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PROGRESS FACILITATION FRAMEWORK FOR CONSTRUCTION OF MEGA METHANOL PRODUCTION PLANTS IN ASALLOUYEH, IRAN

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Abstract: In Asallouyeh, Iran, among five similar methanol producing plants which were simultaneously initiated eight years ago only one has been completed so far. It was wondered what could have been done to facilitate the progress of rest. To this end, dimensions and causes of the corresponding lack of progress were elicited through field observations of the incomplete projects and interviews with experts. Analytic hierarchical process (AHP) was applied to construct the research model followed by a questionnaire survey to make pairwise comparisons of the dimensions and the causes. The respondents' inputs were analyzed by Expert Choice Professional (ECPro) in order to prioritize the items. The study concluded that the political dimension significantly contributed to the status quo of the incomplete projects and "difficult international trading due to political issues" was the most effective cause of keeping the projects behind schedule. Finally, a progress facilitation framework was advanced validity of which was confirmed by the Delphi method.

1 INTRODUCTION

One-off engineering projects are usually hampered by unpredicted economic, social, and environmental challenges (Wenying and Xiaojun, 2011) which unpropitiously affect project success (Sirisomboonsuk et al., 2018) and performance (Elwakil, 2017). For a long time, clients believed that capitalizing on cutting-edge construction equipment and advanced tools as well as employing proficient project members guarantee project success (Zhang et al., 2009). All the same, this school of thought has been currently supplanted by brand-new notions (Sirisomboonsuk et al., 2018). In other words, though determining pivotal project success criteria is an overarching concept, it is not sufficient for successful project completion (Masrom et al., 2015). An easy, precise, and rapid project progress monitoring is complementary to the criteria identification (Alizadehsalehi and Yitmen, 2016; Zhang et al., 2009). If actual progress differs from the scheduled one, corrective practices will be required (Cristóbal, 2017). In order to monitor project progress traditional (Tavakoli, 1990) and BIM-based technics have been suggested (Alizadehsalehi and Yitmen, 2016). The latter adopts technologies which include but are not limited to global positioning system (Jiang et al., 2015), image-based modeling (Han and Fard, 2015), wireless sensor network (Chae et al., 2012), barcodes (Lee et al., 2013), radio frequency identification (Bosché et al., 2015), ultra-wideband (Shahi et al., 2015), and 3D laser scanning (Wang and Cho, 2015). In case these technologies are unavailable, project managers are required to ensure that the project progresses on schedule by means of traditional practices, which cannot be achieved unless the potential barriers to project progress are identified and avoided. Manifestly, all identified barriers cannot be removed at once and it requires the prioritization of the barriers and the removal of high-priority ones at first. Similar to all civil projects, petrochemical projects are subject to numerous barriers (Li, 2016) giving prominence to the significance of progress control (Heravi et al., 2015; Chao and Chen, 2015). Facilitating petrochemical projects progress monitoring through establishing a framework is the ultimate goal of the present paper. To the best of the authors' knowledge, such a study has not been done thus far and therefore is advisable to be undertaken.

2 PROBLEM STATEMENT

Within the last couple of decades, project managers/scholars have recognized that the conventional success criteria known as iron triangle (time, cost, quality) are not sufficient enough to push a project forward with the long-term success trend/plan of an organization. The perception of project success may differ from one industry/stakeholder to another industry/stakeholder. Petrochemical projects are highly complex and enormous number of parameters are to be tracked in order to produce quality products according to the customer requirements and dynamic changes in the market. To succeed in such complex projects, it is vital to be successful in every phase of the project lifecycle. To this end, in this study, dimensions and causes of the corresponding lack of progress were elicited through field observations of the incomplete methanol producing projects and interviews with experts. These inputs were used to structure a progress facilitation framework and help the project owners meet the predefined success criteria.

