Modeling Cost Overrun of Public Schools Projects

نمذجة الزيادة بتكاليف أنشاء مشاريع المدارس الحكومية

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ABSTRACT

Poor cost performance in construction project is a common problem worldwide resulting in significant amount of cost overrun at account closure. This study aims at to develop model relationship between the amount of the cost overrun (CSTOVR) in schools construction projects and accepted bid price (LCO), estimated cost (ECO), contractor rank (GRA), experience of the supervisor engineer (ENXP), location of project (LOCA), year of contracting (YEAR), and contractual project duration (CDR) as input parameters before work starts. The study covers two story (12 classes) school projects awarded by the lowest bid system completed during (2007-2012) in Karbala province-Iraq. Probability distribution is established for each identified parameter and subsequently a simulation is developed to produces artificial data. The simulated parameters are used to develop the regression models to predict the cost overrun. It is found that the two developed regression models have the ability to predict the cost overrun (CSTOVR) for school projects, as an output, with good accuracy having correlation coefficient (R) of (85.9%) and (85.2%), determination coefficient (R^2) of (73.8%) and (72.6%) respectively.

Keywords – Schools Projects, Construction, Cost Overruns, Simulation, modeling, Regression.

المستخلص:

ضعف السيطرة على الكلفة في المشاريع الإنشائية اصبحت ظاهرة شائعة في اغلب دول العالم نتج عنها زيادات واضحة في الكلفة النهائية عند تصفية الحساب. تهدف هذه الدراسة الى نمذجة العلاقة بين الزيادة المتوقعة في كلف انشاء مباني المدارس الثانوية العامة العراقية وبين المدخلات المعلومة قبل بدء التنفيذ التي هي مدة المقاولة، الكلفة التخمينية، خبرة المهندس المشرف، تصنيف المقاول ،كلفة الإحالة ، موقع المشروع، وسنة التعاقد . شملت الدراسة مشاريع المدارس الثانوية ذات (12) صف من طابقين والمحالة بنظام أوطأ العطاءات والمنفذة للفترة بين2007-2012 في محافظة كربلاء.

تم تحديد التوزيع الاحتمالي لكل عامل من العوامل التي تم تعريفها كمدخلات ومخرجات في النموذج الرياضي لتحليل الانحدار ومن ثم توليد بيانات صناعية (محاكاة) من هذا التوزيع الاحتمالي لاستخدامها في بناء النموذج (الموديل) الرياضي للتنبؤ بزيادة الكلفة. تم التوصل الى ان نموذجا الانحدار اللذان تم بنائهما في هذه الدراسة يمكن استخدام أي منهما للتنبوء بزيادة الكلفة في مشاريع المدارس المماثلة للعينه المستخدمة في هذه الدراسة وبدقة جيدة ومعامل ارتباط (85.9%) و (85.2%) ومعامل تحديد (73.8%) و(72.6%) على التوالي.

الكلمات المفتاحية: مشاريع المدارس، المنشآت، زيادة التكاليف، المحاكاة، النمذجة، الأنحدار.

INTRODUCTION

Cost is the essential part for any construction project. It is observed that cost overrun is one of the most frequently occurring issues in construction projects worldwide and it is more severe in developing countries. Like many other developing countries, construction industry in Iraq is also affected by the cost overrun. This needs serious attention for improving the construction cost performance as rarely projects are completed within budget.

Cost overrun of a project refers to the actual 'cost increase' to the client during construction of a building project. It is merely the difference between the value originally envisaged for the project and the value reflected in the final certificate. Cost overruns occur from overspending the allowances, making changes and encountering unforeseen problems. Lack of information about these factors, lack of relevant data, and weak expectations of possible circumstances to be faced by the project are the main challenges facing researchers in this essence.

Cost overrun usually takes place in the construction industry as a result of a large number of uncertainty factors such as: the complexity of the project; how fast to be completed; the location of the project and the degree of unfamiliarity. Project cost overrun can be caused by any rising costs whether from inflation, inadequate analysis of information or costing methods **[1]**.

For the purpose of this research, cost overrun is defined as the difference between the final cost of a construction project at completion and the contract amount, agreed upon between the client and the contractor during the signing of the contract. This research attempts to use real measurable parameters, to be in hand before the project starts, as predictors for the expected cost overrun of school projects.

