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Designing an Optimal Model to Implement and Increase the Profitability of EPC Projects

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Abstract- The purpose of this study is to identify the factors affecting on increasing of contractors 'profits of EPC projects and also to estimate the impact of each factor on the increase of contractors' profits. For this purpose, a questionnaire based on the components extracted from previous studies was prepared and sent to EPC project experts. At this stage, the factors affecting on profitability of EPC projects were identified according to the PMBOK standard. Then, the opinion of experts on the importance of each of the factors affecting on increasing EPC contractors' profits was obtained based on the Likert five-choice range and analyzed using SPSS software. The results show that the timely supply of equipment, avoiding of complex administrative bureaucracy, innovation and use of new technologies, adequate expertise and timely financing have the greatest impact on increasing the profits of EPC contractors, respectively.

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I. Introduction

In industrial projects such as the oil industry, power plants and infrastructure projects that are significantly affected by technological developments, the use of new management methods and structures is inevitable. Using the latest scientific achievements in this field, project managers should avoid using inefficient traditional methods so that they can use new methods to carry out their executive projects within a certain time and budget with the desired quality. Choosing the method of doing the project and choosing the most suitable contract is one of the important decisions of the project. Project implementation system refers to a set of processes in which the type of contract, payment method, the scope of responsibility of each party to the contract, how to resolve disputes between project stakeholders and how to distribute and allocate risk over a lifetime are explained. Due to the importance of choosing the right system, in recent years, several methods have been proposed to select the right system. Choosing the right project implementation method can reduce project costs by an average of 5% and project implementation time by up to 30%, and choosing the wrong system to advance projects can lead to problems such as delays, cost increases, disputes and claims in projects. This choice, which is made in the earliest stages of the project, affects all project implementation processes as well as the efficiency of the project implementation stages. The most common contract methods of project implementation are In-House system, construction management method, Design-Bid-Build system and Design-Build system. From the early twentieth century to the early 1950s, major projects were carried out by architects and engineers involved in the project and managed on their own initiative. In fact, it was in the post-1950s that systematic methods and tools for project management were developed and used (Young, 2005). Along with these changes, the methods of project implementation also changed, partly due to the complexity of projects in the years after World War and the specialization of areas such as design and execution, and part of this was due to the employer's need to exercise more precise controls over the performance of the actors involved in the project. The year 1950 marks the beginning of a new era of project management (Cleland, 2006). Gradually, issues such as cost and time management of the project received special attention, and systems such as the three-factor and four-factor methods for project implementation were formed. Given that the three main actions of the project are financing, design and construction; the five main methods of project implementation are as follows:

1. *In-House system:* Perform all three main actions within the employer organization.
2. *Design-Build system:* Financing by the employer and design and construction separately by external unit resources.
3. *Design-Bid-Build system:* financing by the employer and performing design and construction separately by external separate sources.
4. *Construction Management system:* financing by the employer, design and construction by separate external sources, coordination between design and construction by another external source.
5. *Build-Operate-Tran:* Provides all three main actions from a single external source.

One of the new methods in project implementation is Engineering, Procurement and Construction (EPC) method, which is also called turnkey method. In this type of contract, the contractor company undertakes and performs the engineering, procurement and supply of all equipment and construction of the project independently or with persons who are on the side of the company (William and Johnson, 2004). In Turnkey or EPC contracts, the contractor is responsible

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for the design, procurement and construction, and the other party to the contract (the employer) delivers a completed design according to what has been agreed (Huse, 2002). The contractor in the EPC project needs to be able to act in accordance with the parameters desired by the buyers of their services (Hartman, 2003). In general, it can be said that EPC contracts combine the three stages of engineering, procurement and construction in one contract. In this method of project implementation, despite the limitations for the employer, by transferring all project activities, including design, supply of equipment and activities related to construction, installation and commissioning to the contractor, the employer is relieved of responsibility in this regard. The implementation of industrial infrastructure projects in recent years in developing countries by the EPC method has expanded so much that today many ongoing activities are carried out using this method. Projects are often carried out by the project team as a means to achieve important organizational programs or services (Mahmood et al., 2014). Project management is the foundation of any construction project. Construction projects are multi-faceted and well-organized operations that consist of many tasks focused solely on the purpose of building and operating a project (Martens and Carvalho, 2017). Cost, time and scope have been the sides of the Project Management Triangle (PMT) for many years. These limitations have been linked to measuring project management success (Joslin and Müller, 2016; Larson, E.W., and Gray, 2015).