3 LITERATURE REVIEW

The current section of the article sets out to review some of the most recent papers related to the application of AHP in project management and to give a brief synopsis. Richardson and Amankwatia, 2018 adopted a combined GIS-AHP-based approach to produce a map to assess the watershed vulnerability in Bernalillo County, New Mexico. They utilized the map to identify the portions of the county which were vulnerable to intermittent precipitations. They pointed out that the approach could aid decision-makers and governors of the county to select structural and non-structural storm-water control measures specifically in arid areas. Erdogan et al., 2017 identified major problems of construction management and discussed a nine-stage AHP-based model to resolve decision-making problems in the construction industry by calculating the alternatives weights. Based on literature review and experts' inputs, seven criteria were determined including management performance and employees' qualification, capacity, performance recourses, operation and equipment, technical experience, safety record, and financial stability. They conducted a case study of a swimming pool construction project to evaluate the eligible contractors and choose one with the highest priority. After analyses, the contractor with a total score of 0.551 was selected. Radziszewska-Zielina and Szewczyk, 2016 averred that the key to project performance improvement is preserving a proper relationship with the project stakeholders and focusing on project success. They presented 18 partnering relation parameters and assigned them to collaborative relations between the investor, materials and equipment supplier, subcontractor, designer, and one of the general contractor or project manager. The investigated criteria were quality, safety, cost, and duration. The research featured AHP and Fuzzy AHP algorithms to prioritize the parameters. The authors reported that the more priority a parameter has, the sooner it should be improved to benefit the project as much as possible in terms of quality, safety, cost, and duration. Polat et al., 2016 pronounced that the project selection directly impacts the success of construction companies. They believed that the copious uncertainties make the complicated process of project selection more elaborate and clarified the essence of a project selection tool. Studying urban renewal projects in Turkey, they combined AHP and PROMETHEE approaches to weigh criteria and rank alternative projects. To assess the integrated approach, they applied it to a Turkish construction company predominately doing urban renewal projects through which its usefulness, easiness to use, effectiveness, and practicability were approved. They also recommended using fuzzy numbers to evaluate qualitative items for future researchers.

4 METHODOLOGY

In the present paper, five similar methanol producing plants in Asallouyeh, Iran which were initiated simultaneously eight years ago, were studied. Hitherto, one of them has been almost completed successfully and the remaining four plants are incomplete. Field observations of the incomplete projects were made and face-to-face in-depth interviews with the projects' experts were conducted to elicit the underlying dimensions and causes of the corresponding lack of progress as summarized in Table 1:

Table 1: Identified dimensions and causes of lack of progress in the studied projects

Dimension	Code	Cause	Code
Financial	F	Lack of financial resources.	F_1
Technical	T	Delay in utility supply.	T_1
		Delay in the provision of procurements.	T_2
		Erroneous, inappropriate, or impractical design.	T_3
Managerial	M	Using non-local equipment, materials, workforces etc.	M_1
		Bad prioritization of activities.	M_2
		Inefficient top management.	M_3
Stakeholders-related	S	Inexperienced workforce.	S_1
		Insufficiently encouraged team-working.	S_2
		Managers' strict behavior.	S_3
Political	P	Difficult international trading due to political issues.	P_1

Subsequently, AHP was applied to construct the hierarchical model of the goal, the criterion, the sub-criteria, and the alternatives as illustrated in Figure 1, followed by conducting a questionnaire survey to make pairwise comparisons of the dimensions and the causes. Next, the inputs of the respondents were analyzed by ECPro to prioritize the dimensions and the causes based on which a framework is advanced to facilitate the studied and future methanol production plants progress. The framework was validated by means of the Delphi method.

