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Construction Risk Assessment through Partial Least Square Technique

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Abstract

Construction industry in developing and under developing country has the priority among the other industries. It assumes safe investment in an uncertain market on behalf of privatization. It is most important that the project in this industry is managed as per the best project management planning practice. In the developing country the project manager faces a lot of difficulties to manage the project. There are various factors which are responsible for the project progress and controlling. In this research we incorporate some factors which influence the project progress among all other factors. The main motive of this research is to analyze the factors which are responsible for the progress of the project. From literature survey and expert opinion we consider seven main factors and their 31 sub factors which are analyzed by "PARTIAL LEAST SQUARE STRUCTURE EQUATION MODELING" based on SMART PLS3.0 software. It finally determines which factor in construction project play a major role in the whole risk of that project.

Keywords: PLS-SEM, Smart PLS, Path coefficient. R Square, Composite reliability, AVE, LV.

1. Introduction

Risk in construction project is the condition in which the progress of the project is obstructed by some factors related to contractor's site management, design and documentation related, financial management related factors or some other factors has not been in scheduled time (H. Afshari et al. 2011). Risk in construction industries are often the resulting in cost overrun delay the project schedule, disputes, litigation and complete abandonment of project (Sambasivan and soon 2007). Some project can be found that the terror of not finishing the project on the schedule time, is the main issue of the perticular project manager so that the timely completion is one of the most important factor in all construction project (Belasi and Tukel 1996, Hatush and Skitmore 1997). Project management is assumed to be a critical step in success of any project (Abbasi et al.2015,Masadeh et al.2015). Especially in the civil engineering project, they are different from each other, since everyone is designed for different purpose and for different structure (Hamzah et al. 2011). There are many unpredictable factors are responsible for project success, thus completion the project on time is an indicator of efficiency. However it is very rare to complete the project within stipulated time and estimated cost for particular project.

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`In this research we cover the area of Rau (Indore), and from literature and expert of construction industries we able to decide the factors and sub factors which is major concern about failure of the project. In this way there are seven main factor and 31 sub factors are include which is highly responsible for project failure. Now we distribute 100 prepared questionnaires to the site in- charge or project manager and we get 75 complete responses. Now this statistical data we analyze by PLS-SEM based smartPLS3.0 software.It was developed by Ringle, Wende & will (2005).

2. Factor causing risk in construction project

There are many researches on the risks incorporate in the construction project. Based on the previous researches and expert opinion we consider seven main factors and 31 sub factors we consider in this research.

Table 1: Shows the main factors (Latent variable) their sub factors (manifest Variable) and indicators

S. No.	Main Factor (LV)	Indicator	Sub Factor (Manifest Variable)
1	Contractor's Site Management Related Factors (CSM)	CMS1	Poor site management and supervision Incompetent subcontractors
		CMS2	Scarcity in experience
		CMS3	Inaccurate Time and Cost estimates
		CMS4	Mistakes during construction
		CMS5	Inadequate monitoring and control
		CMS6	
2	Design And Documentation Related Factors (DDF)	DDF1	Frequent design changes
		DDF2	Mistakes and Errors in design
		DDF3	Incomplete design at the time of tender
		DDF4	Poor design and delays in Design
			Delay Preparation and approval of drawings
		DDF5	
3	Financial Management Related Factors (FIN)	FIN1	Cash flow and financial difficulties faced by contractors
		FIN2	Poor financial control on site
		FIN3	Financial difficulties of owner
		FIN4	Delay in progress payment by owner
		FIN5	Contractual claims, such as, extension of time with cost claims
4	Information And Communication Related Factors (ICT)	ICT1	Lack of coordination between parties
		ICT2	Slow information flow between parties
		ICT3	Lack of communication between parties
5	Human Resource (Workforce) Related Factors (LAB)	LAB1	Labour productivity
		LAB2	Shortage of site workers
		LAB3	Shortage of technical personnel (skilled labour)
		LAB4	High cost of labour
6	Non-Human Resource Related Factors (MMF)	MMF1	Fluctuation of prices of materials
		MMF2	Shortages of materials
		MMF3	Late delivery of materials and equipment
		MMF4	Equipment availability and failure
7	Project Management And Contract Administration Related Factors (PMCA)	PMCA1	Poor project management
		PMCA2	Change in the scope of the project Delays in decisions
		PMCA3	making Inaccurate quantity take-off
		PMCA4	

