Available online at http://sanad.iau.ir/journal/ijim/
Int. J. Industrial Mathematics (ISSN 2008-5621)
Vol.17, No.1, 2025 Article ID IJIM-1629, 13 pages
Research Article

Science and Research Branch (IAU)

Structural Equation Model to Improve Value Engineering Implementation in Civil Projects in Iran

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Submission Date:2020/01/07, Revised Date:2020/02/27, Date of Acceptance:2024/08/05

Abstract
Value engineering is a proven management technique for generating benefits and improving the value of Implementation in civil projects. The aim of this study was to Presenting Model to Improve Value Engineering Implementation in Civil Projects in Iran. To this end, engineers and managers in civil projects include 153 staffs were participated in present study, Data were collected by self-questionnaires that. Data analysis was done using structural equation modeling by software Smart PLS 3 in three parts, the measurement model, structural section and overall model. In the first part, technical characteristics of the questionnaires including reliability, validity, convergent and divergent validity were evaluated. In the second part, software significant coefficients were used to evaluate the hypothesis. In the third part, the developed model has substantial explaining power with GoF value of This indicates. Also, the results confirm the positive effect of mediating variables in the proposed model.

Keywords: Value engineering; Civil projects; Risk management.

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1. Introduction

Value engineering is a systematic way of achieving project goals. This process is done by evaluating the objectives of the project and how to achieve them. Value engineering strives to improve design while reducing costs and time, increasing the value of the products in question, with the goal of maximizing efficiency and effectiveness in construction and construction projects. So, all of these factors will result in us controlling our costs as much as possible. In this regard, the use of value engineering as a powerful and reliable tool can be mentioned. Since construction and construction projects usually involve high costs and high complexity in design and implementation, and many factors are involved in the process of designing and operating them, they have a high potential for cost savings, and value engineering knowledge for this purpose. The aim is to optimize the results of the developed building industry projects. Value engineering, introduced to the construction industry in the 1960s, has been used worldwide for over 50 years. Since its introduction, this technique has been widely used in construction projects [1, 2, 3, 4]. The value engineering workshop process involves several important elements, including teamwork, functional analysis, creation, cost–worth, and the systematic application of a recognized technique. The incorporation of these elements into a value engineering workshop job plan distinguishes the value engineering approach from other cost-cutting exercises [1].

Value engineering is a logically organized function and technical knowledge. Seeks to eliminate unnecessary costs and increase project value. Due to timely completion and quality of work is one of the most important factors in reducing the cost of construction projects. It is essential to use the proper approach to avoid unnecessary cost increases and project quality that ultimately lead to timely completion [5]. Value engineering has been used effectively in many countries around the world. The global use of value engineering has attracted both researchers and practitioners to study the use of value engineering workshops in civil projects [1]. Value engineering is a set of techniques and methods, which systematically identify and analyze the value of each function to the customer while identifying the main and secondary functions of a product or service. It also helps project management as a management tool to determine the best way to do this.

2. Research Conceptual Model

The major objective of this study is to develop a model that can assess the performance of civil projects value engineering workshops. Since the results of the research are applicable to Improve Value Engineering Implementation in Civil Projects in Iran, therefore, the research is an applied study and according to the direct relationship between the researcher and the phenomena that is studied, so this study is a field one. Because of the data gathering, the researcher has been in the organizations and data collected by using the questionnaire and interviewing. So, the research is a survey method. Following a comprehensive study of the literature on value engineering and the civil projects in Iran and consultation with experienced value engineering researchers and engineers working on civil projects. in this field, the following "Latent Variable" and "Observable Variable" were selected for final review. (See Table 1)

2.1 Satisfaction with the value engineering results

2.1.1 Recommendations Value Engineering Team Members

In executing project processes, the value engineering team improves the goals of the value engineering workshop by reducing the time and cost of its expert members by reducing the time and cost.

