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Exploring the value management critical success factors for sustainable residential building – A structural equation modelling approach

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ABSTRACT

Sustainability principles should be implemented during all the phases of the decision-making process of constructing residential buildings to achieve maximum gains without compromising the function of such projects. This study identified and examined the critical success factors (CSFs) required for implementing value management (VM) in residential building projects. With a view to the sustainability of such the projects. The CSFs for VM were identified from previous studies, which were then contextually adjusted using both semi-structured interviews and a pilot study via the Exploratory Factor Analysis (EFA) technique. The EFA results showed that the VM CSFs could be categorized into four constructs: stakeholders and knowledge, culture and environment, workshop dynamics, and standardization. Questionnaires were then administered to 214 building stakeholders within the Egyptian building industry. Partial least square structural equation modelling (PLS-SEM) was used to develop the CSFs model. Despite that Egyptian professionals with limited practice experiences were quite knowledgeable about VM, results showed that stakeholders and knowledge were crucial CSFs for implementing VM. The results of this study will be a guide for

decision-makers to reduce costs and improve sustainability by introducing VMs in the Egyptian construction industry.

Keywords: Value management, sustainability, residential building projects, PLS-SEM, Critical Success Factors, EFA.

1. INTRODUCTION

Residential construction is one of the essential community conditions that describe the healthy quality of life and well-being of residents of any country [1]. Residential buildings consume about forty per cent of global power and generate up to one-third of global Green House Gas emissions GHG emissions in developed and emerging nations [2]. Nevertheless, in an ever-changing and urbanizing world, residential allocation cannot sufficiently meet demand [3]. Consequently, rapid urbanization is impeding the access of low-wage earners to affordable housing in both developing and developed countries[4]. In developing countries, it is estimated that 828 million poor people are living in slums and substandard homes. The speculation is that this figure will rise to 1.4 billion by 2020 [3, 5, 6]. These regions have undergone rapid development, which clearly highlights the key role of the residential building in ensuring simple living [7]. As a result, all governments have prioritized the affordable residential building by initiating several affordable residential policies [1]. Nevertheless, there is a controversy about whether residential buildings are affordable for low-income earners [3].

In the context of low salaries, high unemployment rate and sustainability threats, Egypt is considered a high-risk market [8]. The risk is affected by sharp changes in the currency (instability), lack of knowledge on business decisions and restrictions on investment models [9]. It has been experiencing a rapid growth in population since 1950, and is now the most populated country in North Africa[10]. As a result, the lack of adequate and suitable residential building projects is one of the major challenges facing policymakers in Egypt [11].

The need for constructing "sustainable buildings" that are environmentally friendly and resource-efficient has been highlighted in the literature [12]. Wolstenholme et al. [13] further advocate revolutionizing the building field through adopting effective and sustainable building practices. Furthermore, building professionals cannot measure the environmental influences of buildings as they accrue through construction [14]. Therefore, value management (VM) can be combined with the sustainability method at the preliminary and design phases of a project [15, 16]. SAVE [17] confirms that VM is a tool recommended to enhance the sustainability value of a project. It is also represented as the key source of building sustainability [18]. VM is historically seen as a structured and analytical technique designed to accomplish value for money by delivering the required functions at the lowest cost, in line with the quality and functionality needed [19]. However, current views suggest a higher position for VM in defining, describing and supporting customer preferences and objectives early in the procurement phase [20]. VM can improve the sustainability of the construction sector by promoting strategies that seek to lower the costs of building, as the government is a major customer in building projects [21] .This is also in agreement with the suggestion of Tanko et al. [22], who describe the functions of VM to include improving sustainability and performance, while minimizing wastes in the execution of projects.

Despite the fact that VM has become a common tool for solving construction issues in several developed nations, it is yet to receive a similar attention in most developing nations, including Egypt [12, 23]. However, VM is gradually being adopted in developing countries, including Egypt [24, 25]. Concerted efforts towards examining the procedures for implementing VM in Egyptian residential building projects are still lacking [26]. This gap has also been highlighted by Abdelghany et al. [27]. He reported that standard VM implementation is unachievable in Egypt. In addition, recent studies confirm that most building professionals do not adopt VM in their projects [12, 25]. This encourages ad-hoc methods, such as uncoordinated teamwork, that do not reduce building costs. It is important to implement the VM standard in the Egyptian building industry because sustainable environmental policies and various standards and measures have suffered from stagnation since the year two thousand and eleven [28]. Furthermore, the Egyptian government is aiming to make Egypt one of the world's top thirty nations by 2030 [29]. Therefore, there is a need to incorporate VM in Egyptian residential building projects [30].

Based on our arguments, we set out the following research question for this empirical study. What are the requirements needed to implement VM in Egyptian residential building projects? Therefore, there is a need to examine these requirements, which can be achieved by defining the critical success factors (CSFs) of VM[31]. Rockart [32] identifies CSFs as "areas where, if satisfactory, the results will ensure the organization's competitive success." Similarly, Chan et al. [33] and Yu et al. [34] agree that CSFs may be considered as critical management preparation and action fields for ensuring success [35].

Furthermore, the CSFs of VM present active customer support and participation [31] through decision-makers [36]. One of the first initiators of research in this topic is Romani [37]. Nonetheless, Shen and Liu [38] are credited with identifying CSFs by contrasting unique practices in Hong Kong, USA and UK. Despite these modest efforts, there are no data available with regards to the Egyptian construction industry.

Consequently, this research responds to recommendations from some earlier studies on the need to further investigate VMs in developing countries [39]. Thus, this study aims to identify the CSFs of VM using causal inference techniques, such as structural equation modeling (SEM), in order to develop the requirements for implementing VM and achieving sustainability in residential building.

2. CRITICAL SUCCESS FACTORS FOR IMPLEMENTING VM

Accurate tools and methods are required for achieving the goal of increasing the value derived from building projects. VM is an approach that involves the use of strategies that offer an incentive to obtain an increased value for money. Requisite knowledge and awareness of the VM methodology, such as life-cycle costing, innovative thought and the Function Analysis System Technique (FAST) diagram, are important to achieve the objective of the VM [40]. Perera and Karunasena [41], in their analysis of the implementation of VM in the Sri Lankan construction industry, reveal that the usage of VM is comparatively poor compared with developed countries. This has been attributed to the lack of VM knowledge and awareness. In addition, owners are key participants in the execution of construction projects. Thus, their involvement in the application of VM in their project cannot be overemphasized. To encourage the adoption and application of VM in developing countries, VM training is highly crucial [42]. This training is expected to be thorough and must include all the procedures required for applying VM.

Oke and Aigbavboa [42] further propose that this practice must be incorporated as part of the roles and skills expected of the technical participants within the construction industry. This will facilitate a rapid adoption of VM in the construction sector. Similarly, Olawumi et al. [43] argue that VM training is vital for its adoption among construction professionals. Training modality may also include engaging VM specialists from developed nations to provide all VM tools and techniques. Training of construction professionals on VM will minimize the shortage of VM experts in the construction industry [23].

Malla [44] also suggest that offering remuneration for VM study participants may encourage the implementation of VM in construction projects. Perera and Karunasena [41] argue that the division among professionals in the construction industry is an evident obstacle to the extensive adoption of VM in Sri Lanka. This indicates that the cooperation of all construction partners is a key factor in overcoming this hurdle. Conventional construction procurement approach does not support a strong alliance between construction professionals. Hayatu [45] recognizes this and proposes that cooperation among these professionals to adopt VMs can aid working connection and minimize unprincipled actions between stakeholders.

VM organizations are known to promote collective procurement opportunities that synergize the priorities of multiple construction partners to achieve value for clients' capital. Oke and Aigbavboa [42] have shown that proper education on VM not only benefits indigenous construction practitioners, but also promotes its mass application. Hayatu [45] also argues that awareness of VM among project owners will encourage its wider adoption in construction projects. He also submits that the influence of the government in implementing new policies and regulations, such as VM, cannot be overlooked. To this end, the efforts of the US government and its parastatals are helping to increase the implementation of VM throughout the US construction sector. Ahmad [46] also highlights the efforts of the Malaysian government by stipulating a compulsory VM approval provision for all government construction projects. Similar

VM approval provisions are required when executing building projects for the U.S. and Australian governments Yue [47]. Government interventions have promoted the widespread use of VM among building stakeholders.

Perera and Karunasena [41] note that the lack of cooperation from owners of projects constitutes a major problem inhibiting the adoption of VM. Thus, the participation and dedication of the client are important for improving the implementation of VM. . Likewise, policymakers of construction entities should be willing to incorporate this activity as part of their corporate culture. Abd-Karim [48], in his analysis on the implementation of VM in the private sector in Malaysia, highlights that the adoption and implementation of VM must not be limited to some selected clusters of individuals. Rather, the help of the whole community of building professionals must be enlisted.