Hussin and Rahman (2009) showed that 14% of projects are completed for more than the contract amount, while more than 70% of all construction projects are delayed and 10% of the project consumables remain as waste. The construction industry is a project-specific industry, and it is difficult to evaluate the overall performance of construction projects due to the lack of standard method development. The nature of the project, effective project management tools, and the adoption of innovative management approaches are critical success factors (CSF) for construction projects (Akinade et al., 2017). Therefore, the CSF must be determined at the beginning of the project. By focusing on these factors, which are the main input of the project management system, the probability of project success increases. CSF explicitly affects the main objectives of the project including time, cost and scope (Gudien et al., 2014; Lin et al., 2011; Maghsoodi, and Khalilzadeh, 2018; Tripathi and Jha, 2018; Love et al., 2016).

Many factors affect the cost of EPC projects. Contracting companies that carry out EPC projects are looking to make a decent profit. Factors such as project pricing method, design and engineering, quality and duration of equipment supply, project execution time, project execution quality, human resource quality, use of information systems, etc. are effective in increasing contractors' profits. In this study, we intend to analyze the relationship of each of the factors affecting the profitability of EPC projects.

a) Theoretical Foundations and Research Background

EPC project management includes the management of the three main indicators of the EPC concept, namely engineering, procurement and construction and combining them with different financial areas, project scope, time, manpower, communications, risk, supply of goods and quality. The three elements of time, cost and quality are known as the sides of the project triangle. Prerequisite for managing financial costs and proper planning in a project is having a complete scenario of feasible actions and obligations of the employer and the contractor (Habibi et al., 2019). The Project Management Body of Knowledge (PMBOK) is a recognized standard for the project management profession that provides guidelines for individual project management. The PMBOK standard is a comprehensive set of related knowledge, which forms work skills. As a result, this phrase means a comprehensive set of project management knowledge. Project management means the application of knowledge, skills, tools and techniques related to project activities in order to meet project requirements. This application of knowledge requires effective management of appropriate processes. The main goal of project management is to complete the project on time and according to the defined budget. In addition, the project manager needs to work closely with the client and must ensure that the project results meet customer expectations (PMI, 2017). The surest way to understand the success of a project is to evaluate it with the strategic goals of the organization. In order for both project management and project success to occur, it is imperative that the criteria for success be formulated and explained from the initial phase. It is important to note that traditional criteria focus only on the economic aspects, while the social and environmental aspects are also important in determining the success of projects. Therefore, for successful project management, a balance and harmony must be established between these parameters so that a successful project can be achieved in the end. Therefore, projects can be considered a failed project even if they are completed on time and on budget. (Frefer et al., 2018). According to the project management standard, Majd and Mortaheb tried to identify the effective risks in EPC projects in order to obtain the critical path, and analyze the impact points (Majd, and Mortaheb, 2008). Chou et al. (2013) conducted research on professional construction knowledge of project management. In this study, a model was proposed in which the effect of various factors on the success of the project is related to the areas of knowledge studied. These areas of knowledge included project scope, time, project cost