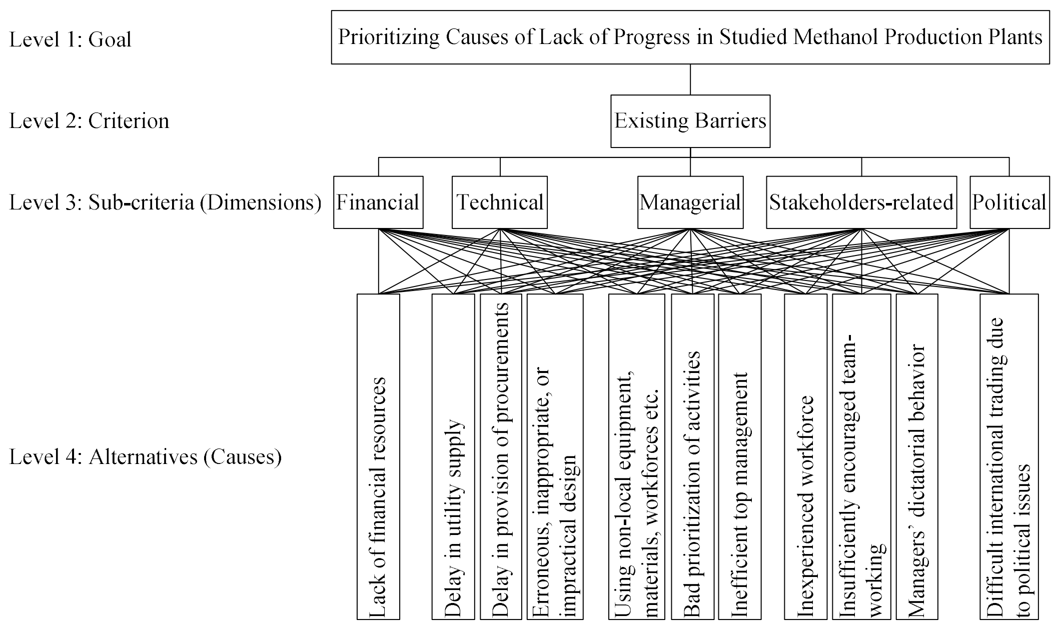

Figure 1: Hierarchical model of lack of progress in the incomplete projects

4.1 Making pairwise comparisons

To compare the items, Saaty's fundamental scale for judgments was applied. To make a pairwise comparison, the following approaches can be adopted: (1) Relying on the judgment of an expert (Saaty and Sagir, 2009) in which bias will not be inevitable (Ishizaka and Labib, 2011), (2) Surveying of several experts and combining their preferences into a consensus one through discussion and unanimous agreement (Ishizaka and Labib, 2011). This approach is less difficult (Saaty, 2016), is widely used by scholars (Abba et al., 2013), and is suggested by ECPro manual (Al-Harbi, 2001), (3) Applying geometric mean method or weighted arithmetic mean method to the ratings of respondents (Ishizaka and Labib, 2011) to produce a single rating for each pairwise comparison. Considering the advantages of the second approach, in this research six experts were invited to participate in a questionnaire survey to make the pairwise comparison of the dimensions and the causes. They were asked to reach an agreement on value of each entry in matrixes of pairwise comparisons to eliminate biases, provide an opportunity to discuss and exchange ideas prior to submission of values, and avoid the drudgeries of geometric and weighted arithmetic mean methods (Saaty, 2016; Abba et al., 2013; Al-Harbi, 2001). It is noteworthy that in the matrixes, elements on the main diagonal are 1 and every other element is the reciprocal of the one in the transpose position as discussed earlier. Therefore, the experts were asked to only fill one side of the main diagonals of the matrixes. The characteristics of the experts are summarized in Table 2.