Some studies indicate that one potential way to enhance the efficiency of VM study is to use information technology. This submission is in consonance with the arguments of Coetzee [49] on the use of an electronic VM exercise for improving the teaching of VM in the South African building industry. Coetzee [49] describes this method as using technological innovations, such as video conferencing, which differs drastically from the workshop organized by the usual physical team. The VM team works on the internet and uses new technologies for their exercise. This is also supported by an earlier study by Fan et al. [50].

Several CSFs of VM have been identified in the literature. For instance, Aghimien et al. [51] observe seven perceived CSFs of VM. These include government’s interest in VM adoption, preparation, engagement and involvement of the client, and public knowledge on the benefits of VM. Others are having a solid understanding of VM techniques, use of electronic VM study strategy and development of a value-added group support system. However, Shen and Liu [38] list 23 CSFs in a systematic literature review on CSFs of VM studies in the construction industry. With the aid of questionnaire surveys, these CSFs are rated and graded into 15 variables, which are considered to be crucial to the performance of VM studies. Client assistance and active engagement are ranked as the most important factors. Next in importance is providing a specific goal for the VM analysis. Multidisciplinary teams are classified as the third most important element, while a trained VM facilitator is in the fourth rank. The VM CSFs obtained from current literature are presented in Table 1.

Table 1: CSFs of VM in the construction industry

VM CSFs	Item code	Item Name	Studies
Stakeholders / Knowledge	SF.SK1	Multidisciplinary VM team	[31, 36, 38]
	SF.SK2	Competence of VM facilitator	[31, 36, 52-54]
	SF.SK3	Efficient contact between participants	[55, 56]
	SF.SK4	Ability to conduct VM workshop	[57]
	SF.SK5	Awareness and experience of VM participants	[31, 36, 38]
	SF.SK6	The commitment of all stakeholders to VM workshop	[38, 55]
	SF.SK7	Technical understanding and experience in the respective fields of the participant	[38]
	SF.SK8	Willingness to accept changes and innovations	[38]
	SF.SK9	Clear definition and scope of different professionals	[55]
	SF.SK10	End-user participation	[31]
	SF.SK11	Ability and personality of participants	[38]
	SF.SK12	Collaboration and outstanding working relationship between participants and agencies	[38, 53, 56]
	SF.SK13	Discipline and attitude of the participants	[31]
Culture/ environment	SF.CE1	Clear and defined objective of VM workshop from participants	[31, 56]
	SF.CE2	Decision-making authority granted to participants by their organization	[31]
	SF.CE3	Establishing and clarifying clients value system	[58]
	SF.CE4	Motivating VM team members to produce VM output	Interview
Workshop dynamics	SF.WD1	A proactive, creative and structured approach	[36, 38]
	SF.WD2	Analysis of project elements and functions	[38]
	SF.WD3	VM feedback mechanism	[57]
	SF.WD4	Customer understanding of the performance optimization function of VM	[57]
	SF.WD5	The input of the original design team	[54]
	SF.WD6	Adequate timing of VM workshop	[38]
	SF.WD7	Background information collected	[31]
	SF.WD8	Orientation meeting	[56, 59]
	SF.WD9	Creatively motivating brainstorming approach	Interview
	SF. WD10	Using new technological tools to speed up creativity and evaluation	Interview
	SF. WD11	VM workshop intervention into the project development cycle	[31]
Standardisation	SF.ST1	Active participation and support of clients	[31, 38, 56] [36]
	SF.ST2	Input from the relevant governmental and local authorities	[52]
	SF.ST3	Regular attendance of decision-maker	[36]
	SF.ST4	VM study plan for implementation	[36, 38, 52]
	SF.ST5	Government commitment to implement VM	[23]
	SF.ST6	Client's enforcement ability to communicate requirements to design team	[38]

3. RESEARCH METHOD AND MODEL DEVELOPMENT

From the review of the literature on CSFs of VM, as shown in Figure 1, a set of 31 CSFs were developed and considered suitable for implementing VM. The qualitative approach, which consisted of 15 semi-structured interviews, was then used to review and modify the factors selected from the previous studies.

A pilot study (Questionnaire I) was then carried out by sending a list of CSFs of VM to residential building professionals with relevant industrial experience. It was done to check the completeness and clarity of the CSFs of VM in combination with the study of these variables and their categories via the Exploratory Factor Analysis (EFA) analysis. As a result, three new factors were added from the experts interviewed making a total of 34 CSFs of VM, as shown in Table 1 for the main survey (Questionnaire II).

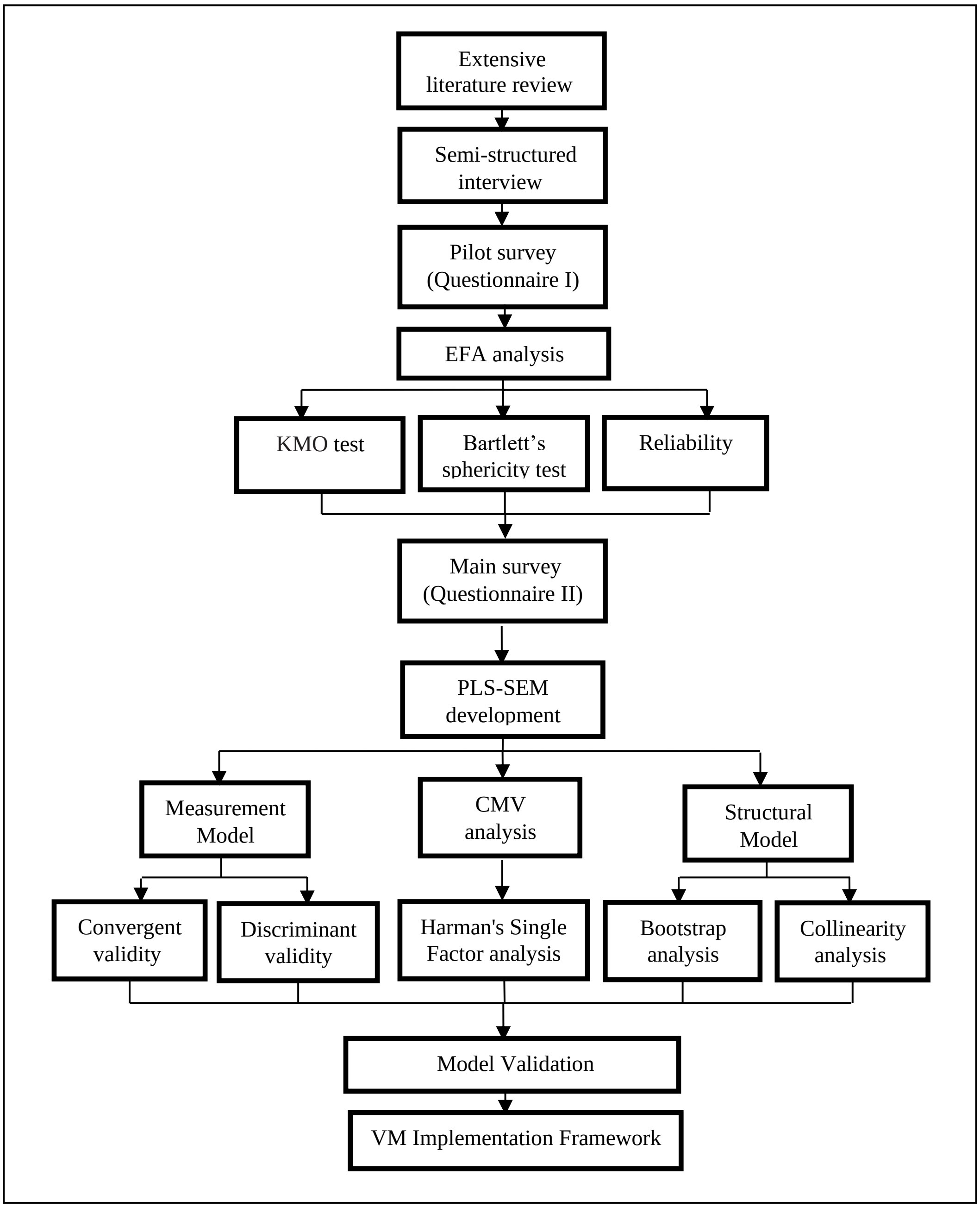

Figure 1: Research design

3.1 MODEL DEVELOPMENT

Partial least square structural equation modelling (PLS-SEM) has attracted massive attention across several fields, particularly business research and social sciences [60]. Various researches that focused on the PLS-SEM approach have recently been published in popular SSCI journals [61-63]. SMART-PLS 3.2.7 the newest software edition, was employed to evaluate the collected data in order to model the priority of the CSFs of VM using SEM. PLS-SEM was initially recognized for its outstanding forecasting purposes over covariance-based structural equation modeling (CB-SEM) [64] although the differences between the two strategies are comparatively slight [65]. The statistical analysis performed in this study comprised the measurement and structural model evaluation technique.