RESEARCH OBJECTIVES

This research aims at to develop model relationship between the measure of the cost overrun (CSTOVR) in schools construction projects and CDR, ECO, ENXP, GRA, LCO, LOCA and the Year of contracting.

RESEARCH HYPOTHESIS

At the project execution phase start, it can be said that awarded bid price (LCO), estimated cost (ECO), contractor rank (GRA), resident engineer experience (ENXP), project location (LOCA, year of contracting (YEAR), and contractual project duration (CDR), are good predictors to the expected cost overrun (CSTOVR) of public school building projects before starting works.

RESEARCH JUSTIFICATION

The reasons for carrying out this research are:

- The large number of under construction school projects accompanied with everlasting cost overrun and the ever-growing demand on additional school buildings in Iraq.
- The need of knowing an accurate anticipated final cost of a construction projects before starting works, is highly essential in budgeting concerns, especially in contingency allocation.

LITERATURE REVIEW

Most of literature review are attempts to identify and rate the causes of cost overrun.

The main causes of cost overrun in UK were identified as: project estimating method, design change, design development, design brief, design team performance and procurement route **[2].**

The three top ranked factors that contribute to cost overruns in Australian road projects are: Design/project scope change, the contract tender price and design scope change [**3**].

The three main causes of cost overrun in Kuwait's private residential project are: contractors-related, materials-related, and owner's financial problems. The amount of cost overrun increases with the increase in total costs **[4].** It is claimed that the reasons for cost overruns can be divided into four categories. These categories are: technical, economical, psychological, and political **[5].**

The factors affecting cost overruns are classified into three groups: macroeconomic factors, management factors, business, and regulatory environment **[6].**

The sub-factors influencing cost overruns in road construction projects are grouped under four main factors: financial, construction parties, construction items, environmental and political group of factors **[7]**. Generally, the primary reasons for actual costs varying from a contractor's original bid price is the incorrect estimates, additional work and revisions in quantities of the work included in the original bid specifications. Unforeseen circumstances include site conditions that differ from those described in the contract documents.

The statistical relationship between actual and estimated costs of road construction was investigated using data from Norwegian road construction over the years (1992-1995). It was found that the size of cost overruns was influenced by completion time of the projects and the regions where projects were situated **[8]**.

It is emphases that the project size, difference between the selected bid and the government estimate, type of construction, level of competition, the quality of the contract document, the nature of interpersonal relations on the project and the policies of the contractor, could have a significant impact on cost overruns **[9]**.

It is claimed that the cost overrun rates decreased as the contract amount increased based on their study for contract costs in Lansing, Michigan **[10]**.

In a study of Southern United States construction contracts, it was found that cost overrun rates increased with increase in the contract amount of construction projects **[11].**

The statistical relationship between actual and estimated cost of road construction activities was investigated based on a sample of (100) road construction projects awarded in the West Bank in Palestine. The findings revealed that the average cost deviation in the investigated activities is as follows: earthworks=(-15.7%), base works = (12.9%), asphalt works = (18.5%) and furniture works = (36.4%) **[12].**

The main finding from a study of (258) transportation infrastructure projects located in 20 nations on 5 continents, is that the cost deviation has not decreased over the past (70) years **[13]**.

As highlighted before, past studies have identified various factors affecting cost overruns in construction projects, this study aims at develop regression model for the amount of cost overrun in terms of quantified inputs at pre execution phase relating to schools projects in Karbala province - Iraq.

DATA COLLACTION

The initial parameters that are intended to be used in the model were collected from the literature review of previous studies. Seven parameters are identified as independent parameters of the regression equation based on the availability of the historical records. These parameters are: LCO, ECO, GRA, ENXP, LOCA, YEAR, and CDR. To bias some factors, the selected projects were awarded under the lowest bid tendering system having the same design and number of classrooms. A historical data is collected from (12) completed schools projects of (12 classes) in Karbala province executed during the years (2007-2012). Using EasyFit Professional Software (version 5.5) to find out the probability distribution for each input parameter as shown in Table (1).

MONTE CARLO SIMULATION

Monte Carlo simulation is a problem-solving technique utilized to approximate the probability of certain outcomes by performing multiple trial runs, called simulations. Monte Carlo simulation attempts to generate a random set of values from known or assumed probability distributions of some input variables involved in a certain problem **[14]**.

