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Time-Cost Relationships of Construction Industry in Bangladesh

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Abstract: Bangladesh is one of the newly born developing countries. Development of construction industry has a significant role in contributing to the overall development of a country. Similar to other developing countries, delay and cost overruns are common problems that cause many negative effects on the efficiency of construction projects in Bangladesh. Therefore, accurately predicting the construction time and cost could bring various benefits to all project parties. This study was carried out to develop existing time-cost relationship in construction projects. The Bromilow's basic has been used to establish time-cost relationships. The research data were collected from fifty nine completed different construction projects through questionnaire survey. Type of clients/ sectors and tender methods are the project characteristics considered in this study**.** The results of analysis indicated that the time-cost models developed for each project characteristic are appropriate due to acceptable coefficient of determination and relatively small mean percent errors. The values of R^2 and adjusted R^2 showed that BTC relationships are good fit and could be applied to the different construction projects. Furthermore, the results also show that the cubic regression model has been generated the maximum values of R^2 in terms of type of public sector projects, while cubic regression model is for all of the remaining characteristics of projects. It means that BTC linear regression model is not the best fit regression model. These findings of this study are expected to be significant contributions to Bangladesh construction industry in controlling current performance of project on time overrun.

Keywords: *Time-cost relationship, Construction project, Regression models, Bangladesh*

I. Introduction:

Bangladesh is one of the newly born developing countries. Development of construction industry has a significant role in contributing to the overall development of a country. Bangladesh is ranked as the 58th country according to the Gross Domestic Product (GDP), listed by the IMF (International Monetary Fund, 2012). The construction sector has been growing fast in Bangladesh in recent years. However, it is affected in its performance due to a lot of problems. In such problems, Hasan (2012) identified many drawbacks in construction projects such as mismanagement on project planning, construction materials, quality control, worker, worker safety, and equipment and tools were remarkable in Sylhet city, Bangladesh. Furthermore, Shaon (2012) identified delay in construction and cost overrun is one of most important problem in Bangladesh. Delays in construction are very costly for most parts and completing project on time is beneficiary to all project parties. In recent years, schedule delay has been identified as the most common problems in Bangladesh, and it has caused a multitude of negative effects on construction projects. Schedule delay is a term in construction industry which refers to a difference between estimated time and actual time of project completion. It can be caused by the actions and/or inactions of the parties (i.e., owner, consultant, contractor, subcontractor, vendor, etc.) or circumstances (i.e., weather, strikes, etc.) beyond their control. This leads to the significant reduction of the efficiency of project performance. Therefore, estimating time and cost is an important mission in the early phase of a construction project, especially in feasibility study. It provides a foundation for making decision whether or not the project is performed on schedule and within budget.

Based on above discussion, the purpose of this study is to finding the best appropriate time-cost model for the current performance of construction projects is a very important mission.

II. Previous study:

A. General review

Time-cost relationship model was first introduced by Bromilow (1969), which is considered as a vigorous and reliable model to enable project time to be calculated according to cost and size of project (Walker, 1994; Kenley, 2001). By this time, a lot of similar studies have been performed to understand this problem for either building or civil engineering projects around the world. Daina and Mladen (2009) validated the applicability of the time-cost model for building projects in Croatia. Le-Hoai and Lee (2009) showed that time-cost relationship is applicable building construction projects in South Korea. Le-Hoai et al. (2009) examined BTC relationship in Vietnam. Hoffman et al. (2007) re-examined BTC model in the USA, Ogunsemi and Jagboro (2006) developed time-cost model in Nigeria. Chen and Huang (2006) investigated the time-cost model in Taiwan, Endut et al. (2006) and Chan (2001) carried out the model in Malaysia. Bromilow and Henderson (1976), Bromilow et al. (1980; 1988), Sidwell (1984), Walker (1995), Ng et al. (2001), and Love et al. 2005) have standardized BTC model in Australia. In addition, Kaka and Price (1991) in the United Kingdom, and Chan and Kumaraswamy (1995); and Chan (1999) in Hong Kong validated the application of BTC model. Yeong (1994) studied the time-cost relationship of building projects in both Australia and Malaysia. Cost of a project is one of the most important key elements for time performance in Australia Bromilow (1974), Bromiloe et al. (1980; 1988), Sidwell (1984), and Walker (1995). Furthermore, a similar research performed by Ireland (1983) showed that the average construction time can be well predicted by cost based on an analysis of in Australia. In addition, Onur and Christian (2012) reported that cost of construction projects and gross external floor area are the major variables related to the construction duration. Therefore, when defining the mutual time-cost relationship, all the building participants' almost main focus kept on the cost of construction (Daina and Mladen, 2009).

B. Bromilow's models:

Bromilow (1974) established time-cost model from a survey of 370 building construction projects in Australian, which helps to predict construction time expressed by the following formula: $T = KC^B$

where, T = the project's duration from the date of site possession to practical completion; C = the final cost of the project in million dollar, that is adjusted to constant labour and material prices; K = a constant describing the general level of time performance for a project with one million dollar; and B = a constant describing how the time performance was affected by project size as measured by the cost.

