Exploring the Relationship between Safety and Health Cost Dimensions and Accident Costs to the Employer of Urban Rail Infrastructure Projects

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Abstract. The Klang Valley Mass Rapid Transit (KVMRT) System is set to be one of the mega projects in Malaysia. Many of the researches have focused on the causes of construction accident occurrences at the site. Whilst, this study focuses on the consequences (i.e., costs) of the occurrences of the accidents for the project. The work injuries create economic issues for our society. The awareness of accident costs is absent because the stakeholders always leave the matters to the insurance company. They are ignorant of the cost of an accident without realising the greatness of its impacts on the industry and the country. Therefore, this study aims to determine the relationship between accident costs and the factors influencing the accident costs of urban rail infrastructure projects to the Employer. All these factors are known as safety and health cost dimensions. For this research, the Employer, also known as a Contractor, is the person who bears the accident costs (direct and indirect costs) of the project. Multiple regression performed on the sixty-two (62) accident cases from the MRT 1 SBK (Sungai Buloh-Kajang) Line Projects. These findings could heighten the importance of the effect of an accident on the Employer's company's economics and budgeting.

1 Introduction

Compared to other industries, the construction industry stands unique because most of its activities often take place outdoors and under conditions that are not conducive to safety and health [1]. Different types of construction projects involve numerous types of hazards identification. The construction of the Mass Rapid Transit (MRT) system, which is the most prestige urban rail infrastructure project in Malaysia, has also been exposed to hazards. Derived from the MRT accident reports, there have been a thousand incident cases for the MRT 1 Project since the project started in 2011.

Both fatal and non-fatal accidents have a highly significant impact on the economic burden of the MRT project stakeholders. Many losses have to be incurred by the parties involved, and these include the victims, families, employers, and society [2–7].

In addition, they also affect the construction company's profit and loss statement due to damages to productivity, property, equipment, and morale as a result of delays in project completion. The costs that are related to these accidents are both indirect costs (not directly measurable) and direct costs (directly measurable, such as sick leave, medical treatment, and so on).

However, it is challenging to quantify the costs of these accidents. [8] revealed that many researchers seem

challenged due to the complexity of the cost assessment and in providing companies with a reliable method for monitoring such measures [9-10]. [3] explained that none of the indirect cost evaluation methods is universal or generalisable. Thus, the employer needs some solid, quantifiable information that includes the true costs of the accidents.

Though some occupational accidents have occurred amongst the MRT Projects, no study has been carried out to measure the costs associated with such accidents to the best of our knowledge. This study bridges this gap by measuring the economic costs of occupational accidents by using quantitative approaches. Therefore, this study aims to determine the relationship between accident costs and the factors influencing the accident costs of urban rail infrastructure projects to the Employer, which are known as the safety and health cost dimensions.

2 Determinants of S&H Cost Parameters

A wide variety of parameters are necessary to calculate the accident costs for the urban rail infrastructure projects. The determinants of the safety and health cost bearers, components, dimensions and categories of this study involved a further validation from the experts in verifying their suitability in the accident costs estimation of urban rail infrastructure projects.

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2.1 Determinants of S&H Cost Bearers

The determination of the cost bearers for the safety and health cost allocations based on the review of safety and health cost model from previous research. The cost is borne by the employer, employees, and the community/government/societies when the accident occurred at the site. The cost bearers were determined to explain in detail the parties who would bear the costs of safety and health from the project's start until completion.

There is a similarity of the classification of the cost bearers found in [11–16]. Three main stakeholders that have emerged for dealing with the safety and health cost allocations are the employer, employee, and government, for all work-related injuries in all types of business sectors.

For this research, the researcher only focused on the employer as the cost bearer. The employer, also known as the contractor, is the person who tends to bear most of the burden for minor and short-term accidents. The cost components that the contractor have to bear are the direct costs (insurable costs) and indirect costs (uninsurable costs).

2.2. Determinants of S&H Cost Components

[17] clarified the cost related to safety and health in the workplace into three groups; safety, non-safety, and other extraordinary costs. Other scholars have analysed the two well-known dimensions of safety and health cost, which are prevention costs and accidents costs [18–20].

Therefore, safety and health costs can be classified into three (3) types which are prevention costs, accident costs, and other extraordinary costs. This research concentrated on the accident costs.

Accident costs can be categorised into the tangible and intangible costs of accidents. Tangible costs of accidents reflect the costs associated with the occurrence of an accident at work, which can be estimated or calculated using traditional cost accounting methods. On the other hand, the intangible accident costs are immeasurable in economic terms, or there are no performance indices to measure their organisational impacts such as impaired company image, low worker morale, labour disputes or market loss [21].

In Malaysia, the accident costs classified into direct costs and indirect costs [22]. The direct and indirect costs have been used in this study to suit the common terms used in the country. Direct costs are those costs that are accrued directly from the accident, which are related to the treatment of the injury and any compensation offered to workers because of being injured. The direct accident costs are typically the insurable costs that are covered by SOCSO and the insurance company, and they are quite easy to calculate. The examples are treatment at site costs, hospital costs, and property damage/repair costs.

