey, 43 causes of delay, five-point scale Kruskal Walis analysis	59
Oyegoke and Al Kiyumi (2017)	Survey, 33 causes of delay, five-point scale Relative importance index	53

Table I.
Studies on causes of delay in construction projects – research method and sample size

A study conducted by Assaf and Al-Hejji (2006) in Saudi Arabia indicated that contractors considered that severe causes of delay had to do with the owners. Moreover, owners and consultants recognized that the highest frequent cause of delay is the awarding of the contract to the lowest bidder. They all agreed that the owner changing orders during construction is a cause of delay. Furthermore, they recommended that owners should pay the contractor on time, minimize change orders, avoid delays in the reviewing and approve of design documents and check for resources and capabilities before awarding the contract to the lowest bidder. Moreover, contractors should ensure that the number of labourers assigned to a job is sufficient and that the workers are motivated, and they should manage their financial resources and plan flow using progress payment. Furthermore, planning and scheduling should be correctly done and site management and supervision should be improved. Finally, consultants should review and approve design documents in a timely manner and should be flexible in evaluating contractor works.

A survey conducted by Doloi *et al.* (2012) determined that the most important causes of delay in construction projects in India were delays in material delivery by vendors, the non-availability of drawings on time, financial constraints on the contractor, increases in the scope of work and obtaining permissions from local authorities. They also found seven underlying causes of delays, namely, lack of commitment, inefficient site management, poor site coordination, improper planning, lack of clarity in project scope, lack of commitment and substandard contracts.

Fallahnejad (2013) investigated the causes of delays in Iran and found that the main causes were inability on the part of contractors to provide imported materials, unrealistic contract timelines imposed by the owner, slow delivery of materials by the owner, slow land expropriation because of resistance from occupants and changes to orders by the owner. He concluded that there was a high degree of agreement between each pair of entities. The author acknowledged, for future research, the need to determine the root causes of delays and then accordingly develop the mitigation measures.

Shehu *et al.* (2014) assessed the causes leading to time overruns in construction projects in Malaysia. Despite some differences of opinion between sectors (public and private) and entities, the results show that there is a certain amount of agreement that the major causes contributing to delays are cash flow problems faced by the contractors and late payment by contractors to sub-contractors or suppliers. Accordingly, the authors recommended that both contractors and suppliers be aware of the owner's financial position prior to entering into any construction projects.

Ruqaishi and Bashir (2015) found out that, in the oil and gas industry in Oman, the major causes of construction project delays were poor site management and supervision by the contractor, problems with subcontractors, inadequate planning and scheduling of the project by contractors, poor management of contractor schedules, delays in delivery of materials, lack of effective communication among project stakeholders and poor interaction with vendors during the engineering and procurement stages. The results revealed a high degree of agreement among owners, consultants and contractors as the causes of delay.

Oyegoke and Al Kiyumi (2017) examined the causes and effects of delays in megaprojects in Oman. They found that the major causes were selection of the lowest bid, the financial situation of the main contractor, delay in decision-making by the developer and poor construction planning by the main contractor. In terms of major effects of the delays, they reported extra costs and project time overruns. As mitigation measures, they suggested the use of experienced contractors and consultants, efficient construction planning by the main contractor and effective site management.

Recently, Zidane and Andersen (2018) conducted a study to identify the top 10 universal delay causes in construction projects. They presented a compilation of multiple studies conducted in different parts of the world on the causes, to which an empirical study on delay causes in Norway was added. An overall ranking index was used to select the "top ten universal delay causes" from the top 10 delay causes for 46 countries worldwide individually. The top 10 universal delay causes are design changes during construction/change orders, delays in payment to contractor, poor planning and scheduling, poor site management and supervision, incomplete or improper design, inadequate contractor experience/building methods and approaches, contractor financial difficulties, owner financial difficulties, resource shortages and poor labour productivity and shortage of skills.

