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## The Effect of PMBOK Knowledge Areas on Critical Success Factors in Oil and Gas Projects in Iran: A SEM Modelling

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### Highlights

- It is almost impossible for project managers to focus on all knowledge area equally; they must be aware that which knowledge areas come first.
- PMBOK knowledge areas significantly influence critical success factors in oil and gas projects.
- The scope management is the most effective knowledge area.

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### Abstract

The complicated nature of oil and gas projects demands the deployment of integrated and effective project management methodologies to achieve the project objectives including the scope, cost and timing of the project. However, the availability of alternative methods such as PMI/PMBOK, IPMA, and PRINCE2, high rate of project failure, and limited available resources can make decision making a challenge for project managers. Identification and ranking the most important factors in project management could be done through different methods i.e., MCDM, Regression analyse, or Structural equation modelings depends on the nature of data and the purpose of research. The main purpose of this research is to provide insight to project managers and oil and gas companies on the effect of PMBOK's 10 knowledge areas including Integration Management, Scope Management, Time Management, Cost Management, Quality Management, Human Resource Management, Communication Management, Risk Management, Procurement Management, and Stakeholder Management on critical success factors in oil and gas industry in Iran. PMBOK knowledge areas were measured through the Project Management Planning Quality (PMPQ) survey and the dependent variables which are critical success factors were operationalized through the Project Implementation Profile (PIP) questionnaire. A total of 100 questionnaires were distributed among project managers, senior managers and project experts in oil and gas organizations in Iran and 72 acceptable responses were received and analyzed through structural equation modelling (SEM). The model is statistically significant and accounts for 33.7 % of the variation of CSFs. The SRMR value of the modified model is 0.098 and therefore the model fit is appropriate. The overall positive relationship between the variables is observed. The results of SEM analysis indicated that the scope management is the most effective knowledge area with the weight equals to 0.855 followed by communication management and risk management with the weights equal to 0.818 and 0.756 respectively.

**Keywords:** Critical success factors, PMBOK, Knowledge areas, Project management, Structural equation modelling

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## 1. Introduction

Various project management structures and practices have been developed that cover all project management aspects with the purpose of improving the project performance. The leading authority on project management is the PMI<sup>†</sup> which was established in United States in 1969. It developed a comprehensive guide for project managers designed by practitioners and specialists based on best practices named Project Management Body of Knowledge (PMBOK). This methodology does not intend to provide a particular approach for all types of projects. Instead, it allows project managers to apply a generic model to their projects. PMBOK (6th edition, 2017) contains five process groups related to a structured project management approach. It also contains 10 project knowledge aspects including Integration Management, Scope Management, Time Management, Cost Management, Quality Management, Human Resource Management, Communication Management, Risk Management, Procurement Management, and Stakeholder Management. However, PMI does not suggest which aspect is expected to be the most effective for project success, instead PMI stated that project managers along with the project team are responsible to determine which areas are appropriate to focus during project implementation (Besner & Hobbs, 2006). Assessing the effect of knowledge areas in different fields may assist in optimized resource allocation which ultimately results in a better success rate (Patanakul et al., 2010). Critical Success Factors (CSFs) are project management practices and processes in which their consistent application will result in project success regardless of the industry (White & Fortune, 2009). The critical success factors associated with project management deployed in current study are Project Mission, Top Management Support, Project Schedule/Plans, Client Consultation, Personnel, Technical Tasks, Client Acceptance, Monitoring and Feedback, Communication, and Troubleshooting.

The purpose of this research is to determine to what extent PMBOK knowledge areas influence CSFs in oil and gas projects in Iran. The results may improve project managers' decision making on the allocations of time and resources among different knowledge areas. The significance of our study is practically and theoretically. In terms of practical significance, having a customized CSFs according to the context could help companies to enhance the success rate of future projects. Theoretically, the discovery of prioritized knowledge area and their relative effects on CSFs will contribute to the project management literature.

## 2. Literature review

Zwikael (2009) investigated the importance of the different knowledge areas during project planning. The study showed that knowledge areas do not have similar impacts on a project's success. They also inferred that the most effective project knowledge areas were time, risk, scope, and human resource. Hanisch et al., (2009) examined the effect of knowledge management in organizational performance. They used 27 structured interviews with the experts in a specific region. It was found that the project performance is mainly determined by cultural factors considering the supporting role of project management methods.