The indirect costs are the costs which are not measurable in economic terms or for which there are no performance indices to measure their impacts on the

organisation. These costs are the consequences of an accident that can be costly. They are more difficult to calculate and tend not to be insurable [21].

There are a few different definitions of indirect costs (uninsured costs); but in general, they are regarded as comprising all of the cost items that are not covered by the worker's compensation insurance. The indirect costs of accidents comprise of several components, such as loss due to the injured worker, inefficiency of the worker who had just recovered from an injury upon resuming work, medical expenses, fines and legal expenses, the employees' productivity, damaged equipment or plants, to damaged materials, and idle machinery or equipment.

2.3. Determinants of S&H Cost Dimensions

The factors influencing the safety and health costs in the construction projects are known as the dimensions that influence the accident costs (direct and indirect costs). Each of the cost dimensions grouped into several categories based on the previous studies. The dimensions are reviewed and summarised in Table 1.

Table 1. Summary of Safety and Health Cost Dimensions & Categories

Author	S&H Cost Dimensions
[17]	Accident rate (phase of project implementation)
[23]	Accident frequency rate, Project hazard level
[8]	Type of accident, Number of lost days, and Number of days of temporary assignment
[24]	Event of injury
[15]	Direct costs-severity of the incident, Indirect Costs-duration of absence and nature
[13]	Days of absence from work (medical leave), Average number of days admitted in general ward, Number of days and income lost
[25]	Number of days lost, Temporary assignment and productivity
[26]	Length of hospital stay in a government hospital
[27]	Average Length of Stay in Hospital (Days)
[16]	Zone of accident

3 Methodology

The respondents, who were the safety personnel at the KVMRT project were required to answer a questionnaire based on the accident cases which had occurred in their projects. The respondents were required to provide information or estimate the accident costs components based on the questions in the questionnaire.

This study conducted on the work package contractors (WPC) from the viaduct (guideway) package of the KVMRT Sungai Buloh Kajang (SBK) Line Project. Eight numbers of WPC, which were representative of eight projects (V1-V8) which selected as the sample of the study. From the above projects, 68 of the reportable accident cases, which were Class 1 (Fatality), Class 2 (Permanent Disability), Class 3 (Temporary Disability) and Class 8 (Dangerous Occurrence), occurred during the construction of those

projects. The respondents returned only a total of 62 questionnaires.

Multiple regression analysis is used to analyse the relationship between variables using the Statistical Package for Social Sciences (SPSS) software. The log transformation is used for continuous data to decrease the variability of the data and make the data conform more closely to the normal distribution. For categorical data, multiple regression used with dummy variables. This robust analysis was applied in this study to determine the most significant variables affecting the accident costs.

Five tests were performed to ensure the reliability and explainability of the MRA models, namely, the pairwise correlation matrix, correlation variance inflation factors (VIF), a coefficient of determination (R^2), F-test, and T-test.

2.1. Measurements of the Major Variables

2.1.1. Safety & Health Cost Components

The significant variables included the safety & health cost components when the accident occurred, which were the medical treatment costs, hospital costs, damage/repair costs, and fine costs.

Whilst for the indirect accident costs, there were twelve cost components which were the accident costs, replacement costs, legal & administrative costs, schedule costs, productivity costs, work in progress costs, recruiting costs, uninsured medical costs, management costs, corrective action costs, ex-gratia costs, and reputation/company image costs.

2.1.2 Safety & Health Cost Dimensions & Categories

Based on the literature review, the five major variables for the direct safety and health cost components were identified. The types of accident classification (AC), the day of the stop work order (SWO), the day of the medical leave (ML), the day of the hospital admission (HA) and the locations of the body's injuries (LBI) should include the scales dealing with estimating the accident costs which are described in Table 2.

Table 2. Major Variables of Accident Costs Components, Dimensions and Categories

Safety & Health Cost Components	S&H Costs Dimensions	S&H Costs Categories
Direct Accident Costs :		
1) Medical Treatment at Site Costs	(AC)	1= Class 1 (Fatality),
2) Hospital Costs		2= Class 2 (Permanent Disability),
3) Damage/Repair Costs		3= Class 3 (Temporary Disability),
4) Fine Costs		4= Class 8 (Dangerous Occurrence)

Indirect Accident Costs:	(SWO)	1= 0-14 days, 2= 15-30 days, 3= >30 days
1) Accident Report Costs	(ML)	1= 0-3 days, 2= 4-7 days, 3= 8-14 days, 4= 15-30 days, 5= >30 days
2) Replacement Costs		
3) Administration Costs		
4) Schedule Costs	(HA)	1= 0-20 days, 2= 21-30 days, 3= >30 days
5) Productivity Loss Costs		
6) Work in Progress Costs		
7) Compensation to Victim/Ex-Gratia Costs	(LBI)	1= No injury, 2= Upper limb, 3= Head, 4= Trunk, 5= Lower Limb, 6= Multiple, 7= Neck
8) Recruiting Costs		
9) Uninsured Medical Costs		
10) Management Costs		
11) Corrective Action Costs		
12) Reputation Loss Costs		

4 Results and Discussions

4.1. Pairwise Correlation Matrix

The pairwise correlation matrix is useful to predict a relationship of variables between two sets of data involving dependence [28]. This test also used as the first step to detect multicollinearity. The multicollinearity test is to see the correlation between each explanatory variable. It is statistically independent to another if the results show no relationship between the explanatory variables [29].