Based on the reviewed literature, the main causes of delays in construction projects reveal some variation depending on the type of project and the context in which the delay takes place. This result supports the suggestions made by some authors that comparable studies should be performed in other countries and on other types of construction projects (Assaf and Al-Hejji, 2006; Sambasivan and Soon, 2007; Lind and Brunes, 2015). Indeed, despite a certain degree of consensus on the more important causes of delays, these studies did identify different, albeit related, sets of causes and show somewhat different rankings for the importance of causes, although some emerge as the most important ones (Zidane and Andersen, 2018). This suggests a need to better understand the underlying causes that aggregate sets of observed causes as has been recommended by Fallahnejad (2013). In terms of delay mitigation measures, the abovementioned studies primarily focused on identifying the main causes of delay; the corresponding mitigation measures, where presented, were fundamentally a list of measures aimed at eliminating or reducing the direct impact of those causes. Olawale and Sun (2010) realized that research to date has been primarily oriented on identifying causes and that there has been limited research studying the underlying causes, thus limiting the ability of stakeholders to control their projects. Moreover, to the best of our knowledge, there are no similar studies in the Portuguese context that have been published in the leading journals.

The research presented herein looks at the Portuguese context and focuses on owners, consultants and contractors in the construction industry. It contributes to project management by presenting effective mitigation measures combining the main causes and the underlying causes of delays in construction projects. Moreover, as emphasized by Zidane and Andersen (2018), few studies have been performed in Europe; therefore, this study will contribute to expanding and improving the knowledge of the causes of delay by providing an empirical study in a European country, i.e. Portugal.

Research methods

The methodology used in this study combined a questionnaire, relative importance index (RII), exploratory factor analysis (EFA) and focus group interviews (FGIs) and the steps mentioned below were followed for this study:

- a literature review (performed in the previous section);
- questionnaire design and data collection;
- results, including the ranking of the causes of delay based on the RII, and the extraction of the underlying causes using an EFA; and
- discussion of the results with a view to developing measures and recommendations to mitigate delays.

The FGI is defined as a primary research technique that collects data through group interaction on a subject set by the moderator (Morgan *et al.*, 1996); it plays an important role in this research because it was used to design the survey questionnaire (first FGI) and to discuss the results and propose recommendations and delay mitigation measures (second FGI). This qualitative research approach provided detailed knowledge of a phenomenon experienced by FGI participants. For the two FGIs, different and independent sets of experts in the construction industry (hereinafter referred to as experts) were considered to ensure consistency and validity of results (Nassar-McMillan and Borders, 2002). Moreover, care was taken in the selection of experts to avoid having any bias within the group. The set of experts in the first FGI was composed of two practitioners from each entity, namely, owners, consultants and contractors; moreover, it contributed to the design of the survey questionnaire. The set of experts in the second FGI comprised just one practitioner from each entity and two invited researchers in project management and contracting in the construction industry; they were used in the discussion of the results and the proposition of recommendations and delay mitigation measures. In both cases, all participants had more than 10 years' experience. Furthermore, in these FGIs, all experts had equal weighting in the decision-making process. Both FGIs were moderated by one of the authors. Particular attention was paid to the moderator's role: the moderator was well informed on the topic of construction project management, and the discussion progressed from the general to specific issues to promote sincerity and reduce bias (Prince and Davies, 2001).

Questionnaire design and data collection

As in similar research works, a survey questionnaire was the tool adopted to evaluate the importance of the causes of delays in construction projects. To guarantee success, a questionnaire must be clear and have no errors or inconsistencies in its design. For this purpose, the basic rules for social surveys were followed when designing the questionnaire

(Forza, 2002). A five-point Likert scale was used to measure the relative importance of the causes (1 - very low to 5 - very high) of delays. Following the critical review of the literature on delays in construction projects, the authors developed a set of 58 major causes of delays inspired by the works of Fallahnejad (2013), Aibinu and Odeyinka (2006) and Assaf and Al-Hejji (2006). Then, the experts in the first FGI translated the items on the questionnaire into Portuguese and adapted them to the context of the Portuguese construction industry by selecting 47 causes that they considered appropriate (Table II). Finally, a pilot test was conducted to check the efficacy of the questionnaire in gathering information and to identify possible errors or misinterpretations in it. As a result, after a few minor corrections, the final questionnaire was ready, which was electronically disseminated to a sample of 320 potential respondents randomly taken from the databases of the Association of Construction and Public Works and Services Companies (AECOPS is the Portuguese acronym), the most representative association for the construction industry in Portugal with more than 2,100 members. Following Dillman's (2000) guidelines, an email with a description of the objectives of the study and a link to the online survey was sent to the potential respondents, followed by a reminder one week later. Another email was sent to non-respondents three weeks after the first email. Furthermore, all respondents were promised access to the final report on the research project.