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Maryman (2011) studied the effect of PMBOK knowledge areas on project success was investigated in manufacturing IT or ERP projects. The study revealed that the knowledge areas with the highest effect on IT or ERP projects were integration management, scope management, human resources management, communication management, and risk management. The effect of different factors on project performance has been widely discussed in a wide range of project contexts. Abu-Hussein et al., (2016) examined the effect of project management factors on project performance in Jordan. Four project management factors including communication, human resource, time, and risk. The author interviewed 24 project managers and found that project management factors have positive effect on project performance. Ochieng et al., (2018) studied the effect of knowledge management and best practices on oil and gas sector. They used a qualitative method by using a semi-structured interview to analyze the relationship between variables. Four subsets of knowledge management have been found to be effective on enhancing the projects. Skinner (2018) investigated the effect of behavior and business knowledge on IT project success. The study utilized liner regression to analyze the relationship between variables. Data were collected through a survey with 90 IT project managers who participated in that survey. The study found that Information system development knowledge and behavior knowledge impacted project success.

Key success factor (KSF) and critical success factor (CSF) is a term which is used interchangeably in project management. Minarro-Viseras (2005) investigated the KSFs in the implementation of strategic manufacturing initiatives. The findings showed that KSFs are those tasks and activities which their appropriate implementation will ensure project success. Molwus et al., (2017) employed factor analysis to categorize collected CSFs including comfort, competence, commitment, and communication and found that stakeholder management plays an important role in success of project. They identified 23 CSFs related to stakeholder management in construction projects. A SEM model of the relationship between CSFs and stakeholder management was developed and the data was collected via questionnaire. Jitpaiboon (2019) studied success factors for a team project and confirmed that project management tools, project management best practices, and support are similarly essential to success during project implementation. The study also showed that good relationships among team members enhance motivation within project teams and improve team and project performance. Wang et al., (2022) reviewed 38 journal articles between 2000 and 2018 on the success criteria and critical success factors (CSFs) for mega construction projects to find out most important factors. The study categorized 36 CSF into 5 categories. The top five were adequate resource availability, partnering/relationships with key stakeholders, adequate communication and coordination among related parties, public support or acceptance and a clear strategic vision. Kukah et al., (2023) identified 37 critical success factors in public private partnership (PPP) power projects in Ghana of which 9 factors were at the top and shared authority was the most important success factor.

The entire PMBOK knowledge areas are considered to have equal importance; however, knowledge area is likely to have significant effect on project success (Zwikael, 2009). Considering the limited number of empirical studies, investigating the impact of PMBOK knowledge area on the critical success factors of projects specifically in oil and gas industry in Iran seems necessary.

### **3. Method**

This study used a non-experimental causal design and deployed non probability sampling that help the researcher to choose from the population of interest. The sample in this method is selected based on the subjective judgment of the researcher instead of random selection. The population incorporate all the project managers, senior managers, and supervisors who were employed by oil and gas organizations in Iran. The independent variables i.e., PMBOK knowledge areas were measured through the Project

Management Planning Quality (PMPQ) survey designed by Zwikael & Globerson (2006) and the dependent variables which are critical success factors were operationalized through the Project Implementation Profile (PIP) questionnaire designed by Pinto and Slevin (1992).

### 3.1 Data collection

Data was collected through online surveys from companies including public companies NIOC<sup>‡</sup>, POGC<sup>§</sup>, ISOICO<sup>\*\*</sup> and NIGC<sup>††</sup> and some private corporations such as petrochemicals and service-oriented companies in oil and gas industry in Iran. Respondents were asked to indicate a degree to which 10 knowledge areas were utilized regarding their last project. We used two instruments for data collection. The data regarding 10 PMBOK knowledge areas were collected through PMPQ questionnaire including 10 items. PIP questionnaire was used for collecting data on 10 CSFs including 50 items (five questions for each CSF). Although 100 surveys were distributed among the project managers, senior managers and supervisors from oil and gas industry, only 72 were received that was considered appropriate for the research study.

### 3.2. Analytical technique

The effect of PMBOK knowledge areas on critical success factors was investigated through Structural Equation Modelling (SEM) by PLS software. The relevant tests on data and model fit were conducted and statistics such as R square, Standardized Root Mean Square Residual (SRMR), Normed Fit Index (NFI), Variance Inflation Factor (VIF), Cronbach's Alpha, Composite Reliability, and indicator weights were also analyzed.

### 3.3. Reliability and validity

- The reliability of the questionnaire calculated using Cronbach alpha. The results (i.e.  $\alpha = 0.93$ ) were higher than minimum value required, so both surveys were considered reliable. Validity of the instruments were confirmed by face validity.

