Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 125 (2015) 40 – 45

Procedia Engineering

www.elsevier.com/locate/procedia

The 5th International Conference of Euro Asia Civil Engineering Forum (EACEF-5)

Analysis of factors affecting design changes in construction project with Partial Least Square (PLS)

A. A. Gde Agung Yana[a,*], Rusdhi H. A.[b], M. Agung Wibowo[c]

[a]*Udayana University, Denpasar, Bali, Indonesia*
[b]*Lambung Mangkurat University, Banjarmasin, South Kalimantan, Indonesia.*
[a,c]*Diponegoro University, Semarang, Central Java, Indonesia*

Abstract

Changes in construction projects are always going to happen and cannot be avoided. Changes causes disruption of performance of construction projects, especially time and cost performance. Many factors can be the cause of changes in construction projects, one of the most influential factor is design change. This study examines the most influential that affect to the design changes in the construction of projects. The influential factors of design changes can be classified into two groups. The internal factors consist of owner, design consultant, construction management consultant, and contractor, while the external factors involve political and economic, the natural environment, advance of technology, and the third-party. The research method employed a questionnaire survey consisting of 31 questions about the occurrence of design changes during the construction of projects, which was distributed to the managers of the construction project. The data was analyzed using Partial Least Square (PLS). The finding shows that the owner is the greatest influential factors on the occurrence of the design changes. The subsequent factors are the design consultant, construction management consultant, political and economic, the natural environment, contractors, third parties, and the advance of technology, which are indicated by the values of the loading factor 0,884, 0,859, 0,846, 0,771, 0,577, 0,523, 0,328, 0,255 respectively. This finding can provide useful information for practitioners to reduce the occurrence of design changes on construction of projects, as well as to improve the performance of the construction projects.

Peer-review under responsibility of organizing committee of The 5th International Conference of Euro Asia Civil Engineering Forum (EACEF-5)

Keywords: design changes: partial least square: performance

* Corresponding author. Tel.:+62811395672.
E-mail address: gungyana87@yahoo.com

1877-7058
Peer-review under responsibility of organizing committee of The 5th International Conference of Euro Asia Civil Engineering Forum (EACEF-5)
doi:10.1016/j.proeng.2015.11.007

1. Introduction

A construction project is particularly prone to a high degree of change for a variety of reasons such as the disruption of monetary, fiscal disorder, lack of time and effective communication, environmental changes and increasing complexity of a project [1,2,3,4,5]. The changes influence its performance, especially the cost and time [1,6,7,8].

The changes of a construction project are caused by many factors in which the most influential factor is the change of design. Burati, Farrington and Ledbetter [9] found that design and construction produced the greatest deviation of construction costs. The deviation was 12.4% of the total cost of a project. They suggested that the deviation caused by design changes was 78% of the total deviation, 79% of the deviation of costs and 9.5% of total construction cost. They also found that two third deviation is caused by a design change.

To reduce design changes during a construction project, identification and evaluation of factors causing design changes during a construction is essential. The factors can be used as references and appropriate strategies to reduce the occurrence of design changes in a construction project.

The aim of this paper is to identify factors causing design changes during a construction and to determine the influence factor level of design changes. Using a questionnaire, which was distributed to respondents involved in a construction project, and Partial Least Square (PLS) method, factors contributing design changes are examined. This method is a technique of Structural Equation Modeling (SEM) that can be applied for any scale data. This method needs few assumptions and small sample size [10].