Table 1: Actual Values of the Parameters that is used to Determine the Best Distribution

No	Input Parameter	Distribution Type	Mean	Std. Devasion	Coef. of Variance	*P*-Value	Max.	Min.
1	Cost Overrun	Uniform	7.63E+7	5.49E+07	7.19E-01	0.838	1.71E+08	-1.87E+07
2	Contractor duration	Normal	299.33	68.48	0.23426	0.813	365	150
3	Estimated Cost	Triangular	9.47E+8	1.58E+08	0.16637	0.43	1.39E+09	7.16E+08
4	Supervisor Experience	Triangular	15.333	5.1854	0.33818	0.411	30	8
5	Grade of Contractor	Normal	4	0.60302	0.15076	0.11	5	3
6	Letting Cost	Cauchy	7.86E+8	8.09E+07		0.909	1.27E+09	1.09E+08
7	Location of project	Uniform	1.4167	0.51493	0.36348	0.143	2	1
8	Year of Contracting	Error	2008	0.66856	3.33E-04		2009	2007

The steps in Monte Carlo simulation, for a set of input variables(CDR, ECO,…, YEAR)and the corresponding output variable(CSTOVR),as a function of(CDR, ECO, …, YEAR),are as follows:

1. Values of each input and output variable (CDR, ECO, …, YEAR), and (CSTOVR) are generated randomly by finding out their probability distribution function using EasyFit Professional software version 5.5 and SPSS program version 22.
2. The above step is repeated hundred thousands of times.
3. The resulted simulated input and output is used to build the regression models.

This study has used the Monte Carlo Simulation to generate (100000) random cases (schools) from the same probability distribution of each input and output to build the regression models as in Table (2).

Table- 2. Descriptive Statistics for Simulated Data

parameter	Mean	Std. Deviation	N
CSTOVR	73920456.5946	42035579.6121	100000
CDR	292.27	68.611	100000
ECO	941439777.851	159833930.894	100000
ENXP	15.32	5.189	100000
GRA	4.00	.579	100000
LCO	824454441.128	161658054.658	100000
LOCA	1.42	.493	100000
Year	2008.00	.577	100000

When the difference between the observed data distribution and the corresponding theoretical distribution is small, then it may be stated with some level of certainty that the input data could have come from a set of data with the same parameters as the theoretical distribution.

MULTIPLE REGRESSION

The regression technique is a statistical modeling method that can be used for analysis and prediction in different knowledge domains. Multiple regression estimation models are well established and widely used in cost estimation and cost overrun prediction. They are effective due to their well-defined mathematical procedure, as well as being able to explain the significance of each variable and the relationships between them. Basically, regression models are intended to find the linear combination of variables which best correlates with dependent variables. The general regression equation is expressed as follows [**15**]:

$$Y = A_o + A_1 I_1 + A_2 I_2 + \dots A_n I_n \qquad (1)$$

Where Y is the total estimated final result, A_o is a constant estimated by regression analysis, A_1, A_2, … A_n are coefficients also estimated by regression analysis, given the availability of some relevant data I_1, I_2,…I_n as measured distinguishable variables that may help in estimating (Y) **[16].**

MODEL FORMULATION

Stepwise regression technique is adopted to analyze historical data in order to provide a powerful model to predict the amount of cost overrun before work starts. The Statistical Package for Social Science SPSS version (22) is used to develop a suitable models.

The steps involved in conducting forward stepwise regression are outlined as follows **[17]:**

1. The first independent variable is selected for entry into the regression equation that demonstrates the highest bivariate correlation with the dependent variable.
2. The second independent variable selected produces the highest increase in R^2 after accounting for the prediction of the first variable.
3. After this second independent variable is added, a second significance test is conducted to determine if the first independent variable remains a statistically significant predictor; if it is not, it is dropped from the equation.

4. This process repeats until either (a) all independent variables have been entered into the equation or (b) entry of the remaining independent variables into the stepwise solution does not produce a statistically significant increase in R^2 as shown in Tables (3).

