KICEM Journal of Construction Engineering and Project Management
Online ISSN 2233-9582

www.jcepm.org
http://dx.doi.org/10.6106/JCEPM.2014.4.3.013

Development of Time-Cost Models for Building Construction Projects in Bangladesh

Rahman MD. Mizanur[1], Lee Young Dai[2], Ha Duy Khanh[3] and Chun Yong Hyun[4]

Abstract: 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. Thus, reliability of this estimate plays a key role in measuring the success of a project. This study was carried out to investigate the time-cost relationship in building construction projects in Bangladesh. The mathematical equation used in this study is based on Bromilow's equation. The research data were collected from sixty-three completed building projects through questionnaire survey. Type of clients, type of projects, and tender methods are the project characteristics considered in this study. The results of analysis indicated that the Bromilow's time-cost (BTC) models developed for each project characteristic are appropriate due to quite high coefficient of determination and relatively small mean percent errors. Among them, the forecasted model for time and cost according to tender methods is the best fit model. It is concluded that the BTC model could be applied in building construction project to predict its time and cost in Bangladesh. Four different regression models were also developed in this study. The results of BTC model between some selected countries were compared to gain the comprehensive view.

Keywords: Time-cost relationship, Project management, 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) [33]. The construction sector has been growing fast in Bangladesh in recent years. During 2008-2009, total employment of construction sector stood at 2.024 million. Even at the current growth rate, the total employment in the construction sector is expected to be 2.88 million by 2014. Therefore, it has been needed to efficient sound management for the quick development of construction industry as well as national economic growth [27]. Similar to other developing countries, time and cost overruns are common problems that cause many negative effects on the efficiency of construction projects in Bangladesh. Construction delay is one of the reasons for contractor's costs increase, (i.e., resource re-planning and construction changes, overhead costs, and other time-related costs) thereby reducing the contractor's profit margin and reputation; and clients must incur an additional holding charges, professional fees, and income loss due to late handover [5].

Construction duration is the most important parameter for evaluating the success of construction project. It is influenced by several factors which are mentioned in many previous studies such as project scope, procurement method, site conditions, inclement weather, and so on.

Thus accurately predicting the construction time and cost could bring various benefits to all project parties. A well-prepared schedule is a critical success factor that has been examined by many researchers. They indicated that time is "money", and if it is not well managed, a lot of problems and difficulties can happen when performing the project. Therefore, understanding time-cost relationship is a better way to predict the impact of project cost due to changes of schedule [2]. Several models for estimating project completion time have been developed by many studies such as Bromilow et al. [6], Walker [30], Ng et al. [24], Skitmore and Ng [29]. However, many construction projects have faced with various types of problems. In such problems, delay is the most common problem due to inaccurate estimate [1]. In this context, Bromilow's time-cost (BTC) model is strongly applicable to estimate the project duration. However, several studies claimed that the application of this model is not suitable. One of them, Le-Hoai and Lee [22] indicated that the original BTC is not the best fit regression form, but they also proposed another better model for Korea construction industry.

Based on above discussion, finding the best appropriate time-cost model for the current performance of construction projects is a very important mission. Choudhury et al. [12] investigated Bromilow's model in only health sector projects in Bangladesh. The results indicated that Bromilow's model is good fit for Bangladesh construction industry at the statistical level of significance of 0.0001. On the basis of idea, the main

[1] PhD Candidate, Interdisciplinary Program of Construction Engineering and Management, Pukyong National University, Busan 608-739, Korea, amizanpknu@hotmail.com
[2] Professor, Department of Civil Engineering, Pukyong National University, Busan 608-739, Korea, ydlee@pknu.ac.kr (*Corresponding Author)
[3] PhD Candidate, Interdisciplinary Program of Construction Engineering and Management, Pukyong National University, Busan 608-739, Korea, hd.khanh@hotmail.com
[4] PhD Candidate, Department of Civil Engineering, Pukyong National University, Busan 608-739, Korea, yongarie@hanmail.net

purpose of this study is to investigate existing time-cost relationships of building construction projects for both public and private sector in Bangladesh.

