E-ISSN: 2676-6167 | P-ISSN: 2538-5100

Journal of Applied Research on Industrial Engineering

www.journal-aprie.com

J. Appl. Res. Ind. Eng. Vol. 9, No. 1 (2022) 68–77.

Paper Type: Research Paper

Investigating Causes of Delay in Natural Gas Distribution Pipeline Projects: a Correlation Analysis (Case Study: Khuzestan Province of Iran)

Hadi Mehrabi Sharafabadi[1], Mohamad Ali Movafaghpour[2,*]

[1] Khuzestan Gas Company, Ahwaz, Iran; hadi.mehrabi@gmail.com.

[2] Department of Industrial Engineering, Facuty of Mechanical Engineering, Jundi-Shapur University of Technology, Dezful, Iran; movafaghpour@jsu.ac.ir.

Citation:

Mehrabi Sharafabadi, H., & Movafaghpour, M. A. (2022). Investigating causes of delay in natural gas distribution pipeline projects-a correlation analysis (case study: Khuzestan Province of Iran). *Journal of applied research on industrial engineering, 9*(1), 68-77.

Received: 30/05/2021 Reviewed: 22/06/2021 Revised: 14/10/2021 Accepted: 23/11/2021

Abstract

The main purpose of this study is to identify the delay factors and evaluate the type ranking of delays in natural gas distribution projects. We have investigated 274 projects in Khuzestan gas company from 2015 to 2020. Projects investigated in this study included urban, rural, transmission lines, industrial pipelines, and construction. We identified 22 delay factors and categorized them into owner, contractor, and other related factors. This research shows that Most of the delay factors are related to owner causes. In addition to identifying the factors, this study also deals with the extent of their relationship. In addition to identifying the delay factors, this study also deals with the extent of their relationship. We showed that delay factors may not be independent and there is a significant association between them. These Relations clearly showed that reduction or elimination of many delay factors lead to eliminating many others. The findings of the research were validated and implemented by company experts.

Keywords: Causes of delay, Natural gas distribution projects, Delay factors correlation, Iran.

1 | Introduction

The success of a project, in addition to achieving project implementation goals and costs, is expected to be completed on time. Delays can cause additional costs to the project stakeholders and make disputes in involved groups. Therefore, it is necessary to have accurate and clear mechanisms for delay analysis to determine its effect on a different part of projects and reveal the causes and reasons of delay. Projects are often delayed. Project management tools and techniques can play an important role in effective management [1]. Project management includes the management of resources, staff, equipment, money, capital, materials, and methods. All the studied projects consist of two separate stages: before construction, there is a period between project identification and contracting, and then the construction period.

Corresponding Author: hadi.mehrabi@gmail.com

http://dx.doi.org/10.22105/jarie.2021.288492.1333

Delays and cost increases may occur in both periods, but the main reasons for delays and cost increases usually occur during the construction period. There are many reasons for delays and increased costs in pipeline projects. These causes can be rooted in more fundamental issues such as social, economic, technological, and political issues.

In distribution line projects, by addressing the root causes of delays, Orangi et al. [16] identified these factors include: design changes, design errors, poor communication, customer/end-user related issues, subsurface investigation inadequacies, issues regarding permissions/approvals, weather conditions, procurement delays, site management problems, subcontractor issues, rework, cultural and heritage management issues.

Pipelines are suitable for long-term usage due to the costs incurred consist of development costs and maintenance costs [15] and due to its huge natural gas resources, Iran has a high potential for distribution projects for domestic and industrial consumers.

Recently, a large number of transferring natural gas distribution projects in Iran have been done. Most of them include transmission pipelines, construction of stations and facilities, urban distribution, industrial pipeline, and rural distribution. This category is summarized in *Fig. 1*.

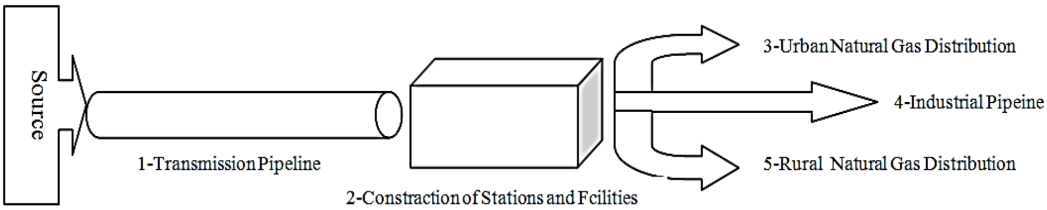

Fig. 1. Types of natural gas distribution projects.