2. Factors Causing Design Change

There are many researches on the occurrence of changes during a construction period. Based on previous researches, there are 31 factors causing design changes [6,11,12,13,14,15,16,17,18,19,20]. These factors can be divided into two major groups: internal and external. The internal factors are caused by parties directly involved within a construction project such as the owners, design consultants, construction management consultant and contractor. The owner has five factors consisting of the owner instruction to modify a design; the owner failure to make decisions or to review documents at the right time; the changes of funding scheme from the owner; and the information provided by the owner is incomplete or incorrect (the scope of the project is not clear). Design consultant has eight factors which consist of non-availability of engineering licensing for engineers; unrealistic period to design; failure of a consultant to provide adequate and clear information in the tender documents; errors and omission of consultants; changes made as a request of a consultant; consultants who are not familiar with the regulations and construction permits; low consultant fee and poor coordination of design team members with the owner. Construction management consultant provides three factors that are comprised of failure of communication amongst parties involved within a construction project; the lack of precise and rapid decisions and there are not carefully check and correct planning documents. Contractor has four factors which consist of an unrealistic construction's schedule; changes initiated by contractors to improve quality and constructability; and the construction budget is too low.

The external factors are factors or parties that are not directly involved in a construction project but they affect design changes such political and economic matters, the natural environment, the advances of technologies and third parties. Political and economic matters have three factors that consist of changes in policies and regulations; decision maker alteration and the effect of inflation and prices fluctuate. The environment has three factors that consist of weather conditions; natural disaster; geological conditions and unforeseen ground conditions. The advances of technologies have three factors that consist of ineffective use of information technology (IT); new construction methods and new materials. Third parties have two factors that consist of complaints from neighborhood; the changes made as the request of an end user/regulator body [6,11,12,13,14,15,16,17,18,19,20].

These abovementioned factors, identified from previous researches, were used as basic references to develop a questionnaire.

3. Research Method

3.1. Concl Research Method

This research used a questionnaire distributed to project managers of construction projects who were employed by the owner, contractor, construction management consultant and design consultant. Since they were directly involved, they deeply understood the problems of design changes occurred within a construction project. This study used ordinal scale with the range of 1 to 5. The level “1” indicated no strong influence; “2” indicated not affecting; “3” indicated doubtful; “4” indicated influences; and “5” indicated very affecting or strong influence.

Structural equation modeling (SEM) was then used to analyze the factors of design changes. SEM is a method developed from a combination between two statistical methods namely the statistical method of factor analysis that is developed for psychology or sociology and a simultaneous equations model that is developed for econometrics [21]. SEM can also be described as an analytical approach that combines a factor analysis, a structural model and a path analysis [22]. Nowadays, there are three types of SEM namely: covariance-based structural equation modeling (CB-SEM), partial least squares structural equation modeling (PLS-SEM) and generalized structured component analysis (GSCA) [21].

This study used PLS-SEM because: 1) this model can be built on the basis of a theory that is not very strong, 2) the sample size is relative small, 3) the aims of analysis is to develop a theory or prediction models and 4) the indicators can be shaped reflective and formative.

The step of structural equation modeling analysis using partial least square (PLS-SEM) can be seen in Figure 1.

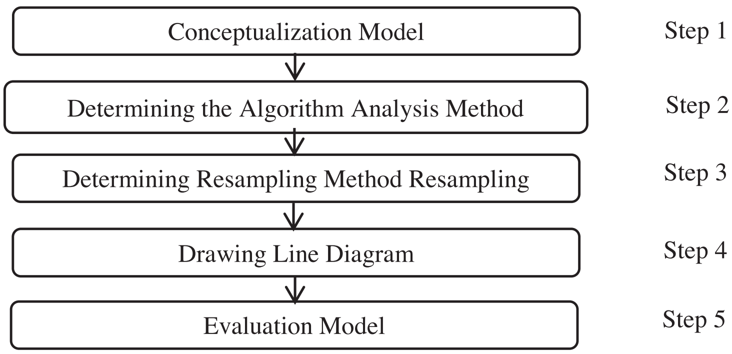

Fig. 1. Stages of Analysis SEM-PLS. [23]

3.2. Survey Response

The questionnaires consisted of 60 questions were distributed to respondents in Sumatra (8.33%), West Java (8.33%), Jakarta (40.00%), Central Java (5.00%), East Java (3.33%), Sulawesi (3.33%), Bali (30.00%), and East Nusa Tenggara (1.67%).