II. TIME-COST MODEL

A. Relationship between Time and Cost

Time-cost relationship model was first introduced by Bromilow in 1969 [3], which is considered as a vigorous and reliable model to enable project time to be calculated according to cost and size of project [30, 19]. 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. Onur and Christian [26] indicated that cost of construction works and gross floor area are major variables for describing the construction duration in Germany. Daina and Mladen [13] validated the applicability of the time-cost model for building projects in Croatia. Le-Hoai and Lee [22] showed that time-cost relationship is applicable building construction projects in South Korea. Le-Hoai et al. [21] examined BTC relationship in Vietnam. Hoffman et al. [16] re-examined BTC model in the USA, Ogunsemi and Jagboro [25] developed time-cost model in Nigeria. Chen and Huang [11] investigated the time-cost model in Taiwan, Endut et al. [14] and Chan [9] carried out the model in Malaysia. Bromilow and Henderson [5], Bromilow et al. [6, 7], Sidwell [28], Walker [31], Ng et al. [24], and Love et al. [23] have standardized BTC model in Australia. Ireland [17] also accomplished similar study to predict the construction time of high-rise commercial projects in Australia. In addition, Kaka and Price [18] in the United Kingdom, and Chan and Kumaraswamy [10]; and Chan [8] in Hong Kong validated the application of BTC model. Yeong [32] 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 [3, 6, 7, 28, 31]. Furthermore, a similar research performed by Ireland [17] showed that the average construction time can be well predicted by cost based on an analysis of 25 high-rise commercial buildings projects in Australia. In addition, Onur and Christian [26] 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 [13]. Furthermore, Endut et al. [14] developed time-cost model according to data collected from projects which were executed between 1994 and 2005. The results showed that there was no distinct evidence to recommend that all parameters of project follow the BTC model.

B. Bromilow's Model

Bromilow [4] 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 millions of Bangladesh Taka, that is adjusted to constant labor and material prices; K = a constant describing the general level of time performance for a project with one million Bangladeshi Taka; 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 [20] 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. In addition, Chan [9] introduced an appropriate BTC model on the Malaysian construction industry through conducting a similar study for public projects between the late 1980s and the early 1990s. Furthermore, Chen and Huang [11] showed that the original BTC model is suitable only for private sector's projects. Moreover, Le-Hoai and Lee [22] indicated that the time-cost relationship can be implemented in the building projects in South Korea. Daina and Mladen [13] also conducted a research to confirm the applicability of the time-cost model for building projects in Croatia. Ogunsemi and Jagboro [25] developed time-cost model for construction projects mainly based on Bromilow's equation in Nigeria.

Chan [8] 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. [21] 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 [25].

III. RESEARCH METHODOLOGY

A. Questionnaire Design

The questionnaire of this research work was mainly designed to collect data related to construction delay and cost overrun. There are three types of question's patterns, i.e., multiple choice, text and checkboxes. Totally seventeen questions were selected to meet the objectives of this study. The text-based questions were used to collect exact information about construction time as well as its costs. The checkboxes-based questions were employed to gather the information of delay factor in construction industry in Bangladesh. The multiple choice-based questions were designed for getting data regarding respondent's information.

B. Data Collection

An online questionnaire survey was used to collect data for the time–cost relationships in building construction

projects in Bangladesh. The methods of sampling are particular target sampling and random sampling was selected for this study. A targeted sampling is a sampling of the subject matter, be that people or other things is selected using certain criteria. Random sampling is a sampling of a population in which the population is first divided into distinct subpopulations, or strata, and random samples are then taken separately from each stratum. The method of delivering the questionnaire is mainly based on electronic mail. The respondents were selected from the catalogue of REHAB (The Real Estate and Housing Association of Bangladesh) and IEB (Institution of Engineers Bangladesh) and other reliable sources. In addition to increasing the representativeness of samples, stratified random sampling was a useful technique that made general statements about the portions of the population [23]. After eliminating the uncompleted questionnaires, 63 data sets were found to be usable in this study.

In a total of 63 data sets, 65% of them are collected from Dhaka, and others are collected from Chittagong (16%), Khulna (5%), Rajshahi (9%), and Sylhet (5%) as shown in Fig. I. The size of projects is separated into six categories according to its cost as shown in Fig. II. Most of projects have cost less than 100 million Bangladesh Taka. Regarding respondent's position of work, majority (44%) of them are contractor; whereas 16%, 38% and 2% are owner, consultant and others respectively (see Fig. III).