Table -3. Summary of Analysis Results

Model	R	R^2	Std. Error of the Estimate	Change Statistics				
				R^2 Change	F Change	df 1	df2	Sig. F Change
1	0.724[a]	0.524	29016259.74249	0.524	109870.31	1	99998	0.000
2	0.838[b]	0.702	22945924.96854	0.179	59908.365	1	99997	0.000
3	0.848[c]	0.720	22257382.15194	0.018	6283.608	1	99996	0.000
4	0.859[d]	0.738	21499667.66576	0.019	7173.536	1	99995	0.000
5	0.867[e]	0.752	20922457.69756	0.014	5594.442	1	99994	0.000
6	0.867[f]	0.752	20921692.28365	0.000	8.317	1	99993	0.004

a. Predictors: (Constant), ENXP, b. Predictors: (Constant), ENXP, Year, c. Predictors: (Constant), ENXP, Year, CDR, d. Predictors: (Constant), ENXP, Year, CDR, LCO,
e. Predictors: (Constant), ENXP, Year, CDR, LCO, ECO f. Predictors: (Constant), ENXP, Year, CDR, LCO, ECO, GRA, Dependent Variable: CSTOVR

From Table (3) it can be seen that the best model is model No. (5) with R^2 (75.2%). The results also showed a lack of effect of the project location (urban - rural) on the model.

Correlation Matrix statistic as shown in Table (4) helped to identify any correlations so that possible modeling biases from using correlated parameters in the same model could be avoided. A notable exception is that for the variables [ECO and LCO], which had a correlation coefficient of (0.922) and is indicative of a strong positive association. This is a normal and expected issue where the estimated cost is used as a guide reference to the letting cost so, they will be adopted in two separated models. As such, it is necessary to avoid using these two parameters in the same model. For the other parameters, there seemed to be no problem with correlation as their correlation coefficients were sufficiently low.

Table-4. Coefficients of Correlation Between inputs

Input	ENXP	Year	CDR	LCO	ECO	GRA
ENXP	1.000	0.129	-0.424	-0.208	0.340	0.003
Year	0.129	1.000	-0.374	0.321	-0.369	-0.001
CDR	-0.424	-0.374	1.000	-0.126	-0.043	-0.004
LCO	-0.208	0.321	-0.126	1.000	-0.922	0.000
ECO	0.340	-0.369	-0.043	-0.922	1.000	0.001
GRA	0.003	-0.001	-0.004	0.000	0.001	1.000

Using stepwise techniques to build two regression models, one excluding the estimated cost and the other excluded the contractual cost for their colinearity. The results are in Table (4) and (5) respectively.

Table – 5. Regression Model including Letting Cost

Model Summary					
Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	Durbin-Watson
1	0.724[a]	0.524	0.524	29016259.74249	
2	0.838[b]	0.702	0.702	22945924.96854	
3	0.848[c]	0.720	0.720	22257382.15194	
4	0.859[d]	0.738	0.738	21499667.66576	
5	0.859[e]	0.738	0.738	21498959.33836	1.997

a. Predictors: (Constant), ENXP, b. Predictors: (Constant), ENXP, Year,
c. Predictors: (Constant), ENXP, Year, CDR, d. Predictors: (Constant), ENXP, Year, CDR, LCO, e. Predictors: (Constant), ENXP, Year, CDR, LCO, GRA, f. Dependent Variable: CSTOVR

Table – 6. Regression Model including Estimated Cost

Model Summary[f]					
Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	Durbin-Watson
1	0.724[a]	0.524	0.524	29016259.74249	
2	0.838[b]	0.702	0.702	22945924.96854	
3	0.848[c]	0.720	0.720	22257382.15194	
4	0.852[d]	0.726	0.726	21996254.02525	
5	0.852[e]	0.726	0.726	21995541.88240	1.996

a. Predictors: (Constant), ENXP, b. Predictors: (Constant), ENXP, Year
c. Predictors: (Constant), ENXP, Year, CDR, d. Predictors: (Constant), ENXP, Year, CDR, ECO, e. Predictors: (Constant), ENXP, Year, CDR, ECO, GRA, f. Dependent Variable: CSTOVR

The results showed that the regression model No. (4) including the contractual cost (LCO), as shown in Table (5), is more powerful with (R^2=73.8%) than the other including the estimated cost (ECO), as shown in Table (6), with (R^2=72.6%). Both models showed that there were no improvement in the model efficiency (no increase in R^2 value) when the contractor classification (GRA) is entered in the model as shown in model no. (5). These models are chosen based on the maximum R^2 and smallest Standard Error of Estimate which is (**21499667.66576**) and (**21996254.02525**) respectively.