If the explanatory variables are highly correlated, it will lead to an unreliable and unstable estimator. Table 3 shows that there were no variables that had the collinearity index above 0.8. According to [30], there are no guidelines on which variables are causing a problem when a pair of variables is shown to have a high collinearity index above 0.8.

Table 3. Correlation Indices

	AC	SWO	ML	HA	LBI	TAC
AC	1					
SWO	.333**	1				
ML	.055	-.063	1			
HA	.333**	-.016	.261*	1		
LBI	.416**	-.038	.005	.432**	1	
TAC	.449**	.218	.048	.175	.405**	1

4.2. Variance inflation factors (VIF)

This study also relied on the VIF values of the independent variables as a procedure for a double check to detect multicollinearity. There are two opinions in indicating high multicollinearity using VIF values. First, [31] stated that a VIF value below 10 indicates low multicollinearity, and [32] and [33] stated that a VIF value below 5 indicates low multicollinearity.

However, according to [30], there is no theoretical basis for choosing which VIF value (either below 10 or below 5) to use to detect multicollinearity. Therefore, this study adopted the value of 10 in detecting suspicious variables regarding multicollinearity. Table 4 indicates that the VIF values for all of the regressors were below five indicating that there was no serious multicollinearity amongst them.

Table 4. Summary of the Multicollinearity Test

Dependent Variable	Independent Variable	VIF
Total Accident Costs (TAC)	(AC)	1.480
	(SWO)	1.188
	(ML)	1.096
	(HA)	1.388
	(LBI)	1.435

4.3. The coefficient of Determination (R^2)

This statistic indicates the percentage of the variance in the dependent variable that the independent variables explain collectively. It measures the strength of the relationship between the model and the dependent variable on a convenient 0-100% scale.

As indicated in Table 5, the R^2 for the MRA model of accident costs was .446. It means that the independent variables of the accident costs explained 44.6% of the variation in the dependent variable.

Table 5. Summary of the Basic Statistics of R^2

MRA Model	R^2	Adj R^2	Sig.
Total Accident Costs	.446	.396	.000

4.4. F-test

The results of the ANOVA test shown in Table 6. The results show that the p-value for the total accident costs was 0.000, which was less than the alpha level of 0.05. Thus, it can be said that this model provides a better fit than the intercept-only model. A regression model that contains no predictors is also known as an intercept-only model.

Table 6. ANOVA Test Results of the Total Accident Costs

MRA Model	F-Value	Sig.
Total Accident Costs	9.004	.000

4.5. T-test

The significant variables for the MRA model shown by the t-test result (Table 7). Out of the five variables analysed for the total accident costs, three variables were significant. It shows that the total accident costs (direct & indirect costs) were significantly affected by the AC ($p < 0.05$), SWO ($p < 0.01$), and LBI ($p < 0.01$). These variables had strong relationships with the total accident costs incurred by the employer.

The results reveal that the total accident costs were affected by the different types of accident classification

(AC) ($\beta=.493$), the number of days for the stop work order (SWO) ($\beta=1.827$) and the different locations of the body's injuries (LBI) ($\beta=.714$).

This finding further reinforced the notion that the costs of an accident incurred by the employer are related to those in previous studies. [3] revealed that the accident category and the number of days lost are factors which should include in the calculations of indirect accident costs. Whilst [13] concluded that the number of days admitted to the hospital is related to the severity of the accident in measuring the economic costs of an occupational accident.

Table 7. The t-values of the MRA Model

Dependent Variable	Independent Variable	Coefficient	t-value	Sig.
Total Accident Costs (lgTAC)	(AC)	.493	2.322	.024
	(SWO)	1.827	3.605	.001
	(ML)	.068	.436	.665
	(HA)	-.450	-.822	.415
	(LBI)	.714	2.773	.008

Similar findings have been observed in other studies. [15, 25, 26] also revealed that all these factors were significantly influential to the total accident costs (direct and indirect costs). Moreover, [24] described the costs of occupational injuries that presented as three influential factors, which were the industry level, worker characteristics, and event of the injury.

However, these results are in contrast to the Occupational Safety and Health (OSH) Calculator developed by the Department of Occupational Safety and Health. The calculator identified a different factor that was significantly affected by the accident costs, which was the zone (location of accident) factor [16].

5 Conclusion

This paper provides valuable insight into the relationship between accident costs and the safety and health cost dimensions. It can be concluded that the types of accident classifications, the day of the stop work order and location of the body's injury were significantly affected by the total accident costs. These findings could facilitate an employer in estimating the accident costs and heighten the importance of the effect of an accident on the company's economics and budgeting. Also, it could enrich awareness in improving preventive measures for a construction project. A reliable estimate of the cost of accidents on construction projects may assist an employer to plan investment in safety measures in a more appropriate manner.

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