3.1.1Common method variance

Common method bias (CMB) was derived from the common methods variance (CMV). CMB helps to explain the discrepancy (or error) in the outcome of an analysis, which is attributable to the measurement method instead of the constructs represented by the measures [66]. CMV could also be described as a variance overlap that could be attributed not just to constructs but also to the types of measurement instrument used [66]. CMV is particularly troublesome whenever data, like a self-administered questionnaire, is acquired from a specific source [67, 68]. In certain circumstances, the self-report data can inflate or prevent the extent of investigated connections and thus trigger issues [68, 69]. This may be important, especially for this study, given that all data is self-reported, subjective, and obtained from a single source. Therefore, it is crucial to address these problems in order to detect any common method variations. A formal systematic one-factor test, as reported in Harman's experiment (1976), was carried out [70]. A single factor emerged from the factor analysis, which accounted for the majority of the variance [68].

3.1.2 Measurement model

The measurement model reveals the current relationship between the objects and their underlying latent structure [71]. The following subsections carefully addressed the convergent and discriminant validity of the measurement model.

3.1.2.1 Convergent validity

Convergent validity represents the degree of agreement among two or more measurements (CSFs) of the same construct (group) [72]. It is known to be a subset of the validity of the construct. In the case of PLS, the convergent validity of the calculated constructs could be determined using three tests [73]: cronbach's alpha (α), composite reliability scores (ρ_c) and average variance extracted (AVE). Nunnally and Bernstein [74] suggested a ρ_c value of 0.7 as the threshold of 'modest' reliability of the composite. For any type of research, values above 0.70 and above 0.60 for exploratory research were acceptable [75]. Finally the last test was AVE. It is a standard measure conducted to assess the convergent validity of constructs in a model, with values larger than 0.50 indicating an appropriate convergent validity [75].

3.1.1.2 Discriminant validity

Discriminant validity indicates that the phenomena being evaluated is empirically unique and suggests that any measurements do not identify the phenomenon being examined in SEM [76]. Campbell and Fiske [77] claimed that the similarity among measures varied from one another should not be too high for discriminatory validity to be established.

3.1.1.3 Structural model analysis

The aim of this study was to model the priority of the CSFs of VM using SEM. For this to happen, the path coefficients between observed coefficients should be identified. In this case, as shown in Figure 6, a one-way causal relationship (path relation) was hypothesized between £ (CSFs of VM constructs) and μ (CSFs of VM implementation). Here, the structural relationship between £, μ and €1 formula in the structural model, which was recognized as the inner relation could be illustrated as a linear equation as follows [78]:

$$\mu = \beta \text{£} + \text{€}1 \qquad (1)$$

where (β) is the path coefficient linking CSFs of VM constructs and the residual variance at this structural level is supposed to reside in (€1). Here, β is the standardized regression weight, identical to the β weight of a multiple regression model. Its sign should agree to what the model forecasts and be statistically important. The matter now is how to establish the significance of the path coefficient, β. As with CFA, a bootstrapping technique available in the SmartPLS3.2.7 software was employed to evaluate the standard errors of the path coefficients. This was done with 5000 subsamples grounded on a suggestion made by Henseler et al. [60], which in turn defined the *t*-statistics for proposition testing. A total of four structural equations for VM CSFs constructs were formed for the PLS Model, representing the inner relations between the constructs and Equation. 1.

3.2 PLS-SEM MODEL VALIDATION

The model developed during the study was validated using the questionnaire survey method. All concerned parties (contractors, clients, and consultants) were informed that they would be included in the validation process. This validation aimed to investigate and discuss different scientific issues that were related to the principle of VM implementation. Hence, VM could be deployed for possible use and acceptance in the field of residential building projects. The parameters used to discuss the model validity included: specificity, logical structure, consistency, efficiency, suitability, comprehensiveness, relevance, practicality, applicability, etc. Leye et al. [79] agreed that the validation process was meant to track the domain model and to address the user's purpose. To assess VM's application parameters [80, 81], twenty-three experts were invited to evaluate the model's findings . In this study, six questions were planned to assess the validity adopted from previous studies [80, 82]. The six questions for the results' validation are summarized as follows:

Q1. Are the CSFs for the implementation of VM as proposed in this study applicable?

Q2. Is the VM implementation model reasonable for identifying the critical factors for implementing VM as proposed in this study?

Q3. Is the causality between the essential CSFs for VM implementation in this study clear to understand and adopt?

Q4. Is the underlying CSFs reasonable regarding VM implementation as obtained in this study?

Q5. Are the evaluation results presented in this study reasonable?

Q6. Can the structural models developed in this study be generalized?

All the above validation questions were based on a five-point rating system, namely: 5 = fully agreed with good results; 4 = almost fully agreed with good results; 3 = partially agreed with acceptable results; 2 = disagreed with poor results; and1 = disagreed with very poor results.

4. DATA COLLECTION AND CASE STUDY

4.1 Semi-structured interviews

Drawing upon the approach suggested by Sanders [83] and Hesse-Biber [84], ten interviews were considered to be appropriate for this form of study. Therefore, fifteen experts were selected on three levels: years of experience, level of education and position through a "purposive sampling" approach. This strategy helped investigators to accomplish research goals following the regulation of the degree of difference between interviewees [85].

Considering the various positions of the building professionals in residential building projects, those interviewed testified to the commitment of the different organizations to the study. Besides, a fair representation of entities was given for a variety of construction activities. It should be remembered that this analysis used a new method among mainstream researchers, known as the abductive approach [86]. This approach uses prior research to provide a theoretical foundation for improving the methods for inquiry and analysis [87]. In the current study, the previous studies were used to create the theoretical structures (CSFs of VM). Besides generating new theories, this approach used the organizational standards needed to test the existing concepts. Subsequent interviews enriched and expanded the process. This study thus used the abduction approach to re-examine and explore the facts, as well as the existing CSFs constructs in a local context.

Consequently, the experts interviewed agreed that a more formal VM adoption strategy should be provided to guide the adoption of VM in projects. They categorized the CSFs of VM into 4 categories, as shown in Table 1. Also, several CSFs were modified, and 3 factors were inserted to the list, as shown in Table 1. The modified and inserted CSFs were used for the development of a pilot study questionnaire.

4.2 Pilot study (Questionnaire I)

A pilot study was conducted via an exploratory factor analysis (EFA) to explore the groups mentioned above (constructions) by sending 200 questionnaires to the Egyptian residential building professionals. The number of participants was within an appropriate range and could be used as a representative sample [88]. The EFA results confirmed the categorization of all CSFs, as shown in Table 1.

4.3 Main survey (Questionnaire II)

According to the preliminary interviews and the EFA assessment (Questionnaire I), appropriate changes and categorization of the CSF classes were made to generate the main survey (Questionnaire II). In order to examine the CSFs of VM, a wider range of potential residential building sector participants were approached for Questionnaire II assets inthe cities of Cairo and Giza in Egypt. This survey was drawn up in 3 main parts: the demographic profile of the respondent, the CSFs of VM (Table 1), and the open-ended questions (to add any CSFs that the participants considered essential to be identified).

Three key groups were contacted: contractors, consultants and clients. They could be further subdivided by profession/occupation as follows: architects, electrical engineers, quantity surveyors, structural and mechanical engineers. Respondents assessed CSFs of VM on an information and experience basis using the Likert 5-point scale, where 5 was extremely high, 4 high, 3 average, 2 small and 1 no or very small. This scale was used in some previous VM studies [89-94]. As VM is moderately recent in Egypt, stratified sampling of the particular subpopulation was considered [29].

Over 280 entities were assessed in the screening study, but only 215 entities contributed to the study. Moreover, the sample size that was used in this study was based on the methodological purpose analysis [95]. Kline [96] opined that a very complex path model needed 200 or bigger sample sizes, while Yin [97] suggested that the sample size should be greater than 100for SEM. Since this study used the SEM approach, a total of 226 participants out of 335 individuals were approached in-person (self-administrated), which translated to a response rate of about 68%. This level of return was considered to be appropriate for this type of study [98, 99]. The high response rate was due to the individual approach and the long time allotted (150 days) for data collection. There were 214 good responses (12 were considered incomplete and discarded).