## 4. Results and discussion

### 4.1. The results of estimated SEM model

A path coefficient analysis is performed to determine the causal effect among variables. The SEM results provide magnitudes of the relationship between the variables. The path values of less than 0.1 indicates a small effect, about 0.3 shows a medium effect and greater than 0.5 is considered a large effect. The results of our estimated structural equation modelling are show in Figure 1.

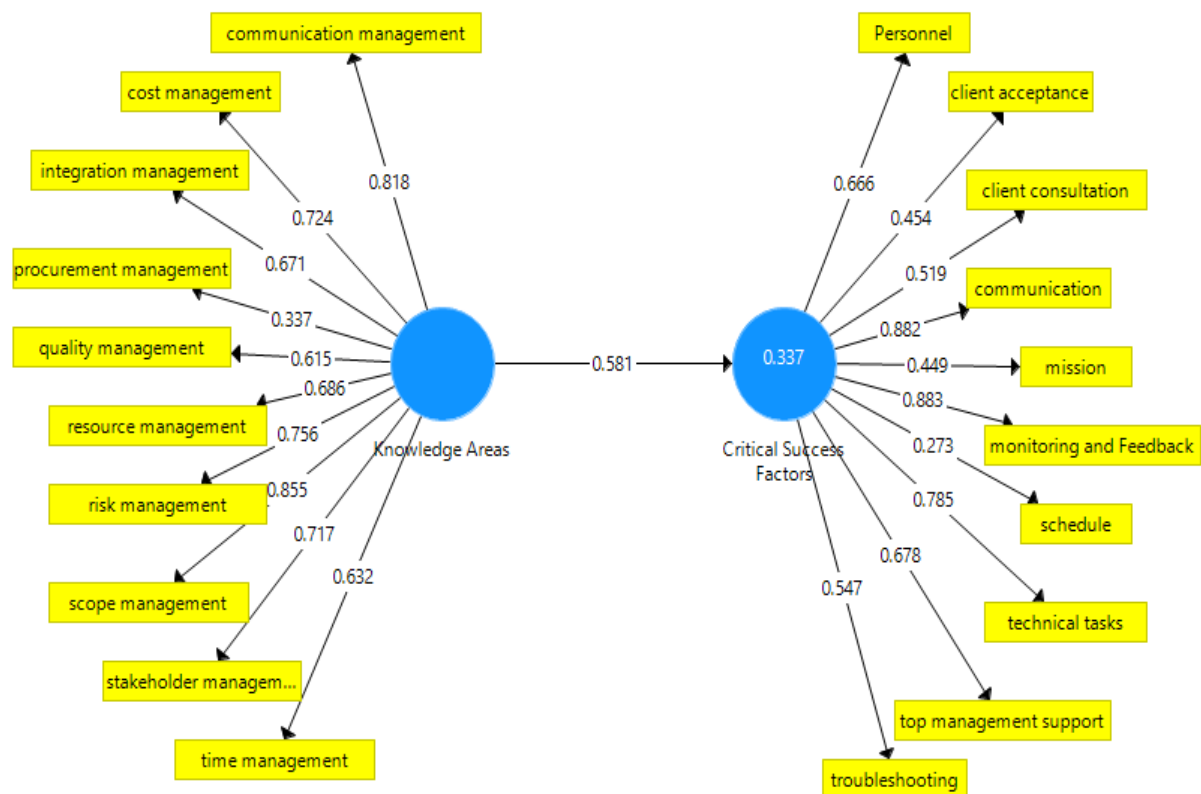
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<sup>‡</sup> National Iranian Oil Company

