

Research Paper

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A DOSE to compare the level of performance between construction projects

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Abstract: The aim of this paper was to compare the level of performance (success) of construction projects between selected countries based on the concept of iron triangle. Following this, the major construction delays, cost overruns and quality factors were identified through an in-depth review of previous research works conducted in Denmark, Nigeria and Gaza Strip. The aggregate impacts of these factors were computed and compared between these countries. The results show that in the case of Denmark, the aggregate impact of the factors responsible for delay, cost overrun and poor quality was found in the impact interval between [0.60–0.80], but in the case of Gaza Strip and Nigeria, the aggregate impacts were found in the impact interval between [0.80–1.0]. This shows that construction projects in Denmark are found to be performed better relative to Nigeria and Gaza Strip.

Keywords: delay, cost overrun, quality issues, impact interval, dose, level of performance

1 Introduction

Customer satisfaction-based project management discipline took place in the 20th century around 1960s (Karaman and Kurt 2015). This customers-need based project management requires successful completion of construction projects. A project is successful when it is completed on time, budget and the required quality (Nyoni and Bonga 2017). These variables that play an important role in project success are known as the ‘iron/golden’ triangle (Bryde and Robinson 2007). Numerous studies conducted in different countries and times have used the

concept of iron/golden triangle to measure construction project performance. However, there is limitation in comparing the performance of construction projects between different countries based on these basic management triangles and their aggregate impacts. The main purpose of this study was to compare the construction performance between countries through identification of the root causes of construction delays, cost overruns and quality factors and computing their aggregate relative importance index (RII).

1.1 The objective of the study

The main purpose of this study was to compare the construction performance between selected countries using the concept of ‘iron/golden’ triangle (construction time, cost and quality) as a factor group.

2 The concept of golden triangle and project performance

Although there is no clear consensus on the concept of project success in the modern project management (Ika 2009), the definition, fulfilling the needs of construction actors, is accepted in many research works (Davis 2014). The concept of project success is divided into two streams called success factors and success criteria (Guggenberger et al. 2021). The success factors stream sets priorities contributing to better achievement (Turner and Muller 2003), and the success criteria stream sets targets for measuring the effectiveness of projects (Ika 2009). Contract agreements between constructions actors often focus on three criteria: time, cost, and quality standard (specification), and these constraints play a significant role in the success of construction projects (Lambropoulos 2013). Traditionally, these three constraints called the ‘golden’ triangle and have been used as a criterion to measure the performance of projects (Atkinson 1999) (Gardiner and Stewart 2000),

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and project management researchers still emphasise the factors that affect these three constraints or project performance measurement criteria (time, cost and quality) that make up the 'golden' triangle (White and Fortune 2002).

Although these three constraints that make up the 'golden' triangle play an important role in the success of construction projects, their importance is ranked according to the requirements set by clients and the project (Lambropoulos 2013). Based on this rank of importance, it is common to measure the performance in terms of completion of the project on time, completion of the project in the planned budget and the completion of the project in the required quality (Mahamid 2017).

2.1 Time factors

In this section of the study, an in-depth review of studies related to construction time overrun has been carried out, and the underlying causes have been identified.

Gunduz and Tehemar (2020) have identified a number of factors as contributing to the delay in construction using multiple criteria. Low level of consultant experience, low level of contractor experience, shortage of construction materials and difficulties in financing the project by a contractor were reported as the most critical ones. In another study, Kazemi and Kim (2020) identified the root causes of delays. Based on Fuzzy Delphi method sanction, governmental management systems, weak project management by the contractor, technical and managerial weaknesses of the consultant, financial problems and delay in payment by the owner, low efficiency of the equipment, low productivity of the workforce, changes in laws and regulations, inappropriate organisational structure linking to the project, changes in the design and changes in the price of materials were a priority. Similarly, Shrivastava and Singla (2020) analysed the interactions among the factors and found that lack of proper construction methodology and sequencing plays a significant role.