2.1.2 Savings Rate

Life cycle costing is used to compare proposals by identifying and assessing economic impacts over the design life of each alternative. In making decisions, both present and future costs are taken into account and related to one another [3]. One result of using value engineering is the cost savings of unnecessary costs. Applying value engineering to a project leads to optimizing life cycle costs, reducing runtime, increasing profits, and improving quality.

2.1.3 Return on investment

In the value engineering workshop, the rate of return on investment is used to evaluate the performance of investments made in different processes. And to compare the processes, the rate of Return on investment on both processes is expertly examined.

2.1.4 Team leader satisfaction of Results

Generally, value engineering workshop goals provide incentives for the team to pursue good recommendations [1]. The value engineering team leader plays an important role in the development of the workshop. Using the FAST diagram, the team leader provides important and essential explanations to progression the value engineering workshop. So that team members have a thorough understanding of project processes. Finally, if the team leader is satisfied with the results, the workshop outcome will be used in the project. It should be noted that "Team leader satisfaction with workshop goal" means "Team leader's satisfaction that the workshop goals were achieved."

2.2 Composition and capability of the value engineering team

2.2.1 Leading value engineering workshop experiences of the team leader

The value engineering team leader must have leadership experience in development civil projects to achieve good results and acceptable performance. Also, can able to lead and guide the value engineering team members well.

2.2.2 Professional level of value engineering workshop team members

The professional level of value engineering workshop team members is also important in generating sound and creative recommendations [1], One of the important points in obtaining desirable results from value engineering is the level of ability and experience of the members of the value engineering team. Always value engineering team abilities and experiences should be greater than the project design team.

2.3 Team Member Participation

2.3.1 Communication and coordination between value engineering team members

The success of a value engineering workshop in implementing complex processes requires complete communication and coordination between the members of the value engineering team. Because the FAST chart will only be applicable when ideas and recommendations reach the consensus of the team members.

2.3.2 Attendance stability of value engineering workshop team member

The basic function of a value engineering workshop is to focus synergy of the civil engineering experts. Attendance and participation in value engineering workshop Cause Stability of team participation is a linchpin to achieve the function.

2.4 Value engineering workshop job plan

2.4.1 Project goals clarity

A key point in an organized value engineering effort is the value of using a work plan. The work plan is a problem-solving approach, which distinguishes value engineering from other cost-cutting measures. Transparency of goals set in achieving civil projects goals is an important part of the value engineering team's work plan.

2.4.2 Completeness and implementation of value engineering workshop

In a good planning for value engineering services, steps are taken for a value engineering workshop. This program includes selecting teams, creating the right work plan, coordinating and fully implementing the value engineering process. As a result, completeness of the work plan leads to the achievement of the value engineering goal.

2.5 The nature of the project

The nature of the project as a temporary organization is analyzed from the perspective of organizational theory. This leads to a reassessment of the definition of a project [6]. Projects and programs are temporary organizations [6] [7] [8]. Thus, every time a new project or program is started, the human resource configuration of the organization must change. This might create pressure. It certainly impacts the work organization, and creates the need for new processes like assigning personnel onto projects, dispersants from projects, and processes for linking project assignments to careers [9]. As well as human resource management and unforeseen problems, there are a lot of pressures on the project at project-oriented organizations when executing the project, which should be managed by project managers, including:

2.5.1 The amount of uncertainty in organization projects

2.5.2 Prompt delivery of the project within the timeframe with the desired results

2.5.3 The need for integration of resources between different parts of the *organization's projects*

2.6 Risk management requirements in civil projects

Risks in the civil projects are unknown events or possible situations that are likely to have a negative or positive impact on the project's goals [10]. In the era of progressive globalization, it is hard to avoid risk, which has become an indispensable part of everyday life. Risk is present everywhere, in every aspect of our life. One of such aspects is the civil projects, where risk is an inherent element [11]. Identification of risks in construction projects is based primarily on determining what types of risks may affect the project, identifying their characteristic parameters and estimating the probability of their occurrence in the project. The need for risk identification stems from the decision-making conditions under which an investor is at the moment [11].

