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ANALYSING THE SIGNIFICANT INFLUENCES OF COST PERFORMANCE IN MALAYSIAN RAIL PROJECTS: EXPLORATORY FACTOR ANALYSIS

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ABSTRACT

Delivering successful rail projects has always been extremely difficult. The fact is widely discussed in developed nations as their outstanding rail networks were known to have significant cost overruns. A comprehensive rail network is progressing in developing nations, and cost overruns have already occurred in nations like China and India. The problem is critical in Malaysia, where poor cost performance has been highlighted for decades. This study aims to establish the significant influences on cost performance of rail projects, by assessing the critical influences that may affect project cost management. Primary data was gathered from 100 cost managers in the rail construction industry. Five (5) main component elements were discovered with a total of fifty (50) related items based on prior studies. Project estimation, project planning, project management, technical experience, and project complexity can be categorized as the primary component aspects. The influences and their respective items are then utilized to create the questionnaire for gathering data. Collected data were then analyzed using Exploratory Factor Analysis (EFA), which focused on the five (5) components and fifty (50) influences that affected rail construction cost performance. The overall variance percentage was 62.514%. Each component has a minimum of four variables, thus complying with the requisite that every component needs a minimum of three variables.

The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy value obtained from the results is 0.813, which is highly close to 1. All components satisfied the Factor Analysis standards as each influence loading is higher than 0.4. Project Planning has the highest Eigenvalue (26.764), while Project Estimation has the lowest Eigenvalue (5.136). Industry professionals need to understand the main elements affecting construction costs. Then the professionals can be empowered with the ability to develop effective strategies to improve cost management in rail projects.

Keywords: *Construction Project Management, Construction Cost Management, Rail projects, Exploratory Factor Analysis (EFA)*

INTRODUCTION

Rail transport has been a significant aspect of the national economic plan, which aims to reduce reliance on road transportation (Lee and Chew-ging, 2017; Mohd Kamar et al., 2017). However, despite substantial efforts, there are considerable challenges associated with successfully executing rail developments (Sadullah et al., 2018). Rail investments are notorious for being highly uncertain, complex, and costly, all of which require taxpayer funds (Olawale and Sun, 2015; Ainul Azman et al., 2018). Cost overruns are a significant issue, with numerous studies from industrialized and developing countries showing that rail projects often experience cost overruns (Ullah et al., 2017).

For instance, rail projects in the Asian region had an average cost overrun of 13.46% (Park & Papadopoulou, 2012), with cost overruns affecting over 30.6% of rail projects in China and 31% on average in India's metro rail projects. 48% of Asian rail projects were published by Andrić et al. (2019) who also highlighted how vulnerable rail projects are to such overruns. In developed countries, instances of cost overruns in past rail projects have also been documented. For example, the Channel Tunnel experienced an 80% cost increase compared to initial forecasts, while the Paris Nord TGV project in France saw a 25% cost escalation (Cantarelli et al., 2012). In Korea, a substantial increase of 122.4% had been identified in the final costs of seven megaprojects compared to their budgets (Han et al., 2009). This issue has persisted for decades, as Pickrell (1992) examined eight U.S. rail projects from 30 years ago and found an average cost overrun of 61%.

In Malaysia, cost overruns have been observed in various rail projects, such as the Electrified Rail Line (ERL) extension (RM29 million overrun) (The Sun Daily, 2015), Mass Rapid Transit (MRT) (15% cost overrun) (Tee Lin, 2012), Electrified Double Track Project (EDTP) Ipoh-Rawang (RM1.14 billion overrun) (Lee Yuk, 2009), as well as EDTP Ipoh-Padang Besar (Business Times, 2012). In the southern part of the Peninsular, Chandragiri et al. (2021) conducted a case study on 20 construction projects, including rail, and identified the major factors causing cost overrun. It was discovered that improper contractor planning, poor site management, and poor contractor experience were identified as the leading causes of cost overrun. This was consistent with the claim made by Shehu et al. (2014).