and quality, procurement management, risk, human resources and communications (Demirkesen and Ozorhon, 2017; Meng, 2012; Ngacho, and Das, 2014). Poor performance of construction projects, especially in terms of time and latency, additional costs and quality defects, has attracted the attention of many construction researchers and project managers (Lo et al., 2006). Numerous studies have been conducted in recent years to identify the factors affecting over time and cost in construction projects around the world (Arditi et al., 2017; Cheng, 2014). These factors include defects in contract management, payment for work performed, imported materials, changes in design and defects in subcontractors, and supplier performance. In addition to the mentioned factors, a combination of variables such as poor labor productivity, material shortages, inaccuracies in estimating required materials, fluctuations in material costs, insufficient experience about the type and location of the project are also the main reasons for increasing time and cost identified during an EPC project in Indonesia. Other factors that have led to poor performance in relation to an EPC project in Hong Kong include errors and inconsistencies in design, poor site management and monitoring, and delays in approvals (Olawale and Sun, 2010). Navai et al. (2015), in the article Examining the existing weaknesses in cost management, examines the method of cost management in construction projects, the current attention to them in the project and identifying their strengths and weaknesses, as well as identifying the factors that are currently for cost management of this type of project is considered paid. They consider providing a precise schedule based on the analysis performed at the time of price bidding as a factor to achieve a successful cost management and also they know providing accurate daily reports away from any numbering to the project control department at any time for optimal cost management (Navaei et al., 2015). In a study on the effect of project management knowledge on the achievements of construction projects, Chou and Yang stated that external, operational, project management, engineering and financial factors have the greatest impact on project success by using PMBOK in projects. (Chou, and Yang, 2012). Examining the efficiency of using PMBOK in construction projects, Rodrigues and Crispim stated that cost control indicators, fluctuations, differences in construction design, material shortages or supply delays can play a major role in reducing project efficiency, which by Using PMBOK in these projects, these indicators should be considered to reduce costs (Rodrigues-da-Silva, and Crispim, 2014). De Carvalio et al. (2015), conducted a study on the impact of project management on project success. They consider time and cost as the basis of project success. They first examined the success factors of the projects and then, considering the factors influencing the success of the project, which were mostly provided by qualified experts, they examined various standards in this field and finally noticed the effect of cost and time factors as the most important. Project success factors and project management standard became the most complete standard for project success (De Carvalho et al., 2015). In the article Factors Affecting the Cost of Construction Tenders, Elhaq et al. (2005), Discuss the points of view of cost-effective surveyors based in the UK. They identified about 67 variables that affect the estimation of the pre-tender construction cost through works and interviews. These factors are divided into 6 categories including customer characteristics, consultant and design parameters, contractor characteristics, project characteristics, contract method, procurement method, external factors and market conditions. Then a questionnaire was used to evaluate and rank these factors. The results show that the costs of construction projects are more influenced by architects and consultants (Elhag et al., 2005). Kaming et al. (1997), In the article Factors affecting construction time and cost increase in long-term projects in Indonesia, factors affecting additional construction time and cost in developing countries such as Nigeria, Saudi Arabia and Indonesia and the relationship between the two Analyzed. The scope of this particular study focused only on long-term projects. In this study, thirty-one managers working on long-term construction projects were interviewed and the following factors were identified as factors affecting the cost of long-term projects in Indonesia: Unpredictable weather conditions, increased material costs due to inflation, incorrect estimation, increased costs due to environmental constraints, insufficient experience of project location, insufficient experience of project type, insufficient experience of local regulations (Kaming et al., 1997).

According to the existing literature and talking to the managers of large companies contracting EPC projects, the hypotheses of the present study are presented as follows:

Hypothesis 1: Proper design and engineering has a positive effect on increasing the EPC contractors' profit.

Hypothesis 2: Proper project planning has a positive effect on increasing the EPC contractors' profit.

Hypothesis 3: Timely financing has a positive effect on increasing the EPC contractors' profit.

Hypothesis 4: Timely supply of equipment has a positive effect on increasing the EPC contractors' profit.

Hypothesis 5: Quality manpower has a positive effect on increasing the EPC contractors' profit.

Hypothesis 6: The knowledgeable project manager and workshop supervisor have a positive effect on increasing the EPC contractors' profit.

Hypothesis 7: Project control has a positive effect on increasing the EPC contractors' profit.

Hypothesis 8: Avoiding complex bureaucracy has a positive effect on increasing the EPC contractors' profit.

Hypothesis 9: Quality materials and equipment have a positive effect on increasing the EPC contractors' profit.

Hypothesis 10: The selection of quality subcontractors has a positive effect on increasing the EPC contractors' profit.

Hypothesis 11: The lack of successive changes in the project implementation team has a positive effect on increasing the EPC contractors' profit.

Hypothesis 12: Adequate expertise in the project area has a positive effect on increasing the EPC contractors' profit.

Hypothesis 13: Proper installation, commissioning and troubleshooting of equipment has a positive effect on increasing the EPC contractors' profit.

Hypothesis 14: Timely payment to the contractor has a positive effect on increasing the EPC contractors' profit.

Hypothesis 15: Applying project cost management has a positive effect on increasing the EPC contractors' profit.

Hypothesis 16: Applying project risk management has a positive effect on increasing the EPC contractors' profit.

Hypothesis 17: Applying project communication management has a positive effect on increasing the EPC contractors' profit.