2.6.1 Risk Management Planning

Risk Planning is the process of deciding how to approach and plan for the risk management activities of a project. This is an important step to ensure that the level, type and visibility of risk management are commensurate with both the risk and importance of the project to the organization [12]. Since the definition of risk is directly related to the project objectives, it is necessary to define the objectives before identifying the risks. The value engineering team leader conducts a project management workshop on the value engineering of Risk Management Planning so that the project goals can be documented and agreed upon by all project stakeholders. Then all project stakeholders will come to a common view on risk management planning and a document called Risk Management Planning will be prepared and approved by all project stakeholders.

2.6.2 Risk identification

Each project is associated with risk-taking. Enterprises and institutions should be prepared for the occurrence of possible risks [11]. Value Engineering Team Leader Re-evaluates project processes with the participation of value engineering team members after identifying the project goals and forming the necessary engineering teams for the project. To make complex and large processes defined, using simpler breakdown structures, into simpler and smaller processes. The value engineering team is then asked to identify project risks using the breakdown structure and record the risks in their checklists by risk, source, risk and impact.

2.6.3 Risk Assessment

According to the results of various evaluations and insights gained from the construction project, the best way to assess the probability and risk effect is to organize specialized sessions in each of the value engineering workshops. After identifying different project risks by the value engineering team, it is necessary to evaluate the risks qualitatively and quantitatively. Providing sufficient detail of the identified risk by the value engineering team provides suggestions in the value engineering workshop. Also, in the process of qualitative evaluation, it is tried to prioritize the risk and probability of risk and its impact on different parts of the project. Then, by quantitatively assessing the risks, the engineering team determines the appropriate timeframe and budget for the project.

2.6.4 Risk Response Planning

Risk Response Planning is the process of developing options, and determining actions to enhance opportunities and reduce threats to the project's objectives. It follows the Qualitative Risk Analysis and Quantitative Risk Analysis processes [12]. This step is of great importance in selecting the appropriate response because of the effectiveness of the risk response. The value engineering workshop will first review the information obtained up to this point.

I. Which separately includes the following.

The final list of identified risks and their assessment so that their probability and impact are assessed. (In the event of a time limit for responding to the risk, priority and important risks will be considered first.)

II. A list of project beneficiaries who may be responsible for the risk response.

III. Using building information modeling as an empowerment in the value engineering team and integrating risk analysis in a specialized manner.

Then, the necessary reactions, such as the use of different insurance policies and other value engineering methods, are performed.

2.6.5 Risk Control and Monitoring

After planning the risk response, the value engineering team leader, in collaboration with the specialized members of the value engineering team, conducts a project risk monitoring and control workshop. In this workshop the actions taken are analyzed and evaluated. With the planned actions to change the status of project risks and to more confidently achieve the project objectives. With the ongoing process of monitoring and controlling project risks, the value engineering team replaces other appropriate strategies if needed and makes the necessary adjustments to the risk management plan.

3. PLS Structural Equation Modeling

PLS-SEM is a regression-based modeling approach which uses a component-based (similar to principal components factor analysis) technique in analyzing path models and PLS path models comprises of two sets of linear equations: the outer model also referred as measurement model and the inner model also referred as structural model [13]. The inner model specifies the relationships between unobserved or latent variables, whereas the outer model specifies the relationships between a latent variable and its observed or manifest variables [14].

This study is quantitative research. Where data is collected through a structured questionnaire among experienced value engineering researchers and engineers working on civil projects. And they are members of the Institute of Value Engineering in Iran. And they are involved in the implementation of civil projects.

The statistical population of this study, due to the limitations in the field of civil projects in Iran, is a number of managers and Experts civil projects development related to the civil projects in Iran. Considering overall purpose of the research, its methodology is a mixed one that its qualitative section is based on semi-structured interviews and quantitative section is based on questionnaire tool. Considering that statistical population of civil projects in Iran, thus this study is selected sample of statistical population instead of statistical population, that the number of appointees initially were determined 170 people. Due to the limitations and existing problems including distances and restrictions of organizations in adoption of questionnaires, only 153 questionnaires were completed and collected.