<sup>§</sup> Pars Oil and Gas Company

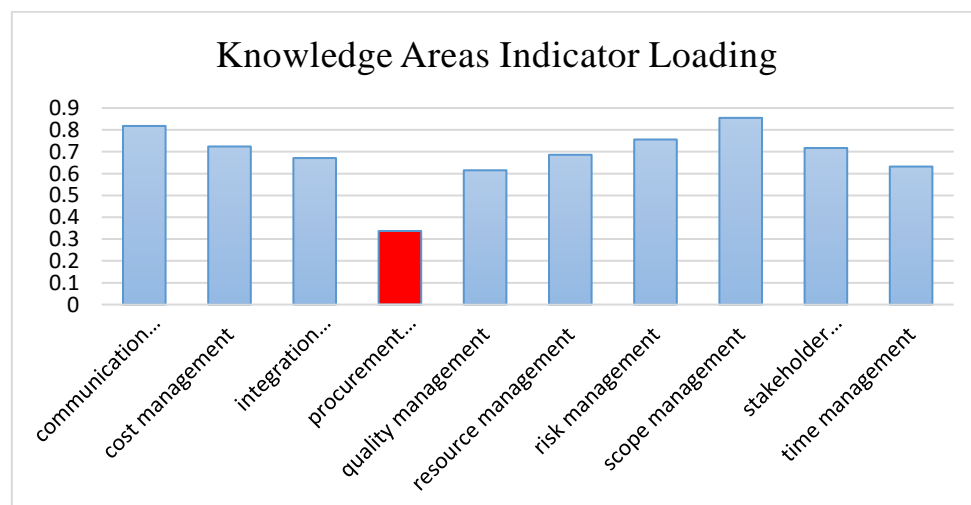
<sup>\*\*</sup> Iran Shipbuilding & Offshore Industries Complex Company

<sup>††</sup> National Iranian Gas Company

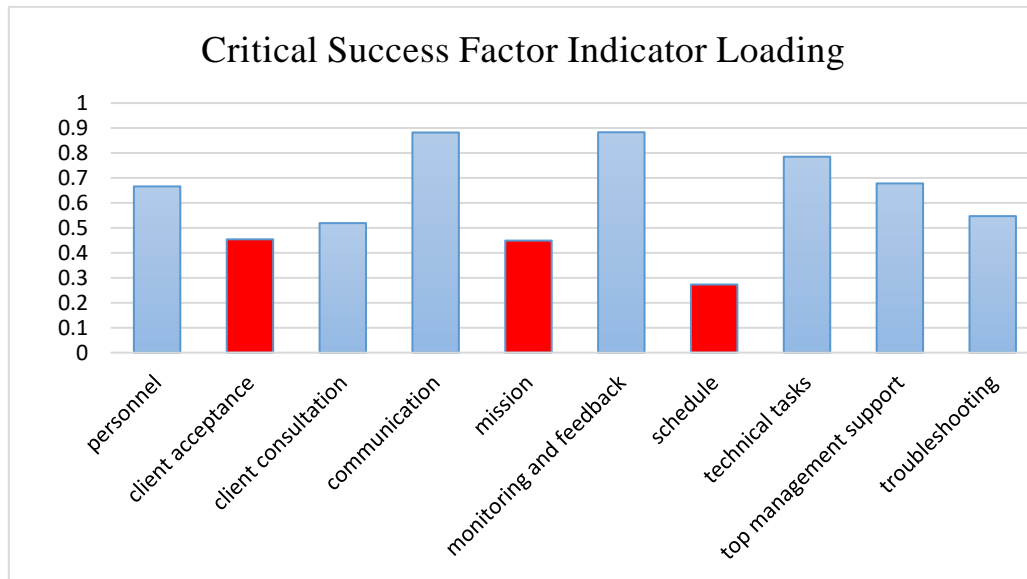
**Figure 1**

Estimated structural equation modelling

The results of our estimated structural equation modelling (Figure 1) show that the magnitude of the effect of knowledge areas on CSFs is 0.581, which is considered a large effect. The recommended value for indicator loadings should be higher than 0.5 and values lower than 0.5 does not have substantial effect. As it is shown, scope management with the weight = 0.855 has the highest value and procurement management with 0.337 is the lowest weight.

**Figure 2**

The loading amount of Knowledge Areas

**Figure 3**

The loading Amount of Critical Success Factors

In terms of critical success factor (Figure 3), monitoring and feedback along with communication have the highest value equals to 0.883 and schedule with 0.273 has the lowest amount of loading.

