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Introducing Risk Ranking Comparative Model in Oil Pipelines Repair Projects Using a Fuzzy Multi-criteria Decision-making Techniques

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ABSTRACT

Background: Project risk management is one of the main topics in project management which provides the possibility of rating risks based on their criticality and giving appropriate and on time response. **Objective:** This is much important in big industrial projects including oil projects. For the present study, first experts' panel and interview were used, based on which 116 main risks in big repair project of 18-inch oil transfer pipeline from Cheshmeh Khosh to Ahwaz were identified and five main risk evaluation indices, i.e. time, quality, safety, cost and environmental effects were ranked based on fuzzy TOPSIS method and fuzzy network analysis process. **Results:** Then, using questionnaire, the probability of occurrence and the effectiveness of each identified risk based on five indices were investigated and at the end, the final ranking of each risk was identified. **Conclusion:** The results of study showed that ranking based on TOPSIS, fuzzy network analysis process had almost the same results, and the five identified critical risks in the studied project are sanction, inflation, rapid changes in rate of materials, materials and equipment, rapid changes of exchange rate and finally, inaccessibility and transaction with supplying foreign products, respectively.

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INTRODUCTION

Risk project is an indefinite event or status which in case of occurrence will have a positive or negative effect on at least one objective of the project. In case of occurrence, each of these indefinite events would affect the cost, timing or quality of the project (Aladpoosh, 2007). Risk management has appeared for maximizing positive events and minimizing the consequences of unfortunate events (Shams and Mortaheb, 2007). Among big and small projects, oil projects are very significant specially in our country. The failure of big engineering projects shows the importance of risk management especially in defense activities, construction and oil industries due to serious problems which might be imposed (Nejad and Yosefi Zanor, 2998). Thus, the essential repair projects are considered as the biggest and most important projects in oil industry and are naturally full of small and big risks which require special planning. In this regard, the repair project of 18-inch oil transfer pipeline from Cheshmeh Khosh to Ahwaz with nominal capacity of 150,000 gallons in a day, is one of the most important pipeline repair projects which has been performed with the aim of more optimization in oil transfer. In this study, it is tried to make some relation between risk management and fuzzy logic and introduce a new method with better execution capability. Then this method has been implemented for repairing 18-inch oil transfer pipeline from Cheshmeh Khosh to Ahwaz and all risks have been identified, then they have been ranked proportionate with effect and probability of occurrence by the use of fuzzy TOPSIS and fuzzy ANP.

Theoretical Principles:

Fleming *et al* argue that the risk priority score method is subjective because the used guidelines for grading of severity, occurrence and identification are different from one organization to another (Moazzez and Salami, 2010). Project management is among those sciences where decision-making does not follow certain system. From the emergence of planning and project control issues, the fact that times are estimated and cost coefficients are indefinite, strengthens the use of concepts of statistics and probabilities in this area. However, various statistical distributions do not have ability to directly use the subjective inferences of experts from the

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time of performing activities, their costs and things like this. As previously mentioned, risk is those event which in case of occurrence can deviate the project from its main and predetermined objectives. The existence of risk in project indicates that there is uncertainty on implementation of projects. Fuzzy computations are proper instrument for modeling and measuring these uncertainties. Use of fuzzy computations in ranking of project risks has some advantages like direct use of subjective inferences of experts in model, higher compatibility of allocated weights to target criteria in final decision-making and accessibility to more objective and realistic results in analysis and ranking of risks.

Fuzzy anp Method:

ANP method proposed by Saati is the extended form of AHP. While AHP deals with providing a framework with unidirectional hierarchical communications, ANP mostly considers complex internal communications between various levels of decisions and ratios. ANP approach with feedbacks of networks has replaced the chain where the communications between levels don't simply introduce in higher or lower, dominate or dominating, direct or indirect (Haleh and Karimian, 2010).

Fuzzy ANP (FANP) is very appropriate when the dependency between selection criteria of possible options is very high, such that FNAP simply determines the relation between criteria (Mohanty *et al*, 2005). In the present study, this method is appropriate since the indices are influential on each other. In this method, the matrixes of pair comparisons between criteria of each row are complemented by the use of triangular fuzzy numbers. Through this method, parameters are obtained in form of triangular fuzzy numbers and calculated in fuzzy form.