Hypothesis 18: Creating innovation and using new technologies in the project has a positive effect on increasing the EPC contractors' profit.

Hypothesis 19: Economic stability has a positive effect on increasing the EPC contractors' profit.

Hypothesis 20: Coherence of organizational structure has a positive effect on increasing the EPC contractors' profit.

Hypothetical Research Model

Based on the hypotheses presented, the hypothetical model of the present study is shown in figure 1.

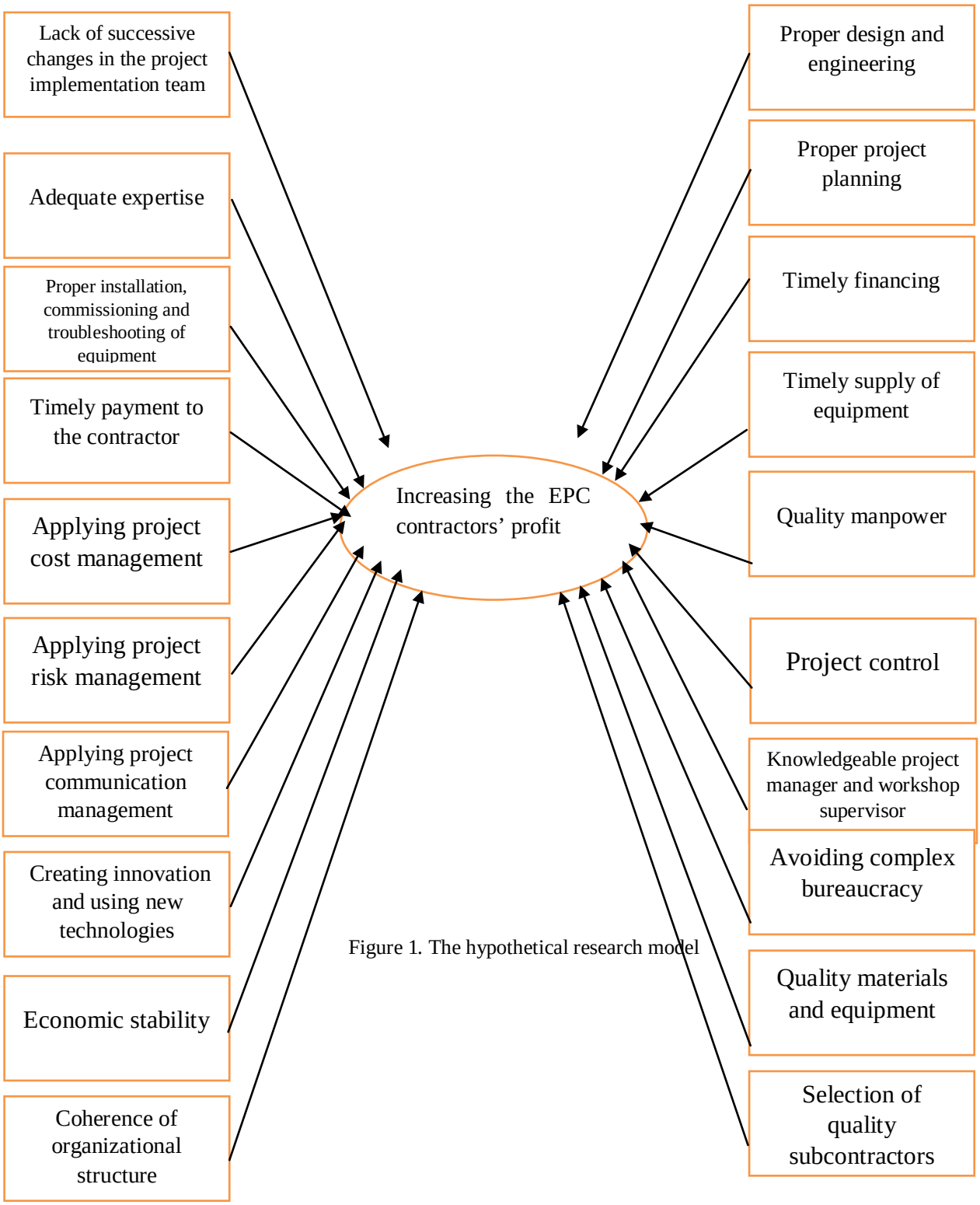

Figure 1. The hypothetical research model

Figure 1: The hypothetical research model

II. Materials and Method

This research was conducted in a descriptive-survey manner. A questionnaire was used to collect information, which included three general sections. The first part included a guide to the questionnaire and the method of answering the questions, the second part was related to the demographic characteristics of the individuals and the third part was the questions related to the research problem. The statistical population of the present study is the managers and experts of contracting companies in the field of EPC projects. The method used is the Delphi method and the sample size is 40 people; the snowball method was used to select the specialists. In this study, to prove the validity of the questionnaire, first a number of questionnaires were provided to experts and after reviewing the opinions of each expert, the questionnaire was modified and the final questionnaire was developed. Thus, the content validity of the questionnaire was confirmed by a number of experts. Cronbach's alpha was used to evaluate the reliability of the questionnaire. The Cronbach's alpha value obtained using SPSS software was 0.89. If the Cronbach's alpha value is higher than 0.7, the questionnaire has good reliability (Nunally and Bernstein, 1978).

III. Results

The highest frequency was related to the age group of 41 to 45 years with 40%. The highest level of education belongs to the master's degree group with 42.5%. The highest job title belonged to the project manager group at 45%. The highest frequency is related to metro projects at 52.5%. The Anderson-Darling test was used to determine the normality of the data. If the null hypothesis of the Anderson-Darling test is confirmed, the data have a normal distribution and therefore parametric tests can be used to analyze the data. The results of this test are shown in Table 1. According to the obtained results, because the significance level of all variables is more than 0.05, the null hypothesis of Anderson-Darling test is confirmed and the data have a normal distribution. To test the research hypotheses, one-sample parametric t-test was used. In this test, H1 indicates the acceptance of the hypothesis and H0 indicates the non-acceptance of the hypothesis. Table 2 shows the results of data analysis on research hypotheses.