Table 2: Characteristics of the experts

Ref.	Gender	Age	Years of Work Experience	Field of Study	Degree	Role in the Company
1	Male	50	20	Civil Eng.	Ph.D.	Project manager
2	Male	48	19	Industrial Eng.	Ph.D.	Technical deputy
3	Female	48	17	Civil Eng.	Ph.D.	Faculty member
4	Male	60	35	Civil Eng.	Ph.D.	Faculty member
5	Female	43	13	Environmental Eng.	M.Sc.	Faculty member
6	Male	56	24	Civil Eng.	Ph.D.	Urban development deputy

4.2 Prioritization

To interpret the obtained judgment matrixes, first, the model presented in Figure 1 was produced through defining the goal, the criterion, and the sub-criteria, and the alternatives in ECPro. Then, the matrixes were incorporated into the software and were analyzed. The analyses are acceptable if the corresponding inconstancy ratios are not greater than 0.10 (Saaty, 2016; Abba et al., 2013; Al-Harbi, 2001). Fortunately, this was the case for the all matrixes asserting the consistency of the judgment matrixes provided by the experts. As soon as data entry process ended in ECPro, the software provided the priorities of the sub-criteria and the alternatives. Owing to the consistency of the judgment matrixes, the desirability of the prioritizations made by ECPro which are presented in Figures 2-7 is corroborated.

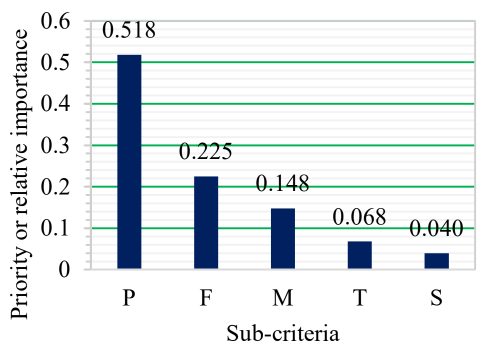

Figure 2: Priorities of the sub-criteria with respect to the goal

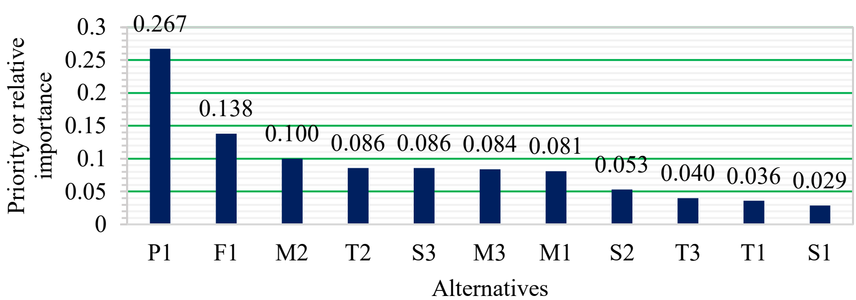

Figure 3: Impact of the financial sub-criterion on the alternatives

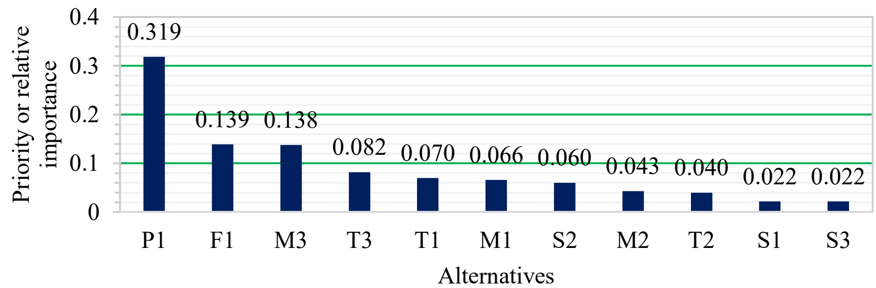

Figure 4: Impact of the technical sub-criterion on the alternatives

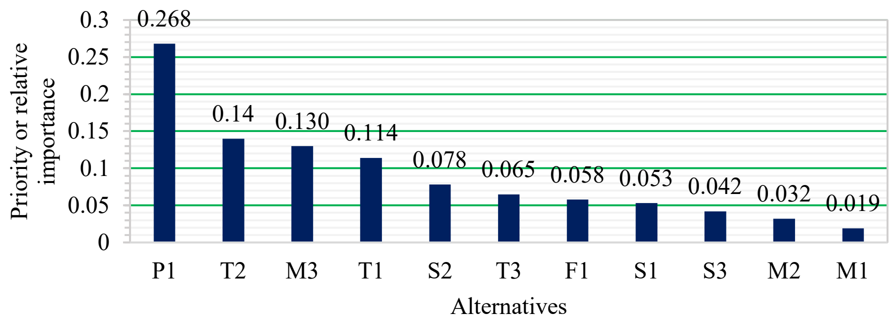

Figure 5: Impact of the managerial sub-criterion on the alternatives.