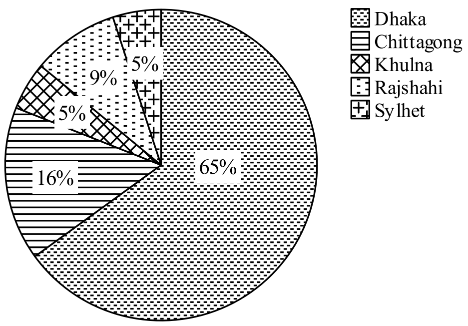

FIGURE I
PROJECT LOCATION IN SURVEY

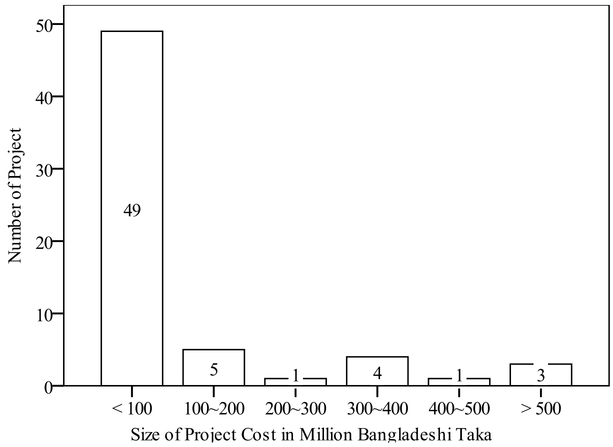

FIGURE II
NUMBER OF PROJECTS INVESTIGATED BY CONTRACT VALUE

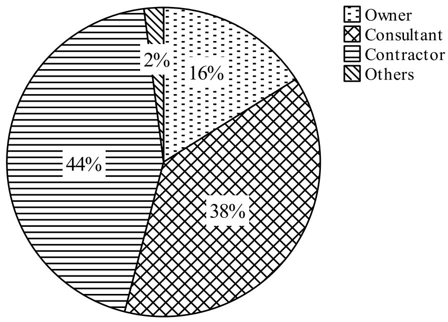

FIGURE III
PROJECT PARTIES IN SURVEY

C. Analysis Tools

The actual data sets of time and cost were collected from completed building projects. They were processed by using SPSS V.18 and Microsoft Excel program. The collected data were divided into different groups according to project characteristics. In order to check the data, Levene's test and ANOVA test have been performed in this study. Levene's test is used to assess the equality of variances for a variable calculated for two or more groups. If the p-value of Levene's test is less than significance level of 0.1, the variances are not equal. Therefore, there is no need to calculate the next step. In contrast, if the p-value is greater than significance level of 0.1, the variances are equal; thus, the precondition for ANOVA test is satisfied. In this case, ANOVA is used to analyze the mean differences between groups and within groups.

A t-test is used to determine whether or not the mean of two groups is significantly different at 5% significance level. In order to assess the accuracy of the predicted model, coefficient of determination (R2) and Mean Absolute Percent Errors (MAPE) are employed as following equations:

$$R^2 = 1 - \frac{Sum\ of\ squared\ errors}{Total\ sum\ of\ squares}$$

$$MAPE = \frac{1}{N}\sum_{1}^{n}\frac{|Predicted - Actual|}{Actual} \times 100\%$$

The coefficient of determination (R^2) and the adjusted coefficient of determination (Adj. R^2) of linear regression are used to indicate the goodness of fit of the models derived from the empirical data sets. If R^2 equals to 1, all the data are good fit to regression line and if R^2 is 0 that means there is no linear relationship exists between considered groups [22].

IV. Analysis and Findings

A. Sample Characteristics

The collected data sets regarding the time and cost of completed building projects were used for analysis. A total of 63 data sets were analyzed to meet the objectives in this study. These projects were completed within eleven years between 2003 and 2013. The unadjusted contract values of these projects ranged from 1.60 million to 2,400.00 million (Bangladesh Taka). The detailed information of sample characteristics is shown in Table I.

Levene's tests indicated that variances of construction time in each group are equal each other due to all p-values are greater than significance level of 0.1; thus, the precondition for ANOVA test is satisfied. ANOVA test for categories in type of client (F = 1.704, p = 0.197), type of project (F = 0.886, p = 0.418), and tender method (F = 0.341, p = 0.713) resulted in the significant differences between actual construction duration means. It is concluded that time performance was significantly different between categories; thus, the further analysis could be conducted separately on these categories. The detailed results of Levene's test and ANOVA test are shown in Table II.

