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Investigation and ranking the causes of delay in EPC projects of nonindustrial buildings of 9, 10, 19, 20 and 21 phases of South Pars of Iran

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A B S T R A C T

Delay is one of the most common causes of construction projects failure in Iran. The larger sizes of the projects, the more risks and costs of delays. In this paper, the causes of delays in EPC contracts of nonindustrial buildings were excavated from the related previous research and several interviews with experts of this subject, and adjusted by the brainstorming technique, Delphi and reconciling the nature of these projects. Then, a questionnaire was distributed among 52 experts working in the South Pars project, and the data were analyzed by descriptive and factor analysis methods. Descriptive analysis revealed that "Inflation and escalation of material prices and human resources salaries", "Unrealistic contract duration and requirements imposed" and "Political situation" were the most significant delay factors. Meanwhile, factor analysis indicates that "Improper construction methods", "Shortage of experienced and skilled labor" and "Long acceptance process (shop drawings, permits, tests and samples)" were the most important causes of delay.

1. Introduction

Time is one of the most principal pillars of any project and is considered as an indicator to evaluate its success. Project success can be defined as meeting goals and objectives as prescribed in the project plan. A successful project means that the project has accomplished its technical performance, maintained its schedule, and remained within budget costs (Frimpong et al., 2003). In construction, delay could be defined as the time overrun either beyond completion date specified in a contract, or beyond the date that the parties agreed upon for delivery of a project (Assaf & Al-Hejji, 2006). In other words, delay is a situation when the actual progress of a construction project is slower than the planned schedule or late completion of the projects (Hamzah et al., 2011). Time delays and cost overruns usually lead to adverse effects on the growth of national economies, contribute to major national losses, and hold back the development of the construction industry. The projects with extensive delays may end up losing their economic justification, which in turn may result in the termination of the project (Senouci et al., 2016). Naturally, the larger the size of the contracts, the more positive impacts of utilization or damages caused by facing delays.

Increasingly adopted by both public and private organizations, the EPC approach has become a favored construction project delivery system that combines the procurement of construction services with a variable amount of engineering services in one contract. By using the EPC approach, clients can expect a contractor as a single-entity responsible for design/procurement/construction, to achieve superior performance in such areas as early builder involvement, innovation, cost savings,

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reduced schedule, and enhanced quality (Du et al., 2016). Oil and gas projects are extremely complex and massive projects which require modern technologies for implementation, the final products are unique and require a numerous interacting sub-system, lots of investments and human resources. Therefore, the implementation of South Pars projects has generally been carried out with EPC contracts.

Delays are one of the major problems related to projects worldwide. Assaf (Assaf & Al-Hejji, 2006) found that only 30% of construction projects were completed within the scheduled completion dates and that the average time overrun was between 10% and 30%. Frimpong (Frimpong et al., 2003) has investigated Causes of delay and cost overruns in construction of groundwater projects in developing countries (Ghana as a case study). He showed that monthly payment difficulties from agencies, poor contractor management, material procurement, poor technical performances and escalation of material prices were the main causes of delay and cost overruns in construction of groundwater projects. Salama (Salama et al., 2008) investigated the causes of delays in UAE oil and gas projects. Al-Momani (Al-Momani, 2000) conducted research on the causes of delays in Jordan projects. Delays are seen in small and large projects around the world, and Iran is no exception. Iran is one of the developing countries in the Middle East with vast oil and gas reserves. This makes construction projects very important in this country. Iran is second in world's proved natural gas reserves with 33721.2 billion cube meters and fourth in proved crude oil reserves with 158 billion barrels reserves (Sweis et al., 2019). Despite the great importance of industrial and non-industrial projects, delays have occurred in the vast majority of projects and cause direct and indirect costs for the parties to the contract, and at a larger scale, for the country. It is necessary to reinforce the theory of risk management, and continuously summarize and accumulate the experiences in the actual construction process to manage the risks of all similar projects (Hung & Wang, 2016). Considering the effects of delay of EPC contracts and its consequences on the economy, cultural conditions etc., and also the unique conditions of construction projects in Iran, it is necessary to conduct research to identify the causes of delays for risk management in future projects.