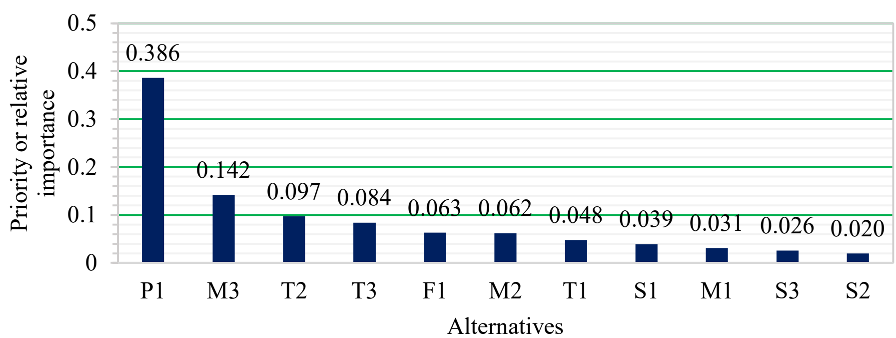

Figure 6: Impact of the stakeholders-related sub-criterion on the alternatives

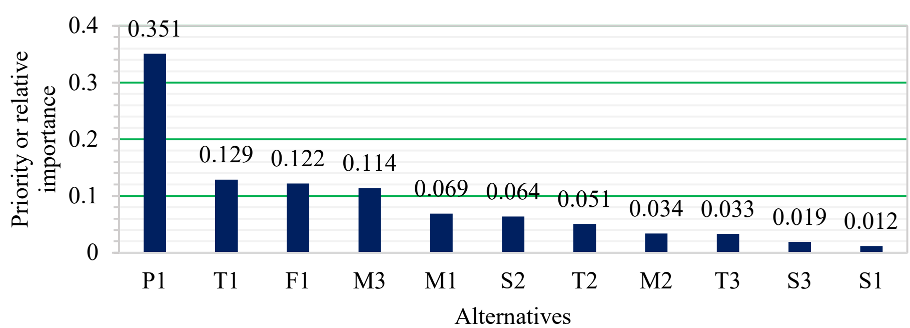

Figure 7: Impact of the political sub-criterion on the alternatives

According to Figure 2 which provides priorities of the sub-criteria with respect to the goal, political barriers mainly caused by international sanctions have the highest priority. To elucidate on, the sanctions hinder Iran trading with other countries due to the imposed bans or difficulties of financial transactions between

Iran and foreign countries, therefore, methanol production plants could not be supplied with the required international procurements. Financial, managerial, technical, and stakeholders-related barriers are respectively determined as the next of highest priority sub-criteria in descending order. Figures 3 to 7 represent the impact of the individual sub-criteria on the alternatives and concomitantly clarify that alternative P1 or "difficult international trading due to political issues" has the highest priority with respect to all sub-criteria. This issue harmoniously resonates with emphases laid by interviewees on the incomplete project sites that due to the difficulties of international trading, the required foreign procurements are not delivered timely or they cannot be purchased from the international manufacturers.

4.3 Progress facilitation framework for methanol production plants

Considering that the obtained rankings introduce political sub-criterion as the one with the highest priority, and the fact that the alternatives are prioritized with respect to this sub-criterion in Figure 7, it is suggested that the barriers be invested on and be taken up in the order they appeared in Figure 7 to facilitate progress of the incomplete projects. Correspondingly, the framework in Table 3 is proposed to accelerate the studied and future methanol production plants progress.