TABLE I
SUMMARY OF SAMPLE CHARACTERISTICS

Category	Characteristics	No. of project	Percent
Type of client	Public sector	23	37%
	Private sector	40	63%
Type of Project	Residential building	35	56%
	Commercial building	14	22%
	Other	14	22%
Tender method	Open	29	49%
	Selective	20	32%
	Other	14	22%
Contract duration (days)	≤ 360	20	32%
	360-540	9	14%
	540-720	11	17%
	720-900	6	10%
	900-1080	13	21%
	≥1080	4	6%
Time overrun	>20%	8	12%
	10 to 20%	5	8%
	-10% to 10%	44	70%
	-20 to -10%	5	8%
	>-20%	1	2%
Cost overrun	>20%	1	2%
	10 to 20%	8	12%
	-10% to 10%	52	82%
	-20 to -10%	1	2%
	>-20%	1	2%

TABLE II
RESULTS OF LEVENE'S TEST AND ANOVA TEST

Categories	Levene's test		ANOVA test	
	Statistics	Sig. Level	F-value	Sig. Level
Type of client	0.023	0.880	1.704	0.197
Type of project	0.735	0.484	0.886	0.418
Tender method	0.308	0.736	0.341	0.713

B. Development of BTC Model

In this section, the time-cost relationships were formed based on the basic equation developed by Bromilow [3]. The data of project time and cost were analyzed according to project characteristics including type of clients, type of projects and tendering methods. To do this analysis, the collected data sets were first divided into three different categories: (1) type of clients that includes public and private sector, (2) type of project that involves residential, commercial, and other building projects, (3) tendering methods that involve open, selective and other tender methods. The BTC relationships for type of clients, type of projects and tender methods are shown in Table III. This analysis has been conducted by using the linear regression tool in SPSS V.18. 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.

TABLE III
BROMILOW'S TIME-COST RELATIONSHIPS

Category	Characteristics	BTC models	R^2
All cases	-	$T = 156C^{0.360}$	0.646
Type of client	Public	$T = 134C^{0.352}$	0.674
	Private	$T = 166C^{0.372}$	0.688
Type of project	Residential	$T = 137C^{0.418}$	0.592
	Commercial	$T = 111C^{0.430}$	0.746
	Other	$T = 172C^{0.301}$	0.771
Tender method	Open	$T = 142C^{0.351}$	0.659
	Selective	$T = 165C^{0.359}$	0.598
	Other	$T = 158C^{0.413}$	0.829

The result shows that one million (Bangladesh Taka's) building projects (T = K, when C = 1) required 156 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, 134 working days are the required time to complete a public sector project while 166 working days are for a private sector project. As mentioned early in the literature review, Bangladesh is a newly developing country; thus,

TABLE IV
SUMMARY OF BROMILOW'S LINEAR REGRESSION RESULTS

Category	Characteristics	Ln(K)	B	R	R^2	Adj. R^2	Standard Error	Sig. Level
All cases	-	5.050	0.360	0.804	0.646	0.640	0.388	0.000
Type of client	Public	4.896	0.352	0.821	0.674	0.658	0.377	0.000
	Private	5.113	0.372	0.829	0.688	0.680	0.360	0.000
Type of project	Residential	4.917	0.418	0.773	0.592	0.585	0.403	0.000
	Commercial	4.711	0.430	0.864	0.746	0.725	0.362	0.000
	Other	5.150	0.301	0.878	0.771	0.752	0.334	0.000
Tender method	Open	4.956	0.351	0.812	0.659	0.646	0.400	0.000
	Selective	5.109	0.359	0.773	0.598	0.575	0.384	0.000
	Other	5.063	0.413	0.910	0.829	0.814	0.300	0.000

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. Different with other countries, time for performing a public project is often shorter than that of a private project. Especially, it is very difficult to change the contract terms in governmental projects if there is any bad situation occurred. Thus, contractors must try to complete projects within approved time or as early as possible. For type of project, residential projects require about 137 days to be completed longer than 111 days required for commercial projects. Kaka and Price [18] reported that private clients in field of commercial building would have to complete as early as possible their projects because of starting business and quickly getting returns on investment. Other types of building projects such as educational, sports, and industrial projects need 172 days to be completed. Regarding tendering methods, the selective tendering method takes about 165 days longer than that of open tendering (142 days) and other types (158 days), e.g., negotiation method. This finding is similar to the previous studies such as [18, 14].