Table 1: Latent Variable and Observable Variable in structural model

Code	Latent Variable	Observable Variable	Code
W	Satisfaction with the value engineering results	Recommendations Value Engineering Team Members	W11
		Savings Rate	W12
		Return on investment	W13
		Team leader satisfaction of Results	W14
V1	Composition and capability of the value engineering team	Leading value engineering workshop experiences of the team leader	V11
		Professional level of value engineering workshop team members	V12
V2	Team Member Participation	Communication and coordination between value engineering team members	V21
		Attendance stability of value engineering workshop team member	V22
V3	Value engineering workshop job plan	Project goals clarity	V31
		Completeness and implementation of value engineering workshop	V32
M1	The nature of the project	The amount of uncertainty in organization projects	M11
		Prompt delivery of the project within the timeframe with the desired results	M12
		The need for integration of resources between different parts of the organization's projects	M13
M2	Risk management requirements in civil projects	Risk Management Planning	M21
		Risk identification	M22
		Risk Assessment	M23
		Risk Response Planning	M24
		Risk Control and Monitoring	M25

Before analyzing the structural model, reliability and validity of the model were evaluated and established. Then, to estimate reflective measurement models outer loadings, composite reliability, average variance extracted, and discriminant validity are evaluated. Table 2,3 and Figure 1 illustrated the evaluation criteria for the model.

Table 2: Outer Loadings and T-value in structural model

Variable		Outer Loadings	T-value	Sig	Decision
M1	M11	0.862	27.72	0.00	Accepted
	M12	0.71	13.11	0.00	Accepted
	M13	0.833	27.62	0.00	Accepted
M2	M21	0.694	12.49	0.00	Accepted
	M22	0.706	16.27	0.00	Accepted
	M23	0.754	16.71	0.00	Accepted
	M24	0.656	11.52	0.00	Accepted
	M25	0.815	26.14	0.00	Accepted
V1	V11	0.895	38.23	0.00	Accepted
	V12	0.869	27.11	0.00	Accepted
V2	V21	0.927	54.86	0.00	Accepted
	V22	0.914	57.4	0.00	Accepted
V3	V31	0.905	54.84	0.00	Accepted
	V32	0.897	46.35	0.00	Accepted
W	W11	0.68	10.83	0.00	Accepted
	W12	0.852	39.22	0.00	Accepted
	W13	0.853	37.82	0.00	Accepted
	W14	0.697	14.16	0.00	Accepted

Examining the outer loadings of the latent variables indicate that loadings are between 0.656 and 0.927 (See Figure 1). Composite reliability scores and the AVE indicate good reliability and validity (See Table 2,3).

Once the construct measurements were confirmed as reliable and valid, the researcher judged the structural model to examine the model's predictive abilities and the relationships between the model components. The results asserted that the structural model and all beta paths are statistically significant ($p < 0.05$) [15].

We confirmed that the measurement model was valid and reliable. The next step was to measure the Inner Structural Model outcomes. This included observing the model's predictive relevancy and the relationships between the constructs. The coefficient of determination (R2), Path coefficient and t-value, Effect size ($f2$), the Predictive relevance of the model (Q2), and Goodness-of-Fit (GOF) index are the key standards for evaluating the inner structural model [16].

The coefficient of determination measures the overall effect size and variance explained in the endogenous construct for the structural model and is thus a measure of the model's predictive accuracy.