**Table 1**

Ranking of the PMBOK Knowledge Areas

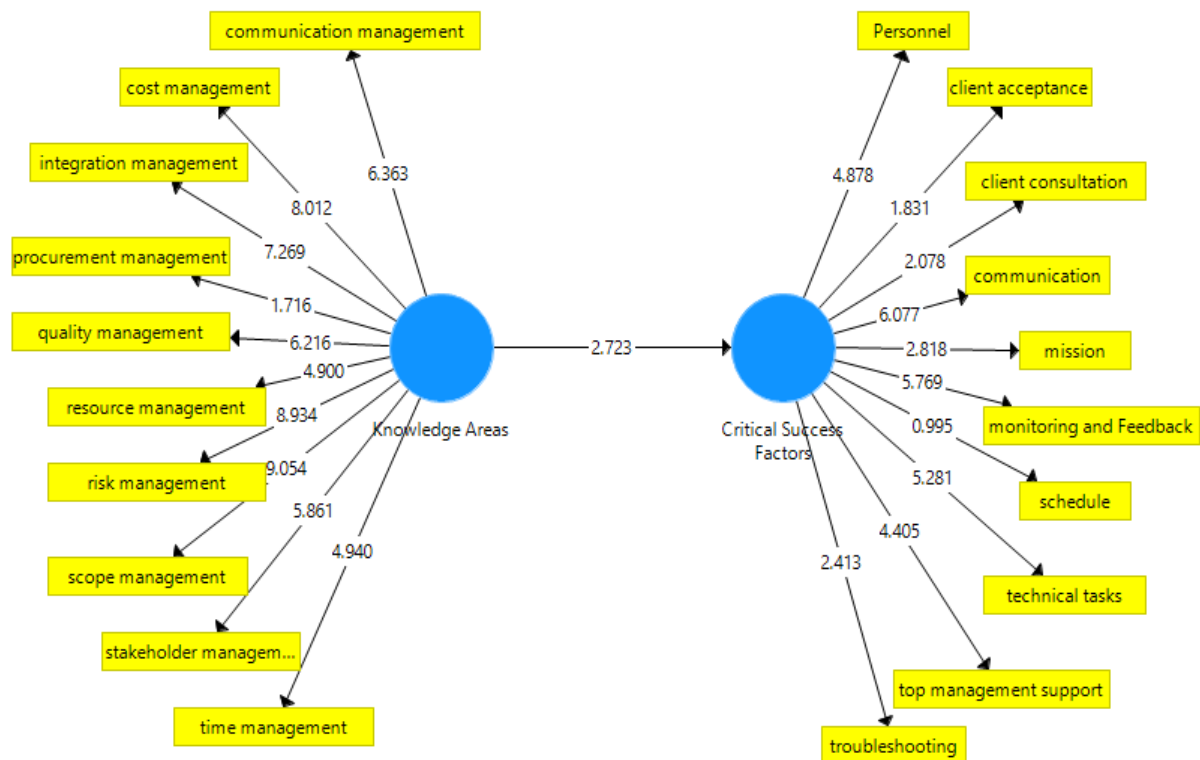
<b>PMBOK Knowledge Area</b>	<b>Weights</b>	<b>Ranking</b>
Scope Management	0.855	1
Communication Management	0.818	2
Risk Management	0.756	3
Cost Management	0.724	4
Stakeholder Management	0.717	5
Resource Management	0.686	6
Integration Management	0.671	7
Time Management	0.632	8
Quality Management	0.615	9
Procurement Management	0.337	10

We provide definitions for the top 5 knowledge area with weight above 0.7. According to PMBOK (6th edition, 2017), Scope management refers to Plan Scope Management; Collect Requirements; Define Scope; and Create WBS. Communication management is defined as Plan Communications Management; Manage Communications; and Monitor Communications. Risk management indicates the areas of Plan Risk Management; Identify Risks; Perform Qualitative Risk Analysis; Perform

Quantitative Risk Analysis; and Plan Risk Responses. Cost management refers to Plan Cost Management; Estimate Costs; Determine Budget; and Control Costs. Finally, Stakeholder Management is defined as Identify Stakeholders; Plan Stakeholder Engagement; Manage Stakeholder Engagement; Monitor Stakeholder Engagement. Stakeholder engagement means listing the main stakeholders inside and outside the project and address their concerns and issues. Throughout the project, project managers need to monitor and control the stakeholder's engagement and satisfaction as well.

The model is statistically significant and accounts for 33.7 % ( $R^2 = 0.337$ ) of the variation of CSFs. PMBOK knowledge areas can be ranked based on the relative weights of SEM model.

Figure 4 shows the bootstrapping analysis performed in the model. As it can be observed from the model, a two tailed t-statistical analysis with maximum 500 iterations were performed and at significance level of 0.05, our model is statistically significant ( $t = 2.723$  at  $p$  value = 0.007). In terms of indicators, procurement management with  $t = 1.716$  is considered nonsignificant from knowledge areas and client acceptance, and schedule with  $t = 1.831$  and  $t = 0.995$  among critical success factors are not statistically significant at  $p = 0.05$ .