Hussain et al. (2023) identified the knowledge gaps in existing research on cost overruns in Malaysian rail projects, which are identifying the underlying causes of cost overruns and exploring the correlation for formulating effective actions. The study identified 79 causes of cost overruns, with the leading causes which are design problems, inaccurate estimation, poor planning, poor communication, and poor financial management. Meanwhile, Plebankiewicz and Wieczorek (2020) propose a cost overrun risk prediction model, which consists of a set of input variables, including project type, project size, project complexity, and project location. The model has been tested on a case study of the Gas-Oil industry and is also applicable to rail projects in Malaysia.

Given the substantial costs often associated with megaprojects, it is imperative to thoroughly assess the potential challenges these rail developments may pose to ensure their successful execution and the efficient allocation of taxpayers' funds (Locatelli et al., 2017). This study aims to uncover the underlying components that influence cost performance in rail projects and assess their internal reliability. Exploratory Factor Analysis (EFA) was the chosen analytical approach since there was no predefined hypotheses regarding the nature of these underlying influences. The lack of precise elements in existing studies presents a significant obstacle to improving cost management in rail projects. This study aims to fill this gap by providing a dependable compilation of knowledge regarding the key influences of cost performance in rail projects. The findings will not only benefit stakeholders and professionals in the rail industry by facilitating more effective decision-making during project implementation but also serve as a guideline for contractors in cultivating a cost-conscious organizational culture.

LITERATURE REVIEW

When actual costs surpass initial projections, this is referred to as a "cost overrun" (Invernizzi et al., 2017). Cost overruns have been an extensively addressed problem, especially in large projects, due to the high costs involved. Flyvbjerg's (2014) study found an 86% risk of cost overruns, mostly in transport projects, with 45% in rail, 45% in bridge, and 20% in road projects (Flyvbjerg, 2014). The study emphasizes the significant likelihood of cost overruns and their significant effects on large-scale projects, particularly those with contract values over £1 billion, like rail projects.

Malaysia has put significant effort into developing the rail network. The Keretapi Tanah Melayu (KTM) double-tracking projects, the Johor Bahru-Singapore Rapid Transit System (RTS Link), the East Coast Rail Line (ECRL) (Ministry of Transport Malaysia, 2022), and the much-anticipated Trans-Borneo Railway (Office of The Premier of Sarawak, 2023) are just a few of the major rail network expansion initiatives in Malaysia. Despite passionate efforts to expand the rail network, the government must evaluate the past cost performance of earlier national rail projects. Cost overruns have previously occurred on the Electrified Double Tracking Project (EDTP) Ipoh-Padang Besar, which resulted in RM1.5 billion in Variation Order claims, 15% on the MRT (The Star, 2009), RM1.14 billion on the EDTP Ipoh-Rawang (The Star, 2012), and RM29 million on the ERL extension (AG Report, 2015). These regional findings are consistent with the global problem of the rail industry's subpar cost performance (Chen et al., 2023).

Globally, significant study has been done to determine the reasons for cost overruns and to delve into the particular elements of rail construction that fuel these overruns (Ullah et al., 2017). However, there is a lack of research that looks at the contractor's perspective on the critical elements affecting cost performance in rail projects (Flyvbjerg et al., 2018; Xu and Huang, 2019). By focusing on the cost implications of external determinants like political, regulatory, legal, and economic factors, Catalao et al. (2019) filled a gap in the existing literature, which primarily investigates internal determinants of cost performance.

The analysis covered 1091 transport projects. Their research showed that the average cost of rework was 11.21%, cost overruns were 13.28%, and schedule overruns were 8.91%. Beria et al. (2018) looked into the discrepancies between budgeted and actual costs in the Italian and Spanish High-Speed Rail programs, concluding that purposeful choices including excessive investment, overdesign, and quality is the root of the difference. Hussain et al. (2023) explored knowledge gaps in existing research on cost overruns in rail projects. Meanwhile, Omotayo et al. (2022) predicted the impact of cost overruns on rail projects in the UK during the COVID-19 pandemic era. These studies frequently show significant cost overruns in rail projects, highlighting the urgent necessity to pinpoint the crucial variables affecting cost performance in rail projects to close the theoretical gap and guarantee efficient cost control in Malaysian rail projects.