The reason for this classification is the difference of stakeholders and the kind of problems that might be faced. For instance, in urban areas, the density of buildings is high and the number of licenses required from public sectors is too much, and traffic and security issues have their complexities. In rural areas, the issue of land acquisition and the economic subjects is more important. Transmission pipelines are almost different from distribution pipelines because of technical and standards needs like internal pressure, etc. Construction projects are related to the construction of office and operational buildings to support the transfer of natural gas to consumers. Industrial line projects are usually built specifically to transfer natural gas to one or more industries.

Fallahnejad [8] identified 43 causes of delay and ranked these causes in Iran gas transmission pipeline projects, he shows that 10 major delay factors include: imported materials, unrealistic project duration, client-related materials, land expropriation, order changes, contractor selection methods, and payment to the contractor, obtaining permits, suppliers, and contractor's cash flow [8].

Mohammed and Suliman [17] identified and ranked 47 delay factors in Pipeline construction projects in the oil and gas industry in Bahrain, some of the factors identified in the study included: poor managerial skill, slow decision making within all project teams; lack of communication between client, consultant, and contractor; inadequate design team; scope variations; unrealistic contract decision and delay in drawings preparation of the project.

In this study, we focused on identifying causes of delay and practical effectiveness in natural gas projects. This research applied to transferring natural gas distribution projects in the Khuzestan state of Iran.

2 | Literature Review

Many investigations have been done to evaluate the causes of delays in construction projects. Durdyev and Hosseini [6] present a systematic review of studies on Continuing Professional Development (CPD) published between 1985 and 2018 about delay factors in projects. They presented the findings of a review of the selected studies in terms of publication trends, an assessment of the contributing countries, institutions, and researchers. Chan and Kumaraswamy [5] surveyed the causes of construction delays in Hong Kong and examined the factors affecting productivity. The survey revealed differences in perceptions of the relative significance of factors including financing and payment for completed works, poor contract management, changes in site conditions, shortage of materials, and improper planning.

Al-Momani [2] investigated the causes of delays on 130 public projects in Jordan and the results indicated that the main causes of delay in construction of public projects relate to designers, user changes, weather, site conditions, late deliveries, and economic conditions. Al-Momani [2] performed a quantitative analysis on construction delays in Jordan. The result of his research specified the main causes of delay in construction of public projects were related to designers, user changes, weather, site conditions, late deliveries, economic conditions and increase in quantity.

Frimpong et al. [9] identified the significant factors that cause delay and cost overruns in the construction of groundwater projects in Ghana. It was shown that consultants, owners, and contractors agree substantially on the ranking of the categories of delay and cost overrun factors. It was also shown that all three groups surveyed ranked the project financing category of delay and cost overrun factors highest, while the labor category was ranked lowest. Assaf and Al-Hejji [4] identified 56 main causes of delay, important delay factors were: preparation and approval of shop drawings, delays in contractor's progress, payments, design changes, relationship between subcontractors and the slow decision making process of the owner etc.

Abd El-Razek et al. [7] investigated the causes of delays and indicated that the most important causes were financed by the contractor during construction, delays in contractor's payment by the owner, design changes by the owner or his agent during construction, partial payments during construction, and non-utilization of professional construction/contractual management.

Tumi et al. [20] identified 43 factors that cause a delay in the construction industry projects in Libya. They categorized delay factors as Inexcusable and Excusable and made offers to avoid them. Kazaz et al. [12] investigated the main causes that affected project durations in Turkey concerning seven categories.

Jaferi et al. [10] have identified the most important risk factors in gas distribution projects and categorized them based on their importance and probability of occurrence. These factors include improper or incomplete package design, shortages of goods, shortages of budget, governmental or people disagreement, and improper selection of contractor. They showed the importance of risk management analysis in identifying major risk-generation areas that require taking appropriate measures in averting or overcoming unexpected operational and performance challenges that affect organizational survival. They present the effectiveness of a proposed method in achieving a more effective project control system.