2.2 Cost factors

In this section of the study, an in-depth review of studies related to construction cost overrun has been carried out, and the underlying causes have been identified.

Pham et al. (2020) used the regression model to identify the causes of cost overruns in construction projects, and as a result, risks, incompetence of parties, firm policies and project policies, poor collaboration of parties and components and transportation and machinery costs

were at the forefront. Similarly, Kamaruddeen et al. (2020) used the relative importance to identify the causes of the increase in construction costs. As a result, shortage of material, lack of plant and spare parts of equipment, acceleration required by clients, change of work scope or changes in material specification by clients, mistakes during construction, fluctuation in prices of raw materials, shortage of workforce, lack of skilled labour, poor project management, poor cost control and awarding of a contract to the lowest bidders were reported as the critical factors. In addition, Herrera et al. (2020) identified failures in design, price variation of materials, inadequate project planning, project scope changes and design changes as contributing factors.

2.3 Quality factors

In this regard, an in-depth review of the research on construction quality factors has been carried out to identify the root causes.

Abdel-Razek (2012) used the Delphi technique and RII in a study to identify the factors to improve construction quality. Improving design and planning during the pre-construction phase, developing and improving quality assurance and control systems, improving the financial level and standard of living of employees, improving the accuracy of cost estimating and proper classification of contractors, consultants and projects were reported as the major improvement factors. In another study, Oke et al. (2017) used the mean item score and standard deviation to identify the causes of poor construction quality and reported use of unskilled and incompetent trade contractors, poor on-site supervision and lack of commitment, poor planning and scheduling and inadequate knowledge as the major factors. In addition, Oyedele et al. (2015) used the frequency index, severity index and importance index to identify the root causes of poor construction quality and reported poor quality of materials delivered to site, low level of skill and labour experience, poor inspection and testing, poor site installation procedure and lack of quality assurance as the main causes of the quality issues.

2.4 The RII, impact interval, and aggregate RII

In the civil engineering area, in particular, in the field of construction management research, it is a common practice to ask respondents for their opinion (Holt 2014). And if the purpose of collecting respondents' point of view is to ordinally arrange factors in terms of importance, level of

agreement, severity and frequency, it is usually analysed using the RII (Holt 2014) as given in Eq. (1) below (Hossain et al. 2019).

$$RII = \frac{\sum_{i=1}^5 w_i x_i}{A \sum x_i} \quad (1)$$

where RII is the relative importance index, w is the weight given to the i th response, x_i is the frequency of the i th response and A is the maximum weight given to the Likert scales.

The value of the RII is always between 0 and 1 (Holt 2014). This implies that the RII or the severity index of each factor lies between these values. To compare the impacts of different factors, it is common to divide the values between 0 and 1 into a number of intervals. The study conducted by Fashina et al. (2021) and Kazaz et al. (2012) classified the values of the RII into five intervals as shown below in Tables 1–3, respectively. In addition, previous studies have shown that factors related to construction delays, cost overruns and poor qualities can be organised into factor groups, and their aggregate impact can be obtained taking the average of the RIIs of the factors in the factor group.

As a reference, the study conducted by Enshassi et al. (2010) defined cost, time and quality as a factor group and computed the aggregate RII of the delay, cost overrun and quality factors using the equation given below (Agbenohevi et al. 2017).

$$\text{Aggregate RII} = \frac{\sum RII}{N} \quad (2)$$

Tab. 1: The impact interval defined by Fashina et al. (2021)

Impact intervals	Given name
[0.0–0.2]	Very low
(0.2–0.4]	Low
(0.4–0.6]	Average
(0.6–0.8]	High
(0.8–1.0]	Very high

Tab. 2: The impact interval defined by Kazaz et al. (2012)

Impact intervals	Given name
0.00–0.80	Not important
0.81–1.60	Somewhat important
1.61–2.40	Important
2.41–3.20	Very important
3.21–4.00	Extremely important

where RII is the RII of the factors in each factor group and N is the total number of factors in each factor group.