Several research studies have sought to determine the factors influencing cost performance in rail projects, and classifications of these factors may vary depending on scholars' viewpoints. Notably, Andrić et al. (2019) conducted a relevant study within the context of Belt and Road projects, identifying critical factors affecting rail project costs by evaluating their probability, impact, and criticality in comparison to other projects. This research identified twenty-four (24) critical factors through comprehensive literature reviews and interviews with industry experts. Key factors found to impact cost performance included design changes, design errors, cooperation between China and Belt and Road Initiative (BRI) countries, loan risks, complex geological terrain conditions, and geopolitical risks.

From this review, we can identify several research gaps. The first one is the lack of contractor perspective. While there have been studies examining the reasons for cost overruns and various elements of rail construction, there is a lack of research focusing on understanding how contractors perceive and influence cost performance in rail projects. Another identified gap is the lack of specific context for Malaysian rail projects. Despite evidence of cost overruns in previous Malaysian rail projects, no in-depth investigations have been conducted to examine the factors contributing to cost overruns in the context of Malaysian rail projects.

Given the plethora of factors identified by various authors, the findings from Andrić et al. (2019) serve as the primary basis for the variables in this research. Information was sourced from a range of references, including construction management literature, journals, articles, and online sources. These sources were meticulously examined to understand the factors influencing cost performance, with a particular emphasis on traditional projects within the rail industry. To address these challenges, this research aims to adapt standard or traditional project management methodologies and processes to suit the specific context of rail projects. Based on relevant literature, a list of fifty (50) influences on cost performance related to rail projects has been gathered and the data were tabulated in Table 1.

Table 1. Influences of Cost Performance in Rail Projects

Categories	Code	Influences	References
A. Project Estimation	A1	Extensiveness of feasibility study	Mohammad et al. (2016)
	A2	Dishonesty in project presentation	Famiyeh et al. (2017)
	A3	Accuracy in estimation of project duration	Olawale & Sun (2015); Hussain et al. (2023)
	A4	Reliability of standards in performing estimates	Zhang et al. (2017)
	A5	Clarity of specifications	Shibani (2015);
	A6	Cost of transporting materials	Zafar et al. (2016)
	A7	Fluctuation in price of materials	Olatunji et al. (2018); Ullah et al. (2017)

B. Project management	B1	Effectiveness of contract management	Park & Papadopoulou (2012); Sarmento & Renneboog (2017)
	B2	Management of contract documentation	Mevada & Devkar (2017)
	B3	Clarity of contract provisions	Hussain et al. (2023)
	B4	Accuracy in bills of quantities	Asmi et al. (2013); Plebankiewicz and Wieczorek (2020)
	B5	Prolongation of awarding contracts	Park & Papadopoulou (2012); Omotayo et al. (2022)
	B6	Efficiency of payment method	Omotayo et al. (2022)
	B7	Administration of contractual claims	Memon & Rahman (2014)
	B8	Sufficiency of project preparation	Sarmento & Renneboog (2017)
	B9	Applicability of construction method	Hussain et al. (2023)
	B10	Efficiency in management of works	Ullah et al. (2017)
	B11	Availability of staff/qualified staff	Mohammad et al. (2016)
	B12	Ability in managing project resources	Cárdenas et al. (2018)
	B13	Competency in managing sub-contractors	Belayutham et al. (2022)
	B14	Quickness in decisions making	Ullah et al. (2017); Gunduz & Maki (2018)
	B15	Ability to adapt with new technologies	Lu et al. (2017)
	B16	Correctness in the usage of contingency budget	Kim et al. (2017)
	B17	Error/defect in works	Park & Papadopoulou (2012)
	B18	Quickness in giving work instructions	Famiyeh et al. (2017); Shibani (2015)
	B19	Alertness in updating project status	Mohammad et al. (2016)
	B20	Efficacy of communication between contractor and client	Adam et al. (2017)
	B21	Efficacy of communication between designer and contractor	Alghonamy (2015)

