The 6th International Conference on Construction Engineering and Project Management (ICCEPM 2015)
Oct. 11 (Sun) ~ 14 (Wed) 2015 • Paradise Hotel Busan • Busan, Korea
www.iccepm2015.org

Design-Build Change Order Impacts in Highway Projects

Kyeong Rok Ryu[1], Kunhee Choi[2], Boong Yeol Ryoo[3], and Julian H. Kang[4]

Abstract: Design-Build (DB) has gained in popularity in roadway projects due to its defining advantage to improve communication and fast-track project delivery. However, very little is known about the impact of change order frequency and occurrence timing pertaining to DB projects. The study analyzes their impacts on project time and cost performance by conducting a rigorous numerical analysis drawing on 530 3R (rehabilitation, reconstruction, and resurfacing) projects completed between 2002 and 2011 in Florida by using a multiple linear regression. The results indicate that DB outperformed Design-Bid-Build in project cost as well as time. Critically, the regression analysis signifies that earlier change order occurrence caused more unfavorable impacts on schedule and cost. The proposed analyses and models will lead to the improved ability of agencies to quickly and more reliably estimate the potential change order impacts on schedule and cost.

Keywords: Design-Build, Change Order, Frequency, Occurrence Timing, Infrastructure

I. EMERGING ISSUES IN HIGHWAY PROJECTS

Most highways in the United States, built between 1950s and 1980s with 20 year life span, have been significantly aged and deteriorated by the drastic increase of traffic demands and overdue design lives (*1-3*). Consequently, the State Transportation Agencies (STAs) have faced the growing needs for simultaneously fulfilling faster project delivery and less traffic disruption (*2; 4*).

In response to this concern, the STAs have turned their eyes from the traditional delivery method to alternative delivery approaches that are known to improve the efficiency of project time and cost (*5; 6*). Historically, Design-Bid-Build (DBB) has been the most accepted conventional approach for public capital projects over five decades in the U.S., and the FHWA regulation did not allow the use of Design-Build (DB) in federally funded projects until a legislative change in 1996 (*6-8*). However, as a traditional DBB method showed the limitations in addressing the aforementioned challenges, new alternative approaches such as DB have become an important project delivery method in the highway industry.

Theoretically, a DB delivery method is believed to improve communication among team members and stakeholders as projects are operated and managed by a single entity, hence allowing to achieve better quality (*9*). In addition to it, DB can demonstrate the power of fast-track construction by overlapping design and construction phases (*10*). However, since changes are inevitable in construction projects, there also has been the high probability of schedule delays and budget overruns in DB projects (*5; 11; 12*).

Although the growing use of DB has led a considerable amount of research on the effectiveness of a DB delivery method throughout the entire Architecture, Engineering, and Construction (AEC) industry (*13*), relatively few studies have focused on the highway sector. More significantly, very little is known about the changer order impacts on project time and cost performance on aspects of change order frequency and occurrence timing under project delivery methods in roadway projects. This research aims to tackle such gaps in knowledge from a quantitative perspective using a large quantity of real-world transportation project data, thus providing numeric measurements of change order impacts to future projects.

II. PREVIOUS STUDIES ON DESIGN-BUILD AND CHANGE ORDER

A. Design-Build Effectiveness in Roadway Projects

Overall past studies on the effectiveness of a DB delivery method in roadway projects conform to the findings of other studies through the AEC industry: a DB approach outperformed a traditional DBB method on aspects of project schedule and cost (*5; 9; 14; 15*). However, there are also several studies that suggested different results.

The findings by Ellis et al.(*16*) indicated that DB led 2 percent less cost overruns than DBB in several highway projects completed in Florida (*5*). The FHWA in 2006 reported that DB reduced the overall duration by 14 percent and the total cost by 3 percent on average while maintaining the same level of quality as compared to DBB (*6*). The research conducted by Shrestha et al. in 2007 analyzed 15 roadway projects and found that DB decreased 6 percent in project cost whist DBB resulted in cost overrun of 4 percent (*17*). Conversely, the later research by Shrestha et al. in 2011 presented conflicting results by comparing large DB and

---

[1] Ph.D. Student (Corresponding Author), Department of Construction Science, Texas A&M University, 3137 TAMU, 328 Francis Hall, College Station, TX 77843-3137, Phone 617/921-2269, krkukk@email.tamu.edu

[2] Assistant Professor, Department of Construction Science, Texas A&M University, 3137 TAMU, 305 Francis Hall, College Station, TX 77843-3137, Phone 979/458-4458, kchoi@tamu.edu