Moreover, efforts were made to address the issue of non-response bias, namely, in the form of a follow-up programme aimed at controlling whether they were indeed different from the respondents (Forza, 2002). For this purpose, some of the non-respondents were contacted by phone and asked to answer a small number of questions from the survey. Because their answers did not significantly differ from those who answered the survey, we assumed that there was no evidence of non-response bias.

Sending out the survey questionnaire yielded 94 completed surveys (Table II). Although the sample size was small, it was within the range used in similar studies (Table I), and the quality of the responses was considered highly reliable for the study because of the respondents' relevant experience. Moreover, using the $\chi 2$ test, it was determined that there was no significant difference between the potential and the actual respondents, at a significance level of 5 per cent. Finally, the respondents' average experience was ~18 years, which comes close to the figures reported in the literature (Assaf and Al-Hejji, 2006). The analysis that follows was performed using the Statistical Package for Social Sciences (SPSS).

Results

Main causes of delays

The RII method was used in this study to assess the relative importance of the causes of delays in construction projects. It has been frequently used in similar studies

Respondent group	Potential respondents	No. of responses	Frequency (%)	Response rate (%)	Respondents' experience (years) <5	5-10	10-20	>20
Owners	70	11	11.7	15.7	0	1	5	5
Consultants	100	30	31.9	30.0	1	4	7	18
Contractors	150	53	56.4	35.5	2	7	22	22
Total	320	94	100	29.4	3 (3.2%)	12 (12.8%)	34 (36.2%)	45 (17.9%)

Table II.
Survey respondent distribution by respondent group

(Sambasivan and Soon, 2007; Fallahnejad, 2013). For each cause, the particular RII is calculated as follows (1):

$$RII = \frac{\sum W}{AxN} \tag{1}$$

where W is the importance given to each cause (1 to 5) with A being the highest importance (5 in this case) and N being the total number of responses. The higher the RII, a value between 0 (not inclusive) and 1, the more important is the cause of delay.

Overall, the main cause of delays indicated by respondents (Table III) was slow decision-making by owner because the timing of decision-making is critical in construction projects. The following four main causes were as follows: change in orders, unrealistic time schedule and specifications in contract, financial constraints on the part of the contractor and bidding and contract award process. Their RIIs were similar to each other and close to the cause that was perceived to be most important. Moreover, respondents indicated delay in progress payments by owner, improper planning and scheduling, owner interference, increase in scope of work and mistakes and discrepancies in drawings as important causes. These results, considering the ten most important causes of delay in the Portuguese construction industry, are in line with the principal causes reported in other studies with seven of the causes included in the top 10 universal causes of delay defined by Zidane and Andersen (2018) (Table IV). However, there are differences in terms of the rankings, and 4 of the 10 most important causes of delay in the Portuguese construction industry are not included in the Top 10 universal causes of delay, namely, slow decision-making by the owner (#1), unrealistic time schedule and specifications in the contract (#3), the bidding and contract award process (#5) and owner interference (#8).

Underlying causes

Following the method of Doloi *et al.* (2012), EFA was used to obtain a greater understanding of the numerous correlated, but seemingly unrelated, observed causes of delays in construction projects by reducing them to fewer factors (referred to as underlying causes). This procedure provides a meaningful understanding of the problem of delays; thus, it allows for designing more effective mitigation measures for said delays. Moreover, any mitigation measure developed for a particular underlying cause has its effectiveness leveraged once it mitigates the effects of all the observed causes under this underlying cause because they are related.

To evaluate the suitability of the survey data for EFA, two tests were conducted: the Kaiser–Meyer–Olkin (KMO) test and Bartlett's test of sphericity (Field, 2013). The KMO test compares the magnitude of the squared correlation between variables to the squared partial correlation between variables. The original causes can be efficiently grouped into fewer underlying causes when the KMO values are >0.5 (Field, 2013). Bartlett's test examines whether the correlation coefficient matrix of causes is an identity matrix with the correlation coefficients outside the primary diagonal close to 0, indicating that not all of the causes are correlated and thus rendering EFA to be unsuitable. The KMO value for the survey data, considering the 26 causes selected out of the original 47, was 0.795, which is greater than 0.5. The result of Bartlett's test was 1.390 (p-value <0.01), which indicated that the correlation coefficient matrix of causes is not an identity matrix. Therefore, both tests suggested that EFA was a suitable method.