The Bromilow's equation can be rewritten in the natural logarithmic form. It has the same shape of the linear equation as follows: $\ln T = \ln K + B \ln C$

C. Model validation:

Kumaraswamy and Chan (1995) conducted a survey for building and civil engineering projects in Hong Kong. The results of their study have been compared with time-cost models previously proposed in Australia and UK. They concluded that BTC model can be applicable in both building projects and civil engineering projects. Furthermore, Chen and Huang (2006) showed that the original BTC model is suitable only for private sector's projects. Moreover, Le-Hoai and Lee (2009) indicated that the time-cost relationship can be implemented in the building projects in South Korea. In addition, Daina and Mladen (2009) also conducted a research to confirm the applicability of the time-cost model for building projects in Croatia. Ogunsemi and Jagboro (2006) developed time-cost model for construction projects mainly based on Bromilow's equation in Nigeria.

Chan (1999) carried out a research in Hong Kong showed that the time-cost model is considered as a convenient tool for both project managers and clients. In fact, it helps to predict the actual optimum time required for delivering a building project in either public or private sector. Similarly, Le-Hoai et al. (2009) investigated time-cost relationships and showed that the BTC model can be applied in estimating and benchmarking the project duration. Therefore, time and cost tend to be the most important and visible targets of project, and they are always considered as a very critical problem because of their direct economic implications (Ogunsemi and Jagboro, 2006).

III. Research methodology:

A. Questionnaire design and data collection

Data related to causes of delay were gathered through a questionnaire. The questionnaire was mainly designed to collect data related to construction delay and cost overrun. The structured questionnaire has distributed to the respondents who have much experience in construction management in Bangladesh. The electronic mail was mainly used to collect data. The method of sampling used in this study was non-probability sampling because of some certain limitations and difficulties. The respondents were selected from the catalogue of REHAB (The Real Estate and Housing Association of Bangladesh), IEB (Institution of Engineers, Bangladesh) and other sources. After eliminating the uncompleted questionnaires, 59 data sets were found to be usable in this study. Detailed information related to respondents and their project characteristics in terms of project party, project type, project involvement, working experience, and project size is provided in Table I.

Table I Summary of sample characteristics

Category	Characteristics	No. of project	Percent
Type of client	Public sector	31	52.54
	Private sector	28	47.46
Project parties	Owner	17	28.81
	Consultant	21	35.59
	Contractor	14	23.73
	Others	7	11.86
Type of Project	Building & residential	35	52.54
	Civil	31	28.81
	Industrial	17	8.47
	Other	5	10.17
Tender method	Open	40	67.80
	Selective	19	32.20
Time overrun	<-20%	1	1.69
	-20% to '-10%	3	5.08
	-10% to 0%	8	13.56
	0% to 10%	33	55.93
	10% to 20%	10	16.95
	>20%	4	6.78
Cost overrun	<-20%	2	3.39
	-20% to '-10%	4	6.78
	-10% to 0%	1	1.69
	0% to 10%	14	23.73
	10% to 20%	5	8.47
	>20%	33	55.93

B. Analysis tools:

In this study, the internal consistency test provided the values of Cronbach's alpha coefficient were 0.680, 0.762, 0.808, 0.767, and 0.734 which are considered to be reliable, for all cases, public, private sector, open, and selective tender method level respectively shown in Table II.

Table II Bromilow's Time-Cost relationships

Particulars		Cronbach 's alpha	Cronbach's alpha based on standardized items
All cases	-	0.680	0.579
Type of client	Public	0.762	0.880
	Private	0.808	0.808
Tender method	Open	0.767	0.845
	Selective	0.734	0.748

Levene's tests indicated that variances of construction time in each group are equal each other due to all p-values are equal and greater than significance level of 0.05 i.e., (p-value>α); thus, the precondition for ANOVA test is satisfied. ANOVA test for categories in type of client (F = 0.771, p = 0.384, and tender method (F = 2.448, p = 0.123) resulted in the significant differences between actual construction duration means. It is concluded that time performance was not significantly different between categories; thus, the further analysis could be conducted separately on these categories as well as combine. A Levene's test verified the equality of variances in the samples (homogeneous of variance, p>0.05) Martin and Bridgmon, (2012). The detailed results of Levene's test and ANOVA test are shown in Table III.

Table III Results of Levene's test and ANOVA test

Categories	Levene's test		ANOVA test	
	Statistics	p-value	F-value	p-value
Type of client	0.008	0.930	0.771	0.384
Tender method	1.797	0.185	2.448	0.123

C. Development of Time-Cost regression models

In this section, the time-cost relationships were formed based on the Bromilow's basic equation $T = KC^B$. The data of project time and cost were analysed according to project characteristics including type of clients and tendering methods. To do this analysis, the collected data sets were first divided into two different categories: (1) type of clients that includes public and private sector and (2) tendering methods that involve open and selective tender methods. The BTC relationships for type of clients, and tender methods are shown in Table IV.