Table 3: Progress facilitation framework for the construction of methanol production plants in Iran

Priority	Barrier	Barrier Description	Solution
1	P_1	Difficult international trading due to political issues.	Convincing the government to improve diplomatic relations with foreign countries.
2	T_1	Delay in utility supply.	Constructing utility production unit before and inside the methanol production plant.
3	F_1	Lack of financial resources.	Conducting prefeasibility and feasibility studies before project initiation.
4	M_3	Inefficient top management.	Devising a mechanism to supervise top managers.
5	M_1	Using non-local equipment, materials, workforces etc.	Using local equipment, materials, workforces etc. when possible.
6	S_2	Insufficiently encouraged team-working.	Promoting team-working through incentives and training.
7	T_2	Delay in provision of procurements.	Ordering procurements earlier.
8	M_2	Bad prioritization of activities.	Strengthening project control department.
9	T_3	Erroneous, inappropriate, or impractical design.	Cross-checking designs before execution.
10	S_3	Managers' strict behavior.	Developing a system to supervise managers' behavior.
11	S_1	Inexperienced workforce.	Evaluating job applicants before recruitment.

4.4 Validating the results

To validate the research findings, the Delphi method was used. The following sections provide details of the validation process.

4.4.1 Helpful guides to the Delphi method

In engineering subfield, different researchers employed or proposed dissimilar and vague structures to adopt the Delphi method, the problem which has been significantly overcome since Hallowell and Gambatese, 2010 developed a comprehensive guideline for the method. Notable information of this guideline on which the authors relied is directly rewritten without major paraphrasing (Hallowell and Gambatese, 2010):

- Numbers of panelists: 8-12
- Number of rounds: 3

Any panelist must satisfy at least four of the following criteria:

- At least 5 years of professional experience in the construction industry
- A faculty member at an accredited institution of higher education
- Member or chair of a nationally recognized committee
- Associated Risk Manager
- Professional registration such as Professional Engineer, Licensed Architect, Certified Safety Professional, Invited to present at a conference
- Writer or editor of a book or book chapter on the topic of construction management
- A primary or secondary writer of at least three peer-reviewed journal articles
- Advanced degree in the field of civil engineering, construction engineering and management, or other related fields (minimum of a B.Sc.)

Also, it is suggested that the panelists score at least one point in four different achievement or experience categories of Table 4 and a minimum of 11 total points in order to qualify for participation.

Table 4: Flexible point system for the qualification of expert panelists

Achievement or experience	Points (Each)
Professional registration	3
Year of professional experience	1
Conference presentation	0.5
Member of a committee	1
Chair of a committee	3
Peer-reviewed journal article	2
A faculty member at an accredited university	3
Writer/editor of a book	4
A writer of a book chapter	2
Advanced degrees:	-
B.Sc.	4
M.Sc.	2
Ph.D.	4

4.4.2 The validation process

The steps taken to validate the results are as follows:

Inviting qualified panelists: Following the explained guideline in the previous section, 12 referees were invited to partake in the validation process of the developed framework through the Delphi method. All the panelists were qualified due to the following:

- They all satisfied four qualification criteria: they were invited to present at a conference at least once, had at least 5 years of professional experience in the construction of petrochemical projects, held M.Sc. or Ph.D. degrees, and were professional engineers.
- They scored more than 11 points.

The first round of the method: Once the qualified panelists were invited, the first round of the survey began. The framework was printed on one side of an A4 sheet and was delivered to the panelists to review and comment on. Three panelists accepted it as it was, eight panelists suggested that F1 or “Lack of financial resources” should be the second most important cause of delay, and one panelist believed that M_2 or “Bad prioritization of activities” should appear among the three top delay causes. Taking into account all of these suggestions, F_1 and M_2 were shifted respectively one and five rows upward, resulting in the revised framework of Table 5.