EFA, using principal component analysis, produced six underlying causes with eigenvalues greater than one (Table V). A varimax rotation was performed on the initial

Table III. RII and ranking of causes of delay

Code	Cause of delays	RII	Rank	Code	Cause of delays	RII	Rank
C02	Slow decision-making by owner	0.849	1	C21	Delay in site mobilization by contractor	0.657	25
C06	Change in orders	0.845	2	C13	Delays and changes in subcontractors	0.655	26
C37	Unrealistic time schedule and specifications in contract	0.845	2	C30	Low labour productivity	0.651	27
C20	Financial constraints on the part of the contractor	0.843	4	C16	Mistakes during construction	0.645	28
C36	Bidding and contract award process	0.828	5	C35	Delay in producing design documents	0.632	29
C01	Delay in progress payments by owner	0.770	6	C14	Inadequate construction methods	0.626	30
C15	Improper planning and scheduling	0.755	7	C29	Lack of qualified labour	0.626	30
C03	Owner interference	0.736	8	C10	Delay in quality control	0.621	32
C05	Increase in scope of work	0.732	9	C12	Waiting time for approval of tests and inspections	0.598	33
C33	Mistakes and discrepancies in drawings	0.728	10	C32	Inadequate equipment	0.596	34
C47	Delay in obtaining permits from authorities	0.726	11	C34	High complexity of drawings	0.587	35
C27	Delay in procurement of materials	0.721	12	C22	Inadequate quality of materials	0.585	36
C26	Changes in material specifications during construction	0.717	13	C19	Poor site management by contractor	0.577	37
C25	Delay in delivery of materials	0.711	14	C04	Delay in handing over the site to contractor by owner	0.574	38
C41	Disputes and negotiations between parties	0.711	14	C31	Equipment availability and failure	0.574	38
C40	Lack of communication between parties	0.696	16	C43	Problems with neighbours	0.566	40
C42	Unforeseen site conditions	0.687	17	C39	Lack of motivation for contractor to finish early	0.560	41
C17	Inadequate contractor experience	0.677	18	C46	Changes in government regulations	0.530	42
C24	Shortage in materials	0.677	19	C28	Change in material prices	0.523	43
C09	Delay in approval of drawings	0.674	20	C11	Lack of control over subcontractor	0.521	44
C45	Weather conditions	0.672	21	C23	Damaged materials	0.511	45
C07	Bureaucracy in owner's organization	0.670	22	C44	Unavailability of utilities in site	0.511	45
C08	Inflexibility of consultant	0.668	23	C18	Site accidents	0.474	47
C38	Mistakes and discrepancies in contract	0.666	24				

Top 10 universal causes of delay, Zidane and Andersen (2018)	Universal ranking	Ranking in the present study (code of the cause)
Design changes during construction/change orders	1	*2 and 9 (C06 and C05)*
Delays in payment of contractors	2	*6 (C01)*
Poor planning and scheduling	3	*7 (C15)*
Poor site management and supervision	4	37 (C19)
Incomplete or improper design	5	*10 (C33)*
Inadequate contractor experience/building methods and approaches	6	18 (C17)
Contractors' financial difficulties	7	*4 (C20)*
Sponsor/owner/owner's financial difficulties	8	*6 (C01)*
Resources shortage (human resources, machinery, and equipment)	9	38 (C31)
Poor labour productivity and shortage of skills	10	27 and 30 (C30 and C14)

