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Developing a Risk Management Model for Research and Development Facilities Construction Projects in Southern Malaysia

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Abstract: The construction industry drives economic growth globally but faces challenges namely outdated practices and inadequate risk management. This research focuses on improving Risk Management in Research and Development (R&D) facilities construction projects, often poorly executed by Project Management Offices (PMOs). Most studies primarily focus on identifying and assessing risks, critical aspects like risk control and monitoring are often overlooked. To address this gap, this research endeavors to formulate a comprehensive risk management model specifically tailored for R&D facility construction projects within the Southernof Malaysia. The methodology involved conducting a descriptive analysis using self-administered questionnaires among 365 professionals in R&D and construction sectors, leveraging Statistical Package for the Social Sciences software. Additionally, structural equation modeling, as depicted through AMOS graphics, was employed to establish a robust and credible model. The findings underscore a significant, positive correlation between PMO requirements concerning Risk Monitoring and Control Practiceswhich encompass risk reassessment, audits, contingency reserves analysis, risk status meetingsand Project Success Factors related to schedule adherence, cost management, facility specifications, and customer satisfaction within the realm of R&D facility construction. By successfully achieving its research objectives, this study has developed practicable project risk monitoring and control practices of risk management model for R&D facilities construction projects, thereby providing a valuable resource for professionals in the field. By integrating these practices into their project workflows, R&D and construction experts can effectively mitigate risks and confront the challenges prevalent in the construction industry, ultimately leading to improved project outcomes.

Keywords: Risk Management, Research and Development, Construction Project, Project Management Office (PMO)

1.0 Introduction

The Malaysian construction sector, MCS for short is a fulcrum in the advancement of the country's economy as the backbone of comprehensive development and growth. Yet, the path to that success, is filled will many obstacles to say the least, and one of those that stands out (especially within Research and Development (R&D) facilities) is the project delays in general. It is at these facilities where groundbreaking technology is translated into tangible customer benefits, hence the importance of having strong risk management frameworks in place to navigate the unknowns inherent to the process.Construction consultants and Project Management Office (PMO) practitioners in enhancing project management practicesfromProject Management Institute (PMI) guidelines.

Malaysia's construction sector increased significantly reaching RM28.2 billion.Civil engineering and building projectscontribute the significant increase in activity reaching RM28.2 billion. Private sector claiming a massive increase of 53,7% of the overall expenditure.At the same time, a distinct rise in R&D efforts from the industries and academic institutions could be observed as well. This boom underlines the necessity to elevate the investment figures in R&D buildings as more investment, more innovation, and more importantly, a very expansive economic picture is dependent on it.

Effective risk management emerges as a linchpin in safeguarding the financial viability and success of these projects. Despite the wealth of academic research on the subject, the practical implementation of risk management within the construction sector often falls short, leaving projects vulnerable to substantial financial losses.In this milieu, Project Management Offices (PMOs) assume a pivotal role in enhancing decision-making clarity and project oversight. Through strategies such as regular reporting mechanisms, dedicated support for project managers [1], and the cultivation of a robust project management culture, PMOs can significantly bolster the resilience and success rates of construction projects, including those in the domain of R&D facilities.

1.1 Problem Statement

The Construction Industry Development Board (CIDB, 2018) has pinpointed several critical factors contributing to project delays, including poor management, subpar quality and productivity, a tarnished industry image, economic instability, workforce shortages, and insufficient data. Within construction, low productivity is often intertwined with inadequate project management, limited technology adoption, unskilled labor, soaring input costs, inaccurate scheduling estimates, manpower shortages, wastage, inadequate maintenance, and hazardous work environments. This sector's unfavorable reputation stems from frequent accidents, job insecurity, ineffective management, meager wages for high-risk roles, and limited avenues for career advancement.

Weaknesses within Malaysia's construction sector, particularly in planning and architecture, have been underscored [2]. Despite established fields like engineering and quantity surveying, constructionresponsible for project executiononly recently formalized its educational framework. This disparity between planning and execution hampers industry growth. Additional concerns include the industry's poor perception, insufficient training structures, lack of recognition for construction technicians, adversarial relationships between consultants and contractors, and suboptimal teamwork.

This study delves into the substantial losses and delays observed in R&D facilities construction projects, attributable to inadequate risk management practices by both internal and external Project Management Offices (PMOs), which can account for up to 85% of project costs [3]. Ineffectual risk management stems from knowledge gaps, inadequate risk monitoring and control, and project managers' failure to adequately consider risks [4] This alarming statistic underscores the urgent need for improved risk management practices within the R&D facilities construction sector. Neglecting risk monitoring can result in accidents, cost overruns, delays, design flaws, equipment malfunctions, labor disputes, diminished customer satisfaction, compromised quality, structural failures, and ultimately project failure [5] adversely impacting organizational performance, reputation, and strategic objectives [4]

Despite the critical importance of risk management, research has predominantly focused on advocating for the adoption and implementation of risk management systems in developing countries [6]. Evaluating the success of these systems necessitates identifying the pivotal success factors for Implementing Risk Management Systems (IRMS) in developing nations. However, scant information regarding actual risk management implementation systems is available from these regions [7] noted that existing studies on risk management in developing countries have predominantly concentrated on risk identification and evaluation, neglecting the examination of applied systems.

The impact of risk monitoring and control on project success in R&D facilities construction in Malaysia remains inadequately understood[8]. Effective risk management, encompassing well-defined scope, budget, work breakdown structures, and communication plans with SMART goals, is imperative [9]. This research endeavors to formulate a risk management model tailored for R&D facilities construction in the Southern of Malaysia, providing a foundational framework for risk management and ensuring project success. The insights gleaned will aid R&D engineers and PMOs in enhancing risk management practices, thereby facilitating successful project delivery.

2.0 Literature Review

This chapter provides an overview of the literature pertaining to the correlation between risk management practices, specifically project risk monitoring and control, and project success within the context of R&D facilities construction in Malaysia. The success of construction projects holds paramount importance for stakeholders and contributes significantly to a country's economic and social progress [10] These projects not only create employment opportunities but also generate income at both national and local levels.