Table 1: Anderson-Darling test results to determine the normality of the data

Variable	Statistics	p-value
Proper design and engineering	0.094	0.192
Proper project planning	0.124	0.200
Timely financing	0.087	0.165
Timely supply of equipment	0.134	0.085
Quality manpower	0.079	0.119
Knowledgeable project manager and workshop supervisor	0.185	0.076
Project control	0.086	0.112
Avoiding complex bureaucracy	0.093	0.087
Quality materials and equipment	0.157	0.134
Selection of quality subcontractors	0.143	0.085
Lack of successive changes in the project implementation team	0.076	0.188
Adequate expertise	0.147	0.121
Proper installation, commissioning and troubleshooting of equipment	0.153	0.067
Timely payment to the contractor	0.076	0.085
Applying project cost management	0.093	0.087
Applying project risk management	0.152	0.0131
Applying project communication management	0.167	0.065
Creating innovation and using new technologies	0.079	0.112
Economic stability	0.154	0.113
Coherence of organizational structure	0.188	0.072

Table 2: One-sample parametric t-test results

Test value = 48						
Variable	t-statistics	Degrees of freedom	Sig. (2-tailed)	Mean difference	95% confidence interval of the difference	
					Lower bound	Upper bound
Proper design and engineering	6.21	39	0.001	8.12	6.59	14.71
Proper project planning	5.78	39	0.021	5.67	5.43	11.10
Timely financing	7.01	39	0.003	6.23	5.96	12.19
Timely supply of equipment	7.58	39	0.0001	8.35	6.71	15.06
Quality manpower	6.92	39	0.001	7.23	6.31	13.54

Knowledgeable project manager and workshop supervisor	6.32	39	0.001	8.12	6.59	14.71
Project control	6.12	39	0.004	6.35	6.02	12.37
Avoiding complex bureaucracy	8.11	39	0.0001	8.36	6.70	15.06
Quality materials and equipment	7.13	39	0.012	4.21	5.61	9.82
Selection of quality subcontractors	5.26	39	0.024	4.13	5.01	9.14
Lack of successive changes in the project implementation team	5.41	39	0.016	4.19	5.32	9.51
Adequate expertise	5.96	39	0.004	6.34	6.03	12.37
Proper installation, commissioning and troubleshooting of equipment	6.45	39	0.002	7.84	6.49	14.33
Timely payment to the contractor	7.05	39	0.001	8.14	6.61	14.75
Applying project cost management	5.48	39	0.017	4.16	5.30	9.46
Applying project risk management	4.67	39	0.031	7.36	6.37	13.73
Applying project communication management	5.13	39	0.023	7.98	6.52	14.50
Creating innovation and using new technologies	6.15	39	0.0001	8.47	6.73	15.20
Economic stability	5.32	39	0.008	8.19	6.61	14.80
Coherence of organizational structure	4.89	39	0.012	4.85	5.76	10.61

According to the results obtained in Table 2, due to the smaller significance level of all variables than 0.05, all research hypotheses were confirmed. The Friedman ranking test was used to prioritize the factors affecting on increasing EPC contractors' profits.