3 The research hypothesis

- The null hypothesis (H_0): there is no difference in the aggregate RII or severity index of the golden variables between selected countries from different regions.
- The alternative hypothesis (H_1): there is a difference in the aggregate RII or severity index of the golden triangle variables between selected countries from different regions.

4 The research methodology

This study was based primarily on secondary data sources and followed a quantitative approach. The main purpose of this study was to compare the construction performance between countries using the concept of the golden triangle. Four basic steps were employed to do this. The first step was to sort out research works related to construction delays, cost overruns and quality from the easily accessible Google Scholar database that represent countries from developed economy, developing economy and a war conflict zone. The second step was to identify the countries in which all three variables, namely time, cost and quality, were used for research. The third step was to identify research works which used the same point of Likert scales (5-point Likert scales) and analyse them based on the RII or severity index. The fourth step was to identify the major time delay, cost overrun and quality factors with their associated RII or severity index. The fourth step was to compute the aggregate RII or the aggregate severity index of

Tab. 3: Major delay factors and their aggregate impact in Denmark

Country	The major delay factors	RII
Denmark	*Unsettled or lack of project funding	0.774
	*Delayed or long process times by other authorities	0.739
	*Unsettled or lack of project planning	0.712
	*Errors or omissions in construction work	0.694
	*Lack of identification of needs	0.690
Aggregate RII		0.722

RII, relative importance index.

time, cost and quality factors and compare between selected countries.

5 Result

In this part of the study, a flow diagram was developed to analyse the result based on the impact interval as

suggested by Fashina et al. (2021). Then, the major delay factors identified from the selected countries have been tabulated (Figure 1).

Described in Tables 3, 4 and 5 below, based on the study conducted by Larsen et al. (2006), the country selected for this study is listed in the first column of the tables, the main factors contributing to construction delays, cost overruns and poor quality in the second