Table IV.
Causes of delay with highest RII – alignment with previous studies

Underlying cause (Cronbach's alpha, eigenvalues, % variance explained)	Code – Cause of delay	Factor loading
I – Improper planning (0.849, 7.611, 13.694)	C15 – Improper planning and scheduling	0.823
	C16 – Mistakes during construction	0.769
	C13 – Delays and changes in subcontractors	0.764
	C14 – Inadequate construction methods	0.682
	C17 – Inadequate contractor experience	0.588
II – Poor consultant performance (0.873, 3.059, 12.404)	C09 – Delay in approval of drawings	0.843
	C10 – Delay in quality control	0.785
	C08 – Inflexibility of consultant	0.762
	C12 – Waiting time for approval of tests and inspections	0.725
III – Inefficient site management (0.853, 2.270, 12.005)	C23 – Damaged materials	0.676
	C11 – Lack of control over subcontractor	0.674
	C22 – Inadequate quality of materials	0.671
	C31 – Equipment availability and failure	0.623
	C44 – Unavailability of utilities in site	0.574
	C29 – Lack of qualified labour	0.544
IV – Owner's influence (0.741, 1.863, 10.284)	C06 – Change orders	0.808
	C05 – Increase in scope of work	0.770
	C03 – Owner interference	0.683
	C02 – Slow decision-making by owner	0.599
V – Bureaucracy (0.705, 1.461, 9.590)	C46 – Changes in government regulations	0,767
	C07 – Bureaucracy in owner's organization	0,767
	C47 – Delay in obtaining permits from authorities	0,577
VI – Sub-standard contracts (0.717, 1.220, 9.270)	C37 – Unrealistic time schedule and specifications in contract	0,775
	C41 – Disputes and negotiations between parties	0,649
	C20 – Financial constraints on part of contractor	0,644
	C36 – Bidding and contract award process	0,644

Table V.
Factor analysis – underlying cause extracted and correlation matrix

results to yield more interpretable underlying causes (Table V). Each underlying cause contained those causes that had the highest factor loadings (the degree to which each cause was related with its assigned underlying cause). To identify the factor loadings as significant for interpreting the extracted underlying cause, their values have to be above 0.5 and the corresponding cross-loadings values have to be below 0.5 (Field, 2013). The six underlying causes extracted from 26 causes explained more than 67 per cent of the total variance (Table V). The remaining 21 causes were found to have no significant correlation with one another and were therefore excluded from further analysis. All Pearson's correlation coefficients among causes were higher than 0.3 (with the exception of a couple of coefficients) (Field, 2013). Finally, Cronbach's alpha was used to check for the internal consistency among the causes that measure a particular underlying cause (Field, 2013). As Table V shows, Cronbach's alpha of each underlying cause was higher than 0.7; therefore, EFA could be deemed appropriate for this study.

The underlying cause, i.e. designated improper planning, was found to be one of the most important causes of delay in construction projects; it comprises five causes related with the contractors. The cause improper planning and scheduling is, in the opinion of the experts, an important issue that generally leads to an improper and overly optimistic estimation of the duration of activities and consequently improper planning and scheduling of the project's activities (Ruqaishi and Bashir, 2015). Lind and Brunes (2015) concluded that lack of competence of contractors and optimism bias were the most relevant explanatory factors for time and cost overruns. Even if the contractor is a suitable fit for a project, pressure to reduce costs leads to unrealistic project planning. The cause mistakes during construction is highly correlated with the contractor's experience (Abd El-Razek *et al.*, 2008; Oyegoke and Al Kiyumi, 2017). According to the experts, delays and changes in subcontractors are situations related to improper planning. If project planning and scheduling are inadequate, then one might expect difficulties in selecting and integrating subcontractors in the execution phase of the project. The cause inadequate construction methods is probably attributed to poor planning and selection of construction methods during the planning phase of the project (Doloi *et al.*, 2012). If the construction methods selected are inappropriate, mistakes will frequently occur. Lastly, the cause inadequate contractor experience was considered a key factor in the poor quality of project planning and an important cause of delays (Oyegoke and Al Kiyumi, 2017).

The underlying cause poor consultant performance includes four causes of delays for which the consultant is primarily responsible. If there is a delay in approval of drawings and a delay in quality control, then the respective activities cannot be initiated as planned and the probability of delayed completion is high. The cause inflexibility of consultants is interpreted as a lack of flexibility on the part of the consultant in the assessment of the non-conformities between the project specifications and the work performed on the construction site, which the experts often consider to be attributed to an overly rigid interpretation of the project specifications concerning issues considered not so important to the success of the project. Finally, the cause waiting time for approval of tests and inspections, if longer than planned, can contribute to the perception of poor performance by the consultant. Moreover, the experts mentioned that occasionally such poor performance could be indicative of a certain lack of experience or willingness to take on certain planned risks on the part of the consultant, something that was mentioned by Oyegoke and Al Kiyumi (2017).