Ansah and Sorooshian [3] have proposed a theoretical framework, the 4P project delays, grouping them based on their shared characteristics. Adam et al. [1] conducted a literature analysis to provide an aggregated ranking of project delays, which was implied to 40 journal articles reporting on delays in publicly-funded construction projects. Sambasivan and Soon [14] Analyzed the delays in the Tanzanian construction industry by using transaction cost economics and structural equation modeling approach. They analyzed 32 delay causes under 7 groups.

Mehrabi Sharafabadi and Movafaghpour | J. Appl. Res. Ind. Eng. 9(1) (2022) 68-77

Tafazzoli and Shrestha [19] identified 30 potential causes of construction delays and assessed the criticality of the factors that cause construction delays and ranked them in USA. Shahsavand et al. [18] identified 78 causes of delay factors. The identified causes are combined into seven groups. The field survey included 58 contractors, 55 consultants, and 62 clients. Mohammed and Suliman [17] identified delay factors included: poor managerial skill, slow decision making within all project teams; lack of communication between client, consultant and contractor; inadequate design team; scope variations; unrealistic contract decision and delay in drawings preparation of the project. They identified the factors causing delays and the risk associated with them in the pipeline construction projects in Bahrain.

3 | Research Objectives and Method

We have broken the studies into three parts:

- *Identify and categorize project delay factors.*
- *Evaluate the Relative Importance Index (RII) and frequency of delay factors in classifiedprojects.*
- *Ranking of delay factors and analyzing their relationships in each project type.*

3.1 | Identifying Causes of Delays

Due to the lack of accurate quantitative indicators for each project delay factor, identification of delay project factors has been done by interviews from 17 experts asked to list causes of delay in projects. By using the screening method, we analyzed extracted factors. We summarized 520 achieved delay factors to 22. (*Table 1*) These extracted factors are categorized as the owner, contractor, and other factors. Delays related to the contractor are outside the scope of organizational operations and management of the owner, these factors include Difficulties in obtaining work permits, poor site management, and supervision by the contractor. Owner caused delays are a direct function of the organization and including design errors/changes, owner lack of experience, problems of land acquisition, supply of materials, delay in performing inspection and approval by consultant or owner, and financial constraints by the owner. Also, another factor is weather reasons. This factor is very important in outdoor pipe construction projects (*Fig. 2*).

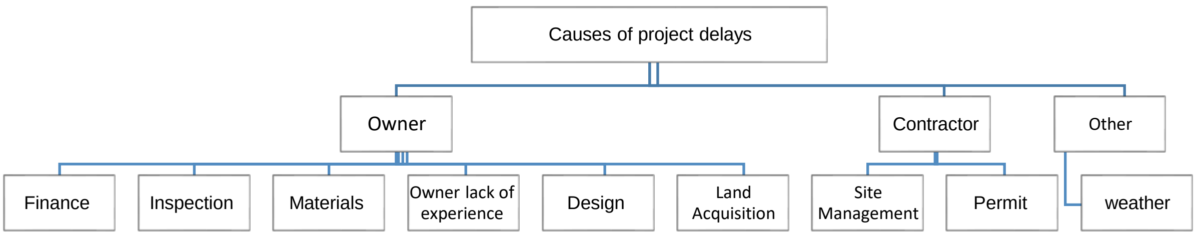

Fig. 2. Classificationon factors of delay causes in pipeline projects.

3.2 | Identifying Frequency of Factors

After we identified and categorized delay factors, we prepared the questionnaire of count distribution to obtain the effect of each of these 22 factors in 274 projects between the years 2015 to 2020. Due to the nature and methods of technical implementation, projects are divided into five main categories: urban, rural, transmission pipeline, construction, and industrial pipeline.

After we prepared the questionnaire about the effects of delays in projects, first we determined the existence of every delay factor and then measured the intensity of it by a five-segmented spectrum parted in all projects. This spectrum included very low, low, medium, high, and very high parts. The results of the survey for this question were analyzed using the RII method [11]. RII is shown in *Eq. (1)*.

$$RII = \frac{\sum w}{A * N}, 0 \le RII \le 1. \quad (1)$$

Where W is the weight given to each factor by respondents and ranges between 1 and 5, A is the highest weight (in this case, 5), and N is the total number of respondents. This index is calculated for different types of projects in *Table 1*.