Construction projects create employment and generate income at both the national and local levels. One primary consideration in construction projects is the monitoring and controlling of risks to reduce the possibility of potentially devastating effects of risks on project performance. This chapter reviewed the existing literature relating to the research and the hypotheses for this study.The primary constructs examined include Risk Monitoring and Control Practices, encompassing activities such as risk reassessment, audits, contingency reserves analysis, and risk status meetings. Additionally, the chapter delves into Project Success Factors, which encompass aspects like adherence to schedule, cost management, facility requirements, and customer satisfaction, all within the specific context of R&D facilities construction projects.

2.1 Theoretical Review

In today's interconnected global landscape, risk has become an inherent aspect of everyday life, particularly within the construction sector. Risk management involves proactive measures aimed at aligning actions with potential outcomes. Risks can be categorized as known or unknown, with unknown risks posing challenges in predicting events that could impact project goals [11]. Understanding risk entails assessing uncertain events, especially in construction, where variables such as time, cost, and quality are susceptible [12]. The construction industry presents unique challenges due to uncertainties stemming from natural phenomena, environmental factors, and organizational structures [13].

Despite numerous studies addressing global construction challenges, fewer have delved into issues specific to the Malaysian construction sector. This review examines the encountered problems in Malaysian construction from both local and international perspectives. Several authors, [14][15][16], have documented these issues. Researcher [12] discovered that nearly half of Malaysian projects experienced delays, resulting in financial losses and negative repercussions for the industry and economy. Additionally,[17] emphasized the urgency of addressing these deficiencies in the new millennium.

Furthermore, numerous researchers, including [18] suggest categorizing Project Management Office (PMO) functions into supportive, controlling, and directive roles, each crucial for effective project management. As defined by the Project Management Institute (PMI, 2017), PMOs are organizational units responsible for establishing and maintaining project and program management standards.Strategic initiatives are imperative for success in today's complex business environment,yet many projects falter in achieving their objectives. Striving for successful business outcomes by enhancing execution management practices, leadership in strategic change and organizational governance, PMOs play a pivotal role in driving strategic change within organizations.

In recent years, the importance of implementing risk management in Research and Development (R&D) industries has gained recognition due to the inherent uncertainties involved [19]. The literature highlights the significance of project risk monitoring and control processes in enhancing risk management efficiency and project success. Effective risk control contributes to reliable financial information, investor confidence, and organizational transparency, while regular risk monitoring enables continuous improvement, stakeholder engagement, and prevention of project failure. Integrating risk monitoring and control practices in R&D facility construction projects is crucial for success, as suggested by existing research.

2.2 Conceptual Framework

The primary objective of this study is to develop a practicable Risk Management model specifically tailored for the construction of R&D facilities. This model is designed to be utilized by R&D professionals involved in facility establishment, as well as internal and external Project Management Office (PMO) practitioners. The success of construction projects holds significant importance for both stakeholders and the overall economic and social development of the country [10].

The research is structured to investigate whether a correlation exists between four key aspects of project risk monitoring and control practices and the overall success of R&D facilities construction projects. These four aspects, termed as risk reassessment, risk audits, contingency reserves analysis, and risk status meetings, serve as the independent variables, while project success is designated as the dependent variable. The conceptual framework for this research is illustrated in Fig. 1.

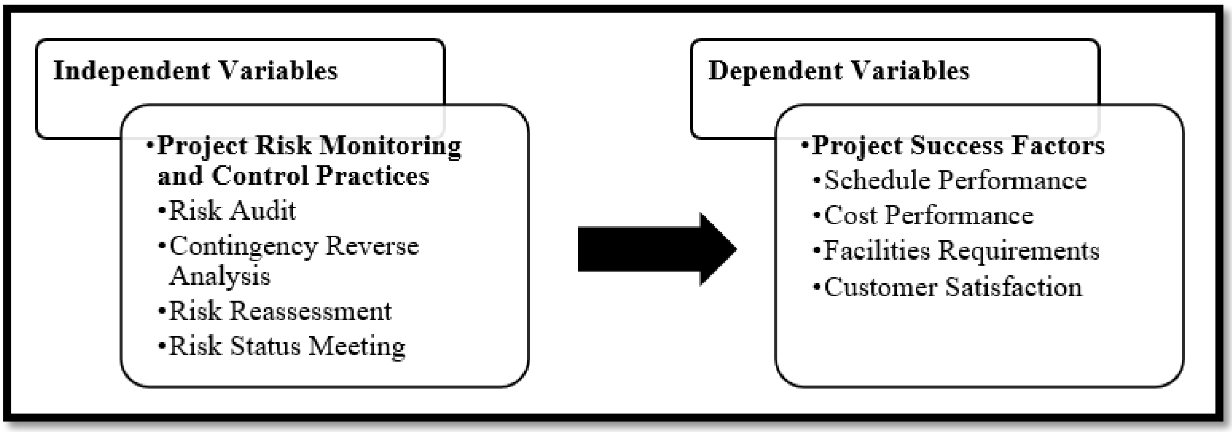

Figure 1: The Independent Variables and The Dependent Variable Conceptual Framework of The Research

The conceptual framework depicted in Figure 1 will be utilized to test hypotheses aimed at determining whether a statistically significant relationship exists between the independent variables and the dependent variable.

2.3 Research Gaps

With a notable emphasis on the implementation of risk management systems in developing countries, researchers have underscored the importance of adopting such frameworks. However, a paucity of comprehensive information on the actual execution of these systems in these nations persists[8]. The majority of studies have predominantly focused on risk identification, assessment, and analysis, often overlooking critical aspects of risk management such as control, monitoring, and response. This research gap leaves pertinent questions unanswered regarding the influence of these processes on project success, thereby highlighting a substantial void in the existing literature.

3.0 Materials and Methodology

A non-probability sampling approach was employed to select research respondents from the Industrial Park in South of Malaysia. The respondents were chosen based on their involvement in R&D facilities construction projects. The administered questionnaire comprised demographic information of the respondents and specific research questions categorized according to stakeholders' roles. The questionnaire structured in a 5-point Likert scale, with responses calibrated as follows: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree.