RESULTED EQUATIONS

After applying multiple regression analysis on the historical data of the whole (100000) simulated school projects data, as shown in Table (7) and (8), the resulted final cost overrun prediction equations are:

C**OSOVR** = $-527.68*10^8 - 60.322*10^5(EXP) + 26.36*10^6\ (YEAR) + 1.4*10^5\ (CDR) - 42*10^{-3}\ (LCD)$ ……………………….Model No. 1

C**OSOVR** = $-543.13*10^8 - 59.69*10^5(EXP) + 27.12*10^6\ (YEAR) + 1.23*10^5\ (CDR) - 27*10^{-3}\ (ECO)$ ……………………….Model No. 2

Table-7. Regression Model Coefficients Including Letting Cost (LCO)

Input	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
Constant	-52768062379.522	276179964.867		-191.064	0.000		
ENXP	-6032250.313	14910.858	-0.745	-404.554	0.000	0.772	1.295
Year	26358012.522	137596.845	0.362	191.560	0.000	0.733	1.365
CDR	143579.338	1299.430	0.234	110.494	0.000	0.582	1.720
LCO	-0.042	0.000	-0.161	-84.697	0.000	0.726	1.377

Table – 8. Regression Model Coefficients Including Estimated Cost (ECO)

Input	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
Constant	-54312862148.871	287860232.022		-188.678	0.000		
ENXP	-5969426.214	15866.738	-0.737	-376.223	0.000	0.714	1.401
Year	27125244.942	143450.305	0.372	189.092	0.000	0.706	1.417
CDR	123135.841	1320.136	0.201	93.275	0.000	0.590	1.696
ECO	-0.027	0.001	-0.102	-48.880	0.000	0.629	1.590

MULTI-COLLIINEARITY ASSESSMENT

To assess multi-collinearity among the variables, Tolerances and Variance Inflation Factors (VIF) examined as shown in Table (7) and (8). Tolerance refers to the proportion of the variance of that variable not accounted for by other predictors in the model and is calculated using the formula ($1–R^2$) for each variable. The range of tolerances is from (0) i.e. perfect collinearity, to (1) i.e. no collinearity.

A tolerance with values less than (0.1) typically indicates a multi-collinearity problem. Variance inflation factor (VIF) is another index for the diagnostic of multi-collinearity, which is just the inverse of the tolerance value. The high value of (VIF) for a variable indicates that there is a strong association between that variable and other remaining predictors **[15]**.

Variables that have high tolerances will definitely have small variance inflation factors. A variance inflation factor in excess of (10) indicates a multi-collinearity problem **[18].**

Since the final cost overrun model predictors have tolerances and (VIF) values that does not violates the aforementioned criteria, therefore, multi-collinearity is not a serious problem in this analysis.

SENSITIVITYANALYSIS

Sensitivity generally refers to the variation in output of a mathematical model with respect to changes in the values of the model’s input. A sensitivity analysis attempts to provide a ranking of the model’s input assumptions with respect to their contribution to model output variability or uncertainty. In a broader sense, sensitivity can refer to how conclusions may change if models, data, or assessment assumptions are changed.

The relative importance of the independent variables is assessed by examining their respective standardized coefficients i.e. Beta values **[15].**

Predictors with higher standardized coefficients such as: supervisor engineer experience (ENXP) parameter and Year of contracting (YEAR) are more important to the regression equation than those with lower values as shown in Tables (7 and 8). It can be concluded that (ENXP) and (YEAR) contribute significantly to the regression model. The small constants of (CDR), (LCO) and (ECO) in the model equations refer to the small effect of them. The exclusion of the (GRA) and (LOCA) parameters is because of their insignificance.

From Figure (1) it can be seen the high importance of supervisor engineer experience (ENXP) parameter in reducing the cost overrun in schools projects. This makes it imperative for relevant authorities to choose competent engineers with good experience in supervising the implementation of school projects. Year of contracting (YEAR) comes next in importance and this unexpected result indicates that the situation of increase in the cost of school projects going on with no learning from past experiences. The results also showed that the increase in duration (CDR) provided by the contractor for the implementation of projects that contribute to the increase in the final cost and this is also a logical.

It is noted that the increase in contractual cost (LCO) reduces the cost overrun of a school project, and this is acceptable because it is approaching the estimated cost, which tends to be higher than the contractual cost and the differences between them will be smaller.