Table 1. RII Calculated for a variety of natural gas distribution projects.

Delay Factor	RII				
	Urban	Rural	Transmission Line	Industrial	Construction
Order changes	0.62	0.67	0.60	0.64	0.76
Delay in Inspection	0.31	0.65	0.60	0.60	0.22
Contractor finance issues	0.41	0.43	0.60	0.80	0.55
Design error	0.36	0.47	0.60	0.64	0.23
Quality of material in site	0.56	0.53	0.28	0.80	0.54
Lack of communication of project team	0.60	0.61	0.90	0.91	0.58
Background of weak claim about project delays	0.63	0.63	0.40	0.60	0.40
Supply of material for projects	0.57	0.77	0.60	0.76	0.40
Equipment	0.37	0.33	0.60	0.60	0.57
Planning and scheduling errors	0.31	0.57	0.76	0.44	0.20
Lack of experience of contractors	0.59	0.70	0.30	0.74	0.64
Payment delays	0.59	0.73	0.60	0.92	0.49
Difficulties in obtaining work permits	0.83	0.76	0.60	0.86	0.58
Clashes with other public sectors	0.51	0.71	0.50	0.93	0.22
Laws and regulations	0.39	0.72	0.65	0.53	0.20
Slow decision making	0.29	0.80	0.35	0.20	0.20
Variation in estimated quantities	0.79	0.85	0.60	0.66	0.53
Adverse weather conditions	0.61	0.79	0.68	1.00	0.64
Lack of motivation of staff monitoring system	0.65	0.68	0.36	0.64	0.56
Design change	0.62	0.74	0.60	0.91	0.47
Land acquisition problems	0.76	0.81	0.73	0.72	0.78
Environmental factors	0.34	0.60	0.35	0.51	0.20

We have aggregated each of the various delay factors in different kinds of projects and find a ranking of each factor (*Table 2*). This ranking of factors could be useful to the management of projects. By focusing on delay factors with a higher ranking, their occurrence can be prevented.

In the next step of our research, we focus on the relationship between project types and their delay factors. Having the rank of each delay factor, we can statistically test the appropriateness of the categorizing of project types and calculate Kendal's tau correlation coefficient between each couple of projects. The Kendall tau-b coefficient is defined in *Eq. (2)* [13].

$$\tau_B = \frac{n_c - n_d}{\sqrt{\left(\left(n_0 - n_1\right)\left(n_0 - n_2\right)\right)}}. \quad (2)$$

Where $n_0 = n(n-1)/2$, $n_1 = \sum_i t_i(t_i - 1)/2$, and $n_2 = \sum_j u_j(u_j - 1)/2$, and t_i = Number of tied values in the i^{th} group of ties for the first quantity, u_j = Number of tied values in the j^{th} group of ties for the second quantity.

Table 2. Delay factors and ranking and categorizing them.

Delay Factor	Ranking in Urban Projects	Ranking in Rural Projects	Ranking in Transmission line	Ranking in Industrial	Ranking in Construction	Category	Type
Background of weak claim about project delays	21	18	21	6	4	Lack of owners Experience	Owner caused delays
Order changes	1	1	5	11	10		
Lack of communication of project team	8	6	18	3	21		
Planning and scheduling errors	13	17	8	7	9		
Slow decision making	20	3	20	22	17		
Variation on estimated quantities	10	5	22	8	18		
Lack of motivation of staff monitoring system	22	9	4	14	11		
Delay on inspection	3	12	7	12	13	Inspection	Owner caused delays
Contractor finance issues	19	21	12	2	2	Site management	Contract or Caused Delay
Quality of material in site	5	13	10	17	14		
Lack of experience of contractors	7	4	17	1	16		
Equipment	6	19	9	10	1		
Land acquisition problems	12	16	6	5	6	Land acquisition	Owner caused delays
Adverse weather conditions	16	22	2	16	20	Weather	Other
Design change	15	7	3	9	7	Design	Owner caused delays
Design error	14	10	1	13	19		
Supply of Material for Projects	2	2	13	21	15	Supply	Owner caused delays
Payment delays	9	15	19	4	22	Finance	Owner caused delays
Difficulties in obtaining work permits	17	20	11	15	3	Permit	Contractor caused delay
Clashes with other public sectors	18	8	14	18	5		
Laws and regulations	4	11	15	19	8		
Environmental factors	11	14	16	20	12		