Table IV Bromilow's time-cost relationships:

Category	Characteristics	BTC models	R^2
All cases	-	$T = 166C^{0.290}$	0.450
Type of client	Public	$T = 150C^{0.287}$	0.581
	Private	$T = 174C^{0.309}$	0.364
Tender method	Open	$T = 133C^{0.311}$	0.530
	Selective	$T = 276C^{0.236}$	0.322

This analysis has been conducted by using the linear regression tool in SPSS V.21. The computed values of coefficient of determination of sample data sets have been investigated to fit with Bromilow's time-cost relationship. In this study, the unit cost of a million (Bangladesh Taka) was used instead of millions of dollars used in the original BTC relationship.

The result shows that one million (Bangladesh Taka's) building projects (T = K, when C = 1) required 166 days to complete for all cases. K is the expected duration of construction (in days) with a unit contract value of 1 million (Bangladesh Taka). For type of client, 150 working days are the required time to complete a public sector project while 174 working days are for a private sector project and so on. As mentioned early in the literature review, Bangladesh is a newly developing country; thus, employment cost is very low. That is about 4 USD dollars for ordinary workers and about 6 USD dollars for skilled workers per day of 8 hour work Rahman et al (2014). Therefore, the managements of significant number of companies have been found to have a more reluctant than public sector approach towards well planned management and using mechanized construction for better outcome from their work (Shaon, 2012).

IV. Result of Analysis:

The scatter plots of Ln C against Ln T of double natural logarithmic relationship between time and cost for all, public, private sector, open and selective tender cases show in the Figures 1, 2, 3, 4, and 5 respectively.

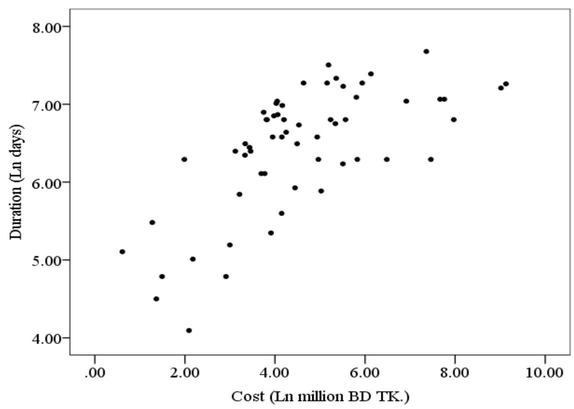

Fig. 1 *Double natural logarithmic relationship between time and cost (all cases)*

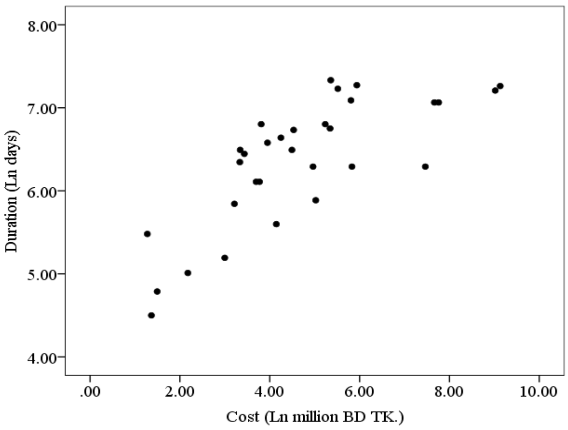

Fig. 2 *Double natural logarithmic relationship between time and cost (public)*

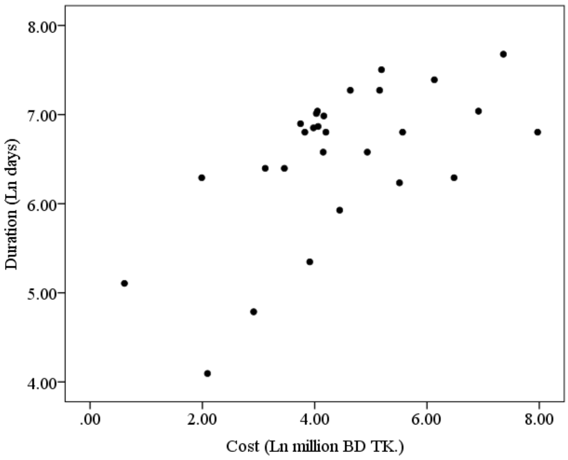

Fig. 3 *Double natural logarithmic relationship between time and cost (private)*

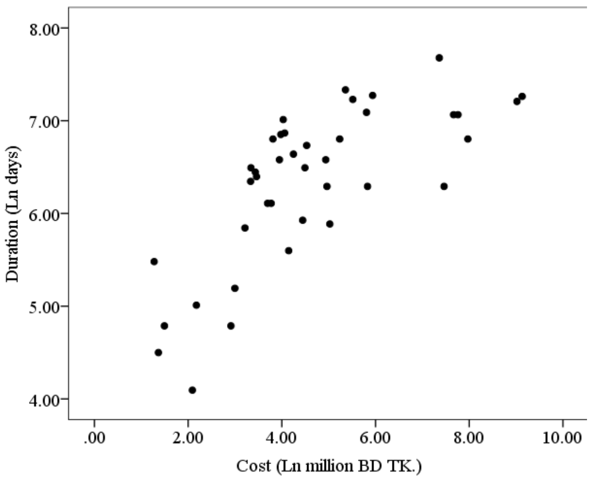

Fig. 4 *Double natural logarithmic relationship between time and cost (open tender)*