The results of the SPSS's output for each possible case are summarized in Table IV. The regression coefficients Ln(K) and B are significant at ($p = 0.000$). The data sets were analyzed for each possible case of project. The results show that models developed in all categories are also statistically significant at $p = 0.000$ as well. R^2 values ranged from 0.592 to 0.829 have been considered as criteria for the goodness of fit of the models derived from the empirical data. The above analyses indicated also that the original BTC model could be applied in building construction projects in Bangladesh too.

C. Comparison with Other Regression Models

TABLE V
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	$T = b_0 . e^{b_1 C}$

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 analyze the data. Le-Hoai and Lee [22] 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 V. The R^2 values of these models have been calculated and presented in Table VI.

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 CUB regression model generated the highest R^2 value (0.674) with all cases of building construction project. Regarding type of clients, the CUB regression model for public and private projects also yielded the highest R^2 value of 0.848 and 0.694 respectively. Regarding type of projects, the CUB regression model is the most suitable model with R^2 values of 0.634 and 0.894 for residential project and other building projects (such as educational projects, sport projects and industrial projects), respectively. Only R^2 value of CUB regression model (0.747) for commercial building is ranked as the second after EXP regression model (0.749). Regarding the tender method, CUB regression model also produced the highest R^2 value of 0.739, 0.864 and 0.877 for open method, selective method and other tender method, respectively.

D. Validation of BTC Model

The validation of BTC model is checked by the *t*-test to see the significant differences between the actual values and predicted values at 5% significance level. Table VII 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 VII contains the results of MAPE calculation for each category. Most of MAPE values are approximately 5%. These results show that the equations in Table III are likely to predict the project duration in terms of project cost.

TABLE VI
R^2 VALUES OF REGRESSION MODELS

Model	All cases	Sector		Project type			Tender method		
		Public	Private	Residential	Commercial	Other	Open	Selective	Other
LIN	0.646	0.674	0.688	0.592	0.746	0.771	0.659	0.598	0.829
LOG	0.557	0.545	0.616	0.477	0.662	0.635	0.538	0.655	0.734
QUA	0.648	0.674	0.693	0.597	0.746	0.775	0.665	0.654	0.832
CUB	0.674	0.848	0.694	0.634	0.747	0.894	0.739	0.864	0.877
EXP	0.628	0.657	0.669	0.575	0.749	0.761	0.638	0.578	0.815

TABLE VII
TIME-COST MODEL VALIDATION

Category	Characteristics	Mean duration with 95% confidence		T-test	MAPE (%)
		Actual	Predicted		
All cases	-	614.77 ± 92.34	614.02 ± 75.19	Not significant	5.16
Type of client	Public	525.43 ± 128.00	524.54 ± 107.32	Not significant	4.70
	Private	672.86 ± 124.03	673.85 ± 104.84	Not significant	4.73
Type of project	Residential	588.74 ± 113.93	588.84 ± 90.15	Not significant	5.29
	Commercial	728.52 ± 239.35	727.57 ± 211.68	Not significant	4.14
	Other	578.06 ± 185.65	577.92 ± 166.63	Not significant	4.52
Tender method	Open	549.86 ± 123.45	550.77 ± 102.81	Not significant	5.00
	Selective	673.00 ± 162.13	674.18 ± 129.55	Not significant	5.10
	Other	680.71 ± 222.51	681.15 ± 206.16	Not significant	3.53

V. 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 VIII. It shows that most studies have been conducted to investigate these parameters in building construction project such as Bromilow [4], Chan [8], Hoffman et al. [13], Ireland [17], Le-Hoai and Lee [22], Ogunsemi and Jagboro [25], and Yeong [32]. A few of studies have also been performed for civil engineering projects such as Daina and Mladen [13]. All studies have used 1 million of their own country's currency as a unit cost of construction except Le-Hoai et al. [21], and Le-Hoai and Lee [22]. 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 VIII). 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 0.646.