Majority of respondents (66.67%) worked in construction projects over 15 years, 16.67% respondents worked in construction projects between 10-15 years, 15.00% respondents had work experiences between 5-10 years, and only a few respondents (1.67%) had work experiences less than five years. From these data, it can be concluded that the respondents had enough experiences in construction projects. Therefore the data obtained were able to provide holistic picture about the problems and factors influencing design changes in construction projects.

4. Result and Discussion

4.1. Validity and Reliability Tests

Validity and reliability tests were conducted to determine the accuracy and reliability of the questionnaire. Validity test was conducted to examine the significance of the correlation coefficient (Pearson correlation) at significant level (α) of 0.05. The test used two-sided tests with significance level of 0.05. The test criteria were 1) if r count> r table, the instrument was declared valid; and 2) when r count <r table, the instrument was declared not valid. Since all instruments in the validity test had r count significance (α) 5%> r table with 5% significance, the instrument used was valid.

The reliability test in this study, which examined the consistency of the research instrument, used Cronbach's alpha values. Since the Cronbach's alpha value was 0.922, the research instrument was qualify reliability or reliable.

The validity and reliability tests conducted showed that the research instrument was valid and reliable.

4.2. Analysis with SEM-PLS

Using SEM-PLS methods supported by SmartPLS 2.0 M3, a model of the influential factors of design changes in the construction projects was developed. The validity and reliability of the model were then evaluated. The validity was tested by convergent and discriminant validity while the reliability was tested by Cronbach’s alpha and composite reliability. Rule of thumb for convergent validity is 1) loading factor> 0.7 in which for an exploratory research, loading factor 0.6-0.7 is still acceptable, 2) communality> 0.5 and 3) average variance extracted (AVE)> 0.5 [23]. PLS-SEM measurement model for design changes can be seen in Figure 2.

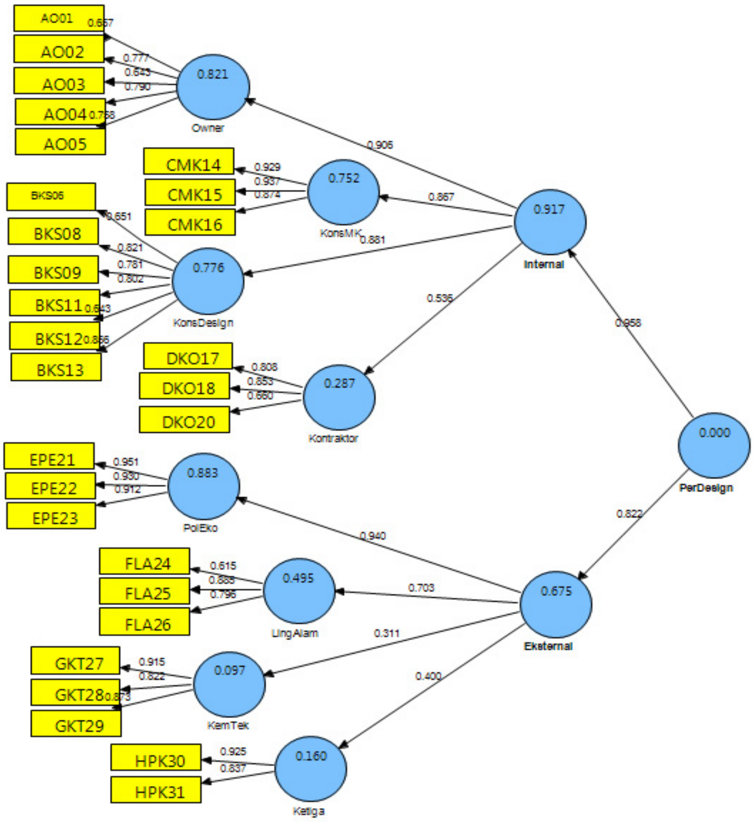

Fig. 2. Measurement Model of Design Change (Source: Results Analysis with SmartPLS 2.0 M3)