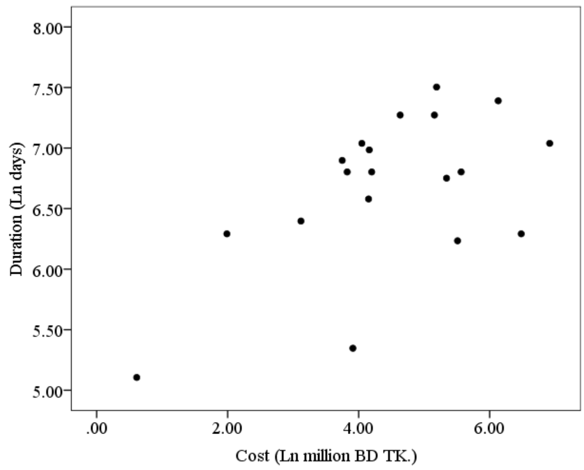

Fig. 5 *Double natural logarithmic relationships between time and cost (selective tender)*

It is shown that there is a trend of an increase in Ln C associated with an increase in Ln T. This trend is likely to be a linear relationship. This means that straight lines that represent the linear relationships between Ln C and Ln T possibly exist in the converted natural logarithmic form of BTC model. Using the experience from the previous projects to predict the current case emphasizes the advantages of BTC model. This type of model can be applied as an alternative tool to objectively estimate the construction time (Chan, 2001) or to benchmark the time performance.

The results of the SPSS's output for each possible case are summarized in Table V. All the regression coefficients Ln(K) and B are significant at ($\alpha = 0.05$). The data sets were analysed for each possible case of project. The time-cost model for overall, public and private sector, and open and selective tender methods are also significant (p-value<0.05) at ($\alpha = 0.05$; F values = 46.571; 40.166; 14.851; 42.867; and 8.079 respectively) and R^2 values ranged from 0.322 to 0.581 have been considered as criteria for the fit of the models derived from the empirical data. The residuals values of Durbin-Watson are 1.471, 1.538, 2.228, 1.408, and 1.473 for model of all cases, public sector, private sector, open tender, and selective tender method respectively. The residuals values of Durbin-Watson are range from 1.408 to 2.228 and the VIF (Variance Influence Factor) values for all models are 1.000. It is concluded that the assumptions of linearity and homogeneity of variance are satisfied.

All cases model has the Adj.R^2 of 0.440 while models for public and private sectors show Adj.R^2 of 0.566 and 0.339 and models for open and selective tender present Adj.R^2 of 0.518 and 0.282 respectively. The model for all cases, the project cost explains 44.0% of the variance of project construction duration. With public project, 56.6% of variance of construction duration is explained by project cost. Moreover, the project cost explains 51.8% of the variance of project construction duration for open tender method. Whereas, these value are 33.9% and 28.2% in the case for private sector and selective tender method correspondingly. "These values are considered reasonable given the nature of the projects, particularly when projects vary widely in location, design, administrative procedures, and facility type among other factors" (Hoffman et al., 2007).

The histogram of frequency and regression standardized residuals considered for all cases, public, private sector, open, and selective tender method are presented in the Figures 6, 7, 8, 9, and 10 respectively. It can be easily seen that the distribution of residuals is similar to the normal distribution. Figures 11, 12, 13, 14, and 15 are shown the straight relationship between expected and observed cumulative probability in normal p-p plot of regression standardized residual for all cases, public, private sector, open, and selective tender method correspondingly. The result of analysis of linearity and homogeneity, normal distribution through (histogram and p-p diagram), auto correlation through Durbin-Watson test, and multi-co-linearity problem test through VIF (Variance Inflation Factor) of variance in Table V indicated also that the original BTC model could be applied in construction projects in Bangladesh too.

Table V Summary of time-cost relationship's linear regression results in SPSS

Category	Characteristics	Ln(K)	B	R	R^2	Adj. R^2	Standard Error	F-test	p-value	Durbin Watson	VIF	Pearson correlation
All cases	-	5.113	0.291	0.671	0.450	0.440	0.596	46.571	0.000	1.471	1.000	0.671
Type of client	Public	5.010	0.287	0.762	0.581	0.566	0.504	40.166	0.000	1.538	1.000	0.762
	Private	5.162	0.309	0.603	0.364	0.339	0.677	14.851	0.001	2.228	1.000	0.603
Tender method	Open	4.892	0.311	0.728	0.530	0.518	0.590	42.867	0.000	1.408	1.000	0.728
	Selective	5.621	0.236	0.568	0.322	0.282	0.535	8.079	0.011	1.473	1.000	0.568

The histogram of frequency and regression standardized residuals considered for all cases, public, private sector, open, and selective tender method are presented in the Figures 6, 7, 8, 9, and 10 respectively.