Table 3: Prioritize the factors affecting on increasing EPC contractors' profits

Variable	Description	Rank	Impact Factor
X1	Timely supply of equipment	1	6.846165
X2	Avoiding complex bureaucracy	2	6.690402
X3	Creating innovation and using new technologies	3	6.20086
X4	Adequate expertise	4	6.097018
X5	Timely financing	5	5.978341
X6	Timely payment to the contractor	6	5.896751
X7	Applying project cost management	7	5.696484
X8	Proper design and engineering	8	5.444296
X9	Knowledgeable Project manager and workshop supervisor	9	5.288533
X10	Quality manpower	10	5.177273
X11	Proper project planning	11	4.873164
X12	Applying project risk management	12	4.769322
X13	Economic stability	13	4.465213
X14	Selection of quality subcontractors	14	4.205607
X15	Project control	15	4.027592
X16	Proper installation, commissioning and troubleshooting of equipment	16	3.997923
X17	Quality materials and equipment	17	3.894081
X18	Lack of successive changes in the project implementation team	18	3.738318
X19	Applying project communication management	19	3.471295
X20	Coherence of organizational structure	20	3.241359

According to table 3 and the results obtained, the proposed model for increasing the profitability of EPC projects is presented as follows, in which the variable "y" indicates the level of profitability.

$$Y=6.84x_1+6.69x_2+6.20x_3+6.09x_4+5.97x_5+5.89x_6+5.69x_7+5.44x_8+5.28x_9+5.17x_{10}+4.87x_{11}+4.76x_{12}+4.46x_{13}+4.20x_{14}+4.02x_{15}+3.99x_{16}+3.89x_{17}+3.73x_{18}+3.47x_{19}+3.24x_{20}$$

IV. Discussion

According to table 3, the parameters of Timely supply of equipment, Avoiding of complex administrative bureaucracy, innovation and use of new technologies, adequate expertise, timely financing, and timely payment to the contractor have the greatest impact on increasing the profits of EPC contractors, respectively.

In EPC projects, the first step is to specify a list of equipment and place an order to purchase it. Until the equipment isn't purchased, practically no progress can be expected for the project. Given that vendors have already been identified, the procurement process should begin as soon as the contract enters into force.

Many companies have complex bureaucracies to buy equipment. Especially when the contractor is a

large company with multiple departments and the authority to carry out the project is not the responsibility of a particular department. In this case, performing inter-sectoral processes, obtaining approval from different parts of the organization, performing the formalities of the transaction commission, etc., will prolong the project process in both the supply of equipment and construction. To prevent such problems, the contractor company should be project-oriented and give full authority to the project manager to manage and complete the project efficiently within the framework of the company's internal regulations.

In every part of the project, from design and engineering to installation, the use of new technologies and innovation will reduce time and cost. Avoiding traditional methods and using new technologies, especially in the construction sector, will have a significant impact on reducing work time. Up-to-date machinery and equipment, the use of computer methods and robots, will facilitate the manufacturing process. In the design and engineering sector, creating innovation can reduce costs and increase company profits. In this regard, it is necessary for the engineering team to have sufficient expertise and knowledge and the necessary training in connection with creating innovation by the company to be held for them.

Another important factor in the profitability of a project is having enough expertise to do it. Many large companies that win tenders do not have enough expertise to complete the project and outsource a large percentage of the work. Assigning different parts of the project to subcontractors will increase the number of contractors and thus increase costs and time. In this case, the project contractor will act as an intermediary between the subcontractors and the employer, and these exchanges will waste time and financial resources. Therefore, the contractor must have sufficient expertise in the field and outsource small parts of the project to the agenda.