VI. CONCLUSIONS

This study has developed the BTC model for building 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 building projects. The performance of BTC models differed according to project characteristics. Among them, the time-cost linear regression model for other tender methods (such as negotiation) is the best model for prediction with R^2 of 82.9% and MAPE of 3.53. 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 exponential regression model has generated the maximum values of R^2 in terms of type of commercial 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 spite of having some certain limitations, the study can provide some useful findings for the researchers and practitioners in Bangladesh construction industry.

One of the limitations is the small sample size. That is only 63 data sets which were collected from building construction projects. Due to this limitation, the predictability of time-cost model in this study might have been influenced. It is obvious that the formats of regression model may differ according to other types of projects such as bridge and road projects, harbor project, industrial project, etc. It is recommended that prospective studies should focus on these projects to gain the general view about time-cost relationship in Bangladesh construction industry.

TABLE VIII
COMPARATIVE ANALYSIS BETWEEN SOME SELECTED COUNTRIES

Study	Year	Location	BTC model			Condition of performance
			K	B	R^2	
Bromilow [4]	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
Choudhury et al. [12]	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
Chan [8]	1991	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
Chan [9]	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
Daina and Mladen [13]	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
Hoffman et al. [16]	2007	USA	27	0.202	0.337	• Sample size: 332 building projects, type of client: no mention, unit cost: 1 million USD
Ireland [17]	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
Le-Hoai et al. [21]	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
Le-Hoai and Lee [22]	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. [24]	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]	2006	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]	1994	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]	1994	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 et al. (this study)	2013	Bangladesh	156	0.360	0.646	• Sample size: 63 building projects, type of client: public and private sector, unit cost 1 million (Bangladesh Taka), 1 BD Taka = 0.0144 USD (at base year 2010)

Note: The currency exchange rate is an approximate value for comparison

ACKNOWLEDGEMENTS

The authors are very grateful to the respondents of various building projects in Bangladesh for their help with the questionnaire. This paper was supported by a Research Grant of Pukyong National University (2013 year).

REFERENCES

[1] N.K. Acharya, Y.D. Lee, H.M. Im, “Investigating delay factors in construction industry: a Korean perspective”, *Korean Journal of Construction Engineering and Management,* Vol. 10, pp. 177-190, 2006.

[2] C. Ameyaw, S. Mensah, Y.D. Arthur, “Applicability of Bromilow’s Time-Cost Model on Building Projects in Ghana”, *Proceedings of 4th West Africa Built Environment Research (WABER) Conference,* Abuja, Nigeria, pp. 881-888, 24-26 July, 2012.

[3] F.J. Bromilow, “Contract time performance expectation and the reality”, *Building Forum,* Vol. 1, No. 3, pp. 70-80, 1969.

[4] F.J. Bromilow, “Measurement and scheduling of construction time and cost performance in the construction industry”, *The Chartered Builder,* Vol. 10, June-July, 1974.

[5] F.J. Bromilow, J.A. Henderson, “Procedures for reckoning and valuing the performance of building contracts”, *The Chartered Builder,* Vol. 10, No. 9, p. 57, 1976.

[6] F.J. Bromilow, M.F. Hinds, N.F. Moody, “AIQS survey of building contract time performance”, *Building Economist,* Vol. 19, No. 2, pp. 79-82, 1980.

[7] F.J. Bromilow, M.F. Hinds, N.F. Moody, “The Time and Cost Performance of Building Contracts 1976-1986”, *The Australian Institute of Quantity Surveyors,* Sydney, 1988.

[8] A.P. Chan, “Modeling building durations in Hong Kong”, Construction Management and Economics”, Vol. 17, pp. 189-196, 1999.

[9] A.P.C. Chan, “Time-cost relationship of public sector projects in Malaysia”, *International Journal of Project Management,* Vol. 19, pp. 223-229, 2001.

[10] D.W.M. Chan, M.M. Kumaraswamy, “A study of the factors affecting construction durations in Hong Kong”, *Construction Management and Economics*, Vol. 17, pp. 189-196, 1995.

[11] W.T. Chen, Y.H. Huang, "Approximately predicting the cost and duration of school reconstruction projects in Taiwan", *Construction Management and Economics*, Vol. 24, No. 12, pp. 1231-1239, 2006.