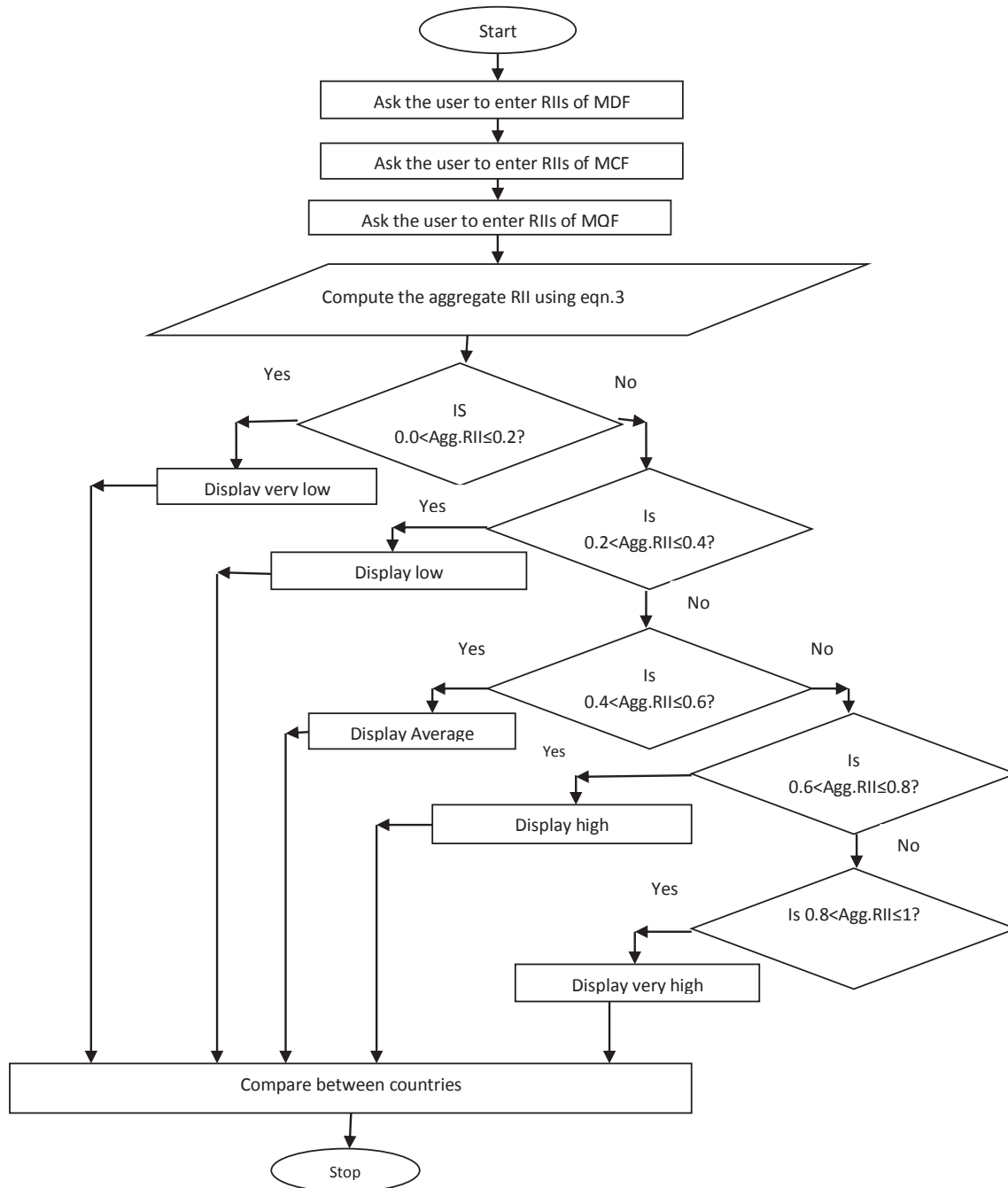


Fig. 1: The data analysis flow diagram developed using the impact interval defined by Fashina et al. (2021). RII, relative importance index.

column and the associated RIIs in the third column. In addition, the aggregate impact of the delay factors, the cost overrun factors and quality factors have been computed using Eq. (2) and are given in row seven and column three of Tables 1–3 and 4.

Described in detail in Table 6, Enshassi et al. (2010) identified the significant factors that affect the

Tab. 4: Major cost overrun factors and their aggregate impact in Denmark

Country	The major cost overrun factors	RII
Denmark	*Errors or omissions in the consultant material	0.766
	*Errors or inconsistencies in project documents	0.726
	*Late user changes affecting the project or function	0.717
	*Lack of preliminary examination before design or tendering	0.700
	*Inexperienced or newly qualified consultants	0.698
Aggregate RII		0.721

RII, relative importance index.

Tab. 5: Major quality factors and their aggregate impact in Denmark

Country	The major quality factors	RII
Denmark	*Errors or omissions in construction work	0.688
	*Inexperienced or newly qualified consultants	0.678
	*Political focus on reduced project costs or time	0.644
	*Unsettled or lack of project planning	0.642
	*Errors or inconsistencies in project documents	0.641
Aggregate RII		0.659

RII, relative importance index.

performance of construction projects. The country selected for this study is listed in the first column, and those listed in the second column are the main causes for construction delays, cost overruns and poor quality. The values given in column 3, 4 and 5 are the impacts of the major construction delays, cost overruns and quality factors in the view of clients, consultants and contractors. Those values described in column 6 are the aggregate impact of the major construction delay, cost overrun and quality factors computed based on the method used by Agbenohevi et al. (2017) and the average impact of each variable (time, cost and quality variables) computed based on the method used by Abbas and Painting (2017).

Described in detail in Table 7 are the major construction delay, cost overrun and quality factors reported by Oyedele et al. (2015), Abisuga et al. (2017) and Oluyemi-Ayibiowu et al. (2019) and their associated RII. In the case of the major quality factors, column 1 indicates the country selected for this study, column 2, 3, 4 and 5 indicate the RII of the major quality factors in the view of architects, engineers, surveyors and builders, and column 6 indicates the average RII computed based on the method used by Abbas and Painting (2017). In the case of the major time delay and cost overrun factors, column 1 indicates the country selected for this country and column 2 indicates the relative and the aggregate RII.