4.4 Model validation survey

All respondents were either highly qualified in the building industry or possessed a reasonable level of education. They all had more than a decade of experience in building projects. Their assessment of the research results was considered accurate, and the feedback received helped to improve the effectiveness and accuracy of the study findings. All respondents were given a one-week timeframe to review the findings of the analysis and answer the validity survey questionnaire.

As shown in Table 2, the stakeholders included were contractors, clients, and consultants. However, stratified sampling method was applied for these sets of respondents. Before the completion of the questionnaires, the models were analyzed by each of the respondents. Each of them reviewed the factors considered, the relationship between the variables, and the objectives of each of them when validating the models.

Ghashat [100] argued that the validity calculation should be based on the respondents' content and not their numbers. The validation survey included twenty-eight (28) respondents. Five (5) respondents' answers were omitted from the study's final consideration as these respondents did not complete the questionnaires. Twenty (23) stakeholders were finally considered for subsequent review due to this finding, and their details are given in Table 2. It is vital to observe that these respondents were invited according to the following selection criteria: (1) non-participation in the development of the research models, i.e., no participation in the interviews and preceding stages of the questionnaire of this study; (2) strong experience in the development and implementation of VM; (3) a comprehensive understanding of the sequences of building work, for at least ten years [80, 82]. It should be noticed that respondents were similarly split into a variety of groups. In comparison, all of the occupations identified were well represented, and the respondents were from both study areas(Cairo and Giza).

Table 2: Profiles of the respondents for model validation

Factors	**Variables**	**Frequency**	**Per cent**
Type of respondents	Consultants	6	26.32
	Clients	9	36.84
	Contractors	8	26.32
		Total of 23	100%
Profession of respondents	Quantity surveying	6	26.0
	Architect	5	21.7
	Civil engineer	5	21.7
	Electrical	3	13
	Construction Manager	4	17.3
State of location	Cairo	13	56.5
	Giza	10	43.5

5. DATA ANALYSIS AND RESULTS

5.1 Exploratory factor analysis (Questionnaire I)

The factorability structure of 34 items related to CSFs of VM has been determined through an exploratory factor analysis (EFA) technique. Numerous well-known factorability parameters have been used for connection. Kaiser-Meyer-Olkin (KMO) is a factor homogeneity measurement and is commonly used to check that the partial correlations among variables are minimum [101]. The KMO index ranges from 0 to 1, with a minimum value of 0.6 assigned to a successful factor analysis [88]. The Bartlett sphericity test also indicates that the matrix for the association is the identity matrix, where $p < 0.05$ is significant [102, 103]. Initially, the KMO sampling adequacy measure is 0.868, above the recommended value of 0.6, and Bartlett's sphericity test is found to be significant [χ^2 (561) = 3994.889, $p < 0.05$].

The anti-image correlation matrix diagonals are all over 0.5, suggesting the validity of inclusion of each variable in the factor analysis. Initial communities are estimates of variance for each variable taken into account by all factors. Small values (< 0.3) suggest variables that do not match well with the factor solution. For this analysis, all the initial communities are above the threshold. All loading factors are more significant than 0.5. The results from the EFA analysis on all 34 items have been used to extract six factors with eigenvalues greater than 1. The eigenvalues and total variance stated by the six factors are 69.595%, as shown in Table 3.

Table 3: Factor loadings of CSFs of VM

	Component loading					
Code	1	2	3	4	5	6
SF.WD5	0.826	-	-	-	-	-
SF.WD7	0.79	-	-	-	-	-
SF. WD10	0.737	-	-	-	-	-
SF.WD6	0.725	-	-	-	-	-
SF.WD1	0.683	-	-	-	-	-
SF.WD2	0.654	-	-	-	-	-
SF. WD11	0.651	-	-	-	-	-
SF.WD8	0.558	-	-	-	-	-
SF.WD3	0.554	-	-	-	-	-
SF.WD9*	0.526	-	-	-	-	0.506
SF.SK5	-	0.850	-	-	-	-
SF.SK7	-	0.741	-	-	-	-
SF.SK6	-	0.720	-	-	-	-
SF.SK8	-	0.712	-	-	-	-
SF.SK1	-	0.636	-	-	-	-
SF.SK11	-	0.615	-	-	-	-
SF.SK4	-	0.606	-	-	-	-
SF.SK13	-	0.603	-	-	-	-
SF.SK2	-	0.600	-	-	-	-
SF.SK10	-	0.526	-	-	-	-
SF.SK9	-	0.505	-	-	-	-
SF.SK12*	-	0.493	0.480	-	-	-
SF.ST1	-	-	0.745	-	-	-
SF.ST5	-	-	0.727	-	-	-
SF.ST3	-	-	0.727	-	-	-
SF.ST6	-	-	0.725	-	-	-
SF.ST2	-	-	0.717	-	-	-
SF.ST4	-	-	0.685	-	-	-
SF.CE3	-	-	-	0.817	-	-
SF.CE1	-	-	-	0.797	-	-
SF.CE2	-	-	-	0.725	-	-
SF.CE4	-	-	-	0.595	-	-
SF.SK3*	-	0.510	-		0.610	-
SF.WD4*	0.509	-	-	-	-	-
Eigenvalues	6.16	5.768	5.155	3.222	1.711	1.646
% of Variance	18.119	16.963	15.162	9.476	5.034	4.842

** These items were excluded due to cross-loading*

As shown in Table 2, the last two components include only two single items (SF.SK3and SF.WD4) that originally belong to other components. In addition to these two items, three other items, including SF.WD9 and SF.SK12, which are cross-loaded into two components, have also been excluded from the main analysis. Pallant [103] therefore suggested that the screen plot and its matrix must be examined and objectively evaluated in order to test the groups (factors) to be extracted/determined. Examination of the screen plot shows a shift (or elbow) in the plot shape, therefore, only the sections above this level are retained. Figure 2 indicates the six aspects that are extracted.

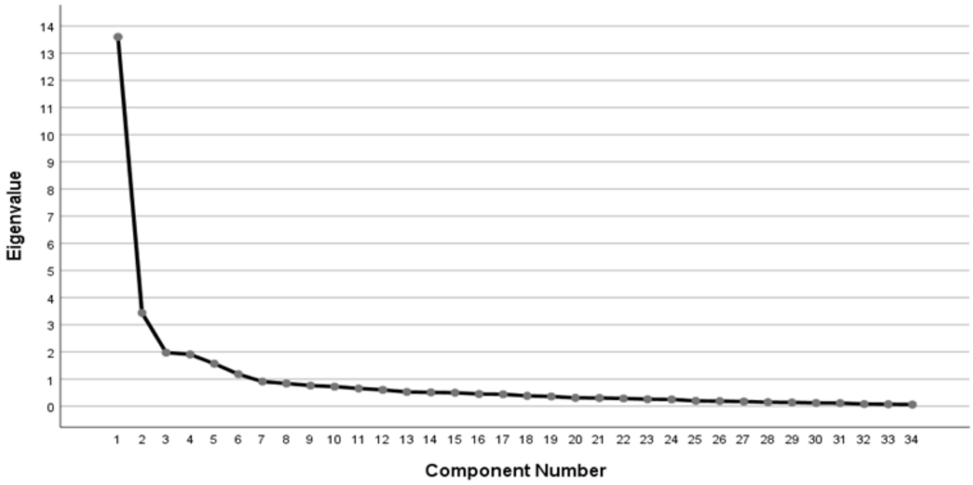

Figure 2. Screen plot result for success factors of VM.

Reliability statistics are developed for the factors derived via the EFA. Variables for each phase of the factor have been determined based on the highest loading of each variable in the structure matrix. According to Nunnally [104], the alpha value of Cronbach greater than 0.6 is appropriate for newly formed measurements. Conversely, when the normal value is 0.7, those over 0.75 are regarded as highly accurate. Therefore, the results of the alpha Cronbach values are appropriate because they are above 0.6. The set average correlations of the items are higher than 0.3 for all the objects, suggesting consistent internal variables [105].

5.2 PLS-SEM model analysis (Questionnaire II)

5.2.1 Status of VM implementation

Respondents are classified according to their years of experience, expertise, and organizational role. Figure 3 shows that respondents with 1 – 5 years, 5 – 10 years, 15 – 20 years and over 20 years of employment are roughly 7.5%, 21% and 26.2% and 13%, respectively. The largest participating classes have 10 – 15 years of experience.

These results reflect the respondents' high skills and experience. Besides, the highest number of participants are drawn from contractors (39.3%), followed by clients/developers (31.8%). The result illustrates that most of the respondents are aware of the survey. Furthermore, about 68% of respondents are aware of the VM concepts, which is an acceptable level of knowledge among stakeholders.