As stated in Construction Industry Development Board (CIDB), total of 179 Certified Construction Project Managers registered under Malaysian Construction Industry (CIDB, 2022) and 128,000 professional and graduate engineers registered with the Board of Engineers Malaysia (2022, BEM). Invest Johor statistic pointed 6,949 employments in R&D Industry in Southern of Malaysia.

Hence, considering the setting of research with 95% confidence level and 5% margin of error from population of 7,128 (estimated R&D industry population based and Construction Project Managers registered under CIDB). The Cochran formula allows to calculate an ideal sample size given a desired level of precision, desired confidence level, and the estimated proportion of the attribute present in the population

Table 1, z-table is short for the “Standard Normal z-table”. The Standard Normal model is used in hypothesis testing, including tests on proportions and on the difference between two means. The area under the whole of a normal distribution curve is 1, or 100 percent. The z-table helps to define what percentage is under the curve at any particular point.

Table 1 : Standard Normal Z Table

Confidence Level	z-score (alpha/2)
80%	1.282
90%	1.645
95%	1.960
98%	2.326
99%	2.576

The sample size calculated based on, p = 0.5. As we want 95% confidence level, and at least 5 percent plus or minus precision. A 95 % confidence level gives us Z values of 1.96, per the normal tables, where

$$n_0 = \frac{z^2 pq}{e^2} \qquad n_0 = \frac{(1.96)^2(0.5)(0.5)}{(0.05)^2} \qquad n_o = 385$$

As the population of this study is small below 100,000, be able to modify the sample size by calculated in the above formula by using this equation:

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}} \qquad n = \frac{385}{1 + \frac{(385-1)}{7128}} \qquad n = 365$$

The suitable sample size for statistical analysis in this research calculated with Cochran's formula required 365 research participants. Consequently, a total sum of four hundred and thirty-eight (438) questionnaires will be distribute across the selected R&D construction zone in Southern Industrials Park, having the mind-set that 20% of the questionnaires would be difficult to get retrieved at the set target time, while some would be treated unacceptably.
Data collection was carried out through self-administered questionnaires. Prior toquestionnaire distribution, validation was conducted by academic and construction experts, resulting in acceptable Cronbach's alpha values, indicating internal consistency. Additionally, experts' inputs were incorporated to enhance the questionnaire's quality.To fulfill the study's objectives, the target population comprised R&D and construction professionals involved in R&D facilities construction projects.

The questionnaires were administered through physical contact and e-mails. The missing data were treated and transferred to the SPSS software. In the analysis, exploratory factor analysis, using the SPSS version 29 software was employed in establishing correlation analysis to address the hypotheses of the research problems [20], the structure of the measurement models, classifying the items into five factors, while the Kaiser-Meyer-Olkin (KMO) as well as the Bartlett's test of sphericity were engaged in confirming the instrument validity by assessing the sample adequacy and multivariate normality of the study variables. Moreover, the structural equation modelling (SEM) further validated the measurement models through the use of AMOS software by establishing satisfactory goodness-of-fit (GFI) indices of the variables of the study.

4.0 Findings

4.1 Demographic Information

The demographic characteristics of the participants in this study are outlined in Tables 2 through 4. The respondents' years of experience ranged from a minimum of 2 years (55.6%), 3 to 5 years (17.0%), 6 to 10 years (23.8%), and over 11 years (3.6%). Furthermore, their educational backgrounds varied, with percentages for Diploma holders (5.5%), Bachelor of Science (BSc) degree holders (67.7%), Master of Science (MSc) degree holders (24.3%), and Doctor of Philosophy (PhD) degree holders (2.5%).

Table 2:Years of experiences in R&D and construction project management

Years of Experiences	Frequency (f)	Percentage (%)
Minimum 2 years	203	55.6
3 – 5 years	62	17.0
6 – 10 years	87	23.8
11 years and above	13	3.6
Total	365	100

Table 3: Academic Qualification

Credential	Frequency (f)	Percentage (%)
Diploma	20	5.5
Bachelor's Degree	247	67.7
Master's Degree	89	24.3
Doctorate Degree	9	2.5
Total	365	100

Table 4: Area of specialization

Job Position	Research and Development Professionals				Construction Professionals			
	R&D Engineer	R&D Senior Engineer	R&D Manager	Position Above Manager	Project Engineer	Construction Manager	PMO Manager	Position Above Manager
Frequency	188	45	60	7	15	26	16	8
Percentage	62.7	15.0	20.0	2.3	23.1	40.0	24.6	12.3
Total	300 respondents				65 respondents			

Regarding their professional roles, those specializing in Research and Development (R&D) included R&D Engineers (62.7%), R&D Senior Engineers (15.0%), R&D Managers (20.0%), and individuals at managerial levels above R&D (2.3%). In the construction field, participants held positions such as Project Engineers (23.1%), Construction Managers (40.0%), Project Management Office (PMO) Managers (24.6%), and individuals at managerial levels above construction (12.3%).

4.2 Instrument Reliability

The reliability test results via Cronbach's alpha values demonstrated high levels of internal consistency for each construct: Risk Audit (RA) = 0.974; Risk Reassessment (RR) = 0.971; Contingency Reverse Analysis (CRA) = 0.945; Risk Status Meeting (RSM) = 0.945 and Project Success Factors (PSF) = 0.961 as detailed in Table 5. These values exceed the threshold (0.7) for significance, respectively[21].

Table 5: Reliabilities Statistics

Construct	Code	Cronbach's Alpha
Risk Audit	RA	0.974
Risk Reassessment	RR	0.971
Contingency Reverse Analysis	CRA	9.945
Risk Status Meeting	RSM	0.965
Project Success Factors	PSF	0.961

4.3 Hypothesis Testing

This research endeavor seeks to confirm the relationship between two component variables by conducting a correlation analysis. Specifically, it examines the correlation between risk monitoring and control practices, which encompass risk reassessment, risk audits, contingency reserves analysis, and risk status meetings, in the context of RDD facilities construction which related to project success factors of project schedule, cost, facilities requirements, and customer satisfaction.