The results of calculations that were conducted for all loading factor value showed that all indicators were above 0.6. These results mean that all indicators were valid. After conducting loading factor test, the tests with an average variance extracted (AVE) and communality from latent variables or constructs were conducted. Using SmartPLS 2.0, the tests showed that the average variance extracted (AVE) and the communality of all constructs were above 0.50. Therefore, the model met the requirements of convergent validity. Based on the value of cross loading, the correlation value of constructs with their manifest variable was greater than the correlation of their manifest variables with the other constructs. It can be concluded that indicators used in this study met the criteria of discriminant validity.

On the other hand, the reliability of the model was tested by measuring the composite reliability (CR) and Cronbach's alpha. Value of composite reliability and Cronbach's alpha must be greater than 0.7. However, the value of 0.6 was acceptable for an exploratory research [24], but it will provide a lower value (underestimate). Therefore, it was recommended to use a composite reliability to test reliability of the constructs [23]. This composite method was used in this study, in which the value for all grades was above 0.7. This result means that the manifest variables or indicators used was valid.

Furthermore, main factors influencing design changes can be determined by calculating the loading factor of each indicator into variable design changes. Loading factor was derived from the calculation of the path coefficients in SmartPLS 2.0 M3. The results obtained by loading factors are shown in Table 1.

Table 1. Loading Factors of Indicator against Design Change (Source: Results Analysis with SmartPLS 2.0 M3)

Factor	Loading Factor
Owner	0,884
Consultant	0,859
Consultant construction management	0,846
Politics and economics	0,771
Natural environment	0,577
Contractors	0,523
Third party	0,328
Advances in technology	0,255

As be seen in Table 1, the owner was the biggest factor that causes a design change in a construction project with a loading factor of 0.884. The other factors were respectively design consultant (0,859), construction management consultant (0,846), political and economic matters (0,771), the natural environment (0,577), contractors (0,523), third party (0,328) and advances in technology (0,255). These results show that the internal factors had more influences than the external factors in design changes of a construction project.

5. Conclusion

Using SEM-PLS method supported by SmartPLS 2.0 M3, this study found that the owner was the main factor that caused design changes in a construction project. The other factors were respectively design consultants, construction management consultants, political and economic matters, the natural environment, contractors, third parties and the advance of technologies. By understand these factors, design changes in construction projects can be minimized.

Acknowledgements

The authors would like to thanks to all respondents from various companies/institutions for their supports in this study.

References

[1] M. Sun and X. Meng, "Taxonomy for Change Causes and Effects in Construction Projects," *Int. J. Proj. Manag.*, vol. 27, no. 6, pp. 560–572, Aug. 2009.

[2] W. Ibbs, L. D. Nguyen, and S. Lee, "Quantified Impacts of Project Change," *J. Prof. Issue Eng. Educ. Pract.*, vol. 133, no. January, pp. 45–52, 2007.

[3] L. O. Oyewobi and D. R. Ogunsemi, "Factors Influencing Reworks Occurrence in Construction: A Study of Selected Building Projects in Nigeria," *J. Build. Perform.*, vol. 1, no. 1, pp. 1–24, 2010.

[4] W. Ibbs, "Construction Change: Likelihood, Severity, and Impact on Productivity," *J. Leg. Aff. Disput. Resolut. Eng. Constr.*, vol. 4, no. 3, pp. 67–73, Aug. 2011.

[5] P. F. Kaming, P. O. Olomolaiye, G. D. Holt, and F. C. Harris, "Factors Influencing Construction Time and Cost Overruns on High-Rise Projects in Indonesia," *Constr. Manag. Econ.*, vol. 15, pp. 83–94, 1997.

[6] A. S. Alnuaimi, R. A. Taha, M. Al Mohsin, and A. S. Al-harthi, "Causes, Effects, Benefits, and Remedies of Change Orders on Public Construction Projects in Oman," *J. Constr. Eng. Manag.*, vol. 136, no. May, pp. 615–622, 2010.