The underlying cause inefficient site management relates to the three major cornerstones of efficient construction site management: resources, labour and equipment. Problems with the supply of materials or resources to the construction site – including the causes damaged materials, inadequate quality of materials and unavailability of utilities in site – are associated with difficult site management and consequent inevitable inefficiency (Assaf and Al-Hejji, 2006). The cause lack of control over subcontractor can reflect a contractor's lack of management skills or lack of an effective contractual framework for engaging subcontractors, which may lead to undesirable conflicts, low productivity and development of negative attitudes on the site (Doloi *et al.*, 2012; Oyegoke and Al Kiyumi, 2017). The cause equipment unavailability and failure indicates inappropriate sourcing, usage and maintenance of equipment, which constitutes a barrier to proper construction site management (Rivas *et al.*, 2011) and reflects poor site management. The cause lack of qualified labour contributes to stress in labour management because qualified labour becomes a scarce resource, thus complicating site management (Ruqaishi and Bashir, 2015).

The underlying cause owner's influence includes four causes of delay that are primarily the owner's responsibility. The causes change in orders and owner interference lead to confusion, misunderstandings and the need to re-do work at the construction site, and inevitably to delays in completion of the construction activities (Alnuaimi *et al.*, 2010). Moreover, owners often tend to increase the scope of the work during the construction, which complicates and hinders site management and pushes up costs, among other things, thus delaying completion of the project. Finally, the cause slow decision-making by owner may be the consequence of a lack of clarity on the owner's part (Odeh and Battaineh, 2002); however, the experts emphasized that the worst situation is lack of clarity combined with owners who are slow in making decisions.

The underlying cause bureaucracy covers three causes of delay. The experts consider changes in government regulations to be one of the major drivers of bureaucracy because constant changes in regulations tend to increase the administrative burden and difficulties for a project. The cause bureaucracy in owner's organization, particularly if perceived as unnecessary, gives rise to increased bureaucracy, which disrupts normal project management and execution (Fallahnejad, 2013). Finally, the cause delay in obtaining permits from authorities has a direct impact on the normal course of the work at the construction site because it inevitably delays the start of activities that depend on permits and is normally associated with issues involving bureaucracy.

The underlying cause sub-standard contracts in the construction industry is an important reason for multiple conflicts and misunderstandings that often result in litigation and arbitration (Mahamid *et al.*, 2012). The cause unrealistic time schedule and specifications in contract, in the experts' opinion, usually results from poor project planning and design, which frequently is a consequence of inadequate or inexperienced contractors or of pressure to reduce the contract price (Oyegoke and Al Kiyumi, 2017). This is usually achieved by decreasing the duration of activities and adopting overly optimistic scenarios regarding weather conditions and the construction site (Hasan and Jha, 2015). Disputes and negotiations between parties are often attributed to issues associated with sub-standard contracts such as payment plans that are inadequate for the real financial needs of the project, a lack of reasonable contingency clauses, a lack of adequate financial penalties and awards, a lack of clear allocation of project responsibilities by the parties involved and under-budgeted activities in the project. The cause financial constraints on part of contractor is often results from underestimating the costs and duration of activities attributed to the contractor's wish to submit a competitive project price bid and payment conditions (Prasad *et al.*, 2019). Finally, the cause bidding and contract award process, which is traditionally based on the proposal with the lowest price, pressures the contractor to reduce the price, thus giving rise to unrealistic contract conditions (Oyegoke and Al Kiyumi, 2017).

Of the six underlying causes of delays in construction identified in this research, three of them were identified in the work of Doloi *et al.* (2012), namely, inefficient site management, improper planning and sub-standard contracts. Although these underlying causes were of the same nature, the causes observed were diverse, thus reflecting differences in the contexts in which these studies were performed.

Mitigation measures

The experts participating in the second FGI were asked to contribute to the discussion of the results and to propose a set of measures to mitigate delays in construction projects (Table VI). To this end, the experts were requested to consider the underlying causes of delays (Table V), aggregating 26 causes and the top ten causes of delays based on their higher relative importance (Table III).