Pearson's correlation analysis conducted to assess the relationships between variableandresults shows in Fig.2was found to be strong positivecorrelation in Contingency Reverse Analysis (0.896), highpositive correlation in Risk Status Meeting (0.994), highpositive correlation in Risk Audit (0.976), substantialpositive correlation in Risk Reassessment (0.738) and statistically significant ($p < .001$).Hence, this shows that increase in Risk Monitoring Control Practices would lead to a higher Project Success Factors. Which means there is a strong positive relationship or high degree of relationship between the two variables [22].

Correlations

		Project_ Success_ Factors	Contingency_ Reverse_ Analysis	Risk_ Status_ Meeting	Risk_ Audit	Risk_ Reassessment
Project_Success_Factors	Pearson Correlation	1	.896**	.994**	.976**	.738**
	Sig. (2-tailed)		<.001	<.001	<.001	<.001
	N	365	365	365	365	365

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 2: Correlation Between Risk Monitoring Control Practices and Project Success Factors

To analyze the hypothesis, employed the multiple linear regression analysis at 95% confidence intervals. The analysis showed a good model fit: F (4, 360) = 10762.039, P < .001, Adjusted R^2 = 0.992 and R^2 = 0.992. Detailed results are presented in Fig.3 and 4.

Model Summary

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.996a	.992	.992	.07241	.992	10763.039	4	360	<.001

a. Predictors: (Constant), Risk_Reassessment, Risk_Status_Meeting, Contingency_Reverse_Analysis, Risk_Audit

Figure3: Model summary for research construct

ANOVAa

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	225.725	4	56.431	10763.039	<.001b
	Residual	1.887	360	.005		
	Total	227.612	364			

a. Dependent Variable: Project_Success_Factors
b. Predictors: (Constant), Risk_Reassessment, Risk_Status_Meeting, Contingency_Reverse_Analysis, Risk_Audit

Figure 4: ANOVA between Risk Management Control Practices and Project Success Factors

The analysis showed Fig.5 that contingency reverse analysis had a positive effect on project success factors (β = 0.207, t = 4.99, P = < .001), hypothesis accepted. The analysis shows that risk status meeting had a positive effect on project success factors (β = 1.37, t = 40.1, P = < .001), indicating hypothesis accepted. Also, the result found a positive influence of risk audit on project success factors (β = 0.49, t = 10.7, P = < .001), indication that hypothesis accepted. Finally, the risk reassessment also had a positive influence on project success factors (β = 0.105, t = 4.346, P = < .001), indication hypothesis accepted.

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.	95.0% Confidence Interval for B Lower Bound	Upper Bound
1	(Constant)	.027	.022		1.197	.232	.070	.017
	Contingency_Reverse_Analysis	.235	.047	.207	4.992	<.001	.142	.327
	Risk_Status_Meeting	1.393	.035	1.373	40.057	<.001	1.324	1.461
	Risk_Audit	.508	.047	.493	10.730	<.001	.601	.415
	Risk_Reassessment	.113	.026	.105	4.346	<.001	.164	.062

Coefficients[a]

a. Dependent Variable: Project_Success_Factors

Figure 5: Regression analysis at 95% confidence intervals

The results indicate that the extensive framework is structured to evaluate the influence of project risk monitoring and control practices on the success of R&D construction projects. This indicates that directly assessing the concept significantly foretells Project Success Factors.

4.4 Exploratory Factor Analysis (EFA)

In relation to the factor analysis, KMO is a test conducted (0.861) to examine the strength of the partial correlation (how the factors explain each other) between the variables. KMO values closer to 1.0 are consider ideal while values less than 0.5 are unacceptable. Additionally, the Bartlett's test of sphericity yielded significant results ($p < 0.01$), as indicated in Fig. 6.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.861
Bartlett's Test of Sphericity	Approx. Chi-Square	13743.146
	df	378
	Sig.	<.001

Figure 6: KMO And Bartletts Test

Furthermore, the total variance explained, which displayed eigenvalues of 1 and above, was supported by the extraction of the components within the categories.Following the criterion of factor loading of ≥ 0.50 as outlined [23], all items were deemed significant and reliable. The items then categorized into five components, as detailed in Fig.7. Subsequently, based on the results of the factor analysis, five constructs were identified using the varimax rotation method with Kaiser normalization.

Rotated Component Matrix[a]

	Component				
	1	2	3	4	5
RA1	.829				
RA2	.826				
RA3	.878				
RA4	.854				
RA5	.845				
RA6	.868				
RA7	.879				
RA8	.831				
CRA1		.933			
CRA2		.938			
CRA3		.946			
CRA4		.929			
CRA5		.947			
CRA6		.930			
RR1			.838		
RR2			.824		
RR3			.853		
RR4			.841		
RR5			.874		
RSM1				.861	
RSM2				.882	
RSM3				.832	
RSM4				.852	
RSM5				.733	
PSF1					.803
PSF2					.784
PSF3					.770
PSF4					.702

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

Figure 7: Rotated Component Matrix

4.5 Confirmatory Factor Analysis (CFA)

Confirmatory factor analysis (CFA) serves as a sophisticated multivariate statistical technique employed to evaluate the extent to which the observed variables accurately reflect the underlying constructs posited by a theoretical framework. By scrutinizing the relationships between observed variables and hypothesized constructs, CFA assesses the degree of fit between the observed data and the proposed measurement model. Essentially, it verifies whether the measured variables adequately capture the intended theoretical constructs, thereby validating or invalidating the underlying measurement theory.

In this analysis, the initial step involved constructing a model based on theoretical propositions, particularly drawing from risk monitoring and control practices, which encompass risk reassessment, risk audits, contingency reserves analysis, risk status meetings and project success factors which related to schedule, cost, facilities requirements, and customer satisfaction in the context of RDD facilities construction. The proposed model encapsulated the anticipated relationships between these theoretical constructs. Subsequently, a rigorous examination of model consistency was conducted to assess the alignment between the proposed model and the observed data.