	B22	Responsiveness of parties within the project	Apolot & Tindiwensi (2013)
	B23	Rapidity in communicating change orders	Mohammad et al. (2016)
	B24	Swiftness in preparing change orders	Hanif et al. (2016)
C. Project Planning	C1	Effectiveness in work scheduling	Al-hazim et al. (2017)
	C2	Proficiency in work schedule management	Plebankiewicz and Wieczorek (2020)
	C3	Effectiveness of material planning	Adam et al. (2017); Venkatesh & Venkatesan (2017)
	C4	Usefulness of resource planning	Mohammad et al. (2016)
	C5	Productivity of cost planning and monitoring	Vaardini et al. (2016); Ullah et al. (2017)
	C6	Competence of risk management	Chandragiri et al. (2021)
	C7	Dependency on specialist works	Chen et al. (2023)
	C8	Limitation of working hours for consultant to supervise over time works	Chandragiri et al. (2021)
	C9	Limitation of working hours for contractor	Venkateswaran & Murugasan (2017)
D. Technical Experience	D1	Experience of design consultants	Lu et al. (2017)
	D2	Experience of technical consultants	Lu et al. (2017)
	D3	Experience of personnel in supervisory duties	Lu et al. (2017)
	D4	Experience of executives in organization	Mohammad et al. (2016); Chen et al. (2023)

E. Project Complexity	E1	Length of project implementation	Cantarelli et al. (2012); Flyvbjerg (2014); Sarmento & Renneboog (2017)
	E2	Inconsistent scope changes during construction	Love et al. (2017); Ullah et al. (2017); Muhamad and Mohammad (2018)
	E3	Conflicts among project organization structure	Famiyeh et al. (2017); Abbas & Painting (2017)
	E4	Unstable condition of the market	Cárdenas et al. (2018)
	E5	Uncertain environmental issues	Awojobi & Jenkins (2016)
	E6	Inflation in economy	Gunduz & Maki (2018)

METHODOLOGY

To investigate the significance of various influences affecting cost performance in comparison to traditional projects, this study employed a questionnaire survey. The questionnaire was developed following an extensive review of relevant literature. To ensure its quality, a construction expert meticulously examined the survey for common questioning issues such as leading, ambiguous, or double-barrelled questions. Feedback from the expert was then incorporated to create the final version of the survey. The feedback obtained is tabulated in Table 2.

Table 2. Feedback from Experts

Num	Comments	Actions
1	The terms of scale used are inaccurate to measure the level of indication	The terms of scale are changed to the frequency of occurrence
2	Negative wordings are used in representing variables	Neutral wordings are used to extract neutral feedback to establish the relationship between variables
3	The objective is unclear	The objective is changed to identify the frequency of occurrence in the past
4	Too many variables presented	Variables are reduced through Pilot Survey analysis
5	Variables are not presented with relationships among themselves	The objectives are altered to suit the variables to enable the conduct of the designed analysis after data collection

6	Explanation of terms is inconvenient for respondents	Explanations of terms are provided on every main point in the questionnaire
7	The aim of the study is not indicated in the questionnaire survey	The aim of the study is indicated in the questionnaire survey
8	Two questions are imposed for each variable (probability & impact)	The questions are retained to sieve through the variables to determine the significant factors
9	Survey questionnaires are distributed by online form	The survey questionnaire shall be distributed by e-mailing a Microsoft Word fillable form

Source: Author

The respondents of the study were randomly selected from cost managers within the Malaysian rail construction industry. Random selection was applied as it represented the entire data population and is most useful when the population is specific and not to be broken into different subgroups (Shi, 2015). The respondents were chosen based on their roles as project cost managers within rail construction companies, including quantity surveyors, contract managers, project managers, directors, and contract executives. The list of eligible companies was compiled from the CIDB Directory of Construction and previously completed rail projects. The questionnaires were distributed to the respondents both manually and via email. A total of 200 sets of questionnaires were distributed, and 102 (51%) completed questionnaires were returned. It is worth noting that current response rates for surveys in the built-environment sector typically range from 7% to 40% (Saleh & Bista, 2017). Therefore, the achieved response rate of 51% in this study is considered acceptable.