As shown in Figure 3, the respondents have different views on VM. The results show that 47.7% of respondents perceive VM as a concept, 47.6% as a technique, while only 4.7% view VM as a profession. This finding shows that about 95% of respondents view VM as either a strategy or a concept. At the same time, the results also show that the majority of the respondents have neither attended a single VM workshop (86%) nor received some sort of VM training (85%).

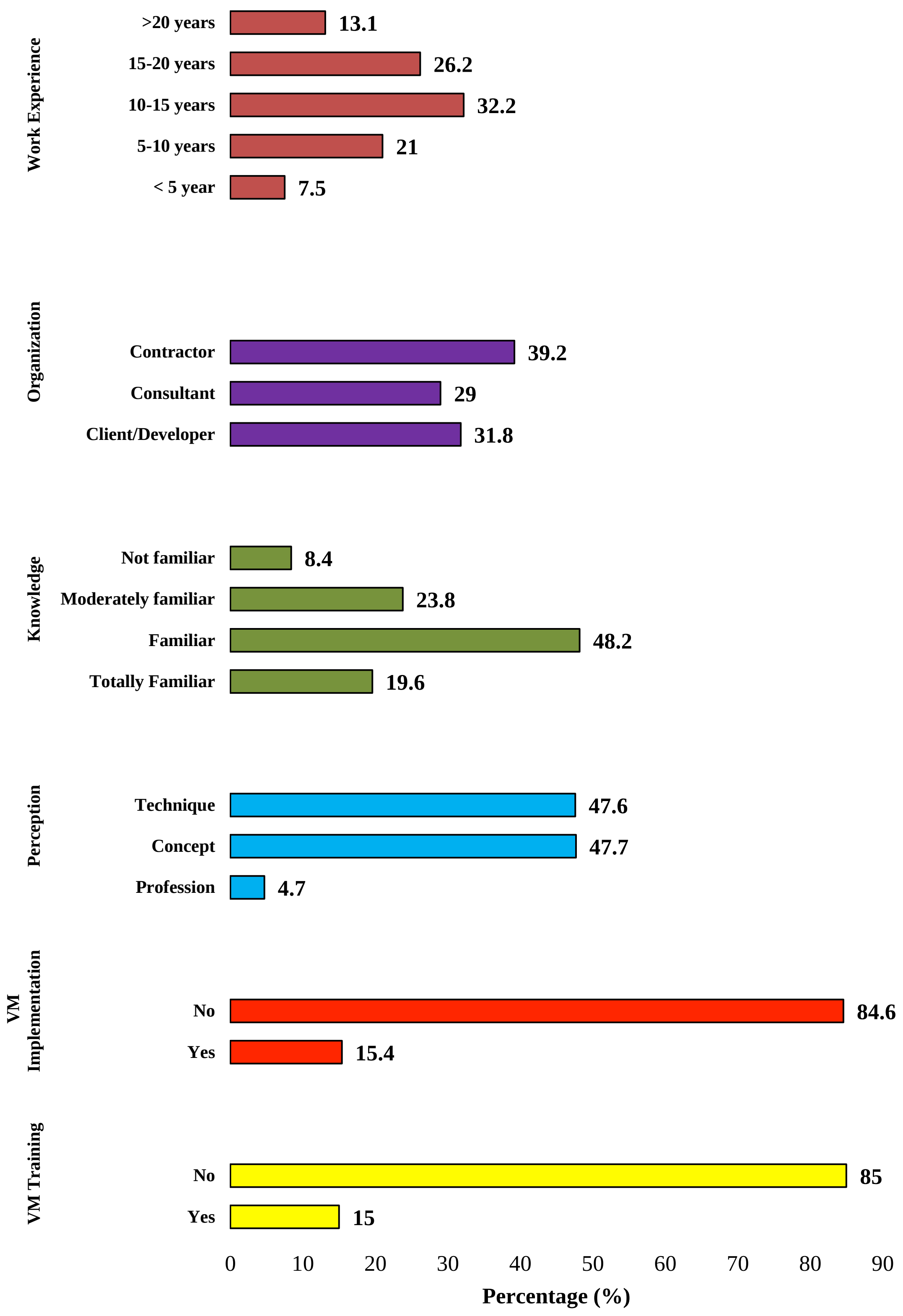

Figure 3. Demographic analysis of the characteristics of participants

5.2.2 Common method bias

Common method bias is a measurement of error (variance) that affects the validity of a study. This represents a systematic error variance associated with the measured and estimated variables [106]. This can be measured by Harman's single factor assessment of models that indicates various structure measurements [70]. The single-factor test has been used in this study to measure the variance of the standard method [107]. If the factors' total variance is less than 50%, then the common method bias does not affect the data [70]. As shown in Table 4, the first set of factors represents 32.75 % of the total variance, which indicates that the common method variance is impossible to influence the results since it is less than 50% [70].

Table 5 Result of common-method variance

Extracted sums of squared loadings		
Total	**% of Variance**	**Cumulative %**
11.13	32.75	32.75

5.2.3 Measurement model

The evaluation of reflective measurement models (CSFs) in PLS-SEM compels the assessment of internal reliability, convergent validity and discriminatory validity. Once the reliability and validity of the measurement model have been founded, the structural model will be evaluated [108]. As illustrated in Table 5, all constructs in the model meet the threshold of α and ρ_c > 0.70 and therefore, are acceptable [109].

Table 5: The result of convergent validity

Constructs	Items	Outer loading		Cronbach's Alpha	Composite Reliability	AVE
		Initial	Modified			
Culture /environment	SF.CE1	0.837	0.837	0.905	0.934	0.779
	SF.CE2	0.873	0.873			
	SF.CE3	0.910	0.911			
	SF.CE4	0.908	0.908			
Stakeholders/ knowledge	SF.SK1	**0.278**	**deleted**	0.934	0.946	0.686
	SF.SK10	0.734	0.749			
	SF.SK11	0.860	0.864			
	SF.SK13	0.860	0.873			
	SF.SK2	0.806	0.814			
	SF.SK4	0.848	0.865			
	SF.SK5	**0.308**	**deleted**			
	SF.SK6	0.840	0.862			
	SF.SK7	**0.341**	**deleted**			
	SF.SK8	0.78	0.792			
	SF.SK9	0.797	0.798			
Standardization	SF.ST1	0.810	0.810	0.884	0.911	0.633
	SF.ST2	0.840	0.839			
	SF.ST3	0.839	0.837			
	SF.ST4	0.859	0.859			
	SF.ST5	0.717	0.719			
	SF.ST6	0.694	0.697			
Workshop dynamics	SF.WD1	0.834	0.848	0.935	0.946	0.660
	SF. WD10	0.814	0.804			
	SF. WD11	0.834	0.827			
	SF.WD2	0.851	0.854			
	SF.WD3	0.772	0.757			
	SF.WD5	0.846	0.857			
	SF.WD6	0.783	0.798			
	SF.WD7	0.735	0.745			
	SF.WD8	0.815	0.813			

Besides, findings in Table 4 indicate that all constructs have passed the AVE test. The AVE’s acceptable level should be higher than 0.5 [73]. The estimates of the AVE values (Table 5), using PLS algorithm 3.0, of all the constructs in this study,, are over 50%. These findings show that the measurement model is convergent and consistent internally. This indicates that the measurement elements are well measured for each construct (group) and do not measure any other construct within the research model. High outer loads on a construct indicate that there is a close relationship between the relevant items for each construct.

The rule of thumb is that items with very low outer loadings (below 0.4) must frequently be removed from the scale [65]. Table 5 presents the outer loadings of the initial and adjusted measurement models for all items. As a result, all outer loads, except for three "SF.SK1," "F.SK5" and "SF.SK7" items, have been omitted from the initial measurement model. This omission is due to a low loading factor of less than 0.5, and indicates their low contribution to the relevant constructs.

5.2.3.1 Discriminant validity

The square root of the AVEs (Table 5) surpassed their correlations with all other constructs, suggesting that there is no association between either of the two constructs. Besides, the values indicate that each predictor obtains the highest loading (Table 6) on the corresponding construct. Eventually, an excellent degree of unidimensionality for each construction can be assured.

Table 6: Cross loadings of measured items.