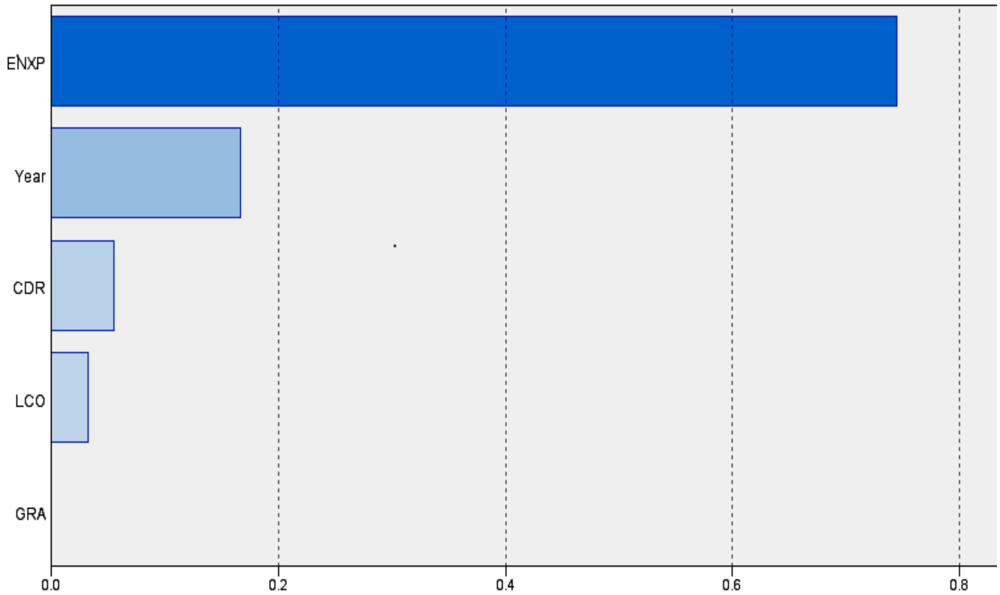

Fig – 1. Model Inputs Importance

CONCLUSIONS

This study analyzed the problem of cost overruns in schools projects before starting works in Karbala province-Iraq. It is carried out using a variety of methods including a literature review and statistical analyses. Clients and contractors can use any of the two constructed model to estimate the extent of future cost overruns amount for school project before starting works and are therefore useful in long term budgeting.

The results suggest that cost overrun increases when the CDR increased, which is expected and this result is consistent with Odeck **[8].**

The developed models provided interesting information about the parameters that could be used as predictors of cost Overruns. It is found that the significant parameters included ENXP, YEAR and CDR parameters. The results showed that the cost overrun increased with the (YEAR), this means that there is no learning from past experience in consistent with Fiyvbjerg et al. **[13]**. The location of the project (LOCA) generally found not influential in contradiction with Odeck **[8]**. The researcher believes that the small area of Karbala province and the rural areas are not too far from urban ones where the schools projects are constructed and have been used in this research as a sample, which leads to cancel the effect of location on the model.

In addition, contractor rank (GRA) is found not influential too. The researcher believes that the contractor classification (GRA) is not real and not interpret the contractor efficiency so, it can be neglected as one of prequalification factors. The ECO and LCO has a decreasing effect in both models and this result is consistent with Odeck **[8]**, Bordat et al. [**9**] and Randolph et al. **[10**] results but in contradiction with Rowland [**11**] study.

The parameters used in the two developed models interpreted about 73.8% and 72.6% of cost overrun of the 12-classe schools projects respectively. The remaining part of cost overrun interpreted by other parameters.

LIMETATION OF THE MODELS

The probability distributions derived from limited number of school building projects (12 schools) and this is the main limitations associated with regression models.

RECOMMENDATIONS

1. Selection of supervisor engineer has a good experience in supervising project implementation.
2. Adoption of scientific methods in determining the contractual time of the project and it not be adopted as a competitive issue between bidders.
3. A reliable cost estimate using the right scientific methods and the completion of an integrated designs to reduce the cost overrun.
4. Data for another design of schools in the whole country can be studied for further confirm the relationship between the independent parameters and cost overrun.
5. The developed model can be checked for applicability on other typical type of school projects such as (16), (18) and (24) classes.

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