The questionnaire used in this study focused on construction cost management in the context of rail projects and was developed by reviewing existing literature. It consisted of two sections. The first section collected personal information about the respondents, including their current job roles, years of experience in the construction industry, and experience in rail projects. The second section contained questions related to the influences of cost performance in rail projects, encompassing fifty (50) variables identified from the literature (see Table 2). The respondents were asked to express their level of agreement with these measures, indicating how these practices affected cost performance in rail projects. The data gathered from these responses were used as variables in the Exploratory Factor Analysis (EFA), a common exploratory method for summarizing the structure of a group of variables (Samuels, 2016).

To ensure the suitability of the dataset for factor analysis, two initial tests were conducted: the Kaiser-Meyer-Olkin (KMO) test and Bartlett's Test of Sphericity. The KMO test yields values between 0 and 1, with values above 0.7 considered suitable for applying EFA (Hair et al., 2017). Additionally, a statistically significant Bartlett test ($p < 0.05$) indicates that the variables share sufficient similarities to initiate the analysis (Hair et al., 2019; Pallant, 2020).

DISCUSSION OF RESULTS

The quantitative analysis of the research data was performed using SPSS version 26. The use of Cronbach's Alpha Coefficient (α) was to evaluate the accuracy of the questionnaire used. The Coefficient (α) result was 0.936, which is considered a good reliability score according to Bujang et al. (2018). The reliability score indicates that the questionnaire is consistent in measuring the latent variables.

The respondents of the research included quantity surveyors, project managers, project directors, and contract executives. The inclusion of different professionals who share similar scopes of work in the rail construction industry as respondents can provide valuable insights into the research. 34% of the respondents have experienced in the construction industry for five to 10 years, and 29% of them had longer experience managing the cost of rail projects. This result proved a sufficient understanding of the characteristics of the respondents and their experiences in the construction industry. This demonstrates the significance of the research outcome. The distribution of respondents had been recorded in Table 2.

Table 3. Distribution of Respondents According to Designation and Experience

Respondent profiles	Categorization	Number of Respondents	Percentage

Type of designation	Project Director	5	5%
	Project Manager	12	20%
	Assistant Project Manager	9	15%
	Quantity Surveyor	12	31%
	Contract Executives	8	29%
Years of Experience in the Construction Industry	1-5	46	45%
	5-10	35	34%
	> 10	21	21%

Source: Author

EXPLORATORY FACTOR ANALYSIS

The Exploratory Factor Analysis (EFA) was utilized to organize the parameters and features identified in Table 3 based on the literature findings. The variables were classified into five distinct categories that influence rail cost performance: (i) Project Estimation, (ii) Project Management, (iii) Project Planning, (iv) Technical Experience, and (v) Project Complexity. To assess the impact of these influences on rail cost performance, the variables were ranked by the indicators in a five-point Likert scale. Likert-type or frequency scales use fixed-option response formats and are designed to quantify attitudes or opinions (Joshi et al., 2015). The following scale measurements were used to determine mean scores: 1 denotes that the situation is not critical (1.00 and 1.80), 2 that it is less critical (1.81 and 2.60), 3 that it is critical (2.61 and 3.40), 4 that it is very critical (3.41 and 4.20), and 5 that it is extremely critical.

The results showed that the data are acceptable for factor analysis, with a Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy of 0.813, which is between 0.5 and 1 (Kim et al., 2017). Bartlett's sphericity test showed a chi-square value of 2579.004 and a p-value of less than 0.01, which indicate the suitability of the data for Factor Analysis (Cabuñas & Silva, 2019) supported by the variance's total value, which comes to 62.514%.