2. Previous studies

Almost all projects, whether in part or in general, are dealing with delays. Many studies had been conducted around the world to decrease the delays risks and the relevant costs. Assaf and Al-Hejji have identified and ranked 76 causes of delays in construction contracts in Saudi Arabia (Assaf & Al-Hejji, 2006). Hung has conducted research on delay risks of EPC hydropower construction projects in Vietnam. He has identified 17 major factors. According to the results of his research, the largest risk factor is Risk from the economy (Hung & Wang, 2016). Al-Momani has investigated and ranked 130 delay factors. He showed that poor design and negligence of the owner, change orders, weather condition, site condition, late delivery, economic conditions, and increase in quantities were the main causes of delay (Al-Momani, 2000). Chan has covered 83 delay factors and classified them in eight major categories. Results indicate that poor site management and supervision, unforeseen ground conditions, low speed of decision making involving all project teams, client-initiated variations and necessary variations of works were the five principal and common causes of delays (Chan & Kumaraswamy, 1997). Kaming revealed that inflationary increases in material cost, inaccurate material estimating and project complexity are the main Factors influencing construction time and cost overruns on high-rise projects in Indonesia. Also the predominant causes of delay were design changes, poor labor productivity and inadequate planning (Kaming et al., 1997). As mentioned earlier, Frimpong (Frimpong et al., 2003) has researched the causes of delays and overspending on the construction of groundwater projects. Sambasivan searched about the causes and effects of delays in the Malaysian construction industry. He revealed that contractor's improper planning, contractor's poor site management and inadequate contractor experience were the most important causes (Sambasivan & Soon, 2007). Senouci has reviewed 122 public projects from Qatar and established the relationships between project contract prices and cost overruns and to develop prediction models for estimating cost overruns (Senouci et al., 2016). Aziz has investigated and ranked 99 delay factors in construction projects after the Egyptian revolution (Aziz, 2013). Sweis and colleagues investigate the Causes of delay in Iranian oil and gas projects (Sweis et al., 2019).

3. The questionnaire, data collection, and statistical population

After covering the previous similar studies, the causes of delay contributed to various types of projects around the world were identified and collected. After that a list of 85 causes of delay was prepared and adjusted to the personality of Iranian projects using brainstorming techniques. For this purpose, the expert's (who also constitute the statistical population of this study) opinions were used alongside the 5490 journal (general conditions of EPC contracts). After completing, merging, and eliminating some of the causes, a coherent list of 34 causes of delay was prepared to provide the validity of the questionnaire.

The identified causes were classified into four main categories: owner-related causes, contractor-related causes, consultant-related causes, and external causes. The symbol assigned to each category is based on this classification. Then, a questionnaire was developed to collect the information of experienced and specialized people in the field of research. Of the 34 causes mentioned in the questionnaire, 20 were related to the contractor sector, 6 were employers, 3 were employer consultants and 5 were related to external factors. The 'Cont.' tag refers to the causes in association with the contractor, 'O' is referred to the owner, 'Cons.' Is for the consultant, and 'E' is referred for the external factors in the questionnaire and the tables. To investigate the effectiveness of each delay risk, a 5-grade scale has been used in this study, the score 1 shows the very low effect, 2 represents low effects, 3 represents moderate effects, a score of 4 indicates high effects, and a score of 5 shows a very high effect. The questionnaire contained some general questions about the specialists' qualifications, their work department, and the relevant work experience. The statistical population of the present study includes the project managers, workshop supervisors, technical office managers, and other experts who have related working experience in the construction of non-industrial projects in phases 9, 10, 19, 20, and 21 of South Pars, who dominate the research literature. According to the initial interviews, the estimation of the statistical population was around 55 to 60. 52 questionnaires were completed and gathered as follows, 21 by owner experts, 11 by consultant experts, and 20 by contractors. The questionnaires were completed and collected through face-to-face meetings, email, WhatsApp, and follow-up by phone call.