Items	Culture and environment	Stakeholders and knowledge	Standardization	Workshop dynamics
SF.CE1	**0.84**	0.25	0.22	0.21
SF.CE2	**0.87**	0.31	0.17	0.30
SF.CE3	**0.91**	0.30	0.14	0.23
SF.CE4	**0.91**	0.34	0.20	0.27
SF.SK10	0.22	**0.75**	0.15	0.16
SF.SK11	0.33	**0.86**	0.19	0.21
SF.SK13	0.32	**0.87**	0.20	0.18
SF.SK2	0.30	**0.81**	0.16	0.17
SF.SK4	0.25	**0.87**	0.12	0.14
SF.SK6	0.34	**0.86**	0.13	0.18
SF.SK8	0.22	**0.79**	0.22	0.17
SF.SK9	0.28	**0.80**	0.13	0.14
SF.ST1	0.17	0.18	**0.81**	0.32
SF.ST2	0.19	0.15	**0.84**	0.30
SF.ST3	0.10	0.17	**0.84**	0.27
SF.ST4	0.22	0.21	**0.86**	0.33
SF.ST5	0.18	0.12	**0.72**	0.22
SF.ST6	0.09	0.07	**0.70**	0.12
SF.WD1	0.21	0.23	0.23	**0.85**
SF. WD10	0.13	0.15	0.28	**0.80**
SF. WD11	0.24	0.17	0.39	**0.83**
SF.WD2	0.31	0.20	0.30	**0.85**
SF.WD3	0.33	0.07	0.33	**0.76**
SF.WD5	0.27	0.18	0.32	**0.86**
SF.WD6	0.21	0.09	0.20	**0.80**
SF.WD7	0.19	0.25	0.15	**0.75**
SF.WD8	0.22	0.13	0.27	**0.81**

5.2.2.2 Path model validation

Once the CSFs of VM have been determined to be a formative construct, we further explore the collinearity among the construct's formative objects by evaluating the value of the variable inflation factor (VIF). All VIF values are well below 3.5, implying that these subdomains contribute independently to the higher-order constructs. Furthermore, a bootstrapping tool is used to predict the significance of the path coefficients. Figure 5 illustrates that all paths are statistically significant at the 0.01 level [72].

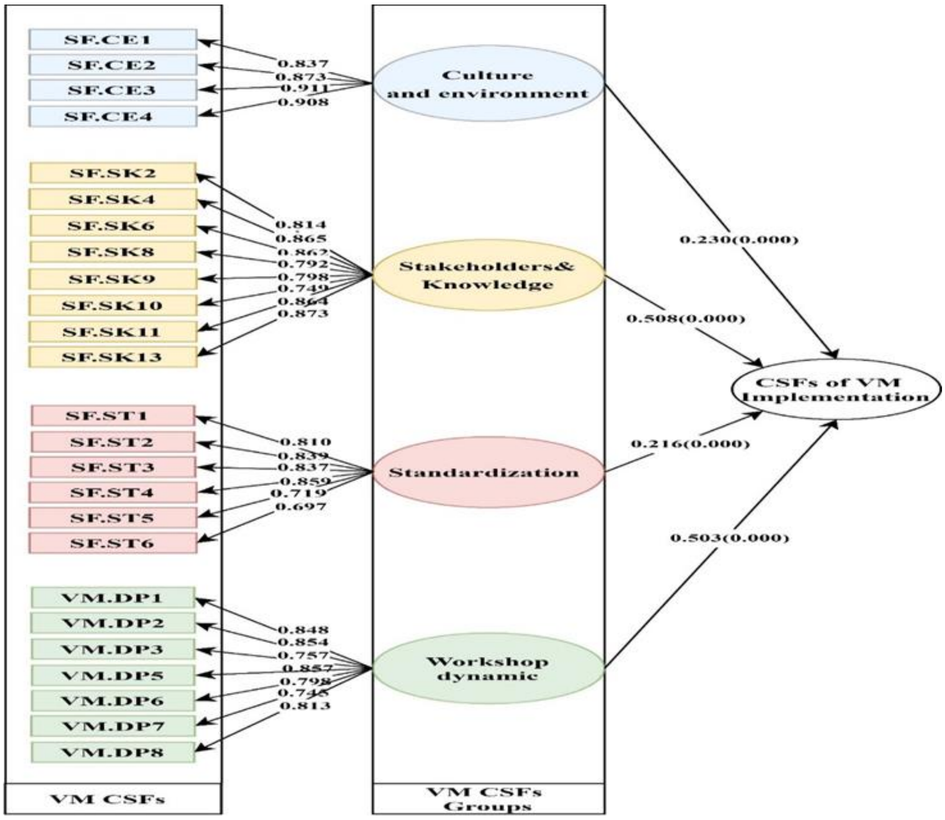

Figure 5. The PLS-SEM structural model (β and outer loading values shown on arrows)

5.3 Model validation analysis

Following the development of the statistical model, an expert's validation has been performed to evaluate the requirements for VM implementation resulting from the proposed model. Table 7 illustrates the results of the proposed six validation questions. The mean scores of the questions indicate that the proposed critical factors and essential elements for VM implementation are applicable in this study.

Table 7: The validation results of the respondents

Question No	Respondents																							Mean score
1	5	4	5	4	4	3	5	4	4	3	5	3	3	5	5	5	4	4	5	4	4	5	5	4.3
2	3	5	4	4	5	5	4	5	4	4	4	5	5	3	4	4	3	5	5	4	3	5	5	4.1
3	5	4	4	5	5	5	4	4	3	5	5	4	4	3	4	3	5	4	4	3	5	3	5	4.2
4	5	3	5	5	5	4	4	5	4	4	5	5	5	3	5	5	5	4	4	5	5	5	4	4.5
5	3	5	5	5	4	4	3	5	3	5	5	5	4	4	4	4	5	5	3	4	3	5	3	4.0
6	3	5	5	5	4	4	4	4	3	5	3	5	5	5	4	4	3	5	3	5	5	4	5	4.3

The findings of the appraisal given in this analysis are also fair. Besides, the structural models developed from this analysis are standardized and generic. In general, the feedback of the 23 respondents confirms the model's concept, purpose, and findings. This means that the model is very important to the building industry. The model is reasonable and accessible to stakeholders, and it is ideal for addressing building issues using VM. Furthermore, it is acceptable and reasonably comprehensive for the industry.

The respondents are also provided space to include their general opinion on the model implementation parameter. The analysis shows that the proposed framework (Figure 6), which is derived from the VM model and utilized as a guide, is large. However, it will not usually extend to most construction contracts. Furthermore, if the model requirements are implemented in the building industry, the attendant advantages include enhancing successful building projects and timely delivery of projects. In addition, if it is strictly adhered to, it will allow both the clients and contractors to execute building projects to an agreed standard. The feedback also means that the suggested parameters and the model protect the areas of implementing VM.

Successful application of the model may not only result in an unexpected rise in the value of Egyptian building projects, but may also promote the reputation of the industry. Model parameters can also be appropriately implemented by stakeholders, such as engineers, project managers, companies, quantity surveyors, etc. The advantages of utilizing the model are: increasing the efficiency of the contractors and guaranteeing for the customer the success of the project in terms of time, expense, and quality. Others include helping to decrease the duration of the project and mitigating the abandonment of projects. Furthermore, the application of this model will ensure that contractors work according to specifications and that they spend money on mobilization payments sensibly. Finally, all the respondents approve almost all of the positive outcomes of this study.

6. DISCUSSION

Despite the strong dependence in many developed countries on VM in construction, its presence is very modest in developing nations. Like many other developing countries, Egypt has suffered from problems and contradictions in the standard of building. This flags the need for VM principles to be implemented to alleviate these challenges. Practitioners' recognition of VM and its key construction activities will dramatically enhance the decision of top management to accept VM as an integral platform/element in their projects.

The successful application of VM is often predicated on the requirement of a wide variety of knowledge (e.g. CSFs affecting VM) in combination with an appropriate degree of understanding of VM from various stakeholders. In comparison with the 51 per cent VM knowledge recorded in a previous study [110], we conclude that the Egyptian building professionals are more aware of its merit (67.7%). This indicates that the awareness on VM is moderately consistent with those from other developing countries, including Malaysia [89] and Myanmar [94]. However, regarding the perception of VM, the result shows that about 95% of the respondents view VM as a concept. This finding is not in line with previous studies that have reported misconception about VM in developing countries [23, 111].

The proposed model illustrates that all four CSFs of VM components have high impact on the implementation of VM. This can enhance the sustainability of residential building projects. Hence, through adopting VM, building enterprises can minimize expenses and time, as well as enhance quality without any loss of projects functions [112].

To this end, despite that Egyptian building professionals have a fairly good perception about VM, they are yet to adopt it. Therefore, there is a need to generate a VM framework to guide these stakeholders to adopt VM. The following subsection discusses how the components derived from the PLS-SEM model can be used to prioritize the CSFs of VM. This is done by offering a VM implementation '*road-map*' for achieving sustainability in residential building projects.