This research has developed a single proposed model set for evaluation, which encompasses four distinct combinations representing the theoretical framework for project success factors within R&D facility construction sites. Confirmatory Factor Analysis (CFA) was then performed on this set of models within the designated framework. This analysis aimed to validate the proposed models by assessing how well they align with the observed data, thereby providing insights into the underlying relationships among the project success factors identified for R&D facility construction sites.

Figure 8: The Concept Model

The concept model Fig. 8described project success factors as dependent and risk monitoring and control practices as independent variables

The subsequent proposed model aims to offer R&D and construction professionals engaged in project management a deeper and more comprehensive comprehension of the advantages and correlations between project risk monitoring and control practices, as well as project success factors. This enhancement aims to elevate the efficacy of Risk Management specifically for R&D facility construction projects in Southern ofMalaysia.

The model will describe and serves as a depiction of the interplay between risk monitoring and control practices and project success factors within R&D facility construction sites. This conceptual framework aims to elucidate the relationships between various elements crucial for project success in this specialized context. Fig. 9 portrays the conceptual model and Fig. 10 providing a visual representation of the covaried with the threshold accepted within the key variables involved. This diagram serves as a blueprint for understanding how risk monitoring and control practices impact project success factors within the context of R&D facility construction sites.

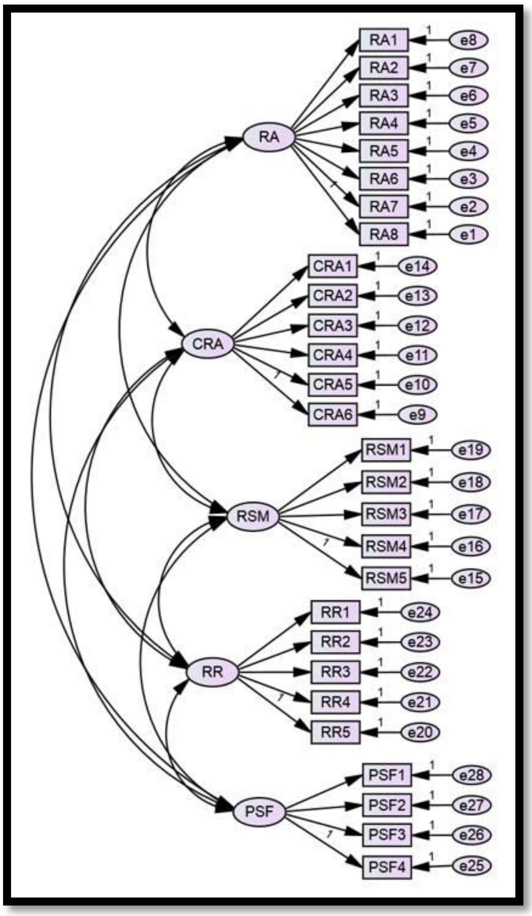

Figure 9: Conceptual Model

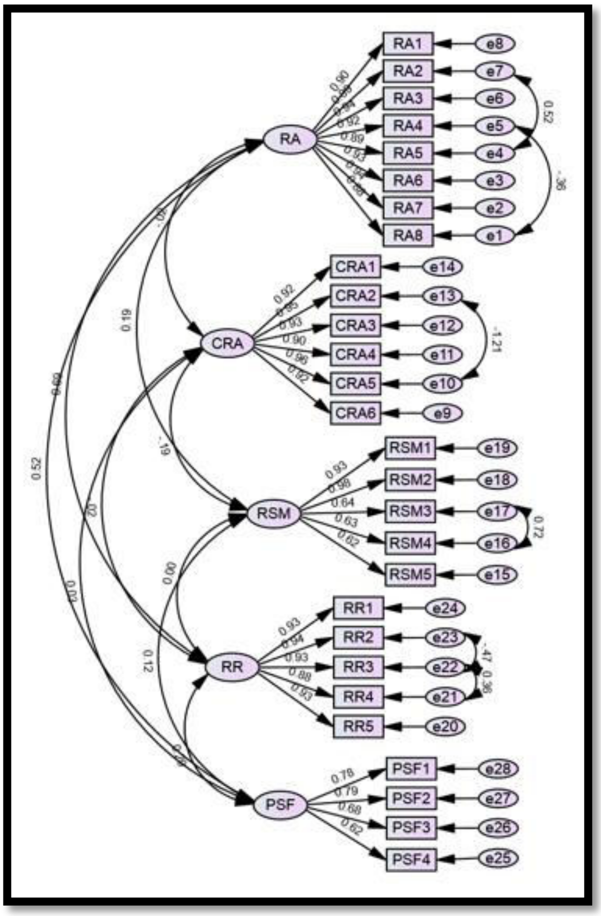

Figure 10:Covaried with Threshold Accepted

Six items were identified with modification indices greater than 20, namely RA2 (e7) to RA5 (e4), RA4 (e5) to RA8 (e1), CRA2 (e13) to CRA5 (e10), RSM3 (e17) to RSM4 (e16), RR2 (e23) to RR3 (e22) and RR3 (e22) to RR4 (e21) as illustrated in Table 6 were covaried.

Table 6: Covariance (Group number 1 – Default model 1)

Estimate Link	M.I.	Par Change
e16 <--> e17	41.930	-0.049
e10 <--> e13	39.267	0.081
e4 <--> e7	34.196	0.037
e21 <--> e22	29.100	0.039
e1 <--> e5	26.301	0.069
e22 <--> e23	22.505	-0.042

Based on the model validity measures, as detailed in Table 7, there are no validity concerns. The Construct Reliability (CR) values are all greater than 0.7, which confirms that the model is consistently reliable. Additionally, Convergent Validity is established, as the Average Variance Extracted (AVE) values exceed 0.5, indicating that the constructs adequately represent the intended theoretical concepts.