**Figure 4**

The t statistics Values of the Model

#### 4.2. Composite reliability

The recommended amount of composite reliability of the constructs in our model via Cronbach's alpha. Related literature recommended that the appropriate Cronbach's alpha should be more than 0.7. Both values are more than 0.7, and considered appropriate for the model. Table 2 shows the related CR values for the constructs.

**Table 1**

Composite Reliability of the Variables

Variables	Composite Reliability
Project Knowledge Areas	0.900
Critical Success Factors	0.865

#### 4.3. Measuring model fit

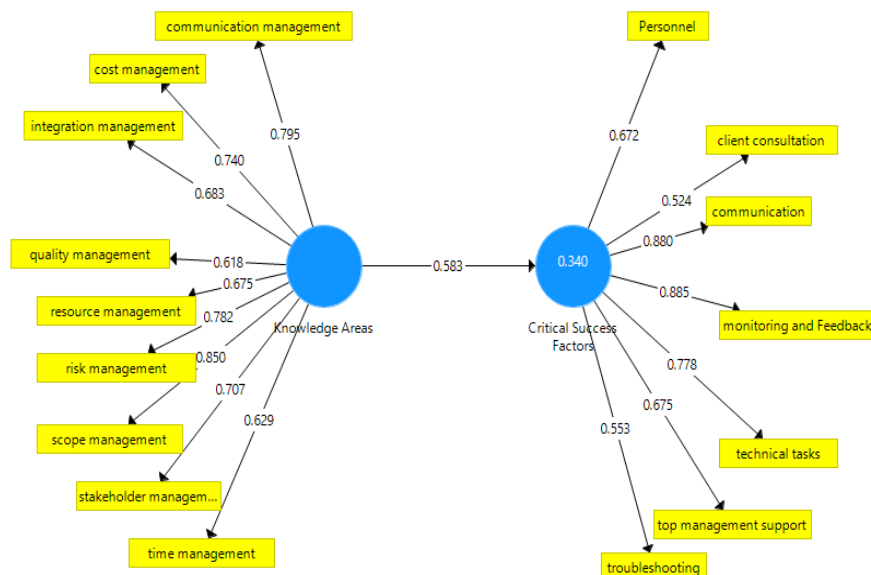
SRMR (Standard Root Mean Square Residual) ranges from 0 to 1, values which are less than 0.05 are considered good fits, while values from 0.08 to 0.1 are considered as acceptable range. The lower the amount of SRMR is, the better the model fits.

**Table 3**

SRMR of the Model

Criteria Measure	Value
SRMR	0.174

Table 3 shows SRMR is higher than 0.1, which means the model should be modified by eliminating the least effective variables. For the purpose of modification, the indicators with weights less than 0.5 must be omitted to increase the model fit. As mentioned earlier, procurement management among knowledge areas and client acceptance, mission and schedule among critical success factors have loadings less than 0.5.

**Figure 5**

SEM Model after Modification

Figure 5 shows the model after the modifications. The path coefficient is increased to 0.583 which is still a large effect. Also, the related R square of the model is raised to 0.340 which indicates that PMBOK knowledge areas predict 34% of the CSFs.



**Table4**

SRMR of the Modified Model

Criteria Measure	Value
SRMR	0.098

Table 4 portrays that the SRMR value of the modified model is 0.098 which is in the acceptable range (0.08 to 0.1) and therefore the model fit is appropriate.

## 5. Conclusions

The objective of this study was to investigate the effect of PMBOK 10 knowledge areas on CSFs in oil and gas projects in Iran. Since it is very difficult for project managers to focus on all knowledge area, they must be aware that which knowledge areas must come first during the course of the project. SEM analysis was used to study the impact of knowledge are of BMBOOK on the critical success factors. The following conclusions can be drawn from this study:

- The magnitude of the effect is 0.583. This indicates that knowledge areas influence critical success factors significantly.
- PMBOK knowledge areas can be ranked based on their loading weights. Initial SEM model showed that procurement management with 0.337 is the lowest weight and thus does not have substantial effect on the critical success factors of the projects in oil and gas industry
- After modification of the estimated model, the most effective knowledge area is scope management followed by communication management, risk management, cost management, stakeholder management, integration management, resource management, time management, and quality management.

## Nomenclature

CFS	Critical Success Factors
ERP	Enterprise Resource Planning
KSF	Key success factor
PMBOK	Project Management Body of Knowledge
PMI	Project management Institute
PIP	Project Implementation Profile
PMPQ	Project Management Planning Quality
VIF	Variance Inflation Factor
NFI	Normed Fit Index
SRMR	Standardized Root Mean Square Residual

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