So we do the following test:

- *H_0: rankings for five types of projects are equal.*
- *H_1: rankings for five types of projects are different.*

As can be seen in *Table 3* the H_0 is rejected and the ranking of the projects are different and our classification is correct for the projects. Spearman correlations have been obtained had the same conclusion.

Table 3. Kendall's Tau_b correlation test for categorizing of projects.

			Urban	Rural	Transmission Pipeline	Industrial	Construction
Kendall's Tau_B	Urban	Correlation Coefficient	1.000	.273	.048	.013	-.160
		Sig. (2-Tailed)	.	.076	.756	.933	.297
	Rural	Correlation Coefficient	.273	1.000	-.091	-.091	-.281
		Sig. (2-Tailed)	.076	.	.554	.554	.067
	Transmission Pipeline	Correlation Coefficient	.048	-.091	1.000	-.004	.134
		Sig. (2-Tailed)	.756	.554	.	.978	.382
	Industrial	Correlation Coefficient	.013	-.091	-.004	1.000	.082
		Sig. (2-Tailed)	.933	.554	.978	.	.592
	Construction	Correlation Coefficient	-.160	-.281	.134	.082	1.000
		Sig. (2-Tailed)	.297	.067	.382	.592	.

4 | Results

Generally, in the study period from a total of 274 investigated projects, 1160 effective factors have been identified. 699 factors were related to the owner, 46 factors related to whether, and 415 factors were related to the contractor. The frequency of factors can be seen in *Table 4*. As it was seen most of the owner's factors related to the lack of experience and design. The effect of permit problems in rural projects is considerable. Most of the owner delays are related to the lack of experience in the project management team. In various ways, this issue leads to slow decisions in the implementation conditions and ultimately delays in the whole project. Design-related delays are the next in this category, the design of network lines in natural gas supply facilities, sometimes encounters unforeseen factors, such as dealing with underground complications that are not considered in the design.

Table 4. Frequency of delay factors

	Design	Owner lack of experience	Materials	Inspection	Finance	Land Acquisition	Permit	Site Management	Weather	Total
Urban	42	128	18	17	19	14	59	78	389	389
Rural	30	72	12	13	6	6	44	40	229	229
Transmission pipeline	11	27	4	3	4	5	17	18	93	93
Industrial pipeline	19	65	10	9	8	9	27	37	193	193
Construction	22	76	12	13	12	13	52	43	256	256
Total	124	368	56	55	49	47	199	216	1160	1160

4.1 | The Relationship between Delay Factors

Most research has been done to identify delay factors assuming the factors are independent. However, it seems that by examining the degree of correlation between the factors of delay, a more accurate understanding can be achieved to eliminate them. To identify the relationship between the delay factors we establish crosstabs of intervals of it intensify then with Chi-square test we would examine the significance of their relationship. The following test statistic can be used in *Eq. (3)*.

$$\chi^2 = \sum (f - e)^2 / e. \quad (3)$$

Where f is the actual frequency of delayed project factors, and e is the corresponding expected frequency. In this research, we found three significant relationships which are discussed in the sequel.

4.1.1 | Relationship between design and materials factors

To investigate the relationship between design and materials we extracted 56 common delay factors. *Table 5* shows the Frequency of observed and expected counts of it. Since the value of the test statistic is less than the value of $\chi^2_{0.05}$, the null hypothesis should be accepted. The chi-square statistic value obtained is equal to 61.631 therefore the significance of the relationship between these factors proved with P-value is 0.000. Pearson correlation between them obtains 0.672 and Spearman correlation is 0.661.

The reason could be wherever change occurred in the project plan or the initial design hadn't adapted with real project performance, the supply department could face disorder and Shortage of Material. As a result, the project also would be delayed in supplying equipment and Material.

Table 5. Materials * design cross tabulation.