Table 3. Loading of Influences (variables) Into Respective Components

Component 1: Project Estimation		
1	Changes in design & specifications	0.778
2	Accuracy in estimation of project duration	0.744
3	Accuracy in estimation of risks	0.736
4	Adequacy of site investigation	0.725
5	Availability of materials	0.509
6	Extensiveness of feasibility study	0.469
7	Clarity of contract provisions	0.410
Component 1: (7) Influences		Eigen Value = 1.900
		% of Variance = 5.136
Component 2: Project management		
1	Ability in managing project resources	0.894
2	Competency in managing sub-contractors	0.831
3	Proficiency in monitoring of works	0.740
4	Efficiency in management of works	0.713
5	Efficacy of communication between contractor and client	0.699
6	Availability of staff/qualified staff	0.617
7	Sufficiency of project preparation	0.417
8	Efficacy of communication between designer and contractor	0.401
Component 2: (8) Influences		Eigen Value = 3.151
		% of Variance = 8.515
Component 3: Project Planning		
1	Productivity of cost planning and monitoring	0.841
2	Financial condition of contractor	0.838
3	Financial condition of client	0 .812
4	Effectiveness of material planning	0.794
5	Usefulness of resource planning	0.781
6	Effectiveness in work scheduling	0.768
7	Proficiency in work schedule management	0.756
8	Delay in project implementation	0.737
9	Competence of risk management	0.627
Component 3: (9) Influences		Eigen Value = 9.903
		% of Variance = 26.764
Component 4: Technical Experience		

1	Experience of technical consultants	0.901
2	Experience of personnel in supervisory duties	0.789
3	Experience of design consultants	0.754
4	Experience of contractor organizations	0.751
5	Experience of executives in organization	0.637
Component 4: (5) Influences		Eigen Value =2.777
		% of Variance = 7.509
Component 5: Project Complexity		
1	Relocation of existing services	0.855
2	Relocation of existing infrastructure	0.852
3	Difficulty of construction procedures	0.834
4	Size of project	0.826
5	Complexity of design	0.746
Component 5: (7) Influences		Eigen Value =5.399
		% of Variance = 14.593

Source: Author

The study utilized Exploratory Factor Analysis (EFA) to organize the parameters and features identified in Table 3 based on the literature findings. The variables were classified into five distinct categories that describe the influences on rail cost performance: (i) Project Estimation, (ii) Project Management, (iii) Project Planning, (iv) Technical Experience, and (v) Project Complexity. The study ensured that each component had at least five variables, satisfying the requirement that each component have at least three variables (Watkins, 2018). and each variable had a loading greater than 0.4, satisfying the Factor Analysis criterion (Rahn, 2014).

The first component, Project Estimation, had an eigenvalue of 1.900 and accounted for 5.136 percent of the variance overall. The loading for the seven influences that make up this component ranges from 0.778 to 0.410. The finding is consistent with a study by Osei-kyei & Chan (2017) which found inadequate cost estimation to be the main cause of cost overrun in construction projects in Ghana. On the other hand, Lee et al. (2022) found that project estimation is not a significant factor affecting the cost performance of rail transit projects in South Korea. Despite the contradicting discussion, the survey result shows that project estimation is a major influence on rail cost performance. There are main influences that made up the component including design and specifications changes, accuracy in estimating duration, risks, and site investigation. The estimation part is mainly the responsibility of project consultants and therefore should be the focus of the discussion (Zafar et al., 2016).

The second component, Project Management, had an eigenvalue of 3.151 and accounted for 8.515 percent of the overall variance. Items in this component have loadings that range from 0.894 to 0.410, proving the high correlation to this component. Kamaruzzaman (2012) asserted that poor project management practices along with inadequate planning, and lack of technical expertise are the main cause of cost overrun in construction projects in Malaysia. Based on the responses from the respondents, the major influences on cost within the project management scope were the management of resources, sub-contractors, and works as well as monitoring and efficiency of communication among the project team. On the other hand, Wang et al. (2021) found that project management is not a significant factor affecting the cost performance of high-speed rail projects in China. Nevertheless, the project management techniques remain a significant part of ensuring project success and it falls into the responsibility of the main contractors (Hetemi et al., 2020).