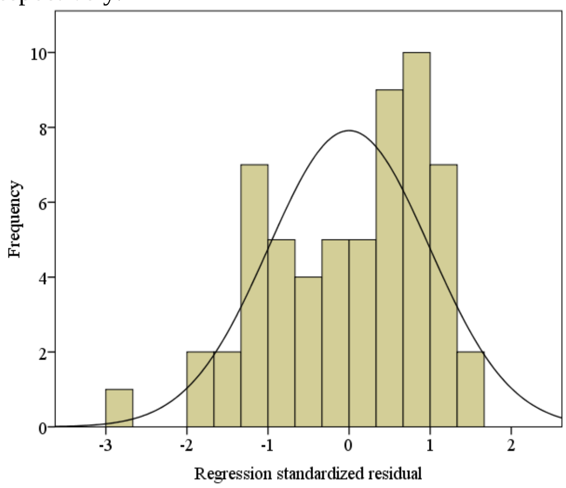

Fig. 6 *Histogram of linear regression analysis (all cases)*

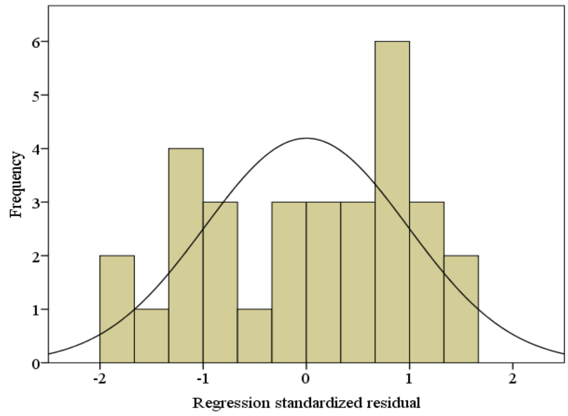

Fig. 7 *Histogram of linear regression analysis (public sector)*

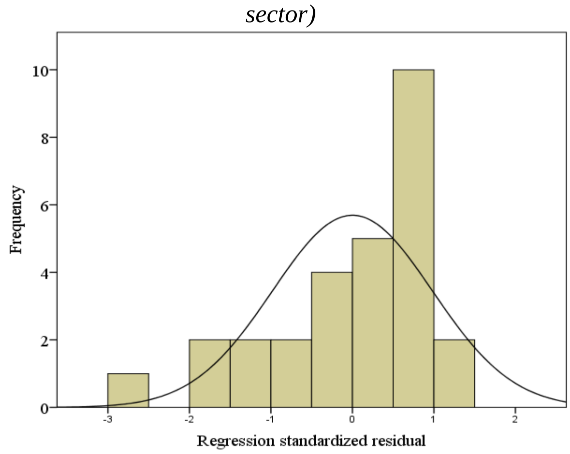

Fig. 8 *Histogram of linear regression analysis (private sector)*

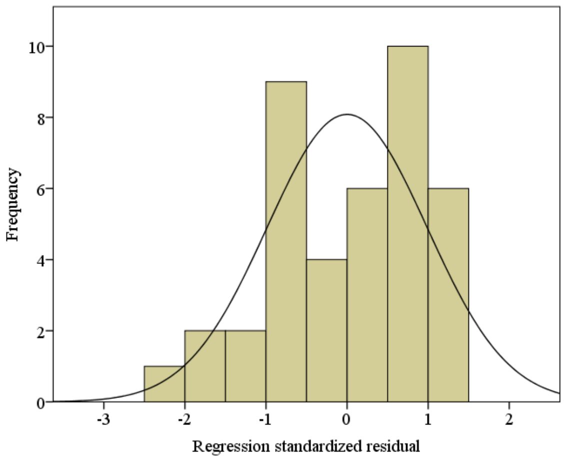

Fig. 9 *Histogram of linear regression analysis (open tender)*

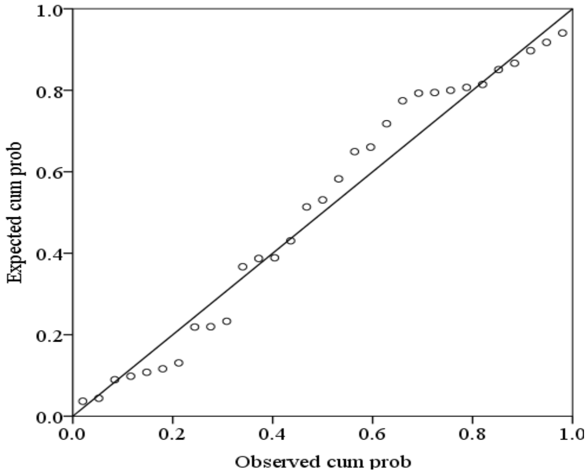

Fig. 12 *Normal p-p plot of linear regression standardized residual (public)*

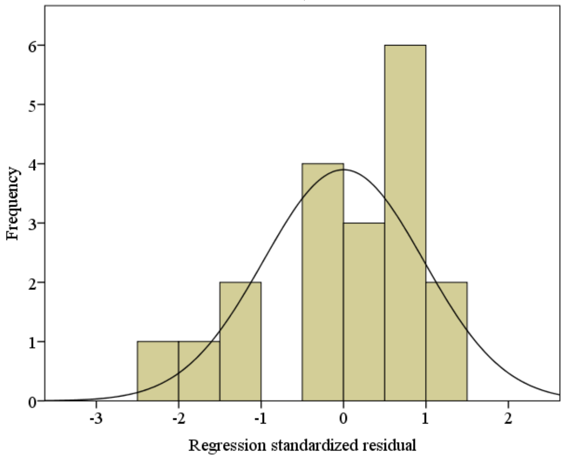