			Low and very Low	Medium and High	Total
Materials	Low and very Low	Observerved Count	15	3	18
		Expected Count	7	11	18
	Medium and High	Observerved Count	6	32	38
		Expected Count	14	24	38

4.1.2 | Relationship between design and owner lack of experience

To investigate the relationship between design and Owner lack of experience, we extracted 56 common delay factors. *Table 6* shows the frequency of observed and expected counts of them.

The chi-square statistic value obtained is equal to 63.672, therefore the significance of the relationship between these factors proved with P-value = 0.000. Pearson correlation between them obtains 0.584 and Spearman correlation is 0.610.

Table 6. Performance * design cross tabulation.

			Low and Very Low	Medium and High	Total
Owner lLck of Experience	Low and Very Low	Observed Count	20	4	24
		Expected Count	11.1	12.9	24
	Medium and High	Observed Count	6	26	32
		Expected Count	14.9	17.1	32
Total		Count	26	30	
		Expected Count	26	30	

The analysis of this correlation can be expressed as follows: whenever there is a change in the project plan or the initial plan is not compatible with the actual scope of the project, the performance department and the owner supervision department need to change the plan and new coordination, this creates new delays and clearly shows that the organization can eliminates many of the owner-related delays by reducing design delays.

4.1.3 | Relationship between site management of contractor and owner lack of experience

To investigate the relationship between site management and lack of experience of owner's staff, we extracted 216 common delay factors. *Table 7* shows the frequency of observed and expected counts of it. The chi-square statistic value obtained is equal to 90.566 therefore the significance of the relationship between these factors proved with a P-value = 0.000. Pearson correlation between them obtains 0.308 and Spearman correlation is 0.297.

This correlation indicates that in cases where the contractor is weak in site management due to insufficient experience in the decision-making of the owner's staff, we will most likely face delays related to the owner.

Table 7. Owner lack of experience * site management of contractor cross tabulation.

			Site Management (Contractor)					Total
			Very Low	Low	Medium	High	Very High	
Owner Lack of Experience	Very Low	Observed Count	21	4	14	6	5	50
		Expected Count	12.5	8.3	11.6	9.7	7.9	50
	Low	Observed Count	15	17	6	8	8	54
		Expected Count	13.5	9	12.5	10.5	8.5	54
	Medium	Observed Count	9	5	24	11	2	51
		Expected Count	12.8	8.5	11.8	9.9	8	51
	High	Observed Count	7	4	2	14	3	30
		Expected Count	7.5	5	6.9	5.8	4.7	30
	Very High	Observed Count	2	6	4	3	16	31
		Expected Count	7.8	5.2	7.2	6	4.9	31

5 | Conclusion

In this research, because of the difference of condition of projects, we categorize them into five types and then we identified the delay factors and their frequencies. Because we identified factor rankings in each type of project, we used Kendall's tau test to validate this category. This test showed that the separation of projects was done well. In transmission line projects, lack of communication of the project team (RII=0.9), planning and scheduling errors (RII=0.76), and Land Acquisition Problems (RII=0.73) are the most important. This may be due to the level of complexity of these projects and the amount of land required compared to other types of projects.

Land Acquisition Problems (RII=0.78) and Order Changes (RII=0.76) are most important in construction projects. The required land dimensions, which are often used to build natural gas pressure reduction station, the location of facilities are important factors in delaying land acquisition. Changing orders by owner during construction is the second most important factor in this category. In urban projects, Obtaining Work Permits from the public sector is very important and has been the most important in the delay factors (RII=0.83). Variation in estimated quantities in rural projects is most important factor for decreasing of risk of delay project (RII=0.85).

Most of the owner factors related to the lack of experience. After that the design has the highest frequency. In contractor factors site management and permit factors have high frequency. The chi-square test showed a significant association between the design and materials factors and also between design and lack of experience of owner factors and site management of contractor and owner lack of experience factors. These relations clearly show that reduction or elimination of many design delay factors can eliminate many performance or supply delay factors and the use of efficient and experienced personnel in the owner sector can prevent many delays related to the contractor.