The third component, Project Planning, had an eigenvalue of 9.903 and accounted for 26.764 percent of the variance overall. This component includes nine variables with loadings ranging from 0.841 to 0.627. The result was consistent with a study by Zhang et al. (2022) which found that project planning, project management, and technical experience are significant factors affecting the cost performance of rail transit projects in China. The survey outcome showed that project planning was a significant influence on cost performance, through the financial planning of contractors and clients. This has been proven to be significant as discussed by Belayutham et al. (2022). Other than that, different aspects of planning had been identified as significant in terms of material, resources, risk monitoring, and scheduling. It was also observed that planning had been established to be the cornerstone of project success (Molinari et al., 2023), hence the substantial need for it to be comprehensive and accurate.

Technical Experience, the fourth component, has an eigenvalue of 2.777 and contributes 7.509% of the total variance. This component has five influences and loadings that range from 0.901 to 0.637. The component correlated with the most research compared to the other components (Bao, 2018; Chevroulet et al., 2012; Hutchinson, 2016). Technical experience is a significant issue not just in rail construction but in other construction-related industries such as Modular Construction System (MCS) (Mohammad et al., 2016), Industrialised Building System (IBS) (Azman et al., 2018), and civil construction (Gunduz & Abdi, 2020). The need for competent technical expertise rises significantly with the emerging technologies integration into construction in line with Construction 4.0 (Samwel et al., 2018).

The fifth component which is Project Complexity includes variables that have characteristics such as while out of a project's control, nonetheless still have an impact. With an eigenvalue of 5.399, this component also provides 14.593 percent of the overall cumulative variance. The items in this component have loadings that range from 0.855 to 0.656. A study by Alsuliman (2019) found that project complexity, which affects project size, and project duration altogether are significant factors affecting the cost performance of construction projects in Saudi Arabia. The study was further concurred by Wang et al. (2021) who found that project complexity is a significant factor affecting the cost performance of high-speed rail projects in China. The well-known fact is that the rail projects are highly complex (Prasetijo et al., 2019). The survey showed that the significant parts of project complexity are the relocation of existing services and infrastructures, complex construction procedures, design, and the size of the project itself.

CONCLUSION

Cost management entails the ability to keep project expenses within the allocated budget while accomplishing project objectives. This study aims to perform an Exploratory Factor Analysis (EFA) on the influences of cost performance of rail construction projects in the Malaysian construction industry. The results revealed that all variables identified through an extensive literature review are pertinent and suitable for the conducted survey. These empirical findings bridge an existing gap in knowledge regarding rail project management by addressing critical and relevant influences that impact cost performance in rail projects.

According to the research results, there are five primary components influencing cost performance in rail projects, accounting for a total variance percentage of 62.514%. These five key components are as follows: (i) Project Estimation, (ii) Project Management, (iii) Project Planning, (iv) Technical Experience, and (v) Project Complexity.

The results of this study might give industry professionals insightful information that will help them customize conventional project cost management systems and procedures to improve the affordability and sustainability of rail project delivery. Additionally, industry professionals can prioritize their efforts in particular areas of cost management, increasing efficiency and effectiveness by focusing on variables with high criticality values and big mean gaps.

The implications from this study may extend beyond the confines of the current research in enhancing public perception and trust in government rail investments, encouraging global competitiveness in the rail industry, and promoting best practices in adopting effective rail cost management. Most importantly, the ability to manage costs effectively equips the rail industry to tackle future challenges, especially with multiple emerging technologies in the market.

Some limitations to this research also need to be expressed which are resources such as limited time, funding, and access to the necessary expertise for the data collection. External events such as the COVID-19 pandemic also stunted the progress of the research and the findings obtained are challenging to be adopted and implemented by the industry professionals.

Hence, the study recommends further research in a more comprehensive risk assessment at the project planning stage to investigate potential risks and uncertainties that can lead to cost overruns, enhance collaboration between multiple stakeholders (government agencies, contractors, and financiers), integrate robust and updated project management techniques into rail cost management. In addition, further research on benchmarking Malaysian rail projects against similar rail construction projects in other countries focusing on management practices, costs, and timelines to identify areas for improvement and best practices need also be considered.

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AUTHOR CONTRIBUTIONS

All three authors were involved in the research design, administration of survey questionnaire, data collection and analysis, and the write-up of this manuscript. All authors have thoroughly reviewed and given their approval for the final manuscript, indicating their collective agreement on its content and findings.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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