Table 2: Guidelines for PLS-SEM application (Ken Kwong- kay Wong,2013)

Topic	Suggestion	Reference
Measurement scale	Avoid using a categorical scale in endogenous constructs	Hair et al., 2010
Maximum number of iterations	300	Ringle et al., 2005
Bootstrapping	Number of bootstrap "samples" should be 5000 and number of bootstrap "cases" should be the same as the number of valid observations	Hair et al., 2011
Inner model evaluation	Do not use goodness-of-fit (GoF) Index9	Henseler and Sarstedt, 2013
Outer model evaluation (reflective)	Report indicator loadings. Do not use Cronbach's alpha for internal consistency reliability.	Bagozzi and Yi, 1988

Table3: Guideline for reliability and validity of PLS- SEM model (Ken Kwong- kay Wong,2013)

What to check?	What to look for in SmartPLS?	Where is it in the report?	Is it OK?
		Reliability	
Indicator Reliability	Outer loadings" numbers	PLS Calculation Results Outer Loadings	Square each of the outer loadings to find the indicator reliability value. 0.70 Or higher is preferred. If it is an exploratory research, 0.4 or higher is acceptable. (Hulland, 1999)
Internal Consistency Reliability	Reliability" numbers	PLS Quality Criteria Overview	Composite reliability should be 0.7 or higher. If it is an exploratory research, 0.6 or higher is acceptable. (Bagozzi and Yi, 1988
		Validity	
Convergent validity	AVE" numbers	PLS Quality Criteria Overview	It should be 0.5 or higher (Bagozzi and Yi, 1988)
Discriminant validity	"AVE" numbers and Latent Variable Correlations	PLS Quality Criteria Overview (for the AVE number as shown above) PLS Quality Criteria Latent Variable Correlations	Fornell and Larcker (1981) suggest that the "square root" of AVE of each latent variable should be greater than the correlations among the latent variables

3. Research Methodology

This study a questionnaire distribution to project managers of the construction project who were employed by the owner, construction management consultant, contractor and design consultant they have better understanding the factor causing the risk in the construction because they were directly involve into the construction work. This research used a normal scale with range 1 to 5. In this scale, 1 shows no strong influence, 2 shows no influence, 3 indicate normal, 4 indicated influencing and 5 indicated strong influencing factor.
Structure equation modeling (SEM) was used to analyze the factor which causing risk in the construction project. it is a statistical method for priorities the factors. There are three types of structural equation modeling

- CB-SEM (Covariance based structural equation modeling) which is used for confirmatory and rejecting theory
- PLS-SEM (partial least square technique structural equation modeling) which is used for exploratory analysis
- GSCA (Generalizes structural component analysis)

In this research we used PLS-SEM because

- The minimum required sample size is relatively small.
- To develop the prediction model.
- It is used because the theory is not very strong.
- The indicator can be arrange in reflective or in formative model.

The step of PLS-SEM using smartPLS3.0 software:

- To collect the data from construction site, and arrange in .CSV file format of MS Excel sheet.
- To create the model in the smartPLS3.0 after import the data sheet into the software.
- Apply PLS algorithm and determine all required parameter such as path coefficient, r square value, composite reliability, and average variance extracted (AVE)
- If any value of indicators which is below than the permissible limit, we can delete those indicator and re-apply the PLS technique.
- To check the significance of path coefficient and outer loading we apply the bootstrapping process and with the help of T-value and P-value check the significance of data.
- Now as per their path coefficient we ranked the all latent construct similarly as per outer loading we rank the indicators of latent variables

4. Results

4.1 Analysis with PLS-SEM

There are mainly two type of structure model is used in this method that is reflective and formative structure model we use reflective model for this study. With help of PLS-SEM method using smartPLS3.0 a model of factor influencing the risk in the construction project was developed. The result of this study we discuss in the form of

- Explanation of target endogenous variable variance (R square)
- Inner model path coefficient and significance check by bootstrapping process
- Outer model loading and significance.
- Indicator reliability
- Convergence validity and discriminent validity

4.2 Explanation of target endogenous variable variance (r square)

The value of R square explains shows how much the variance of the latent variable is being explained by the other latent variables. The coefficient of determination R^2 value is 0.999 for the all latent variable (CMS, DDF, FIN, ICT, LAB, MMF, PMCA) is substantial explain 99.9% of the variance in overall risk.