4. Research methodology

The collected data were analyzed by descriptive and factor analysis. In descriptive analysis, the mean score of each factor indicates the importance of that factor of delays. Therefore, causes can be ranked accordingly. To evaluate the normality of the data, the skewness and strain of the data have been investigated. The score of each delay factor is obtained by the following relationship:

$$x_j = \frac{\sum_{i=1}^{n} f_{ij}}{n} \tag{1}$$

in the questionnaire (i=1,…,52). f_{ij} is the response coefficient of the i'th expert about the j'th factor. This numerical coefficient is between 1 and 5 (based on the answers of the questioners – very low, low, medium, high, and very high). Confirmatory factor analysis has been used to investigate the structure of the factors more accurately. For this purpose, SPSS software is used. Firstly, the desired structure is modeled for the software, then the causes with load factors less than 0.3 had been removed from the structure. After modifying the final structure, the significance of each factor had been evaluated by T_Value (based on T_Value test). The reliability of the data and structure had been tested by the partial least squares method. Thus, the Cronbach alpha of each cause should be greater than 0.7, and the combined coefficient of each factor should not be less than 0.7. Cronbach's alpha is calculated based on the following relationship:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} S_i^2}{s_x^2}\right) \tag{2}$$

In Eq. (2) relationship, α is the Cronbach's alpha coefficient, *k* is equal to the number of questions, S_i^2 refers to i^{th} question variance, and s_x^2, is the variance of the whole test.

Validity was evaluated by divergent and convergent methods. Divergent validity has been measured by the cross-load test and convergent validity was evaluated by mean extracted variance and combined coefficient. The mean value of the extracted variance is calculated by the following relationship:

$$AVE = \frac{\sum_{i=1}^{k} \lambda_i^2}{\sum_{i=1}^{k} \lambda_i^2 + \sum_{i=1}^{k} \mathrm{var}(e_i)} \tag{3}$$

In Eq. (3) relationship, k is the total number of items measured in the corresponding model. Also, λ_i is the load factor of the specific item being examined and var(e_i) is the value of the variant error of item *i*. Finally, the quality of the model is measured by CV Com values. After constructing and evaluating the model, the effect of the variables (owner, consultant, contractor, and external factors) will be determined based on the path coefficient. The causes of delay will be ranked according to the relevant factor load. Eventually, the final coefficient which is the result of multiplying the load factor in the corresponding path coefficient has been used for ranking the causes of delays.

5. Analysis results and discussions

Qualitative characteristics of the statistical population and general ranking of the causes was provided by descriptive analysis. But it is not possible to investigate which of the main categories (owner, contractor, consultant or extra factors) had the most effective role in delay occurrence by descriptive analysis. Factor analysis has been used to clarify the organization ranking. As well as investigating the structure validity more accurately. The confirmatory factor analysis was used in two conditions. Since the number of questionnaires filled by owner and contractor experts was almost equal, factor analysis was performed once for all filled questionnaires, and once just for questionnaires filled by owner and contractor experts. Comparing the results of these two modes of analysis was used to test the bias of consultants in filling the questionnaire.

5.1 Descriptive analysis

The information about the project organizations, qualification and work experiences of the questionnaires are as mentioned in Table 1. 98% of the statistical population has bachelor or higher degrees, and 71% of them have more than 10 years of related experience.

Table 1

Qualitive specifics of the statistical population

Respondent's organization %		Respondent's qualification %		Respondent's work experience %	
Owner	40	A.S	2	5 ~10	29
Consultant	21	B.S	52	10 ~20	46
Contractor	38	M.S or higher	46	More than 20	52

"Inflation and escalation of material prices and human resources salaries", "Unrealistic contract duration and requirements imposed", "Political situation", "Weakness and defect of documents in design phase" and "Insufficient data collection and service before design phase" had the highest mean score and thus the most importance on delay occurrence respectively. According to the results, "Weakness and defect of documents in design phase" was the most significant cause of delay in association with the EPC contractor. Unfortunately, despite the great importance of the design stage and its impact on the next stages, the main reason for delay related to the contractor is the design stage. As we know, the life cycle of the project is spent between the design, procurement and construction stages, and since the design stage is the first step in the cycle, any delays in this phase may cause further delays in the future. Factors such as "Insufficient data collection and service before design phase" and "Inadequate design-team experience" which are related to the design phase, are ranked respectively. This shows that the contractors' design team was more effective than other sectors for delays. Meanwhile "Unrealistic contract duration and requirements imposed" was the most important cause of delays related to the owner organization.