Table 7: Model Validity measures

	CR	**AVE**	**MSV**	**ASV**	**RR**	**RA**	**CRA**	**RSM**	**PSF**
RR	0.965	0.848	0.476	0.138	0.921				
RA	0.974	0.824	0.476	0.188	0.690	0.908			
CRA	0.975	0.869	0.037	0.010	-0.016	-0.020	0.932		
RSM	0.880	0.605	0.037	0.019	-0.003	0.168	-0.192	0.778	
PSF	0.794	0.501	0.247	0.084	0.274	0.497	0.028	0.108	0.708

Fig. 11 showcases the structural model, offering insight into how the theoretical constructs are operationalized and Fig. 12 shows the measured through observed variables. This model elucidates the specific indicators used to quantify each latent construct, facilitating a comprehensive assessment of the proposed relationships.

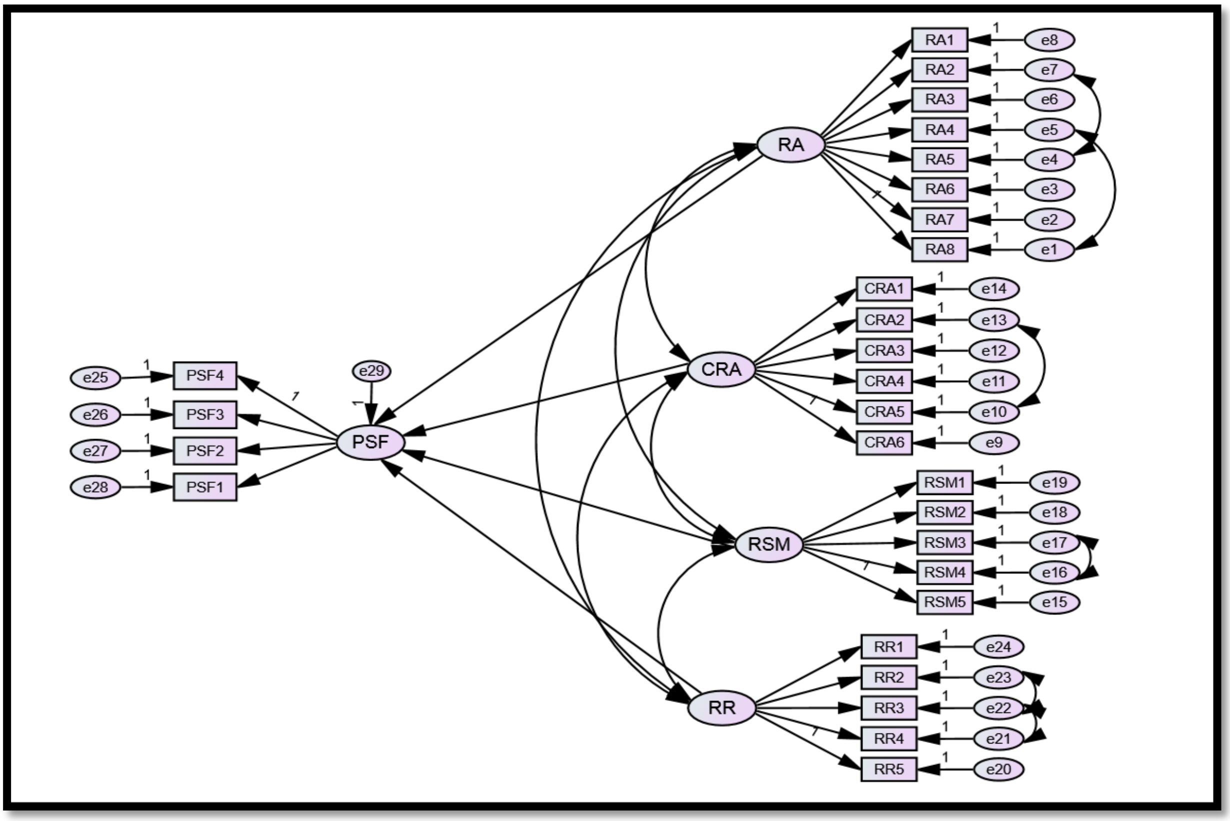

Figure 11: Structural model

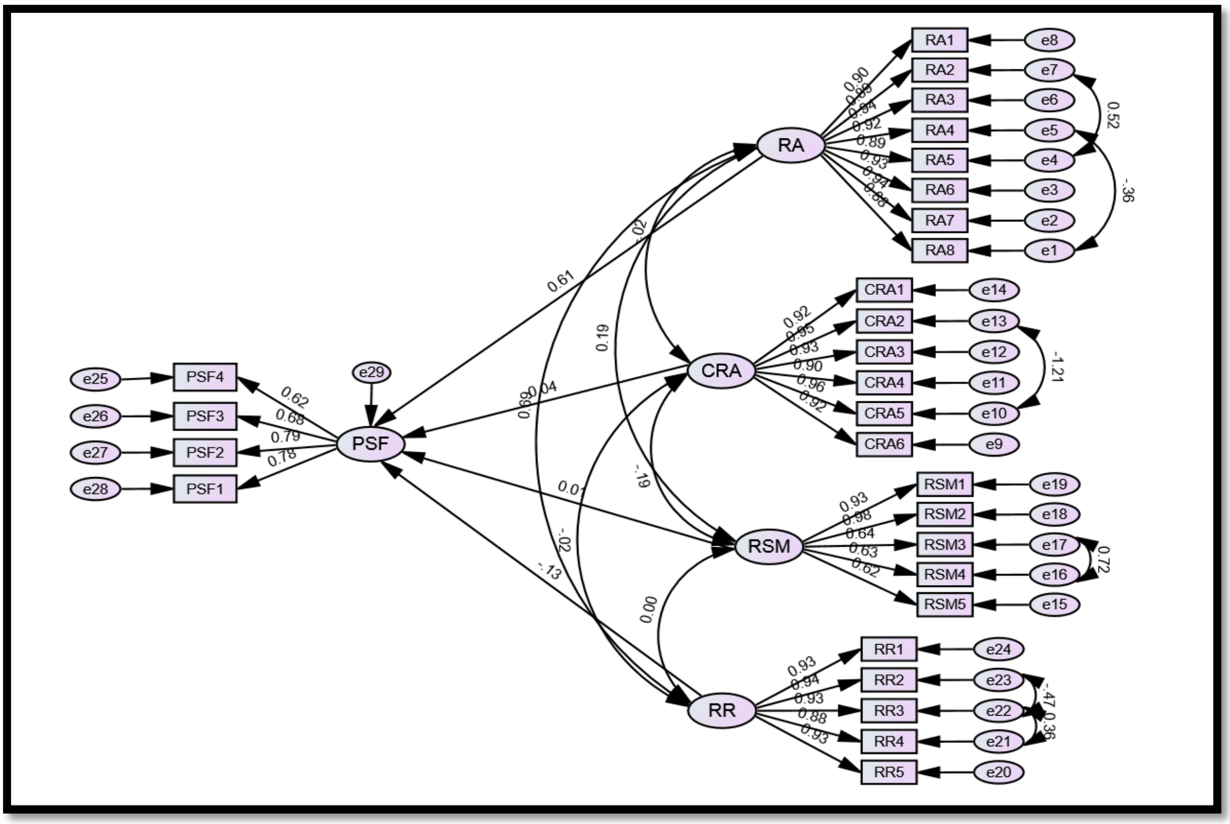

Figure 12: Measurement model

The initial experiments shows that the model was not fit, and model modification commenced by covaried the high modification indices. Hence, RA1, RA8, CRA1, CRA2, RSM2, RSM5 and RR4 removed to improve the model fit. Modification indices essentially represent chi-square tests for individual equality constraints, indicating that high values suggest the respective parameter constraint is less valid [24].

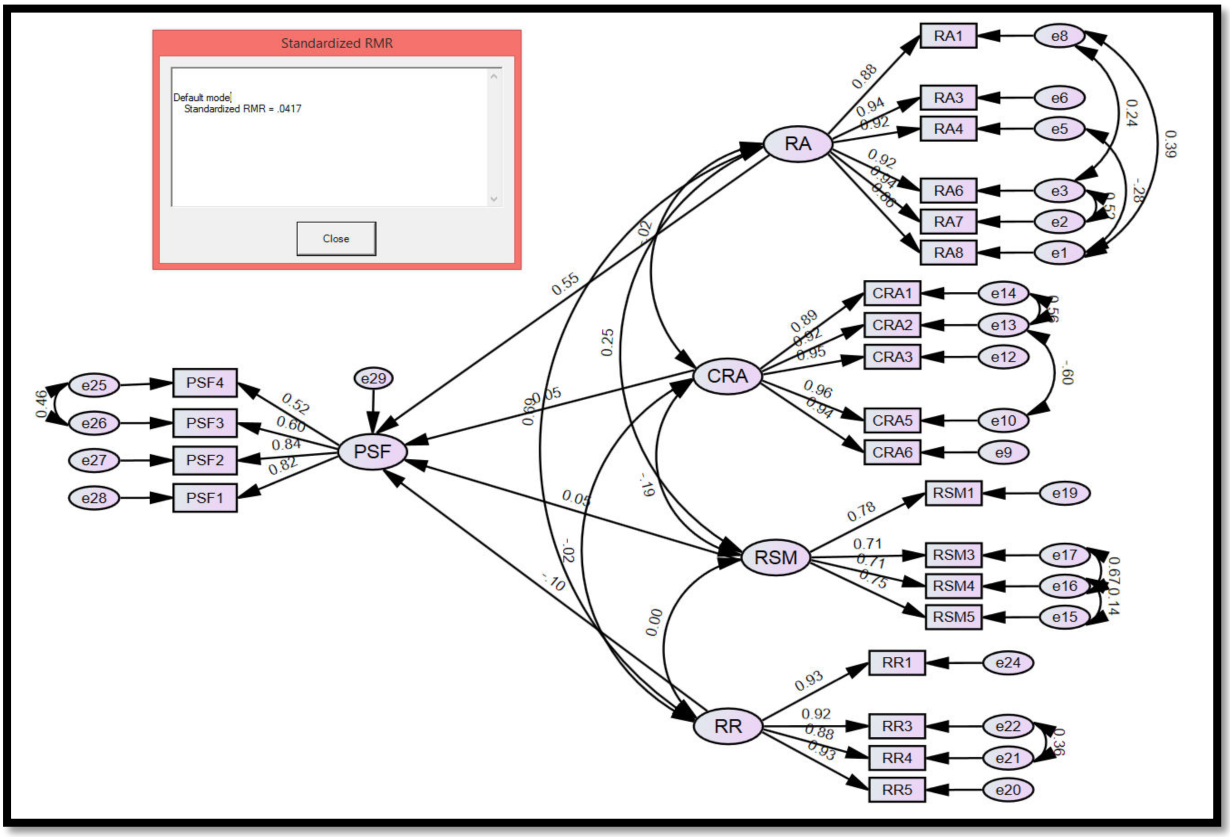

Figure 13:Confirmatory Factor Analysis Modified Model