[3] Associate Professor, Department of Construction Science, Texas A&M University, 3137 TAMU, 306 Francis Hall, College Station, TX 77843-3137, Phone 979/845-4343, bryoo@tamu.edu

[4] Associate Professor, Department of Construction Science, Texas A&M University, 3137 TAMU, 304 Francis Hall, College Station, TX 77843-3137, Phone 979/845-7055, juliankang@tamu.edu

DBB projects in which DB had 8 percent cost growth and 21 percent schedule delays but DBB showed less impacts of 6 percent in cost and 5 percent in time (*12*). However, their findings were not statistically significant. In recent years, Minchin et al. studied 51 highway and bridge projects completed between 2002 and 2011 in Florida and found similar results on aspects of cost overrun, 40 percent in DB and 20 percent in DBB (*11*). Yet, schedule delays in DB and DBB indicated 20 percent and 23 percent, respectively.

B. Change Order Frequency

Several studies on change order frequency have focused mainly on the investigation of factors influencing change order frequency. Rowland examined the causes, causality, and effects of change orders by studying projects in Georgia and indicated that the project complexity increased change orders and consequent cost and time overruns (*18*). Hester et al. studied the forms of dispute including the frequency and magnitude of change orders in insulation works in Texas (*19*). In 2004, Bordat et al. focused on the bidding-related factors affecting change order frequency in Indiana high construction projects (*20*). Recently, Anastasopoulos et al. analyzed the influence of project type, contract type, project duration, and size on change order frequency by applying a count-data model with five contract data of Indiana roadway projects (*13*). Their findings showed that projects with larger amount and longer duration experienced fewer change orders.

C. Change Order Timing

Relatively few studies have investigated the impacts of change order occurrence timing and most of them have focused on labor productivity. The overall results indicated that later changes had more undesirable impacts on productivity of labor.

The first attempt to quantify such impacts was conducted by Allen and Ibbs in 1995 (*21*). In their study, 104 projects from 35 different companies were analyzed to test whether later changes were implemented less efficiently than earlier ones. Yet, they were not able to statistically prove the hypothesis. The subsequent study by Hanna et al. used 61 projects from 13 mechanical contractors and included a weighted timing factor for change order occurrence timing into a formula (*22*). Although they concluded that later change orders had more negative impacts on labor productivity, the study could not quantify the effect of change order occurrence timing. Chick suggested the similar but significant findings that later changes tend to have more impact due to the limited time, large amount of material, and construction and crew interruption (*23*).

Moselhi et al. introduced a new neural network model to quantify the timing impact of change order on construction productivity based on the analysis of 33 work packages in Canada and the USA (*24*). The model represented the buildup and rundown of labor hours along the project period. Another study conducted by Ibbs examined the timing impact of change orders on labor productivity by categorizing projects into threefold: early (25% of the projects that change order was considered fastest), normal (middle 50%), and late (slowest 25%) (*25*). The regression analysis indicated that earlier changes caused a small amount of change. Contrary to the previous studies that mostly studied commercial and electromechanical work, Serag et al. tackled highway projects (*26*). They used 11 variables collected from 16 Florida heavy construction projects and concluded that late occurrence of change orders significantly increased the project costs.

III. RESEARCH OBJECTIVES AND METHODS

A review of the literature indicated that there is a lack of knowledge about the change order impacts on project performance in highway construction projects under a DB delivery method. Therefore, the main objectives of this study are to quantify the impact of change orders in DB infrastructure projects on project schedule and cost by testing and validating the following research hypotheses:

1) DB projects experienced less time and cost overruns
2) More frequent occurrence of change orders caused more negative impacts on project performance
3) Change Orders in the later stage had more unfavourable impacts on project performance

The study objectives are achieved by conducting a rigorous numerical analysis drawing on 530 3R (i.e., rehabilitation, reconstruction, and resurfacing) projects completed between 2002 and 2011 in Florida. The research methods also include the following four steps:

1) The collected 3,007 roadway construction data were stratified by project types and project delivery methods
2) 530 3R projects under project delivery methods of DB and DBB were then extracted for the unbiased analysis results
3) To develop models that quantify the impacts of change order frequency and occurrence timing on project performance under the two project delivery methods, a multiple linear regression analysis with categorical variables was conducted
4) The robustness of the proposed models was tested and confirmed by employing the Predicted Error Sum of Square (PRESS)

For the analyses, the research assumed that all projects are statistically independent as they were implemented independently in different places and times. It was also assumed that schedule and cost change resulting from change orders are not in synchrony. Therefore, the analyses on project time and cost were individually conducted. Finally, the study also assumed that all contractors had the identical ability to deliver the project, in order to concentrate on exploring the pure impact of change orders on project performance.