Table 5: Revised progress facilitation framework for the construction of methanol production plants in Iran

Priority	Code	Barrier Description	Solution
1	P_1	Difficult international trading due to political issues.	Convincing the government to improve diplomatic relations with foreign countries.
2	F_1	Lack of financial resources.	Conducting prefeasibility and feasibility studies before project initiation.
3	M_2	Bad prioritization of activities.	Strengthening project control department.
4	T_1	Delay in utility supply.	Constructing utility production unit before and inside the methanol production plant.
5	M_3	Inefficient top management.	Devising a mechanism to supervise top managers.
6	M_1	Using non-local equipment, materials, workforces etc.	Using local equipment, materials, workforces etc. when possible.
7	S_2	Insufficiently encouraged team-working.	Promoting team-working through incentives and training.
8	T_2	Delay in provision of procurements.	Ordering procurements earlier.
9	T_3	Erroneous, inappropriate, or impractical design.	Cross-checking designs before execution.
10	S_3	Managers' strict behavior.	Developing a system to supervise managers' behavior.
11	S_1	Inexperienced workforce.	Evaluating job applicants before recruitment.

The second round of the method: In the second round, the panelists were requested to review the revised framework. Receiving no further comments, fortunately a consensus was reached and they unanimously confirmed its validation.

5 RESULTS AND DISCUSSION

The projects in the petrochemical industry encompass a myriad of uncertainties trammeling their progress. In these projects keeping abreast of the project progress is indispensable for the sake of success. A petrochemical project with slow pace will be fraught with intertwined scheduling, financial, managerial, environmental, and technical problems accentuating paramountcy of identifying and mitigating barriers to the project progress. Therefore, the present paper underlined the significance of progress monitoring in petrochemical projects. Study of five methanol production plants unveiled dimensions and causes of lack of construction progress in four of them which were structured through the application of AHP. To the best of the authors' knowledge, although AHP has widely been used in the construction industry, it rarely has been used to develop a framework for time management of petrochemical projects. To this end, a questionnaire survey was carried out to make pairwise comparisons of the dimensions and the causes. The results of this survey were analyzed by ECPro to prioritize the dimensions and the causes. It was concluded that the political sub-criteria contributed to the current status of the incomplete projects most. Furthermore, alternative P_1 or "difficult international trading due to political issues" is deemed to be the most effective one in keeping the projects behind the schedule. Based on these findings a framework was developed to facilitate existing and current methanol production plants. A subsequent Delphi study proved the validity of the framework. In summary, the paper contributes to project management and petrochemical engineering body of knowledge, by introducing AHP as a practical managerial tool, emphasizing on importance of prioritizing existing problems before dealing with them, and explaining how to develop and evaluate a framework as a panacea to the problem of lack of construction progress in petrochemical projects.

6 CONCLUSIONS

Delay in Iranian petrochemical projects is a significant problem urgently needing an action. Providing a solution for time management of these projects will highly benefit the national petrochemical industry and the dependent industries, the people, and the government. Finding such a solution requires answering the following key questions:

- What are the main causes of delays in incomplete petrochemical projects?
- What can be done to facilitate their progress?

Providing compelling responses to these questions was the main focus of this paper. With this purpose in mind, the authors conducted a case study of five Iranian methanol producing plants among which four were behind schedule. Based on the findings, a framework which helps overcome the scheduling problems of Iranian petrochemical projects was advanced. It is due to the fact that the identified barriers, especially the high-ranking ones, are not specific to the studied projects, but to all Iranian petrochemical projects. This framework could be further developed in future to create a success break down structure for petrochemical projects.

7 RESEARCH LIMITATIONS

The current study focused on prioritization of 5 dimensions and 11 causes using AHP and ECPro. The dimensions and causes are derived from field observations of methanol production plants so the findings and results are not applicable to other sorts of petrochemical projects. Furthermore, employing other prioritization methods may lead to different prioritizations from those obtained in this paper.

8 ACKNOWLEDGMENT

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