Fig. 10 *Histogram of linear regression analysis (selective tender)*

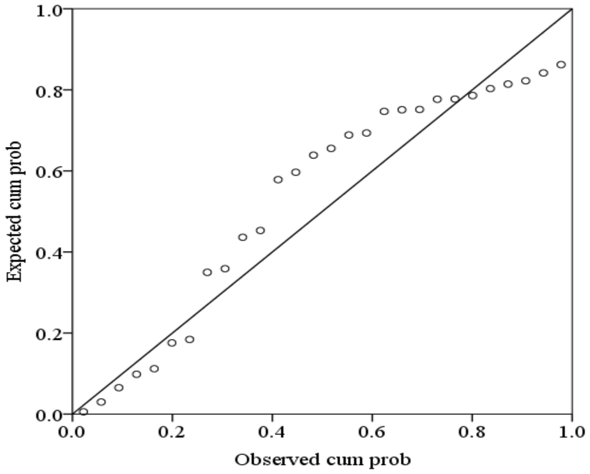

Fig. 13 *Normal p-p plot of linear regression standardized residual (private)*

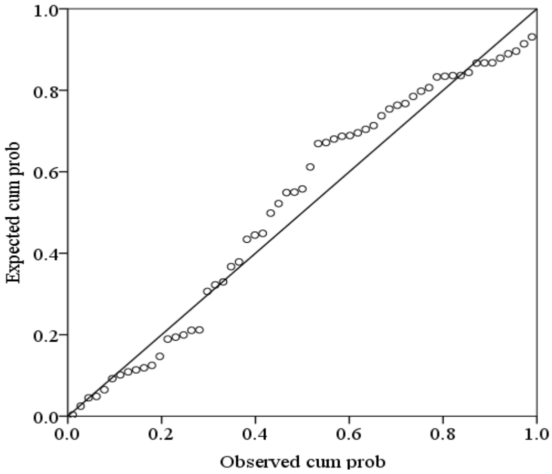

Fig. 11 *Normal p-p plot of linear regression standardized residual (all cases)*

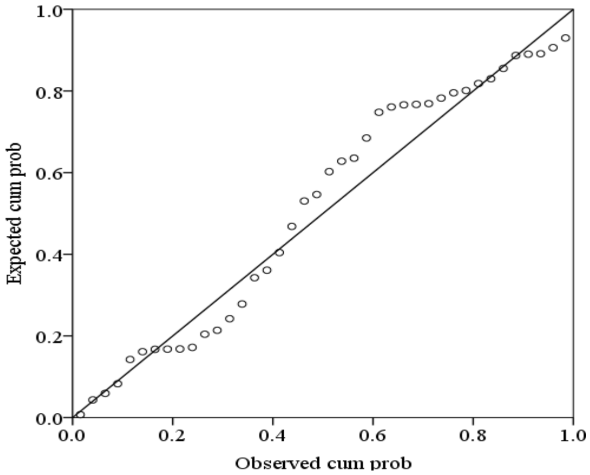

Fig. 14 *Normal p-p plot of linear regression standardized residual (open)*

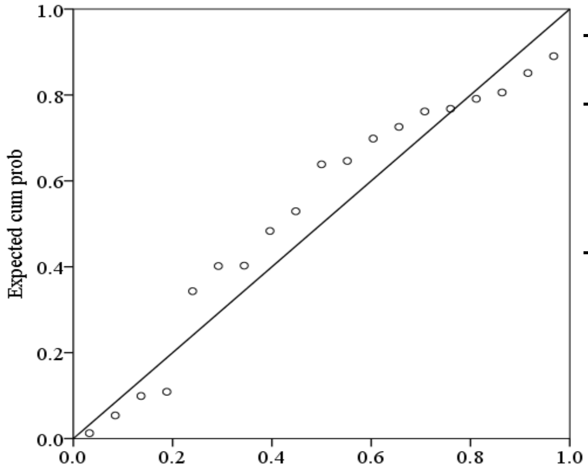

Fig. 15 *Normal p-p plot of linear regression standardized residual (selective tender)*