6.1 CSFs of VM implementation framework for achieving sustainability success in residential building

The proposed framework is outlined in Figure 12. After the confirmation of VM CSFs' association through the proposed model, the framework is developed to include the critical CSFs of VM within the Egyptian residential building industry. These VM CSFs should be satisfied before VM can be effectively introduced in the Egyptian construction industry, requiring more consideration from policymakers. Since,the requirements for implementing VM are validated factors from structural models of CSFs of VM application, the proposed framework describes and connects some variables, which will serve as the foundation for the VM implementation [113].

Most importantly, VM implementation requirements will particularly comprise variables validated by the measurement and structural models [82]. Consequently, the measured items (factors) of this construct have been established, and all paths of the study has been confirmed and supported, as shown in Figure 5. The following subsections illustrate the framework items as generated from the proposed model and validated by experts.

6.1.1 Stakeholders and knowledge

The importance of stakeholders in construction projects is undeniable [114]. The PLS-SEM model proposes this component as having the highest effect on the CSFs of VM implementation with an external coefficient of 0.508 through **“***Stakeholders and knowledge*” component. It should be noted that activity SF.SK5 “Knowledge and experience of participants on VM” and SF.SK7 “Professional knowledge and experience of participant’s respective disciplines” of this factor are excluded on the grounds of non-correlation. This result is in agreement with those of Tanko et al. [57]. This first principal component involves CSFs, such as multidisciplinary VM team, the competence of VM facilitator, and the capability to conduct VM workshop. Others are the commitment of all professionals to VM study, readiness to acknowledge changes and new alternatives, and precise definition and scope of different stakeholders. Finally, owner and customer contribution, ability and personality of participants, and discipline and attitude of the participants are included in these CSFs. These findings agree with the work of Tanko et al. [57].They confirm that clients and other stakeholders with the necessary awareness and experience are crucial in facilitating the VM methodology

6.1.2 Workshop dynamics

The second principal component is related to “Workshop dynamics”. It comprises CSFs, such as proactive, creative and structured approach, analysis of project’s elements and functions, VM feedback mechanism, and input of the original design team. Further CSFS include adequate timing of VM workshop, background information collected, orientation meeting, and usage of modern technical instruments to improve innovation and appraisal. The impact of the “workshop dynamics” on the CSFs of VM appears to be the same as “*Stakeholders and knowledge”* with an external coefficient of 0.503. This suggests that the level of success factors for the implementation of VM by stakeholders and expertise is higher than the median range (high-medium level). This is also in tandem with the submission of Mohamad Ramly et al. [31]. They opine that the structured process and work plan represent the core principles of VM, which differentiate them from other management methods.

Besides, one of the most vital stages in VM workshop is the creativity phase. It aims to enhance the project by suggesting new alternatives as creativity is the act of pushing old things or ideas collectively in a new sustainable way[115]. Besides, Coetzee [49] argues that technological progress should be taken into account and used in VM activities as digital solutions enhance connectivity and accessibility[116]. This suggests that the technological approach in VM should be adopted to overcome evaluation analysis in VM workshop.

6.1.3 Culture and environment

The third principal component is related to *“Culture and environment ".* This component is made up of the circumstances and environment in which individuals operate to facilitate successful interaction and working ties between professionals [52].This involves CSFs, such as clear and defined objective of VM workshop from participants, decision-making authority granted to each participant by their respective organization, establishing and clarifying clients’ value system, and motivating VM team members to produce a VM output. “Culture and environment”, with an external coefficient of 0.230, ranks third on the scale of success factors for VM implementation. This finding is in line with the report by Tanko et al. [57]. They show that the position of VM participants and the possibility that functions and sustainability of building projects are identified, defined and classified via a team-oriented, structured and problem-solving approach fall within the "environment" factor. This will optimize the value of construction practice fully.

6.1.4 Standardization

The last on the scale of success factors required for the implementation of VM is related to "*Standardization*". It has an external coefficient of 0.16. This involves CSFs, such as active participation and support of clients, input from the relevant government departments and local authorities, regular attendance of decision-maker, VM study plan for implementation, and government commitment to implement VM. As the normalization-related factors illustrate, the government can produce all of VM's policies since it is the largest consumer and investor. Besides, it has a significant amount of capital formation involved in investments in the development of property and infrastructure [22]. In order to include wide-ranging opportunities to facilitate the use of sustainable products and technologies, government officials, and the regulator of the building industry are key proponents and regulators [117]. The support and active participation of the government in the implementation of the VM on current residential building practices will, therefore, be vital [22]. If the authorities work the client and top management to clearly define and offer appropriate assistance (i.e. financial incentives), the obligation (i.e. obligatory environmental guidelines) for the introduction of sustainability requirements will be resolved. Therefore, improvements will be recorded in the procedures of VM implementation.

From the above discussion, the scope of VM requirements is outlined in Figure 6.

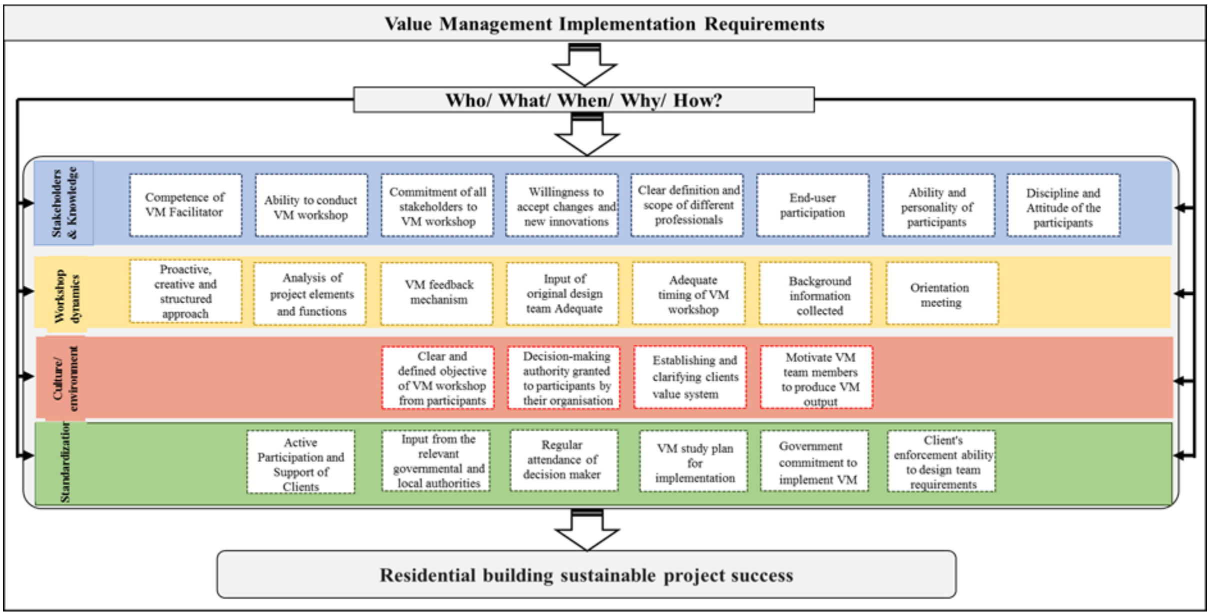

Figure 6. Requirements for VM implementation for achieving sustainability in residential building

These requirements have five questions, based on Aini [106] framework for VM implementation, and tailored to the VM theory based on the proposed model outputs. Consequently, this study provides answers to these five questions according to a suggested framework to support VM's role in enhancing residential building sustainability as follows:

- *Who* is involved in a VM workshop? The construction professionals (architects, electrical engineers, quantity surveyors, civil and mechanical engineers) and other stakeholders [26]. Zainul-Abidin [118] confirms that the interaction between stakeholders and professionals raises the chance to encourage clients and end-user to respect sustainability success. Furthermore, there is a need for stakeholders with relevant skills and experience to participate in VM. This ensures that the objectives of VM are easily achieved.

Fong [119] identifies limited, relevant interactions as the prime factors that contributed to reduced implementation of VM in Hong Kong. In China, the lack of field VM experts, that the project team could learn from, contribute to the poor implementation of VM [120]. On the other hand, Jaapar and Torrence [121] consider the lack of adequate expert participation and their poor facilitation skills negatively influence the Malaysian VM activities. Another study also show that team members appear to be more involved and committed to a project or plan if they are more informed and aware of the project or program progress [122]. Adopting VM is no different from other services or projects. It needs support and guidance from experts with relevant experience and active participation in the activities [120, 123, 124].