Table 2

Ranking of the causes based on descriptive analysis

Organization	Code	Cause of delay	Mean score	Organizational ranking	Total ranking
Contractor	Cont.01	Insufficient data collection and service before design phase	4.019	2	5
	Cont.02	Weakness and defect of documents in design phase	3.635	10	18
	Cont.03	Contractor weakness in equipment procurement (including long-lead items)	4.059	1	4
	Cont.04	Contractor weakness in equipment procurement (including long-lead items)	3.481	14	24
	Cont.05	Contractor weakness in material procurement	3.539	13	22
	Cont.06	Delay in contractor's payment to subcontractors and suppliers	3.423	18	28
	Cont.07	Improper construction methods	3.212	20	33
	Cont.08	Shortage of experienced and skilled labor	3.577	11	20
	Cont.09	Low contractor capacity in the construction phase (rework)	3.460	17	27
	Cont.10	Delay in sub-contractors' work	3.706	9	16
	Cont.11	Obsolete technology	3.577	12	21
	Cont.12	Poor communication and coordination by contractor with other parties	3.865	4	9
	Cont.13	Inadequate design-team experience	3.827	5	10
	Cont.14	Changes in material types and specifications during construction	3.462	16	26
	Cont.15	Change and/or error in design	3.726	8	15
	Cont.16	Lack of involvement of operations and maintenance staff in the design phase	3.333	19	30
	Cont.17	Contractor poor budget management	3.765	6	13
	Cont.18	Contractor poor human resource management	3.480	15	25
	Cont.19	Planning and scheduling deficiencies	3.923	3	7
	Cont.20	Inadequate managerial skills	3.731	7	14
Owner	O.21	Change of scope	3.588	3	19
	O.22	Delays in contractor's payment by owner	3.808	2	11
	O.23	Unrealistic contract duration and requirements imposed	4.173	1	2
	O.24	Delay to furnish and deliver the site to the contractor by the owner	3.308	5	31
	O.25	Deflect in feasibility study	3.519	4	23
	O.26	Delays in inspection and testing of work by owner	3.135	6	34
Consultant	Cons.27	Long acceptance process (shop drawings, permits, tests and samples)	3.904	1	8
	Cons.28	Delays in inspection and testing of work by consultant	3.289	3	32
	Cons.29	Long decision-making process by consultant	3.692	2	17
External	E.30	Change in orders in procurement phase	3.942	3	6
	E.31	Immature local markets for goods and materials	3.769	4	12
	E.32	Inflation and escalation of material prices and human resources salaries	4.308	1	1
	E.33	Political situation	4.273	2	3
	E.34	Change in rules, laws, regulations and standards	3.423	5	29

After the contractor's design unit, the management unit had the most impact on the delays. Because “Planning and scheduling deficiencies”, “Poor communication and coordination by contractor with other parties”, “Contractor poor budget management” and “Inadequate managerial skills” were all contractors’ managerial skills and ranked 3, 4, 6 and 7 among all contractors’ causes, respectively.

“Long acceptance process (shop drawings, permits, tests and samples)”, “Long decision-making process by consultant” and “Delays in inspection and testing of work by consultant” were the consultants most affective causes of delay respectively.

“Inflation and escalation of material prices and human resources salaries' ', " Political situation” and “Change in orders in procurement phase” were the most effective external delay causes, and also some of the most important factors based on the descriptive analysis results.

“Change in rules, laws, regulations and standards” was the next external factor. According to the interviews with the experts, this factor rarely occurs, but in case of occurrence, it has had a vast impact on delays. The ranking of the delay factors based on the mean score is presented in Table 2 for all categories and also in general.

5.2 Factor analysis (first mode)

In this section, all of the responses have been considered to model the construction. The load factor of Const.1, Const.3, Const.12, Const.13, Const.14, Const.15 and Const.20 was less than 0.3, and therefore they have been eliminated from the model structure. Elimination of some of the causes from the studied structure does not mean that these factors are unimportant in delays, but only in terms of statistics science in factor analysis, there can be no relationship between those factors and delays.