V. Comparison with other regression models:

In an attempt to find a model that possibly explains a larger portion of variance in construction duration in terms of construction cost, several forms developed to examine the relationship between independent variable (i.e., cost) and the dependent variable (i.e., time) were employed to analyse the data. Le-Hoai and Lee (2009) reported that cubic regression model provided the highest value of R^2. There are five common models used in this study to predict actual construction duration including cubic regression (CUB), quadratic regression (QUA), logarithmic regression (LOG), linear regression (LIN), and exponential regression (EXP). These models were constructed to identify the best fit model for time-cost relationships by comparing the value of R^2 between them. The formulas of selected regression models have been shown in Table VI.

Table VI Different forms of time-cost models

Regression model	Equation
LIN	$T = b_0 + b_1C$
LOG	$T = b_0 + b_1 \ln C$
QUA	$T = b_0 + b_1C + b_2C^2$
CUB	$T = b_0 + b_1C + b_2C^2 + b_3C^3$
EXP	$T = b_0 .e^{b_1 C}$

The R^2 values of these models have been calculated and presented in Table VII. The results show that BTC model is not the best fit model in terms time and cost of construction projects. It could be seen that the QUA regression and CUB regression model generated the highest R^2 value (0.554) with all cases of completed construction project. Regarding type of clients, the CUB regression model for public and private projects also yielded the highest R^2 value of 0.702 and 0.456 respectively. Regarding the tender method, CUB regression model also produced the highest R^2 value of 0.659 and 0.442 for open method and selective method, respectively. In addition, QUA regression has been provided same R^2 value of 0.442 for the selective tender method.

Table VII R^2 values of regression models

Model	All cases	Sector		Tender method	
		Public	Private	Open	Selective
LIN	0.450	0.581	0.364	0.530	0.322
LOG	0.515	0.684	0.393	0.629	0.427
QUA	0.554	0.697	0.442	0.657	0.442
CUB	0.554	0.702	0.456	0.659	0.442
EXP	0.438	0.567	0.352	0.508	0.331

VI. Validation of time-cost model:

The validation of time-cost model is checked by the *t*-test to see the significant differences between the actual values and predicted values at 5% significance level. Table VIII shows that the mean actual duration and mean predicted duration were nearly indifferent due to *t*-test result are not significant. The last column in Table VIII contains the results of MAPE calculation for each category. Most of MAPE values are varies from 6.44% to 11.57%. These results show that the equations in Table VI are likely to predict the project duration in terms of project cost.

VII. Comparison between some selected countries:

The purpose of this section is to observe a comprehensive view of time-cost relationship in different countries. Fourteen studies from nine countries have been selected to satisfy this objective. Among them, there are four studies conducted in Australia with different time period. The parameters of BTC model (K, B and R^2), as well as its conditions for establishment are shown in Table IX. It shows that most studies have been conducted to investigate these parameters in building construction project such as Bromilow (1974), Chan (1991), Hoffman et al. (2007), Ireland (1983), Le-Hoai and Lee (2009), Ogunsemi and Jagboro (2006), and Yeong (1994). A few of studies have also been performed for civil projects, building and others project such as Daina and Mladen (2009). All studies have used 1 million of their own country's currency as a unit cost of construction except Le-Hoai et al. (2009), and Le-Hoai and Lee (2009). To be easy to understand the relationship of time and cost between countries, this study has exchanged their currency to USD at the base year of study (also shown in Table IX). Due to the different currency rates between countries, the values of K and B are totally different. Four studies in Australia mentioned above even show different K and B values. The R^2 values of BTC model from the previous studies are ranged from 0.205 to 0.850 while that of this study is 0.450.

VIII. Limitations:

One of the limitations is the small sample size. That is only 59 data sets which were collected from building and residential, civil, industrial, and others projects. Due to this limitation, the predictability of time-cost model in this study might have been influenced. The accuracy of empirical collected projects data such as amount of projects' cost and completion time could also reduce the goodness of fit of BTC model. These two problems arise from the sensitivity of primary collected data.