However, there are also several limitations in this study. Firstly, in an effort to conduct unbiased analyses, the study only focused on 3R projects which were major parts of overall projects. Consequently, the results of the study might have limits to be applied to other project types such as new construction and bridge works. In addition, the test variables were log-log transformed to satisfy test assumptions. As a result, a part of initial dataset that feature project time and cost savings were excluded. Finally, since the number of change orders in each project varied zero to tens, there are the one-to-multi relationship when using all change order occurrence timing data. In an attempt to avoid this issue, the study only used a single occurrence timing which is associated with the maximum cost change as the parameter for change order occurrence timing.

IV. DEFINITION OF TERMS

The study used the following measures to implement the research objective.

- Change order frequency (CO frequency) = Number of specification agreements
- Change order occurrence timing ratio (CO timing) = Time point length that maximum cost amount occurred due to a change order / Total project duration
- Schedule growth ratio (SGR) = (Final completion date – Original contract date) / Original contract date
- Cost growth ratio (CGR) = (Final project cost – Original contract cost) / Original contract cost

CO frequency is measured by the number of specification agreements in each project. When a change order occurs, the owner and the contractor make a specification agreement accommodating additional work which is not included in the original contract. Therefore, such numbers stand for how frequently a project experienced change orders. CO timing is the ratio that indicates the time point when the most critical change order amount arose during the projects. Low Co timing implies that the most costly change order arose in the early stage of the project. SGR and CGR are used for measuring project time and cost overruns, respectively. If the ratio equals zero, the project was completed as estimated. Any positive value in either SGR or CGR implies schedule delays or cost overruns in the project.

V. DATA COLLECTION

In this study, a large quantity of real-world transportation data was used. The Florida Department of Transportation (FDOT) provided the principal source of data which contains 3,007 highway construction projects completed between 2002 and 2011 in Florida. The data include abundant information such as work types, delivery and contracting methods, schedule, cost, and change orders. In an attempt to conduct unbiased analyses, the study classified the primary data by project types and delivery methods.

Various project types were identified through the classification procedure, such as 3R, new construction, bridge works, and so on. For decades, the paradigm of transportation infrastructure construction has shifted from new construction to rehabilitation (*1-3*). The primary dataset also reflect such a paradigm shift in transportation infrastructure projects, which 3R projects comprise 42 percent in number and 50 percent in expenditure. In response to this trend change in highway projects, the research concentrated on 3R projects. All 3R projects were then stratified by their delivery methods and projects without delivery methods were excluded. The final dataset, in turn, compromised 530 3R projects under DB and DBB.

VI. CHANGE ORDER IMPACT ON PROJECT PERFORMANCE

In an effort to develop prediction models that quantify the impacts of change order frequency and occurrence timing on project performance in transportation projects under project delivery methods, a multiple linear regression analysis was conducted. All numerical variables were log-log transformed to satisfy heteroscedasticity for the regression analyses. It is also essential to check a multi-collinearity issue among the independent variables. All values of the variance inflation factor (VIF) ranging from 1.0046 to 1.0492 suggested that there was no multi-collinearity problem in the proposed model as shown in table 1 and 2. Both schedule and cost performance prediction models indicated that all three independent variables were significant at the 95% confidence level. Significant F-ratios ($p<.001$) and reasonable R-squared values of 0.2250 and 0.2366 presented that the two proposed models were adequate.

Table 1. Change Order Impacts on Schedule Performance by Project Delivery Methods

$Log\ (SGR) = \beta_0 + \beta_1 \cdot Log\ (CO\ Frequency) + \beta_2 \cdot Log\ (CO\ Timing) + \beta_3 \cdot I$ (*where DBB: I = -1, DB: I = 1*)

Parameter	Estimate	Std Error	*t-Ratio*	*p-value*	VIF
Intercept	-1.9699	0.1897	-10.39	<.0001	
Log (CO Frequency)	0.3261	0.0823	3.96	0.0001	1.0492
Log (CO Timing)	-0.7414	0.2587	-2.87	0.0050	1.0415
Project Delivery Method					
DB	-0.3312	0.1599	-2.07	0.0406	1.0126
DBB[a]	0.3312	0.1599	2.07	0.0406	
R^2	0.2250				
N	117				
F-ratio (p-value)	10.9338 (<.0001)				