5.1 | Recommendations

We recommend performing research for identifying the effect of delay factors on different parts of the life cycle in naturalgas projects. Also, we recommend a mathematical modeling study using the relationship between factors and the frequency of delay factors in projects. Weighting of factors can also be done using the opinion of experts and mathematical models.

References

[1] Adam, A., Josephson, P. E. B., & Lindahl, G. (2017). Aggregation of factors causing cost overruns and time delays in large public construction projects: trends and implications. *Engineering, construction and architectural management*, *24*(3), 393-406.

[2] Al-Momani, A. H. (2000). Construction delay: a quantitative analysis. *International journal of project management*, *18*(1), 51-59.

[3] Ansah, R. H., & Sorooshian, S. (2018). 4P delays in project management. *Engineering, constructionand architectural management, 25*(1), 62-76.

[4] Assaf, S. A., & Al-Hejji, S. (2006). Causes of delay in large construction projects. *International journal of project management*, *24*(4), 349-357.

[5] Chan, D. W., & Kumaraswamy, M. M. (2002). Compressing construction durations: lessons learned from Hong Kong building projects. *International journal of project management*, *20*(1), 23-35.

[6] Durdyev, S., & Hosseini, M. R. (2019). Causes of delays on construction projects: a comprehensive list. *International journal of managing projects in business*, *13*(1), 20-46.

[7] Abd El-Razek, M. E., Bassioni, H. A., & Mobarak, A. M. (2008). Causes of delay in building construction projects in Egypt. *Journal of construction engineering and management*, *134*(11), 831-841.

[8] Fallahnejad, M. H. (2013). Delay causes in Iran gas pipeline projects. *International journal of project management*, *31*(1), 136-146.

[9] Frimpong, Y., Oluwoye, J., & Crawford, L. (2003). Causes of delay and cost overruns in construction of groundwater projects in a developing countries; Ghana as a case study. *International journal of project management*, *21*(5), 321-326.

[10] Jaferi, F., Sajadi, S. M., Alinaghian, M., & Beyranvand, M. (2014). Investigation of project risk management in project-based organizations using the PMBOK guideline case study: national gas company of Lorestan province. *Journal of applied research on industrial engineering*, *1*(2), 50-58.

[11] Johnson, J. W., & LeBreton, J. M. (2004). History and use of relative importance indices in organizational research. *Organizational research methods*, *7*(3), 238-257.

[12] Kazaz, A., Ulubeyli, S., & Tuncbilekli, N. A. (2012). Causes of delays in construction projects in Turkey. *Journal of civil engineering and management*, *18*(3), 426-435.

[13] Kendall, M. G. (1970). *Rank correlation methods*. Charles Griffin.

[14] Sambasivan, M., & Soon, Y. W. (2007). Causes and effects of delays in Malaysian construction industry. *International journal of project management*, *25*(5), 517-526.

[15] Nurprihatin, F., Octa, A., Regina, T., Wijaya, T., Luin, J., & Tannady, H. (2019). The extension analysis of natural gas network location-routing design through the feasibility study. *Journal of applied research on industrial engineering*, *6*(2), 108-124.

[16] Orangi, A., Palaneeswaran, E., & Wilson, J. (2011). Exploring delays in Victoria-based Astralian pipeline projects. *Procedia engineering*, *14*, 874-881.

[17] Mohammed, R. M. M., & Suliman, S. M. A. (2019). Delay in pipeline construction projects in the oil and gas industry: part 1 (risk mapping of delay factors). *International journal of construction engineering and management*, *8*(1), 24-35.

[18] Shahsavand, P., Marefat, A., & Parchamijalal, M. (2018). Causes of delays in construction industry and comparative delay analysis techniques with SCL protocol. *Engineering, construction and architectural management*, *25*(4), 497-533.

[19] Tafazzoli, M., & Shrestha, P. P. (2018). Investigating causes of delay in U.S. construction projects. *53rd ASC annual international conference proceeding* (pp. 611-621). Washington State University. https://www.researchgate.net/publication/316794271_Investigating_Causes_of_Delay_in_US_Construction_Projects

[20] Tumi, S. A. H., Omran, A., & Pakir, A. H. K. (2009, November). Causes of delay in construction industry in Libya. *The international conference on economics and administration* (pp. 265-272). Faculty of Administration and Business, University of Bucharest, Romania.