The underlying cause improper planning, which covers several causes of delays related to contractors and to poor planning and scheduling is, according to the experts, largely a result of the bidding and contract award process, which often leads to the selection of the proposal with the lowest price, thus frequently resulting in the selection of contractors with less experience and an inadequate skill set. Accordingly, the appropriate mitigation measure should consider the adoption of bidding and contract award processes based on the most economically advantageous bid and the development of realistic plans and scheduling for the construction project, thus ensuring that project drawings are complete, on time and free of mistakes and omissions (Table VI; MM1; MM2; MM3).

As with the previous underlying cause, inefficient site management reinforces the importance of good site management and the need for the owner to hire contractors that have capable site managers, reliable equipment readily available and dependable suppliers of materials to mitigate the effects of delays in construction projects (Oyegoke and Al Kiyumi, 2017). Accordingly, owners should hire contractors with a proven record in terms of

Code	Measures to mitigate delays
MM1	Adoption of bidding and contract award processes based on "the most economically advantageous" bid
MM2	Development of realistic plans and scheduling for the construction project
MM3	Ensuring that project/design drawings are complete, on time and free of mistakes and omissions
MM4	Selection of contractors with capable site managers, available and reliable equipment and dependable subcontractors and suppliers of materials
MM5	Selection of consultants with the experience and adequate skills for the project
MM6	Consultants should be provided with proper work conditions in the construction site
MM7	Improving owners' engineering and project management skills
MM8	Participation of the owner in the project planning and design to guarantee that their requirements are all taken into account
MM9	Assessment of both time and financial impacts in the event that the owner decides to change the project
MM10	Ensuring the owner has the capacity to take critical decisions on the project in a timely manner
MM11	Preparation of the project documentation in accordance with the legal and regulatory framework
MM12	Knowledge by those involved in the project of the legal and regulatory framework, and expectable modifications
MM13	Ensuring effective information flow between the participants in the construction project, including public entities. For example, by adopting BIM technology
MM14	Inclusion in the contracts of formal and legal instruments to correctly manage the risks (financial and others) associated with the execution of projects

Table VI. Measures to mitigate delays in construction projects capable site managers, available and reliable equipment and dependable subcontractors and suppliers of materials (Table VI; MM4).

The EFA revealed the underlying cause, i.e. poor consultant performance. However, according to the experts, the perception of poor consultant performance may be related to the excessive strictness of consultants linked, in the case of inexperienced consultants, to poor construction site management by contractors and frequently to the lack of quality in the conditions in which the consultant works, indicating that care must be taken when interpreting consultant performance. Hence, owners should select consultants with the adequate skills and experience and provide them with proper work conditions such that they can conveniently perform their tasks (Table VI; MM5; MM6).

The underlying cause owner's influence indicates that owners are primarily to be blamed for any lack of clarity as to the project scope, which, according to the experts, can be explained by the owner's lack of engineering and construction project management skills, something that is linked with low-quality construction projects. Consequently, the owner should participate in the project planning and design to guarantee that their requirements are considered. Moreover, owners should consider both time and financial impacts if they decide to change the project (Table VI; MM7; MM8; MM9; MM10).

With respect to the bureaucracy underlying cause, the experts agreed that the portuguese authorities have a tendency towards increased bureaucracy but they also mentioned the owner's lack of skills and the frequent need for revision and adaptation of construction projects. Hence, those involved in a project should be aware of the legal and regulatory framework, expectable modifications and accordingly prepare the project documentation. Furthermore, information should flow in an effective way between the participants in a construction project, including public entities, which could be achieved by adopting BIM (Almuntaser *et al.*, 2018) (Table VI; MM11; MM12; MM13).

The last underlying cause, i.e. sub-standard contracts, which is primarily the outcome of the common process for bidding and awarding contracts based on the lowest price, is aggravated by the owner's lack of engineering and project management skills according to the experts, leading owners to accept proposals from inadequate and inexperienced contractors without questioning technical and economic viability. Hence, realistic plans and scheduling should be prepared, and the bidding and contract award processes should be based on the most economically advantageous bid. Moreover, the contracts should include instruments to correctly manage the risks associated with the execution of projects (Table VI; MM1; MM14).