[a] Reference variable in the effect coding

Table 2. Change Order Impacts on Cost Performance by Project Delivery Methods

$Log\ (CGR) = \beta_0 + \beta_1 \cdot Log\ (CO\ Frequency) + \beta_2 \cdot Log\ (CO\ Timing) + \beta_3 \cdot I$ (*where DBB: I = -1, DB: I = 1*)

Parameter	Estimate	Std Error	*t-Ratio*	*p-value*	VIF
Intercept	-3.4203	0.1390	-24.61	<.0001	.
Log (CO Frequency)	0.1429	0.0573	2.50	0.0142	1.0056
Log (CO Timing)	-0.3947	0.1553	-2.54	0.0126	1.0081
Project Delivery Method					
DB	-0.4532	0.1080	-4.20	<.0001	1.0046
DBB[a]	0.4532	0.1080	4.20	<.0001	1.0046
R^2	0.2366				
N	107				
F-ratio (p-value)	10.6414 (<.0001)				

[a] Reference variable in the effect coding

In a look at the aspects of the three independent variables in the models, they showed similar correlations toward both dependent variables, schedule growth ratio (SGR) and cost growth ratio (CGR). The degree of change order frequency had the adverse impact on cost as well schedule performance of projects. This implies that more frequent change orders result in more unfavorable effects on project performance as commonly perceived. As regards the effectiveness of DB, the focal point of this study, the proposed models suggest that DB projects were less affected by change orders in project schedule and cost. In other words, a DB approach were more effective in hindering the undesirable effects of change orders. This confirms the findings of the past studies that DB is a preferable alternative delivery method which can fulfil the shortcomings of the tradition delivery approach.

Regarding the effect of change order occurrence timing, the proposed models showed the correlations opposite to the previous studies. Later occurrence of change orders pertinent to the maximum cost change had less impacts on project schedule and cost. In construction projects, uncertainties and the scope of projects decrease in the late stage of projects. Therefore, it would be plausible that such diminished uncertainties and project scope in the late construction phase can confine the degree of adverse change order impacts. For instance, if a specification modification arises in the early stage of a roadway project, it may cause larger impacts through entire remained processes than a change in the late stage. In other words, ripple effects of change orders are inversely proportional to the degree of project completion.

The prediction models can be graphically depicted as shown in Fig. 1. When fixing the value of change order timing to of 0.58 which is the mean value of total 3R projects, project performance showed the logarithmic trend along to the increase of change order frequency. Contrary to this, change order timing had the impact of exponential decay on project performance when fixing the value of change order frequency to the mean value 2.2. Both examples visually showed project schedule was more subjective to change order frequency and occurrence timing than project cost.

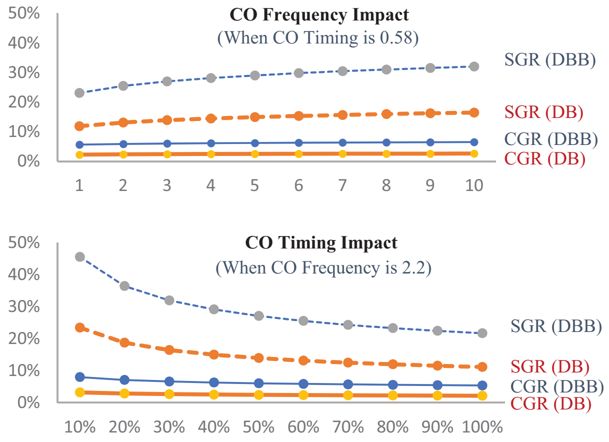

Fig. 1. Project Performance Change by CO Frequency and CO Timing

VII. MODEL VALIDATION

For a quantitative model, it is very crucial to validate the accuracy and reliability of the model. The Predicted Error Sum of Square (PRESS) was applied to validate the robustness of the proposed models. The PRESS is one of the widely used and preferred validation methods when there is difficulty to test the model with new data or holdout sample from the original data (27; 28). The PRESS statistic of a regression model is computed by summing the squared residuals between the predicted values of the original model and the predicted values of each subset model for each observation.