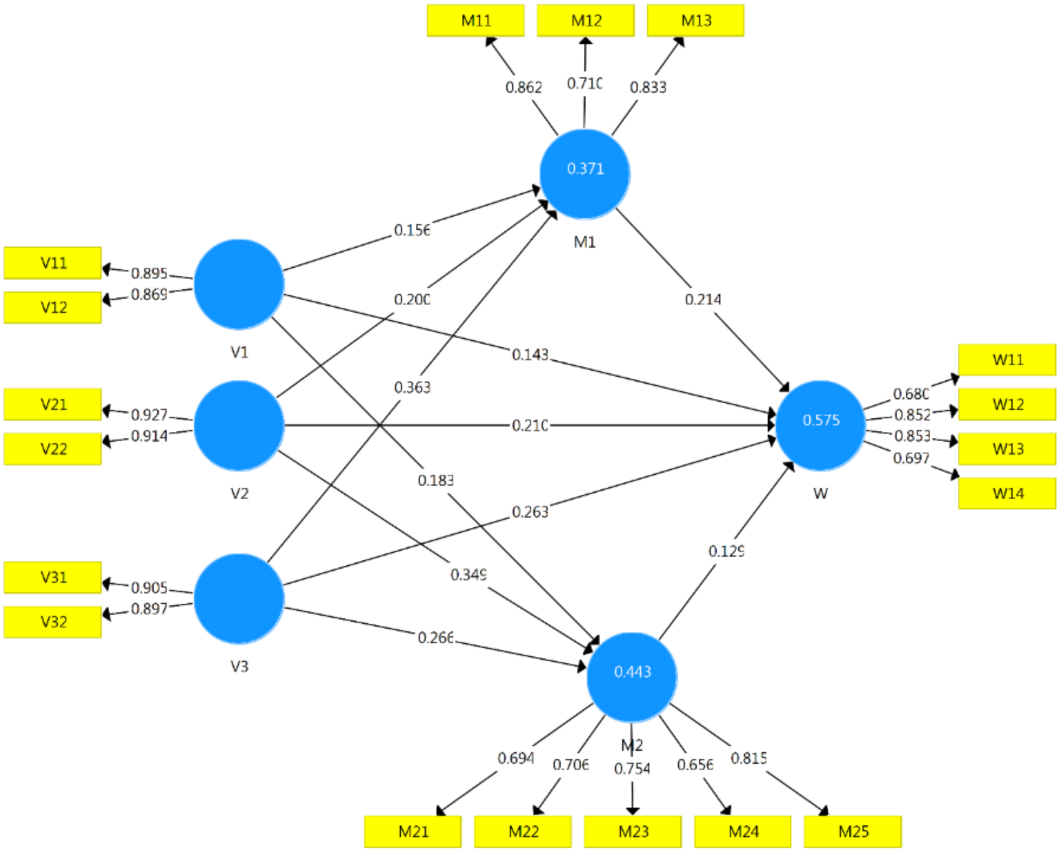

Fig. 1. The Result of Path Coefficients

Numbers within the circles illustrated how much the variance of the latent variable is being explained by the latent variables. In this survey, as Table 3, Figure 1 showed, the coefficient of determination, R2, is 0.575 for the “Satisfaction with the value engineering results” endogenous latent variable which indicated that the five latent variables “Composition and capability of the value engineering team, Team Member Participation, Value engineering workshop job plan, The nature of the project, Risk management requirements in civil projects”. Besides, the results indicate an adequate predictive validity of the study’s model.

This test is calculated using the blindfolding technique to measure the quality of the PLS-SEM model. To measure Q2, mainly cross-validated redundancy was applied. The decision on Q2 is that the value higher than zero (>0) for an endogenous construct means that the PLS-SEM model has predictive relevance for a given endogenous construct. Similarly, a value (≤0) indicates that the model is not relevant to predict the given endogenous factor. In this study, the model value was (See Table 3), (“The nature of the project” (0.219), “Risk management requirements in civil projects” (0.212), “Satisfaction with the value engineering results” (0.317)); greater than the standardized threshold and therefore had adequate predictive relevance for the endogenous latent construct.