4.3 Inner model path coefficient and significance by bootstrapping

The path coefficient (numbers on arrow) explains how strong the effects of one latent variable on LV (latent variable) it also enable us to rank of the latent construct. Bootstrapping is the statistical process to check the structural path significance by the standard t-value and p-value. The result shows the rank 1st with highest influencing LV is PMCA, 2nd is MMF, 3rd , 4th 5th 6th are CMS, LAB, FIN & ICT and 7th is DDF Which is the lowest influencing latent variable to the overall risk in construction project

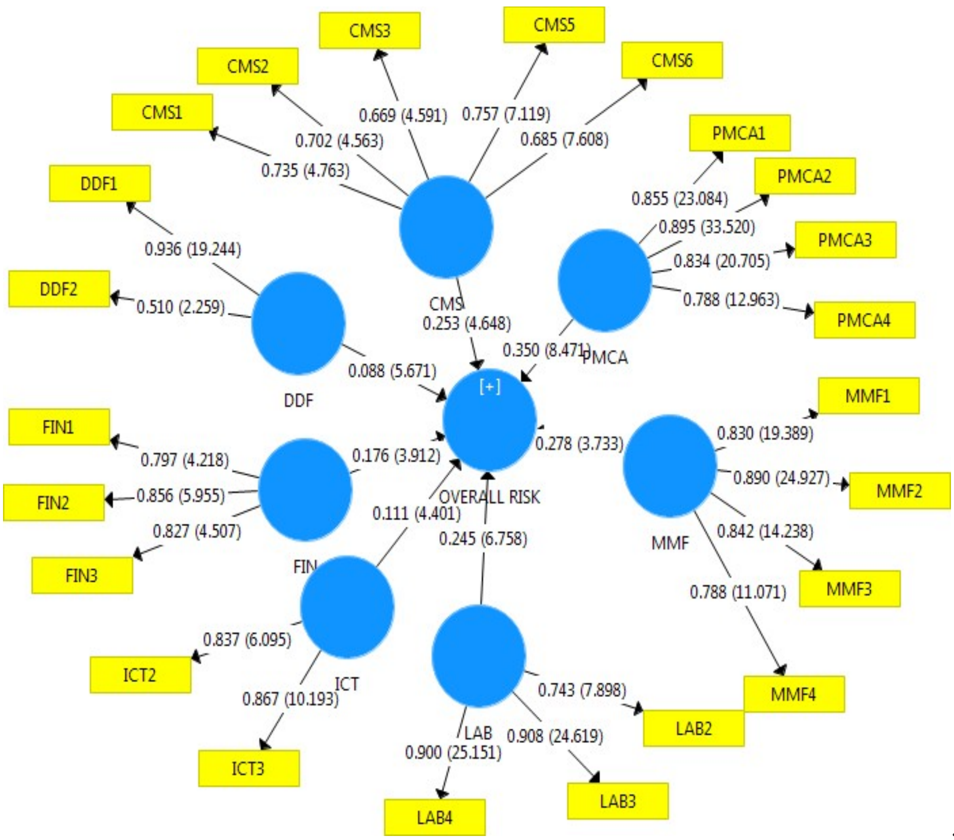

Fig1: Path coefficient with t-value

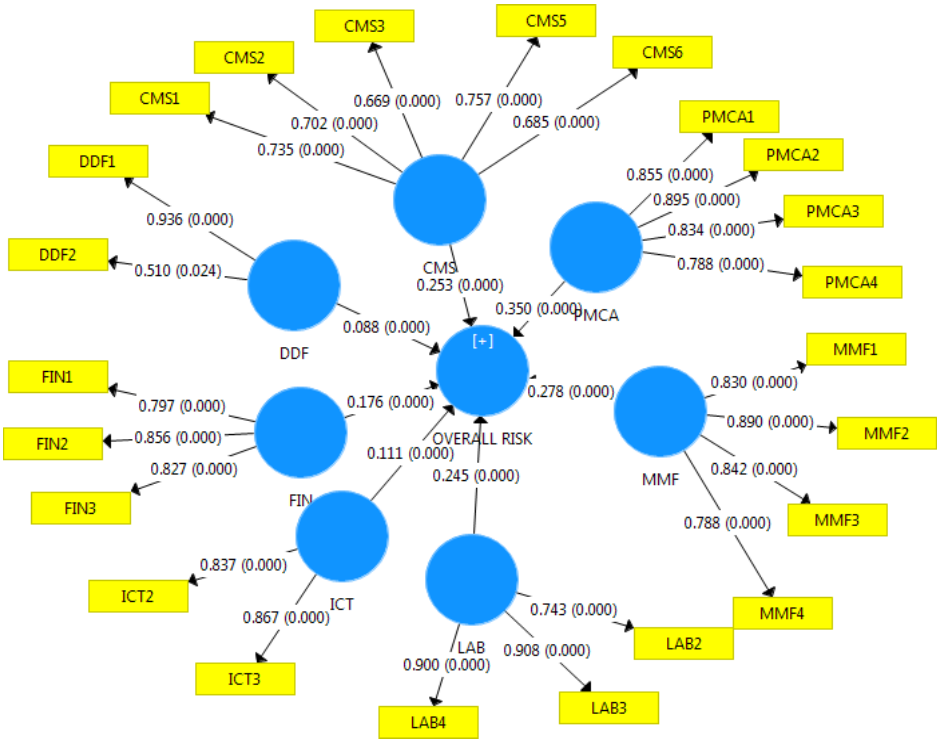

Fig.2: Path coefficient with p-value

Table4: path coefficient with significance check

Latent Variable	Path Coefficient	Rank	t- value	p-value	Check T>1.96 P<0.05 for significance
Contractor's Site Management Related Factors (CSM)	0.253	3	4.588	0.000	significant
Design and Documentation Related Factors (DDF)	0.088	7	5.584	0.000	Significant
Financial Management Related Factors (FIN)	0.176	5	3.897	0.000	significant
Information and Communication Related Factors (ICT)	0.111	6	4.340	0.000	Significant
Human Resource (Workforce) Related Factors (LAB)	0.245	4	6.713	0.000	Significant
Non-human Resource Related Factors (MMF)	0.278	2	3.700	0.000	Significant
Project Management and Contract Administration Related Factors (PMCA)	0.350	1	8.291	0.000	Significant

4.4 Checking the reliability and validity of measurement model or outer model

Composite reliability is the degree to which measurement are free from error for yield consistent result. The meaning of Reliability is consistency or reproducibility or in general we can say the reliability is a measure to produce same result of repeated trial (Carmines & Zeller 1979) for exploratory research **CR> 0.7**