Table VIII Time-cost model validation

Category	Characteristics	Mean duration with 95% confidence		T-test (α = 0.05)	MAPE (%)
		Actual	Predicted		
All cases	-	797.29 ± 123..03	726.14 ± 117.43	p = 0.000	8.19
Type of client	Public	723.87 ± 158.42	686.20 ± 171.15	p = 0.000	6.93
	Private	878.57 ± 197.17	1352.41 ± 115.84	p = 0.000	11.57
Tender method	Open	738.38 ± 152.43	983.52 ± 74.41	p = 0.000	10.61
	Selective	921.32 ± 216.68	837.36 ± 132.36	p = 0.000	6.44

Table IX Comparative analysis between some selected countries

#	Study	Location	BTC model			Condition of performance
			K	B	R^2	
1	Bromilow (1974)	Australia	313	0.30	-	• Sample size: 370 building projects, type of client: public and private projects, unit cost: 1 million Australian dollar, 1 Australian dollar = 0.70 USD
2	Choudhury et al. (2002)	Bangladesh	149	0.27	0.650	• Sample size: 35 health sector projects, type of client: private sector, unit cost: 1 million Bangladesh Taka, 1 Bangladesh Taka = 0.0182 USD
3	Chan [8]	Hong Kong	152	0.29	0.850	• Sample size: 110 building project, type of client: no mention, unit cost: 1 million Hong Kong, 1 Hong Kong dollar = 0.1129 USD
4	Chan (2001)	Malaysia	269	0.315	0.407	• Sample size 51 educational, residential projects, type of client: public projects, unit cost: 1 million RM (Malaysian ringgit), 1 RM = 0.26 USD
5	Daina and Mladen (2009)	Croatia	88	0.540	0.800	• Sample size: 17 building and 27 road projects, unit cost: million Kunas (Croatia), 1 Kunas = 0.2174 USD
6	Hoffman et al. (2007)	USA	27	0.202	0.337	• Sample size: 332 building projects, type of client: no mention, unit cost: 1 million USD
7	Ireland (1983)	Australia	219	0.47	0.576	• Sample size: 25 building project, type of client: no mention, unit cost: 1 million Australian dollar (1979), 1 Australian dollar = 0.89 USD
8	Le-Hoai et al. (2009)	Vietnam	94	0.338	0.189	• Sample size 77 building projects, type of client: public and private sector, unit cost: 1 billion Vietnam Dong (VND), 1 Vietnam dong (VND) = 0.00005 USD
9	Le-Hoai and Lee (2009)	South Korea	341	0.175	0.764	• Sample size: 34 building projects, type of client: public/ private, unit cost 1 billion Korean Won, 1Korean Won = 0.0009 USD
	Ng et al. (2001)	Australia	130	0.310	0.588	• Sample size: 93 completed projects, type of client: public and private sector, unit cost: 1 million Australian dollar, 1 Australian dollar = 1.12 USD
	Ogunsemi and Jagboro [25]	Nigeria	63	0.262	0.205	• Sample size: 87 building construction projects, type of client: public and private sector, unit cost: 1 million Naira, 1 Naira (Nigerian NGN) = 0.0079 USD
	Yeong [32]	Australia	269	0.215	-	• Sample size: 87 building projects, type of client: public and private sector, unit cost: 1 million Australian dollar, 1 Australian dollar = 1.21 USD
	Yeong [32]	Malaysia	518	0.352	-	• Sample size: 51 building projects, type of client: public sector only, unit cost: 1 million Malaysian RM, 1 RM (Malaysian ringgit) = 0.21 USD
	Rahman, Md. Mizanur (this study)	Bangladesh	166	0.290	0.450	• Sample size: 31 building, 17 civil, 5 industrial, and 6 others projects, type of client: public and private sector, unit cost 1 million (Bangladesh Taka), 1 BD Taka = 0.0144 USD (at base year 2010)

IX. Conclusions:

This study has developed the BTC model for different construction projects in Bangladesh. The values of R^2 and adjusted R^2 showed that BTC relationships are good fit and could be applied to the different construction projects. Moreover, all the regression coefficients Ln(K) and B are significant at ($\alpha = 0.05$). The time-cost model for overall, public and private sector, and open and selective tender methods are also significant (p-value<0.05) at (α = 0.05; F values = 46.571; 40.166; 14.851; 42.867; and 8.079 respectively). The performance of BTC models differed according to project characteristics. Among them, the time-cost linear regressions model for public sector is the best model for prediction with R^2 of 58.1% and MAPE of 6.93%. The residuals values of Durbin-Watson are 1.471, 1.538, 2.228, 1.408, and 1.473 for model of all cases, public sector, private sector, open tender, and selective tender method respectively. The residuals values of Durbin-Watson are range from 1.408 to 2.228 and the VIF (Variance Influence Factor) values for all models are 1.000. It is concluded that the assumptions of linearity and homogeneity of variance are satisfied. This study also performed the construction of four different regression models to compare with BTC linear regression model. These models are logarithmic model, quadratic model, cubic model, and exponential model. The results show that the cubic regression model has been generated the maximum values of R^2 in terms of type of public sector projects, while cubic regression model is for all of the remaining characteristics of projects. It means that BTC linear regression model is not the best fit regression model. In addition, regarding comparison study between some selected countries, the R^2 values of BTC model from the previous studies are ranged from 0.205 to 0.850 while that of this study is 0.450. In spite of having some certain limitations, the study can provide some useful findings for the researchers and practitioners in Bangladesh construction industry.

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