Timely supply of equipment and construction of the project according to the schedule, requires timely financing by the contractor. Financial problems and non-payment on time will delay the schedule, which will lead to a lack of equipment on time and, consequently, failure to build the project on time. The contractor company must plan so that it can inject the necessary financial resources into the project as planned. Of course, this requires the timely payment of the contractor's claims by the employer. In fact, EPC projects are two-way projects in which both the contractor and the employer must meet their obligations according to plan so that both parties can benefit.

Sometimes in EPC projects, the employer can not provide the necessary financial resources to complete the project, which leads to a prolongation of the project implementation process and the contractor suffers. In many cases, the contractor finances the purchase of equipment, but after delivering the equipment to the employer and performing the construction operation, his claims are not paid by the employer. This will result in severe losses to the contractor. In such a situation, to avoid losses, the contractor must consider an appropriate strategy to continue the work.

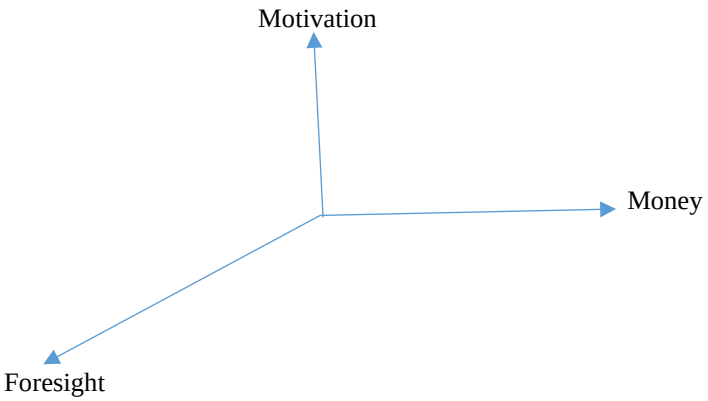

Figure 2: Contractor strategy for the project

According to figure 2, if the employer does not pay the contractor's claims, the contractor can adopt one of the following strategies.

1. The employer has motivation to complete the project on time: In this case, the contractor can use the pressure lever on the employer and in exchange for receivables, complete the continuation of the project.
2. The employer has no motivation to complete the project on time but has the money: in this case, the contractor must adopt a peaceful and patient strategy and gradually receive her claims through management meetings.
3. The employer has neither the motivation nor the money to complete the project: in this case, the focus must be on foresight. If the employer is a large company with the ability to define a large number of projects in the future and the contractor wants to cooperate in those projects, it is better to pursue the same strategy peacefully and patiently.

But if the contractor does not intend to cooperate with the employer in future projects, the appropriate strategy would be a legal complaint.

V. Conclusions

According to the existing literature, factors such as poor contract management, payment for work performed, delay in import of materials and equipment, changes in design and defects in subcontractors, poor supplier performance, poor labor productivity, material shortages, inaccuracies in estimating required materials, fluctuations in material costs, insufficient experience about the type and location of the project are also the main reasons for increasing time and cost identified during an EPC project in Indonesia. Other factors that have led to poor performance in relation to an EPC project in Hong Kong include errors and inconsistencies in design, poor site management and monitoring, and delays in approvals (Olawale and Sun, 2010). Examining the efficiency of using PMBOK in construction projects, Rodrigues and Crispim stated that cost control indicators, fluctuations, differences in construction design, material shortages or supply delays can play a major role in reducing project efficiency, which by Using PMBOK in these projects, these indicators should be considered to reduce costs (Rodrigues-da-Silva, and Crispim, 2014). Also Unpredictable weather conditions, increased material costs due to inflation, incorrect estimation, increased costs due to environmental constraints, insufficient experience of project location, insufficient experience of project type and insufficient experience of local regulations leads to increased costs (Kaming et al., 1997).

The results of the present study confirm all previous studies. On the other hand, in this study, we calculated the effect of each factor on increasing the profit of EPC contractors. The results show that if EPC contractors design their structure in such a way that it is far from any complex administrative bureaucracy and uses specialized human resources and exploits new technologies and innovations, the project will be completed in a short time and it will be done with high quality, which will reduce costs and increase profits. In this regard, the procurement and purchase of project equipment must be done according to a strict schedule, which requires financing for the project. For this purpose, the cash flow of the project must be carefully designed first, the critical points in it must be identified, and the cash flow chart must be updated on a monthly basis.

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