$$CR = \frac{(\sum \lambda_i)^2}{(\sum \lambda_i)^2 + (\sum \epsilon_i)}$$

CR = composite reliability
λ = Outer loading of indicator
ϵ = measurement error

Validity of a model is the degree to which two measure latent variables are theoretically related to each other and it can be check by convergent validity test AVE (average variance extracted) and by Fornell and Larcher's Discriminant validity. **The AVE should be > 0.5** and the in Discriminent validity the value of one latent variable should be higher than other correlation value among the latent variable

$$AVE = \frac{\sum \lambda_i^{\ 2}}{\sum \lambda_i^{\ 2} + \sum_i var(\epsilon_i)}$$

Table 5: shows the composite reliability and AVE value

S. no.	Latent variable	Composite reliability (CR)	Average variance extracted (AVE)	Result Of Significance
1	CMS	0.836	0.505	significant
2	DDF	0.708	0.569	significant
3	FIN	0.866	0.684	significant
4	ICT	0.841	0.726	significant
5	LAB	0.889	0.728	significant
6	MMF	0.904	0.703	significant
7	PMCA	0.908	0.712	significant

Table 6: Fornell and Larcker (1981) Discriminant validity

	CMS	DDF	FIN	ICT	LAB	MMF	PMCA
CMS	0.710						
DDF	0.497	0.754					
FIN	0.417	0.131	0.827				
ICT	0.344	0.310	0.239	0.852			
LAB	0.449	0.430	0.303	0.505	0.853		
MMF	0.151	0.326	0.086	0.115	0.300	0.838	
PMCA	0.298	0.378	0.391	0.176	0.354	0.537	0.844

Result shows that all latent variables have perfect discriminated validate. For example the latent variable DDF's AVE is determine to be 0.569 (from AVE Table) then its square root becomes 0.754. This number is more than the correlation value in column of DDF (0.131, 0.310, 0.430, 0.326, 0.378) and also more than those in the row of DDF (0.497). Same types of observation is also made for the latent variable CMS, FIN, ICT, LAB, MMF, and PMCA the result indicates that discriminate validity is well established