Table 3: Results of measurement model evaluation

Variable	(0.7< Alpha)		(0.7<CR)	AVE>0.5	R^2	R^2 Adjusted	Q^2
M1	**0.913**	0.722	0.845	0.647	0.371	0.359	0.219
M2		0.776	0.848	0.529	0.443	0.432	0.212
V1		0.716	0.875	0.779	-	-	-
V2		0.821	0.918	0.848	-	-	-
V3		0.768	0.896	0.811	-	-	-
W		0.775	0.856	0.601	0.575	0.561	0.317

Guidelines for assessing $f2$ are (Cohen, 1988 [17]): values of 0.02, 0.15, and 0.35, respectively, represent small, medium, and large effects of an exogenous latent variable on an endogenous latent variable. Effect size values of less than 0.02 indicate that there is no effect. In some places I have also found that standardized path coefficients with absolute values less than 0.1 may indicate a “small” effect, values around 0.3 a “medium” effect, and values greater than 0.5 a “large” effect. and the results and inference are tabulated in table 4.

Table 4: Effect sizes of the structural model (f^2)

	W	V1	V2	V3	M1	M2
W	-	-	-	-	-	-
V1	0.033	-	-	-	0.029	0.044
V2	0.052	-	-	-	0.036	0.125
V3	0.068	-	-	-	0.101	0.068
M1	0.068	-	-	-	-	-
M2	0.022	-	-	-	-	-

Finally, Table 5 showed the discriminant validity which was determined according to the Fornell and Larcker (1981) criterion [18]. The off-diagonal values in the matrix in this table signify the correlations between the latent constructs. Thus, the outcomes specify that there is discriminant validity between all the constructs based on the cross-loadings criterion.

Table 5: Fornell-Lacker

Latent Variable	M1	M2	V1	V2	V3	W
M1	0.805					
M2	0.44	0.727				
V1	0.414	0.444	0.882			
V2	0.492	0.588	0.356	0.921		
V3	0.574	0.588	0.514	0.653	0.901	
W	0.584	0.565	0.499	0.614	0.672	0.775

The GOF index is used to empirically verify if the proposed model sufficiently explains the empirical data. There is a standardized approach for the validation of a global path model, in which a value between 0 and 1 is interpreted. For instance, a value of 0.10, 0.25, and 0.36 indicates small, medium, and large GOF, respectively, as a measure for global validation of a path model [19]. This study calculated a GOF value of 0.397 (See Table 5), which shows strong validation of the global path to make a model parsimonious and plausible [20].

Table 6: Goodness-of-Fit (GOF) index

Variable	R^2	Communality	GOF
M1	0.371	0.303	$\sqrt{\overline{Communalities} \times \overline{R^2}} = \sqrt{0.341 \times 0.463} = 0.397$
M2	0.443	0.305	
V1	-	0.303	
V2	-	0.427	
V3	-	0.365	
W	0.575	0.343	
average	0.463	0.341	

4. Conclusion

The findings from this study can provide decision making support for *"Civil Project Managers"* and through the suggested solutions, *"The nature of the project"* and *"Risk management requirements in civil projects"* Provide conditions for successful implementation of development projects. The study results highlight the importance and the extent to which *"Composition and capability of the value engineering team"* and "Team Member Participation" and *"Value engineering workshop job plan"* may impact *"Satisfaction with the value engineering results"* reflection.

One of the important issues in selecting civil project contractors in the construction sector is their safety performance in past work, safety performance in project processes will significantly reduce project risks. Experience modification rate (EMR) can be one of the main criteria for selecting civil contractors in the Civil Project. The value engineering team can take essential steps in project development by enhancing value engineering performance in civil engineering projects by conducting workshops related to Experience modification rate (EMR) analysis and providing new benchmarks to mitigate project implementation risks.

The value engineering team can also use building information modeling as a factor in analyzing ideas put forward in value engineering workshops.

It is also suggested to conduct research on the formation of Iran's National Value Engineering Database in the Civil Project to incorporate value engineering models in Civil Project in Iran, to develop a comprehensive plan for the use of the Urban Development and Renovation Organization with the necessary expertise "value engineering" and "building information modeling".