Table 3
Factor analysis results (first mode)

Organization	Code	Cause of delay	Load factor	Path coefficient	Final coefficient	Organizational ranking	Total ranking
Contractor	Cont.01	Insufficient data collection and service before design phase	---	0.834	---	---	---
	Cont.02	Weakness and defect of documents in design phase	0.452		0.377	12	25
	Cont.03	Contractor weakness in equipment procurement (including long-lead items)	---		---	---	---
	Cont.04	Contractor weakness in equipment procurement (including long-lead items)	0.599		0.500	9	18
	Cont.05	Contractor weakness in material procurement	0.678		0.565	6	10
	Cont.06	Delay in contractor’s payment to subcontractors and suppliers	0.516		0.430	11	21
	Cont.07	Improper construction methods	0.752		0.627	2	3
	Cont.08	Shortage of experienced and skilled labor	0.752		0.627	1	2
	Cont.09	Low contractor capacity in the construction phase (rework)	0.696		0.580	5	9
	Cont.10	Delay in sub-contractors' work	0.709		0.591	3	7
	Cont.11	Obsolete technology	0.663		0.553	7	11
	Cont.12	Poor communication and coordination by contractor with other parties	---		---	---	---
	Cont.13	Inadequate design-team experience	---		---	---	---
	Cont.14	Changes in material types and specifications during construction	---		---	---	---
	Cont.15	Change and/or error in design	---		---	---	---
	Cont.16	Lack of involvement of operations and maintenance staff in the design phase	0.374		0.312	13	26
	Cont.17	Contractor poor budget management	0.707		0.590	4	8
	Cont.18	Contractor poor human resource management	0.661		0.551	8	12
	Cont.19	Planning and scheduling deficiencies	0.558		0.465	10	20
	Cont.20	Inadequate managerial skills	---		---	---	---
Owner	O.21	Change of scope	0.715	0.769	0.550	2	13
	O.22	Delays in contractor’s payment by owner	0.540		0.415	5	24
	O.23	Unrealistic contract duration and requirements imposed	0.347		0.267	6	27
	O.24	Delay to furnish and deliver the site to the contractor by the owner	0.773		0.594	1	6
	O.25	Deflect in feasibility study	0.673		0.518	4	16
	O.26	Delays in inspection and testing of work by owner	0.679		0.522	3	15
Consultant	Cons.27	Long acceptance process (shop drawings, permits, tests and samples)	0.850	0.746	0.634	1	1
	Cons.28	Delays in inspection and testing of work by consultant	0.797		0.595	3	5
	Cons.29	Long decision-making process by consultant	0.801		0.598	2	4
External	E.30	Change in orders in procurement phase	0.563	0.743	0.418	5	23
	E.31	Immature local markets for goods and materials	0.569		0.423	4	22
	E.32	Inflation and escalation of material prices and human resources salaries	0.642		0.477	1	19
	E.33	Political situation	0.708		0.526	3	14
	E.34	Change in rules, laws, regulations and standards	0.678		0.504	2	17

Load factors, path coefficient, and ranking of the delay factors in this mode of factor analysis are shown in Table 3. The path coefficient indicates the variable impact on delays phenomenon. Obviously, the greater obtained path coefficients, the more effective the variable on delay phenomenon. Thus, the contractor, owner, consultant, and external factors have the greatest impact on the delays in projects with the EPC contract in South Pars respectively.

“Long acceptance process (shop drawings, permits, tests and samples)” was the most effective factor in delay occurrence. After that “Shortage of experienced and skilled labor” and “Improper construction methods” were the most important factors respectively. While “Unrealistic contract duration and requirements imposed” had the least load factor, and thus the least impact on delay occurrence. This factor has the last rank in this case, which has the second-highest rank based on the average score in descriptive analysis. "Political situations" also ranked 14th, while it was the third most important cause of delay in descriptive analysis.

Comparing the obtained coefficients confirms the high proximity of delay factors to each other. As it’s shown, the first ranking factor has been just 33% more effective than the 19th factor. However, 70% of all factors were in the range between the first and nineteenth places.

5.3 Factor analysis (second mode)

In this part, just the response from owners’ and contractors’ experts have been used to model the structure. Factors Cont.1, Cont.2, Cont.3, Cont.12, Cont.13, Cont.14, Cont.15 and Cont.16 were eliminated due to the less than 0.3 load factor. Load factors, path coefficient, and ranking of the delay factors in this mode of factor analysis are shown in table 4.

According to the obtained path coefficients, contractor, owner, consultant and external factors had the greatest impact on delay respectively.

Based on achieved results, “Improper construction methods”, “Low contractor capacity in the construction phase (rework)”, “Shortage of experienced and skilled labour”, “Change of scope”, “Long acceptance process (shop drawings, permits, tests and samples)” and “Long decision-making process by consultant” has had the greatest impact on delays respectively. Meanwhile “Immature local markets for goods and materials” and “Unrealistic contract duration and requirements imposed” have had the least impact on delay occurrence.