As shown in Table 8, the names of the countries selected for this study are listed in column 1, and in columns 2, 3 and 4 are the aggregate impact of delays in construction, cost overruns in construction and quality factors in construction, respectively.

Tab. 6: The major construction delay, cost overrun and quality factors and their associated average and aggregate importance index in Gaza Strip

		Owner	Consultant	Contractor	Overall
Country	The major delay factors	RII			
Gaza Strip	*Average delay because of closures leading to materials shortage	0.941	0.896	0.943	0.927
	*Unavailability of resources as planned through the project duration	0.871	0.858	0.904	0.878
	Aggregate RII				0.902
	The major cost overrun factors				
	*Escalation of material prices	0.847	0.832	0.889	0.856
	Aggregate RII				0.856
	The major quality factors				
	*Unavailability of personals with high experience and qualification	0.859	0.848	0.865	0.857
	*Quality of equipment and raw materials in project	0.835	0.84	0.861	0.845
	Aggregate RII				0.851

RII, relative importance index.

Tab. 7: The major construction delay, cost overrun and quality factors and their associated RII, average RII and aggregate RII in the case of Nigeria

Country		RII in the view of different stakeholders				
		Architect's	Engineer's	Surveyor's	Builder's	Average RII (%)
Nigeria	Major quality factors					
	Poor quality of materials delivered to site	82.4	84.55	85.00	81.82	83.44
	Low level of skill and labour experience	80.74	78.18	70.00	81.82	77.69
	Poor inspection and testing	79.29	80.91	85.00	82.22	81.86
	Poor site installation procedure	79.29	69.09	82.50	74.55	76.36
	Lack of quality assurance	75.71	73.36	80.00	80.00	77.27
	Aggregate RII					79.32
	Major delay factors	RII (%)				
	Cash flow problem	90				
	Shortage of construction materials	89				
	Client's financial difficulty	86				
	Inadequate consultant experience	85				
	Incompetent project team	85				
	Aggregate RII	87				
	Major cost overrun factors	RII (%)				
	Risk and uncertainty related factors	89.5				
	Lack of financial power of client	88.5				
	Weak regulation and control	88.2				
	Corruption	82.6				
	Variation of prices	81.3				
	Indiscriminate change in design/work	80.1				
	Aggregate RII	85.03				

RII, relative importance index.

Tab. 8: The aggregate impacts of the three variables (MDF, MCF and MQF) and their impact intervals for the selected countries

Countries	Aggregate RII of MDF	Impact interval	Aggregate RII of MCF	Impact interval	Aggregate RII of MQF	Impact interval
Denmark	0.722	(0.60–0.8]	0.721	(0.60–0.8]	0.659	(0.60–0.8]
Gaza Strip	0.902	(0.80–1.0]	0.856	(0.8–1.0]	0.851	(0.80–1.0]
Nigeria	0.87	(0.8–1.0]	0.8503	(0.8–1.0]	0.7932	(0.60–0.8]

MCF, Major cost overrun factors; MDF, Major delay factors; MQF, Major quality factors.

6 Discussion

Based on the iron triangle (time, cost and quality), aggregate RII and impact interval concepts, performance or success comparisons between projects in the selected countries were conducted, and the results are discussed below.

6.1 The aggregate impacts of the major causes of cost overruns

The results in Figure 2 show that the aggregate impact of the increase in construction cost on Gaza Strip is 0.856,

on Nigeria is 0.8503 and on Denmark is 0.721. Although construction cost overruns are a global phenomenon (Saidu et al. 2017), the results in this study indicate that the aggregate impacts of the causes of cost overruns in Gaza Strip and Nigeria are very high. These results reinforce that 100% of the construction projects in Palestine run out of budget (Mahamid and Dmaidi 2013) and about 52.4% of completed projects in Nigeria experience a cost overrun of 44.6% (Saidu et al. 2017). On the other hand, the result in Figure 2 indicates that the aggregate impact of the major causes of cost overruns in Denmark is relatively weak compared with Gaza Strip and Nigeria. This result reinforces that the cost overrun of construction projects in Europe is lower than that of other countries (Lind 2013).