- *What* is the significance of carrying out a VM workshop? It is mainly for optimizing the value of residential building projects and achieving the overall sustainability success [125]. VM's implementation grants an in-depth assessment of the sustainability aims and anticipations of projects from the client or owners' insight [125]:
- *When* is VM workshop needed? VM workshop is required during value opportunities and decision-making process [26]. Rosłon [126] confirms that decision making is an extremely time-consuming process with complex stages because of the difficulty of building procedures. However, adopting VM in this critical time can improve the project by defining and understanding the projects' aim [127]. Furthermore, the factors required for standardization need to be implemented to achieve good allocation of resources like time and cost to adopt VM. VM procedures should be given a reasonable time to ensure full

implementation of all VM activities [124, 128]. Proper time will also enable the project team to change and build up their current VM project model [129].

VM delivery system requires proper budget allocation and monitoring, which is a primary indicator of successful VM implementation [130]. Nguyen and Ogunlana [122] propose that sufficient funding can be made available via the VM Program. They further stress that the project management and VM team should have the comfort of providing adequate budget or support to ensure VM projects are not delayed or halted due to a lack of financial resources. Financial resources are imperative if projects or programs like VM are to be effective. Belassi and Tukel [131] in a study find location of financial resources as the highest-ranked critical success factor in a project or system. Securing top management's financial resources for a significant project or system implementation has been a significant challenge for programs, such as value management, where outcomes are difficult to measure [130]. Financial resources should be made available before VM is incorporated to ensure its smooth and efficient adoption [123, 128, 132, 133].

- *Why* is a VM workshop needed? VM is desirable because it helps in realizing construction policies and has the potential to achieve sustainability. VM is traditionally established as a structured and organized process deployed to achieve value for money through conveying needed functions with the lowest cost in line with the quality and sustainability required [19]. Furthermore, it supports the stakeholders in allocating the project resources integrated with their functions effectively [42]. However, from the fact that developing countries have poor knowledge regarding why they should adopt VM [23, 111], a culture environment needs to be adopted to overcome this obstacle. Such factors, "Clear and defined objective of VM workshop from participants” and “Establishing and clarifying client’s value system” can solve this problem.

- *How* can a VM workshop be carried out? VM can be carried through VM phase’s activities (information, function analysis, creativity, evaluation, development, and presentation). All these are derived from the VM standard generated by SAVE [17]. However, from the proposed framework (Figure 6), we can observe that the adoption of VM in the Egyptian construction industry needs more consideration from the aspect of workshop dynamics CSFs. Such CSFs include “Proactive, creative and structured approach” that can improve the dynamic of a VM workshop between the team members. Stakeholders and project team members need to establish a willingness to work with other stakeholders, project team members, and external parties to ensure team life is achieved [134]. When established, team dynamics determine how a team will respond, behave, or perform. It is often considered an invisible force that can significantly affect team members' behavior and interactions, which mostly results in team dynamics, that functions are complicated and ambiguous [135].

6.2 Managerial implications

The reorganization of CSFs can be useful for generating a ‘*road-map*’ to be used by stakeholders, such as project owners and contractors in executing VM in their projects more effectively. Besides, this reorganization can result in a *benchmark* for establishing a useful framework for the successful transformation of construction players through VM stages. This will replace the outdated environmental and sustainable performance that has been in place since 2011 after the Arab Spring [28]. Consequently, Egypt needs to adopt VM in order to achieve a sustainable economy, since the economy is frequently associated with the argument on sustainable growth [136].

The '*road-map*' will assist in Egypt's aspiration in having a stable, sustainable and competitive economy, and becoming one of the top 30 countries in the world [29]. Also, the '*road-map*' developed from this study can, to a great extent, encourage the implementation of VM in other developing nations where building projects are adopted through equivalent way [51]. This is more significant in developing countries as they face many limitations, such as seeking huge costs to achieve environmental issues [137]. Therefore, VM can provide these countries with the opportunities for incorporating sustainability in the design procedures of construction projects [15, 16]. However, this study creates a significant contribution in the following specific ways with significant implications within the building industry:

- It presents a database of the VM standards and their associated factors to identify their competitiveness and global market survival through VM integration.
- It supports owners, consultants, and contractors in assessing and selecting VM implementation to optimize building projects' planning, efficiency, and consistency.
- It showcases a scientific proof that could guide Egypt and other developing countries in adopting VM.
- The range of construction related VM and VM research have mainly cantered on developed nations (UK, US, Hong Kong, and Australia) and other countries, such as Malaysia, China, and Saudi Arabia. Consequently, there is no research on VM implementation in the Egyptian building industry and limited studies on

implementing VM in a developing country. That is why this research has successfully connected VM to the building industry in Egypt. This provides a strong foundation for discussing the practice of VM in enhancing the reliability of local building projects and filling the knowledge gap.

- This study provides a valuable instrument that can assist decision-makers interning in the impartial development of VMs. In this study, the prediction method for partial least square (PLS-SEM) is uniquely proposed, for the first time, to discuss the VM in the construction industry. As such, this approach could be a game-changer in building projects, particularly in developing countries. Even though the research has been conducted in Egypt, it is assumed that this paradigm shift leads to comparable situations and constraints in other developing countries.

- The findings in this work can contribute to VM implementation in Egyptian building projects. Our findings provide an understanding of the purposes of deploying VM, which include the reduction of unnecessary cost and proper cost allocation for each project. Thus, all interested parties can focus on the project's purpose in terms of expense, time, and efficiency by developing and implementing the planned strategies. Ultimately, there is a positive impact in achieving a high degree of sustainability in a project.

- The results of this study also provide a guideline or a benchmark for reducing the problems associated with the execution of a project. These included overrun costs, project completion, and unclear specifications. in addition, this research provides proprietors or employers with the insight on the ways to incorporated VM to enhance the success of their projects.

- Identifying the critical factors regarding CSFs of VM and identified new VM factors did not mention in the previous studies, which can lead to implementation VM.

6.3 Theoretical implications

Whilst sustainable concept development is not new [138], it seems to play an ever more vital role in several enterprises [139]. The proposed prioritizing model provides a requirement for VM implementation, especially in the field of sustainable residential building. This study identifies the CSFs for the VM implementation through the proposed model. These CSFs are useful in overcoming the current barriers faced in successfully implementing VM in the Egyptian buildings industry. Correspondingly, the gap between practice and theory of VM will be decreased through this study. However, to the best of our knowledge, no research has been done to analyze the CSFs of VM implementation in the Egyptian construction industry. Initially, this study empirically identifies the significant CSFs of VM that can aid the implementation of VM in the construction industry. This finding provides a foundation for researchers, particularly in the field of construction management, who want to undertake further research on the CSFs of VM in developing countries. To this end, the theoretical aspects of this analysis offer a mathematical foundation for identifying the CSFs of VM that can be effectively used in Egypt and other developing countries. The four components of the CSFs of VM in the construction industry in Egypt have been comparatively tested using the unique PLS-SEM. Consequently, this study offers a mechanism that can assist policymakers who are interns to incorporate VM impartially.

7. LIMITATIONS AND FUTURE RESEARCH

While this research contributes significantly to both the academia and the practice, such limitations are opening up opportunities for future research. Two hundred and twelve respondents are used in the data analysis. A larger sample size may observe another significant effect. Therefore, by using the PLS estimate method, the issue with small samples could be mitigated. The three respondents' groups (client, contractor, and consultants) are all viewed as a homogenous group in this analysis. Future study will seek to model the relationship between various user groups in the industry.

CONCLUSION

For many countries, VM is mostly used and approved as a very useful tool for achieving the value of money and enhancing a project's aims and sustainability. In contrast, the application of VM in developing economies is very modest. Egypt, like many other developing countries, has encountered discrepancies and anomalies in quality housing, including large-scale projects. To alleviate this condition, VM is recommended. Therefore, this study has modeled the priority of CSFs of VM using SEM. Based on literature review, the identified CSFs of VM have been explored through a semi-structured interview and the EFA analysis. The model is then empirically authenticated employing the PLS-SEM method using the data from 214 professionals from the building industry in Egypt. The '*road-map*' generated from the model will provide a guide for building professionals to reduce costs and enhance sustainability by adopting VMs in Egypt country and other developing countries.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Ahmed Farouk Kineber: Conceptualization, Investigation, Data curation, Writing -original draft. **Idris Othman:** Supervision, Writing**-** review & editing. **Ayodeji Emmanuel Oke:** Supervision, Writing**-** review & editing. **Nicholas Chileshe:** Writing**-** review & editing. **Tarek Zayed:** Writing**-** review & editing.

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