Similar to the first mode of factor analysis, final coefficients of factors are very close. So, the first ranking factor was just 31% more effective than the 19th, while 70% of all factors were in the range of first to nineteenth ranks.

Table 4
Factor analysis results (second mode)

Organization	Code	Cause of delay	Load factor	Path coefficient	Final coefficient	Organizational ranking	Total ranking
	Cont.01	Insufficient data collection and service before design phase	---		---	---	---
	Cont.02	Weakness and defect of documents in design phase	---		---	---	---
	Cont.03	Contractor weakness in equipment procurement (including long-lead items)	---		---	---	---
	Cont.04	Contractor weakness in equipment procurement (including long-lead items)	0.572		0.502	10	20
	Cont.05	Contractor weakness in material procurement	0.682		0.601	5	9
	Cont.06	Delay in contractor’s payment to subcontractors and suppliers	0.618		0.542	8	14
	Cont.07	Improper construction methods	0.764		0.670	1	1
	Cont.08	Shortage of experienced and skilled labor	0.741		0.650	3	3
	Cont.09	Low contractor capacity in the construction phase (rework)	0.748		0.656	2	2
Contractor	Cont.10	Delay in sub-contractors' work	0.609	0.877	0.534	9	16
	Cont.11	Obsolete technology	0.492		0.431	12	24
	Cont.12	Poor communication and coordination by contractor with other parties	---		---	---	---
	Cont.13	Inadequate design-team experience	---		---	---	---
	Cont.14	Changes in material types and specifications during construction	---		---	---	---
	Cont.15	Change and/or error in design	---		---	---	---
	Cont.16	Lack of involvement of operations and maintenance staff in the design phase	---		---	---	---
	Cont.17	Contractor poor budget management	0.623		0.546	7	13
	Cont.18	Contractor poor human resource management	0.660		0.579	6	11
	Cont.19	Planning and scheduling deficiencies	0.553		0.485	11	21
	Cont.20	Inadequate managerial skills	0.702		0.616	4	7
	O.21	Change of scope	0.766		0.636	1	4
	O.22	Delays in contractor’s payment by owner	0.556		0.461	5	22
Owner	O.23	Unrealistic contract duration and requirements imposed	0.517	0.830	0.429	6	25
	O.24	Delay to furnish and deliver the site to the contractor by the owner	0.711		0.590	2	10
	O.25	Deflect in feasibility study	0.687		0.570	3	12
	O.26	Delays in inspection and testing of work by owner	0.617		0.512	4	19
	Cons.27	Long acceptance process (shop drawings, permits, tests and samples)	0.854		0.632	1	5
Consultant	Cons.28	Delays in inspection and testing of work by consultant	0.814	0.740	0.602	3	8
	Cons.29	Long decision-making process by consultant	0.844		0.625	2	6
	E.30	Change in orders in procurement phase	0.756		0.536	1	15
	E.31	Immature local markets for goods and materials	0.585		0.415	5	26
External	E.32	Inflation and escalation of material prices and human resources salaries	0.735	0.709	0.521	2	17
	E.33	Political situation	0.728		0.516	3	18
	E.34	Change in rules, laws, regulations and standards	0.645		0.457	4	23

6. Discussion and Conclusion

According to the results of the descriptive analysis, "Political situation" and the resulting economic sanctions, would cause "Inflation and escalation of material prices and human resources salaries" which were the most significant causes of delays in EPC projects in South Pars. Then, "Unrealistic contract duration and requirements imposed", "Weakness and defect of documents in design phase" and "Insufficient data collection and service before design phase" have been the most important causes of delay respectively. In EPC contracts, the contractor is the only organization that has the responsibilities of engineering, procurement and construction. Thus, obviously the performance of contractors has the greatest impact on delays, which is also proved by both modes of factor analysis. Among all of the contractors' units, the design and engineering unit has had the greatest impact on delay occurrence. "Weakness and defect of documents in design phase", "Insufficient data collection and service before design phase", "Inadequate design-team experience" and "Change and/or error in design" are associated with the contractors' design and engineering unit. While the construction unit has performed better than other contractors' units. In both cases of factor analysis, contractor, owner, consultant, and external factors have had the greatest impact on delay occurrence in the EPC projects of South Pars respectively. As we know, the contractor has the most responsibility and workload in EPC contracts, so it was not out of the question that the contractor would have the most path coefficient. Also, increasing the path coefficient of the contractor in the second case of factor analysis, compared to the first mode, shows that the experts of the consultants have a stricter opinion of the contractor organization than other organizations' experts. Comparing owners' path coefficients in two modes of factor analysis, shows that the owner has less impact on delays from consultants' point of view. However, in both cases, the contractor has the greatest impact on delays compared to other organizations, and consultants' path coefficient has been very close. Therefore, the opinions of experts, regardless of which organization they work in, have been almost the same about the consultant organization.