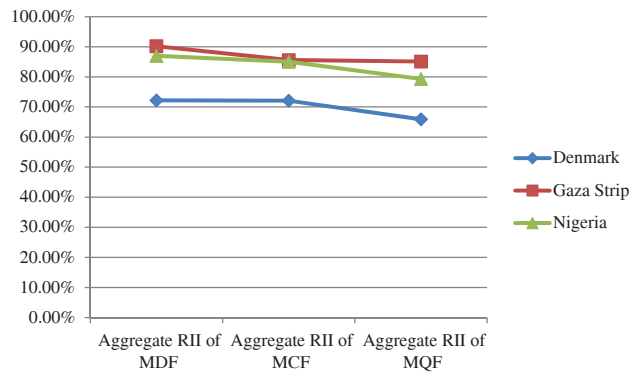


Fig. 2: The aggregate impact of construction delay, cost overrun and quality factors in the case of Denmark, Nigeria and Gaza Strip.

6.2 The aggregate impacts of the major causes of construction delays

In terms of the aggregate impacts of the causes of construction delays, the results in Figure 2 show construction projects in Gaza Strip (Agg. RII = 0.902), Nigeria (Agg. RII = 0.870) and Denmark (Agg. RII = 0.772). These findings indicate that the aggregate impacts of the causes of delays in Gaza Strip and Nigeria were significant. These results reinforce that, in Middle East countries, projects experience lengthy delays (Islam and Trigunarsyah 2017), and Nigeria experiences construction project delays with an average delay of 19–181% (Aibinu and Odeyinka, 2006). On the other hand, the aggregate impact of the causes of construction delays in Denmark is relatively low. This reinforces that 35–65% of construction projects in Denmark were completed on time (Ballard and Howell 2003).

6.3 The aggregate impacts of the major construction quality factors

Although the definition of quality varies depending on the type of organisation, in this study, the term construction quality was taken to meet the requirements for construction or ‘reduce rework or defects’ (Atkinson 1998). According to the results of Figure 2, the aggregate impact of the quality factors on construction projects in Gaza Strip is 0.85, in Nigeria is 0.7932 and in Denmark is 0.659. From these results, it is clear that the quality factors have highest impacts in the Palestinian and Nigerian construction projects. These results reinforce that the cost of rework and construction defects in Palestine accounts for 10–15% (Mahamid 2016) and in Nigeria up to 22% of the total cost in construction

buildings (Oke and Ugoje 2013). In contrast, the aggregate impact of the quality factors on construction projects in Denmark is relatively less, with the result being that the annual cost of reworks and construction defects was up to 10% (EBST 2004).

7 Conclusion

This study was conducted to compare the performance of construction projects between selected countries, namely Denmark, Nigeria and Gaza Strip, based on the concept of golden triangle and aggregate impact. The major time delay, cost overrun and quality factors have been identified from research works conducted in these selected countries. The aggregate impact of each factor group (time, cost and quality) was computed using the formula given in Eq. (2). The results showed that the aggregate impact of the golden triangle components in the case of Denmark are (time factors aggregate RII = 0.722, cost factors aggregate RII = 0.721, and quality factors aggregate RII = 0.659), in the case of Nigeria are (time factors aggregate RII = 0.87, cost factors aggregate RII = 0.8503, and quality factors aggregate RII = 0.7932), and in the case of Gaza Strip (time factors aggregate RII = 0.902, cost factors aggregate RII = 0.856, and quality factors aggregate RII = 0.851). From this result, it can be understood that the aggregate impacts of the causes of construction time delays, cost overruns and poor qualities in Gaza Strip are high, and in Nigeria and Denmark, it decreased, respectively.

This study is limited to the three selected countries. It is recommended to consider more countries and compare the construction performances based on the concept of golden triangle and aggregate RII.

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