[7] M. A. F. Wasfy, "Severity and Impact of Rework, A Case Study of a Residential Commercial Tower Project in The Eastern Province-KSA," King Fahd University, 2010.

[8] E. Serag, A. Oloufa, L. Malone, and E. Radwan, "Model for Quantifying the Impact of Change Orders on Project Cost for U.S. Roadwork Construction," *J. Constr. Eng. Manag.*, vol. 136, no. September, pp. 1015–1027, 2010.

[9] J. L. Burati Jr., J. J. Farrington, and W. B. Ledbetter, "Causes of Quality Deviations in Design and Construction," *J. Constr. Eng. Manag.*, vol. 118, no. 1, pp. 34–49, 1992.

[10] G. Wiyono, *Merancang Penelitian Bisnis dengan Alat Analisis SPSS 17.0 & SmartPLS 2.0*, Cet. Perta. Yogjakarta: UPP STIM YKPN, 2011.

[11] P. E. D. Love, D. J. Edwards, H. Watson, and P. Davis, "Rework in Civil Infrastructure Projects : Determination of Cost Predictors," *J. Constr. Eng. Manag.*, vol. 136, no. March, pp. 275–282, 2010.

[12] C. Wu, T. Hsieh, and W. Cheng, "Statistical Analysis of Causes for Design Change in Highway Construction on Taiwan," *Int. J. Proj. Manag.*, vol. 23, no. 7, pp. 554–563, Oct. 2005.

[13] Andi, S. Winata, and Y. Hendarlim, "Faktor-faktor Penyebab Rework Pada Pekerjaan Konstruksi," *Civ. Eng. Dimens.*, vol. 7, no. 1, pp. 22–29, 2007.

[14] R. Perkins, "Sources of Changes in Design–Build Contracts for a Governmental Owner," *J. Constr. Eng. Manag.*, no. July, pp. 588–593, 2009.

[15] T. Hsieh, S. Lu, and C. Wu, "Statistical Analysis of Causes for Change Orders in Metropolitan Public Works," *Int. J. Proj. Manag.*, vol. 22, no. 8, pp. 679–686, 2004.

[16] I. D. Cox, J. P. Morris, J. H. Rogerson, and G. E. Jared, "A Quantitative Study of Post Contract Award Design Changes in Construction," *Constr. Manag. Econ.*, vol. 17, pp. 427–429, 1999.

[17] A. S.-T. Chang, "Reasons for Cost and Schedule Increase for Engineering Design Projects," *J. Manag. Eng.*, vol. 18, no. January, pp. 29–36, 2002.

[18] A. S. T. Chang, J. S. Shih, and Y. S. Choo, "Reasons and Costs for Design Change During Production," *J. Eng. Des.*, vol. 22, no. 4, pp. 275–289, Apr. 2011.

[19] A. Husen, *Manajemen Proyek : Perencanaan, penjadwalan, dan Pengendalian Proyek*. Yogjakarta: Penerbit Andi, 2009.

[20] A. A. G. A. Yana, "Factors That Cause Design Changes In The Implementation Of Construction Project," in *The 4th International Conference of EACEF (European Asian Civil Engineering Forum)*, 2013.

[21] R. Waluyo, "Model Interaksi Antara Culture, Knowledge Management dan Performance di Perusahaan Konstruksi," Universitas Diponegoro, 2014.

[22] P. D. Sugiyono, *Statistika untuk Penelitian*, Cet. 20. Bandung: Penerbit CV. Alfa Beta, 2012.

[23] H. Latan and I. Ghozali, *Partial Least Square Konsep, Teknik dan Aplikasi Menggunakan Program SmartPLS 2.0 M3*. Semarang: Badan Penerbit Universitas Diponegoro, 2012.

[24] J. F. Hair, W. C. Black, B. J. Babin, and R. E. Anderson, "Multivariate Data Analysis," 7ed ed., Pearson Prentice Hall, 2010.