5. Discussion and conclusion:

In this study the latent variable of risks in construction industries have been identified through a questionnaire survey and expert opinion. With the help of partial least square technique we analyzed all factors which governing the overall risk in construction projects. For this we create a model and tested it. Model was tested by composite reliability convergent and discriminate validity and also with the help of bootstrapping process. Table 4 shows the value of path coefficient which shows the influence level of latent variable. As per this table we can see the latent variable PMCA (Project Management and Contract Administration Related Factors) is the highest influencing factor to the overall risk with path coefficient value 0.350 sequentially other influencing factor such as Non-Human Resource Related Factors (MMF) with 0.278, Contractor's Site Management Related Factors (CSM) with 0.253, Human Resource (Workforce) Related Factors (LAB) with 0.245, Financial Management Related Factors (FIN) with 0.176, Information and Communication Related Factors (ICT) with 0.111 and lowest influencing latent construct to overall risk is Design and Documentation Related Factors (DDF) with path coefficient 0.088. Table 4 also shows the test for model with t and p statistical value which shows the all latent variable having significant value. Table 5 shows the value of reliability of model by composite reliability and convergent validity by AVE value. This table shows all latent variable have establish good reliability and validity. Table 6 shows the discriminent validity of the PLS model which showing well established discriminent validity in this model.

References

- Abbasi, M. S., Tarhini, A., Hassouna, M., & Shah, F. (2015). SOCIAL, ORGANIZATIONAL, DEMOGRAPHY AND INDIVIDUALS'TECHNOLOGY ACCEPTANCE BEHAVIOUR: A CONCEPTUAL MODEL. *European Scientific Journal, ESJ*, *11*(9).
- Afthanorhan, W. M. A. B. W. (2013). A comparison of partial least square structural equation modeling (PLS-SEM) and covariance based structural equation modeling (CB-SEM) for confirmatory factor analysis. *International Journal of Engineering Science and Innovative Technology*, *2*(5), 198-205.
- Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structural equation models. *Journal of the academy of marketing science*, *16*(1), 74-94.
- Belassi, W., & Tukel, O. I. (1996). A new framework for determining critical success/failure factors in projects. *International journal of project management*, *14*(3), 141-151.
- Crisci, A., & D'Ambra, A. (2013). EXTERNAL ANALYSIS IN PLS-PATH MODELING FOR THE EVALUATION OF THE PASSANGER SATISFACTION. *Journal of Applied Quantitative Methods*, *8*(1).
- Friman, M., & Fellesson, M. (2009). Service supply and customer satisfaction in public transportation: The quality paradox. *Journal of Public transportation*, *12*(4), 4.
- Gye-Soo, K. (2016). Partial least squares structural equation modeling (PLS-SEM): An application in customer satisfaction research. *Int. J. ue-Serv. Sci. Technol*, *9*, 61-68.
- Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *Journal of Marketing theory and Practice*, *19*(2), 139-152.
- Hamzah, Noraini, M. A. Khoiry, Ishak Arshad, Norngainy Mohd Tawil, and AI Che Ani. "Cause of construction delay-Theoretical framework." *Procedia Engineering* 20 (2011): 490-495.
- Hatush, Z., & Skitmore, M. (1997). Evaluating contractor prequalification data: selection criteria and project success factors. *Construction Management and Economics*, *15*(2), 129-147.
- Henseler, J., & Sarstedt, M. (2013). Goodness-of-fit indices for partial least square path modeling. *Computational Statistics*, *28*(2), 565-580.
- Hulland, J. (1999). Use of partial least squares (PLS) in strategic management research: A review of four recent studies. *Strategic management journal*, *20*(2), 195-204.
- Ringle, C. M., Wende, S., & Will, S. (2005). SmartPLS 2.0 (M3) Beta, Hamburg 2005.
- Sambasivan, M., & Soon, Y. W. (2007). Causes and effects of delays in Malaysian construction industry. *International Journal of project management*, *25*(5), 517-526.
- Wong, K. K. K. (2013). Partial least squares structural equation modeling (PLS-SEM) techniques using SmartPLS. *Marketing Bulletin*, *24*(1), 1-32.
- Yana, A. G. A., Rusdhi, H. A., & Wibowo, M. A. (2015). Analysis of factors affecting design changes in construction project with Partial Least Square (PLS). *Procedia Engineering*, *125*, 40-45.