[12] I. Choudhury, M. Khan, A. Matin, "Relationship between Construction Time and Project Cost of Health Sector Construction Works in Bangladesh", *ASC Proceedings of the 38th Annual Conference*, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, pp. 337-342, 11-13 April, 2002.

[13] C.P. Diana, R. Mladen, "Construction time-cost model in Croatia", *Engineering Modeling 1-4*, pp. 63-70, 2009.

[14] I.R. Endut, A. Akintoye, J. Kelly, "Relationship between duration and cost of Malaysian construction projects", *Proceedings of the International Conference in the Built Environment in the 21st Century*, Kuala Lumpur, pp. 299-309, June, 2006.

[15] J. Fortune, D. White, "Framing of project critical success factors by a system model", *International Journal of Project Management*, Vol. 24, pp. 53-65, 2006.

[16] G.J. Hoffman, A.E. Thal, T.S. Webb, J.D. Weir, "Estimating performance time for construction projects", *Journal of Management in Engineering (ASCE)*, Vol. 23, No. 4, pp. 193-199, 2007.

[17] V. Ireland, "The role of managerial actions in cost, time, and quality performance of high rise commercial building projects", *PhD thesis*, Univ. of Sydney, Sydney, Australia, 1983.

[18] A.P. Kaka, A.D.F. Price, "Relationship between value and duration of construction projects", *Construction Management and Economics*, Vol. 9, No. 4, pp. 383-400, 1991.

[19] R. Kenley, R. "The predictive ability of Bromilow's time-cost model: a comment", *Construction Management and Economics*, Vol. 19, No. 8, pp. 759-764, 2001.

[20] M.M. Kumaraswamy, D.W.M. Chan, "Determinants of construction duration", *Construction Management & Economics*, Vol. 13, No. 3, p. 209-217, 1995.

[21] L. Le-Hoai, Y.D. Lee, J.W. Cho, "Construction of time-cost model for building projects in Vietnam", *Korean Journal of Construction Engineering and Management (KICEM)*, Vol. 10, No. 3, pp. 130-138, 2009.

[22] L. Le-Hoai, Y.D. Lee, "Time-cost model of building construction projects in Korea", *Korean Journal of Construction Engineering and Management (KICEM)*, Emerald Group Publishing Limited, Vol. 27, No. 13/14, pp. 549-559, 2009.

[23] P.E.D. Love, R.Y.C Tse, D.J. Edwards, "Time-cost relationships in Australian building construction projects", *Journal of Construction Engineering and Management (ASCE)*, Vol. 131, No. 2, pp. 187-194, 2005.

[24] S.T. Ng, M.M.Y. Mak, R.M. Skitmore, K.C. Lam, M. Varnam, "The predictive ability of Bromilow's time-cost model", *Construction Management and Economics*, Vol. 19, No. 2, pp. 165-173, 2001.

[25] D.R. Ogunsemi, G.O. Jagboro, "Time-cost for building projects in Nigeria", *Construction Management and Economics*, Vol. 24, No. 3, pp. 253-258, 2006.

[26] D. Onur, S. Christian, "Determinants of construction duration for building projects in Germany", *Engineering, Construction and Architectural Management*, Vol. 19, No. 4, pp. 444-468, 2012.

[27] MD. R.R Shaon, "Investigation of construction delay of real estate companies in Dhaka city", *Bachelor of Science thesis*, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh, 2012.

[28] A.C. Sidwell, "The time performance of construction projects", *Architectural Science Review*, Vol. 27, pp. 85-91, 1984.

[29] M. Skitmore, T. Ng, "Australian project-time analysis: Statistical analysis of intertemporal trends", *Civ. Eng. Pract.*, 19(5), 455–458, 2001.

[30] D.H.T. Walker, "Construction time performance-Melbourne research findings", in *Proceedings of ARCOM Conference 1994*, Loughborough, UK, pp. 275- 284, September, 1994.

[31] D.H.T Walker, "An investigation into construction time performance", *Construction Management and Economics*, Vol. 13, No. 3, pp. 263-274, 1995.

[32] C.M. Yeong, "Time and cost performance of building contracts in Australia and Malaysia", *MSc thesis*, Univ. of South Australia, Adelaide, Australia, 1994.

[33] http://en.wikipedia.org/wiki/List_of_countries_by_GDP_(nominal) Financial report by International Monetary Fund, 2013.