"Shortage of experienced and skilled labor" and "Improper construction methods" are amongst the first three ranks of effectiveness in both cases factor analysis, which indicates the great impact of these factors. However, in descriptive analysis, ranks of these two factors are 20 and 33, respectively. The order of influence of consultants' factors was the same in all three modes of statistical analysis. Therefore, it can be concluded that both descriptive and factor analysis confirm each other. "Delays in contractor's payment by owner" and "Unrealistic contract duration and requirements imposed" were owners' the most effective factors, while the results of factor analysis shows that they have the least effect on delays.

Table 5 shows the ranking of factors in descriptive and factor analysis.

Table 5
Overall rankings

Organization	Code	Cause of delay	Descriptive analysis ranking	Factor analysis (1) ranking	Factor analysis (2) ranking
Contractor	Cont.01	Insufficient data collection and service before design phase	5	---	---
	Cont.02	Weakness and defect of documents in design phase	18	25	---
	Cont.03	Contractor weakness in equipment procurement (including long-lead items)	4	---	---
	Cont.04	Contractor weakness in equipment procurement (including long-lead items)	24	18	20
	Cont.05	Contractor weakness in material procurement	22	10	9
	Cont.06	Delay in contractor's payment to subcontractors and suppliers	28	21	14
	Cont.07	Improper construction methods	33	3	1
	Cont.08	Shortage of experienced and skilled labor	20	2	3
	Cont.09	Low contractor capacity in the construction phase (rework)	27	9	2
	Cont.10	Delay in sub-contractors' work	16	7	16
	Cont.11	Obsolete technology	21	11	24
	Cont.12	Poor communication and coordination by contractor with other parties	9	---	---
	Cont.13	Inadequate design-team experience	10	---	---
	Cont.14	Changes in material types and specifications during construction	26	---	---
	Cont.15	Change and/or error in design	15	---	---
	Cont.16	Lack of involvement of operations and maintenance staff in the design phase	30	26	---
	Cont.17	Contractor poor budget management	13	8	13
	Cont.18	Contractor poor human resource management	25	12	11
	Cont.19	Planning and scheduling deficiencies	7	20	21
	Cont.20	Inadequate managerial skills	14	---	7
Owner	O.21	Change of scope	19	13	4
	O.22	Delays in contractor's payment by owner	11	24	22
	O.23	Unrealistic contract duration and requirements imposed	2	27	25
	O.24	Delay to furnish and deliver the site to the contractor by the owner	31	6	10
	O.25	Deflect in feasibility study	23	16	12
	O.26	Delays in inspection and testing of work by owner	34	15	19
Consultant	Cons.27	Long acceptance process (shop drawings, permits, tests and samples)	8	1	5
	Cons.28	Delays in inspection and testing of work by consultant	32	5	8
	Cons.29	Long decision-making process by consultant	17	4	6
External	E.30	Change in orders in procurement phase	6	23	15
	E.31	Immature local markets for goods and materials	12	22	26
	E.32	Inflation and escalation of material prices and human resources salaries	1	19	17
	E.33	Political situation	3	14	18
	E.34	Change in rules, laws, regulations and standards	29	17	23

7. Discussion and Conclusion

In this study, we tried to identify and rank the causes of delay in EPC contracts in South Pars in Iran. As the EPC contract is one of the most general types of contracts, the results of this study can be used for other kinds of contracts as well. The case study was about nonindustrial buildings of 9, 10, 19, 20 and 21 phases of South Pars, which had been executed between 2007 and 2017. So that the results of this study should be reconsidered due to the pandemic of the COVID-19 in recent years. Almost all projects faced vast problems that had not been encountered before. Thus, investigating these novel conditions is highly recommended.

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