When the computed PRESS is close to the Sum of Squared Error (SSE), which is the sum of the squared differences between each observation and the model's mean, it suggests significant predictability and accuracy of the proposed model. The estimated value of PRESS and SSE statistic in the proposed models were 47.3109 and 44.0671 for the schedule performance model, and 28.8402 and 27.1071 for the cost performance model, respectively. As the proposed models present close values between PRESS and SSE, it ensures the robustness of the models in predicting the change order impacts on project performance under project delivery methods.

VIII. DISCUSSIONS AND CONCLUSIONS

A DB delivery method has gained more popularity in the highway industry to overcome the limitations of the traditional DBB approach in fast-track construction. Despite the growing use of DB, very little is known about the impacts of change order frequency and occurrence timing on project schedule and cost performance in DB infrastructure rehabilitation projects. This study aimed to tackle such gaps in knowledge by analyzing 530 3R projects completed between 2002 and 2011 in Florida. A multiple linear regression analysis with categorical variables of DB and DBB was used to quantitatively model the impacts of change order frequency and occurrence timing on project schedule and cost.

The predictive models developed in the study provided statistically significant implications on the impacts of change order frequency and occurrence timing on project schedule and cost performance in a DB project delivery setting. The results affirmed the findings of most previous research that DB outperforms DBB in project time and cost. Overall, project schedule was more prone to change orders than project cost. Specifically, the models presented that the use of DB is beneficial in reducing the adverse impacts of change orders. The magnitude of change order frequency showed the logarithmic impact on schedule and cost growth of projects. However, change order occurrence timing indicated the conflicting results to the previous studies as it showed the impact of exponential decay on project performance. The models in this study suggested that earlier occurrence of change orders had more unfavorable impacts on project time and cost. The possible explanation would be that change orders in the later stage of a project have less ripple effects on project performance, as uncertainties and scope of a project fall off in proportion of the project progress. Based on these results, the research recommends that practitioners in the highway construction industry actively consider front-end planning which can minimize change order occurrence and its unfavorable impacts in the early stage of a project (*29; 30*).

Although a DB method is beneficial for not only fast-tracking construction but also mitigating schedule and cost overruns, it is still relatively new in transportation infrastructure construction as compared to the entire AEC industry. The findings and ideas of this study can assist STAs to make better-informed decisions and consequently help them better respond to changes on project schedule and cost when change orders arise in a DB delivery setting. Critically, the proposed analyses and models will lead to the improved ability of agency engineers to quickly and more reliably estimate the potential schedule and cost impacts of change orders by having advanced knowledge about their consequences which are analyzed through the proposed models. Finally, future research is suggested for extending the research scope to other project types such as new construction, bridge works, and others, and statewide regions and including other internal or external factors which affect project performance.

REFERENCES

[1] Choi, K., and Y. H. Kwak. Decision support model for incentives/disincentives time–cost tradeoff. *Automation in Construction,* Vol. 21, 2012, pp. 219-228.

[2] Lee, E.-B., K. Choi, and S. Lim. Streamlined strategies for faster, less traffic-disruptive highway rehabilitation in urban networks. *Transportation Research Record: Journal of the Transportation Research Board,* Vol. 2081, No. 1, 2008, pp. 38-45.

[3] Napolitan, F., and P. C. Zegras. Shifting Urban Priorities?: Removal of Inner City Freeways in the United States. *Transportation Research Record: Journal of the Transportation Research Board,* Vol. 2046, No. 1, 2008, pp. 68-75.

[4] Choi, K., Y. H. Kwak, J.-H. Pyeon, and K. Son. Schedule effectiveness of alternative contracting strategies for transportation infrastructure improvement projects. *Journal of construction engineering and management,* Vol. 138, No. 3, 2011, pp. 323-330.

[5] Ellis, R. D., J.-H. Pyeon, Z. J. Herbsman, E. Minchin, and K. Molenaar. Evaluation of alternative contracting techniques on FDOT construction projects. 2007.

[6] FHWA. *Design-Build Effectiveness Study*, Washington, DC. http://www.fhwa.dot.gov/reports/designbuild/designbuild0.htm.

[7] Ibbs, C. W., Y. H. Kwak, T. Ng, and A. M. Odabasi. Project delivery systems and project change: Quantitative analysis. *Journal of construction engineering and management,* Vol. 129, No. 4, 2003, pp. 382-387.

[8] Tran, D. Q., and K. R. Molenaar. Impact of Risk on Design-Build Selection for Highway Design and Construction Projects. *Journal of Management in Engineering,* Vol. 30, No. 2, 2013, pp. 153-162.