Furthermore, Fig. 13 depicts the modified Model, illustrating the adjustments made to the original model based on the findings of Confirmatory Factor Analysis (CFA). These modifications aim to enhance the fit of the model to the empirical data by addressing discrepancies and refining the measurement model.

For Risk Assessment (RA), the standardized regression weights range from 0.86 (RA8) to 0.94 (RA3), indicating the strength of the relationship between the latent variable and its indicators. In the context of Contingency Reverse Analysis (CRA), the standardized regression weights range from 0.89 (CRA1) to 0.96 (CRA5). For Risk Status Meeting (RSM), the standardized regression weights range from 0.71 (RSM3) to 0.78 (RSM1) and for Risk Reassessment (RR), the standardized regression weights range from 0.88 for RR4 to 0.93 for RR1. For Project Success Factors (PSF), the standardized regression weights range from 0.52 for PSF4 to 0.84 for PSF2.

4.6 Summary of Measurement Model

The process of evaluating model fit (Fig. 14) involves examining how closely the model matches a particular set of observed data points. This analysis aims to gauge the degree of alignment between the model's predictions and the actual observations. Metrics used to assess fit typically encapsulate the extent of the discrepancy between the observed values and those projected by the theoretical model. This comparison helps researchers determine the effectiveness and accuracy of the model in representing the real-world phenomena under consideration.