References

[1] W. Chen, P. Chang and Y. Huang, "Assessing the overall performance of value engineering workshops for construction projects," *International Journal of Project Management,* p. 514–527, 2010.

[2] A. Palmer, J. Kelly and S. Male, "Holistic appraisal of value engineering in construction in United States," *Journal of Construction Engineering and Management,* vol. 122, no. 4, p. 324–328, 1996.

[3] A. Dell'Isola, Value Engineering: Practical Application for Design, Construction, Maintenance, and Operations, RSMeans, 1997.

[4] W. Chen and P. Chang, "Utilization computer to enhance the efficiency of value engineering study," *Journal of Civil and Hydraulic,* vol. 35, no. 1, p. 78–85, 2008.

[5] A. Kazaz, M. Birgonulb and S. Ulubeylia, "Cost-based analysis of quality in developing countries: a case study of building projects," *Building and Environment,* vol. 40, p. 1356–1365, 2005.

[6] J. Turner and R. Muller, "On the nature of the project as a temporary organization," *International Journal of Project Management,* vol. 21, no. 1, pp. 1-8, 2003.

[7] R. Gareis, Happy Projects!, Vienna: Manz, 2005.

[8] J. Sydow, L. Lindkvist and R. DeFillippi, "Project-Based Organizations, Embeddedness and Repositories of Knowledge: Editorial," *Organization Studies,* vol. 25, no. 9, p. 1475–1489, 2004.

[9] M. Huemann, A. Keegan and J. R. Turner, "Human resource management in the project-oriented company: A review," *International Journal of Project Management,* vol. 25, no. 3, p. 315–323, 2007.

[10] R. Yarahmadi and P. Moridi, "Health, Safety and Environmental Risk Assessment in Laboratory Sites," *Journal of Health and Safety at Work,* vol. 2, no. 1, pp. 11-26, 2012.

[11] P. Szymański, "Risk management in construction projects," *Procedia Engineering,* vol. 208, p. 174–182, 2017.

[12] S. Burtonshaw-Gunn, Risk Financial Management in Construction, Gower, 2009.

[13] I. A. Rahman, A. H. Memon and A. T. A. Karim, "Examining Factors Affecting Budget Overrun of Construction Projects Undertaken through Management Procurement Method Using PLS-sem Approach," *Procedia-Social and Behavioral Sciences,* vol. 107, pp. 120-128, 2013.

[14] C. M. Ringle, M. Sarstedt and E. A. Mooi, "Response-Based Segmentation Using Finite Mixture Partial Least Squares Theoretical Foundations and an Application to American Customer Satisfaction Index Data," in *Data Mining*, Annals of Information Systems, 2010, pp. 19-49.

[15] M. Tabatabaee Yazdi, K. Motallebzadeh, H. Ashraf and P. Baghaei, "A latent variable analysis of continuing professional development constructs using PLS-SEM modeling," *Cogent Education,* vol. 4, pp. 1-15, 2017.

[16] S. Hussain, Z. Fangwei, A. F. Siddiqi and Z. Ali, "Structural Equation Model for Evaluating Factors Affecting Quality of Social Infrastructure Projects," *Sustainability,* vol. 10, no. 5, pp. 1-25, 2018.

[17] J. Cohen, Statistical power analysis for the behavioral sciences, New Jersey: Lawrence Erlbaum Associates, 1988.

[18] C. Fornell and D. F. Larcker, "Evaluating Structural Equation Models with Unobservable Variables and Measurement Error," *Journal of Marketing Research,* vol. 18, p. 39–50, 1981.

[19] M. Tenenhaus, V. Vinzi, Y.-M. Chatelin and C. Lauro, "PLS path modeling," *Computational Statistics & Data Analysis,* vol. 48, no. 1, pp. 159-205, 2005.

[20] G. Henseler and P. R. Hubona, "Using PLS path modeling in new technology research: Updated guidelines," *Industrial Management & Data Systems,* vol. 116, no. 1, pp. 1-19, 2016.