Furthermore, the results of the ranking of the causes of delay, considering the top ten causes (Table III) in which five of them are linked to the owner reveals the importance of owner actions as a driver of delays in construction projects. This is consistent with the literature (Fallahnejad, 2013), which highlights that the behaviour of the owner is decisive in delays. However, the experts argued that the uncertainty arising from the economic crisis in the Portuguese construction industry has impacted the owners' role as drivers of delays. Indeed, the crisis affected owners by causing them to postpone decisions that could have a financial impact, change orders and delay payments, thus interfering with the normal execution of the project (Hasan and Jha, 2015). Therefore, the delay mitigation measures must consider the decisive role of the owner/developer in the emergence of causes of delays in construction projects. The mitigation measures presented in Table VI (MM1; MM7; MM8; MM9; MM10) already reflect preoccupation with the role of the owner. Finally, only two of the top ten causes are not included in the 26 causes in the underlying causes of delay, namely, slow decision-making by owner and mistakes and discrepancies in drawings.

However, measures to mitigate these two causes of delay have already been considered in Table VI (MM3; MM7).

The delay mitigation measures presented in Table VI highlight the importance of the owner in avoiding delays in construction projects. It is the responsibility of the owner to guarantee the right skills of engineering and project management, either in-house or by hiring qualified consultants from outside; the formulation of realistic plans and scheduling; the selection of the most suitable bid and contract award processes that possible focus on the most economically advantageous bid; the inclusion in contracts of mechanisms to manage financial and others risks associated with the execution of projects; and lastly, the selected contractor picks dependable subcontractors and suppliers, capable site managers and provides the consultants with appropriate conditions and information concerning the status of the project.

With regard to contractors, these should have experienced and capable site managers, reliable equipment at their disposal and dependable subcontractors and suppliers. Contractors should have the capabilities that allow them to assess both time and financial impacts in the event that the owner decides to make changes to the project and to force the inclusion in the contract of instruments to protect them from the risks associated with the execution of construction projects. As far as the consultants are concerned, they should use experienced professionals with adequate skills for the project type and should demand timely access to the construction site and proper work conditions. Finally, all the participants involved in the construction project should promote an environment where information flows effectively among them, e.g. by adopting BIM.

Conclusions

This study used a survey to identify the main causes and the underlying causes of delays in the Portuguese construction industry with the aim of developing measures to mitigate those delays. RII revealed that the main causes of delays were slow decision-making, changes to orders, unrealistic time schedules and specifications in contracts, financial constraints on the part of contractors and the bidding and contract award processes. EFA revealed six underlying causes of delay, namely, improper planning, poor consultant performance, inefficient site management, owner's influence, bureaucracy and sub-standard contracts. Finally, experts in a FGI proposed a set of measures to mitigate delays considering the underlying causes and the ten top causes of delays. These results highlight the importance of the owner in avoiding delays in construction projects.

As for the practical implications for the construction industry in Portugal, the owners should adopt bidding and contract award processes based on the most economically advantageous bid; improve their engineering and project management skills; promote the development of realistic plans and scheduling; select contractors with capable site managers, reliable equipment and dependable subcontractors and suppliers and select consultants with adequate experience and adequate skills. Moreover, BIM implementation is recommended for an effective flow of information. Finally, formal and legal instruments to manage the risks associated with project execution should be included in the project contract.

Previous studies have been primarily oriented towards finding the most important causes of delays in construction projects and, where mitigation measures are presented, they are usually a list of measures that do not consider the relationships between causes. Compared with the literature, the mitigation measures proposed are expected to be more effective in this study because they were developed by experts in FGI after considering both the underlying causes of delays and the ten top causes of delays. Accordingly, this study contributes to project management in construction by highlighting the importance of the owner in the causes of delays and providing an empirical study of the causes of delays and respective mitigation measures in Portugal and by adding a new study to the body of knowledge in Europe.

The main limitations of this work results from the small number of respondents in the survey, and from the qualitative research method used (FGIs), the results of which could be influenced by participants' subjective opinions. Care must, therefore, be taken before applying the findings of this study in a generalized way to other geographic and economic contexts.

A future avenue of research could be to replicate this study in different contexts, to develop the mitigation measures for delays in construction projects further and to explore the effectiveness of those measures.

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