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	66	309.167	114	.000	2.712
Saturated model	276	.000	0		
Independence model	23	6227.791	153	.000	40.705

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.025	.915	.873	.610
Saturated model	.000	1.000		
Independence model	.220	.298	.216	.267

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.950	.933	.968	.957	.968
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.745	.708	.721
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	195.167	146.711	251.285
Saturated model	.000	.000	.000
Independence model	6074.791	5819.955	6335.958

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.849	.536	.403	.690
Saturated model	.000	.000	.000	.000
Independence model	17.109	16.689	15.989	17.406

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.069	.059	.078	.001
Independence model	.330	.323	.337	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	423.167	429.445	645.461	702.461
Saturated model	342.000	360.835	1008.882	1179.882
Independence model	6263.791	6265.774	6333.990	6351.990

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	1.163	1.029	1.317	1.180
Saturated model	.940	.940	.940	.991
Independence model	17.208	16.508	17.926	17.214

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	165	180
Independence model	11	12

Figure 14: Model Fit Summary

Table 8: The summary of model fit

Fit Category	Measure	Estimate	Threshold	Interpretation
Absolute Fit	CMIN/DF	2.712	< 3.00	Excellent
	RMSEA	0.069	< 0.08	Excellent
	GFI	0.915	> 0.9	Excellent
	SRMR	0.042	< 0.08	Excellent
Incremental Fit	NFI	0.950	> 0.9	Excellent
	CFI	0.968	> 0.9	Excellent
	TLI	0.957	> 0.9	Excellent
	IFI	0.968	> 0.9	Excellent
Parsimony Fit	PNFI	0.708	> 0.5	Excellent
	PCFI	0.721	> 0.5	Excellent

Table 8 summarized and interpretthe SEM model fit parameters with threshold from Fig. 14.

5.0 Conclusion and Recommendation

5.1 Conclusion

This study aimed to address the issue of construction companies facing significant losses due to insufficient project risk monitoring and control by project managers overseeing R&D construction projects. Its objective was to examine whether implementing project risk monitoring and control practices is associated with project success in such projects. The findings revealed a statistically significant positive correlation between the PMO's prescribed Risk Monitoring and Control Practices, encompassing risk reassessment, audits, contingency reserves analysis, and status meetings and key Project Success Factors adherence to project schedule, effective cost management, fulfillment of facilities requirements, and customer satisfaction in the context of RDD facilities construction.This research offers valuable insights for practitioners seeking to effectively navigate risks within their field. It delves into the intricate connections between project risk monitoring and control practices and project performance, providing project management professionals with a deeper understanding. Organizations can leverage the findings to develop policies and procedures aimed at addressing project risk management challenges, thereby enhancing the likelihood of successful project completion.

The study's results indicated a strong, positive, and significant correlation between project success factors and the implementation of project risk monitoring and control practices. While correlation doesn't imply causation, it suggested that an increase in the utilization of these practices was associated with enhanced project success. Despite participants acknowledging the benefits of these practices, they were not widely adopted, leading to significant financial losses for construction organizations, sometimes amounting to as much as 85% of the total project cost [3]. Despite the availability of various project risk monitoring and control practices, many project managers continue to either overlook or hesitate to implement them[25]. This reluctance stems from a lack of awareness regarding the advantages of project risk monitoring and control practices.On the contrary, construction organizations should prioritize the consistent utilization of project risk monitoring and control practices to enhance project success rates. This requires fostering awareness, ensuring ongoing application, and providing adequate training to promote understanding and effectiveness of these practices in R&D construction projects. The study's findings underscored the positive correlation between the use of project risk monitoring and control practice (risk reassessment, audits, contingency reserves analysis, and status meetings) and key Project Success Factors (schedule, cost, facilities requirements, and customer satisfaction). Therefore, by actively and consistently integrating these practices into their daily project activities, R&D and construction professionals can mitigate risks and address challenges prevalent in the R&D facilities construction, contributing to improved project outcomes.

5.2 Recommendation

This study has several strengths that enhance the validity of its findings and underscore the need for further research on this topic in other sectors of the economy. In addition to the R&D facilities construction industry, future research should explore the impact of project risk monitoring and control practices on project performance in various industries such as agriculture, healthcare, and education. Expanding the scope of research to these sectors will improve the generalizability of the current study's findings.According [26], replicating original research with different samples enhances the generalizability of the study results. Understanding how project risk monitoring and control practices influence project performance across diverse industries will help organizations manage, monitor, and control risks more effectively, thereby increasing the likelihood of delivering successful projects. This broader perspective is essential for developing comprehensive risk management strategies that can be applied universally.

The sample size of this study comprised 365 respondents. Due to the relatively small number of participants, it is necessary for future studies to incorporate a significantly larger sample size to obtain more comprehensive information regarding the factors contributing to the issue at hand. A larger sample will help prevent skewed results and better serve the study's objectives.As argued [27] that using large samples enables researchers to detect smaller, subtler, and more complex effects in the study results. However, researchers should exercise caution when using large samples. The sample size should be sufficient to ensure robust and reliable findings but not so large that it alters the significance levels of the study's results. Properly balancing sample size is crucial to maintaining the validity and accuracy of the research outcomes.

Since this was a quantitative study, future research could employ mixed methods to further explore this topic and verify whether the findings remain consistent. Mixed methods research combines both qualitative and quantitative approaches within the same study. Utilizing mixed methods can help researchers avoid biases that are inherent in single-method approaches, allow for the comparison of qualitative and quantitative data, and enhance the accuracy of the study's findings, thereby providing a more comprehensive understanding of the phenomenon under investigation.Additionally, [28] argued that studies employing a mixed-methods approach achieve a deeper and broader understanding of the phenomenon compared to studies that rely solely on either a quantitative or qualitative approach. The integration of both methods provides readers with greater confidence in the study's results and the conclusions drawn from them.Although mixed methods could be beneficial for this study, it is important to note that they can be expensive and time-consuming, particularly when collecting qualitative and quantitative data simultaneously. Despite these challenges, the mixed-methods approach offers significant advantages in terms of the depth and reliability of research findings, making it a valuable consideration for future studies on this topic.

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