[9] Hale, D. R., P. P. Shrestha, G. E. Gibson Jr, and G. C. Migliaccio. Empirical comparison of design/build and design/bid/build project delivery methods. *Journal of construction engineering and management,* Vol. 135, No. 7, 2009, pp. 579-587.

[10] Gould, F. E., and N. E. Joyce. *Construction project management*. Prentice Hall, 2009.

[11] Minchin, R. E., X. Li, R. R. Issa, and G. G. Vargas. Comparison of cost and time performance of design-build and design-bid-build delivery systems in Florida. *Journal of construction engineering and management,* Vol. 139, No. 10, 2013.

[12] Shrestha, P. P., J. T. O'Connor, and G. E. Gibson Jr. Performance comparison of large design-build and design-bid-build highway projects. *Journal of construction engineering and management,* Vol. 138, No. 1, 2011, pp. 1-13.

[13] Anastasopoulos, P. C., S. Labi, A. Bhargava, C. Bordat, and F. L. Mannering. Frequency of change orders in highway construction using alternate count-data modeling methods. *Journal of construction engineering and management,* Vol. 136, No. 8, 2010, pp. 886-893.

[14] Molenaar, K. R., and A. D. Songer. Model for public sector design-build project selection. *Journal of construction engineering and management,* Vol. 124, No. 6, 1998, pp. 467-479.

[15] Songer, A. D., K. R. Molenaar, and G. D. Robinson. Selection factors and success criteria for design-build in the US and UK. *Journal of Construction Procurement,* Vol. 2, No. 2, 1996, pp. 69-82.

[16] Ellis, R. D., Z. J. Herbsman, and A. Kumar. *Evaluation of the FDOT design/build program*. Florida Department of Transportation, 1991.

[17] Shrestha, P. P., G. C. Migliaccio, J. T. O'Connor, and G. E. Gibson. Benchmarking of large design-build highway projects: One-to-one comparison and comparison with design-bid-build projects. *Transportation Research Record: Journal of the Transportation Research Board,* Vol. 1994, No. 1, 2007, pp. 17-25.

[18] Rowland Jr, H. J. The causes and effects of change orders on the construction process.In, DTIC Document, 1981.

[19] Hester, W. T., J. A. Kuprenas, and T. Chang. Construction changes and change orders: their magnitude and impact. *Construction Industry Institute, Source Document,* Vol. 66, 1991.

[20] Bordat, C., B. McCullouch, and K. Sinha. An analysis of cost overruns and time delays of INDOT projects. *Joint Transportation Research Program*, 2004, p. 11.

[21] Allen, W., and C. Ibbs. Quantitative Impacts of Project Change. *Construction Industry Institute, Source Document,* Vol. 108, 1995.

[22] Hanna, A. S., J. S. Russell, T. W. Gotzion, and E. V. Nordheim. Impact of change orders on labor efficiency for mechanical construction. *Journal of construction engineering and management,* Vol. 125, No. 3, 1999, pp. 176-184.

[23] Chick, D. The Time Value of Project Change. *Cost Engineering-Morgantown,* Vol. 41, No. 6, 1999, pp. 27-32.

[24] Moselhi, O., I. Assem, and K. El-Rayes. Change orders impact on labor productivity. *Journal of construction engineering and management,* Vol. 131, No. 3, 2005, pp. 354-359.

[25] Ibbs, W. Impact of change's timing on labor productivity. *Journal of construction engineering and management,* Vol. 131, No. 11, 2005, pp. 1219-1223.

[26] Serag, E., A. Oloufa, L. Malone, and E. Radwan. Model for quantifying the impact of change orders on project cost for US roadwork construction. *Journal of construction engineering and management,* Vol. 136, No. 9, 2010, pp. 1015-1027.

[27] Choi, K., M. Haque, H. Lee, Y. Cho, and Y. H. Kwak. Macroeconomic labour productivity and its impact on firm's profitability. *Journal of the Operational Research Society,* Vol. 64, No. 8, 2012, pp. 1258-1268.

[28] Ott, R., and M. Longnecker. *An introduction to statistical methods and data analysis*. Cengage Learning, 2008.

[29] George, R., L. C. Bell, and W. Edward Back. Critical activities in the front-end planning process. *Journal of Management in Engineering,* Vol. 24, No. 2, 2008, pp. 66-74.

[30] Gibson, G. E., Y.-R. Wang, C.-S. Cho, and M. P. Pappas. What is preproject planning, anyway? *Journal of Management in Engineering,* Vol. 22, No. 1, 2006, pp. 35-42.