Fuzzy Topsis Method:

TOPSIS technique is a compensatory model where the transactions between indices are allowed and changes in one index can be compensated by an opposite change in the other index. This technique was proposed for the first time by Hwang & Yoon in 1981. Based on this, each problem in form of MCDM with m options evaluated by n indices can be considered as a geometrical system with m points in n-dimension space. In this method, the distance of the intended option from ideal is considered positive and negative such that the selected option should have the least distance from ideal solution and maximum distance from negative ideal (Asqar Pour, 2013). In fuzzy TOPSIS method, the weighting of indices and investigation of each index by respondents are done based on the spectrum of fuzzy numbers.

Review of Literature:

Jouzi and Iran Khahi in their study evaluated the environmental risk of gas pipelines through AHP method. For evaluation of environmental risk of gas pipelines, they proposed an indexing system and hierarchical analysis process (Jouzi and Iran Khahi, 2010). Furthermore, in another study, the ranking of projects' risk has been investigated through various multi-criteria decision-making techniques. The presented case study deals with risks' ranking through TOPSIS method; moreover, ANP technique has been introduced as one of the effective techniques for ranking the project's risks (Jebel Ameli, Rezaei Far and Chaei Bakhsh, 2007). In another study, Sayadi *et al* used TOPSIS method for ranking of the available risks in tunnel projects (Sayadi *et al*, 2009). Dari *et al* presented a combined approach in risk analysis in another study. ANP-FMEA method takes into account the mutual relations of risk factors and provides a systemic and flexible approach in risk management by offering a developed structure (Dari *et al*, 2010). Dezfoli Nejad *et al* investigated the risk analysis due to unpredictable criteria through fuzzy logic method. In this study, passive defense approach was used for risk analysis due to army attract to civil projects (Dezfouli Nejad *et al*, 2012). In a study carried out in reconstruction project of Directorate of Technical Buildings and Lines of Islamic Republic of Iran Railway, Kazem Zadeh and Sharif Mousavi tried to present a model for time risk evaluation of civil projects (Kazemi Zadeh and Sharif Mousavi, 2011). Mousavi *et al* introduced fuzzy specialized system as an efficient instrument in project risk analysis in their paper entitled "Presenting a Fuzzy Specialized System for Projects' Risk Analysis). Moreover, they practically validated the designed fuzzy specialized system for evaluation and periodization of project risks (Mousavi *et al*, 2009).

In another study done in 2006, the risk evaluation in Brazil pipelines was investigated. In this study which evaluated pipeline risk and acceptable risk in Brazil, risk analysis was used as an instrument for determining the permitted environmental risk and acceptable risk in pipeline projects (Kirchhoff, 2006). In 2007, a survey was done entitled, "Risk Management in Oil and Gas Projects in Vietnam". In this study, first a questionnaire was prepared and distributed for identification of project's risks based on studies and investigation of related literatures. In the first step, after data collection, 59 risks were identified as effective risks in project (Nguyen *et al*, 2007). In 2008, a research work was carried out in Pakistan on the risk analysis in performing pipeline projects. First, the researcher divided the big projects to, 1. Implementation risk (which is related to the subject of this thesis), 2. Post implementation risk (utilization). Then, he introduces the implementation risk in five main sections including, 1. Political risk, 2. Socio-economic risk, 3. Technical risk, 4. Organizational risk, 5. Natural and unpredicted events' risk, 6. Financial risk (investment), 7. Safety and security risk, 8. Environmental risk. Each of these categories includes various subcategories (Mubin, 2008).

Methodology:

This is a descriptive study in terms of data collection method since its objective is to describe the studied conditions or phenomena. On the other hand, since the study intends to discover the realities, and questionnaire is used for data collection, it is considered as survey study. Furthermore, for proper conclusion for precise ranking of risks, expertise procedure was used. For learning the early concepts of present study, library studies were used, for data collection of projects the documents were investigated and for identification and evaluation or project risks, field study are used. To maintain validity, data has been obtained from the experts who are the managers of project. The reliability of the questionnaire related to risk qualitative analysis was calculated by SPSS, which at the end, the Chronbach's Alpha value for questionnaire was above 0.9 in all dimensions which indicates the high reliability of the questionnaire. The following procedures were used in the study:

1. Comprehensive review of risk management literature, risk ranking, ranking methods and fuzzy logic: at this stage, most of the studies on risk management and risk fuzzy ranking and its related issues are studied.
2. Identification of risks: the early indices related to conceptual model of the study were extracted through expert survey in form of experts' panel in two main groups, 1. Feasibility study (before implementation), and 2. Operationalization (at the time of implementation) and 12 secondary groups (1. Natural, local, regional; 2. Laws, regulations and bylaws, 3. Economic, 4. Political, 5. Planning, 6. Detailed study, 7. Conventional, 8. Evaluation, 9. Organizational, 10. Supervision on implementation, 11. Technical, executive and 12. Contractor).
3. Risk evaluation: since the identified risks in this study are effective on the project's objective from different perspectives, to avoid holism and to make more precise the identified risks, it is required to define indices which are indicative of risk effects on different aspects of project. Thus, various criteria have been introduced for evaluation or risks through investigation of local and foreign studies. After investigations and getting experts' comments, five indices were selected as evaluation criteria which by affecting them, the project risks can affect the general objectives of the project. These indices include: 1. Time, 2. Cost, 3. Safety coefficient, 4. Quality and 5. Environmental issues. The identified risks in the previous stage are evaluated by experts' ideas, based on the influence of each risk on each index (time, cost, quality, safety coefficient and environment) and by estimation of probability of occurrence of each of these risks.
4. Ranking of risk evaluation indices using fuzzy ANP and fuzzy TOPSIS: five referred indices are weighted based on experts' ideas through fuzzy ANP and fuzzy TOPSIS methods. The identified risks and above indices have been investigated as the main variables of this study. Moreover, through their quantification and analysis, the research questions are answered.
5. **5.** Data analysis: in this process, the general ranking is done by the use of data collected in previous stages and by multiplying the mean value of each risk's significance in the index weight and obtaining the significance of each risk. The research process has been presented in figure 1.

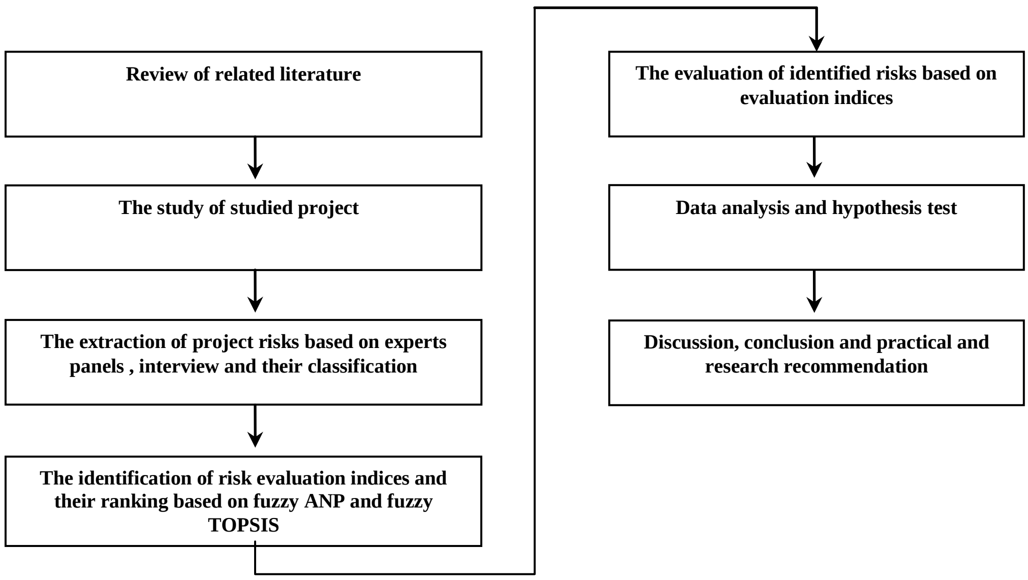

Fig. 1: Research process

Statistical Sample and Population:

The sampling method in this study has been census and the sample includes 32 subjects equal to the number of population. These 32 individuals have been engaged in repair project of 18-inch oil transfer pipeline from Cheshmeh Khosh to Ahwaz and have been fully aware of different aspects of the project.

Data Analysis:

Risk identification process includes determination and identification of effective risk on project and documentation of their features. In performing the study and in the first step for realization of effective risks, experts' panel, direct interview with managing director, middle and executive managers, experts and contractors and holding various meetings with them (32 individuals), 116 risks were identified and determined. In the next step, the identified risks were classified into 2 main groups and 12 subgroups, the results of which have been presented in table 1.

Table 1: Risk grouping to primary and secondary groups (source: the results of study)

Primary Group	Secondary Group	Row	Risk explanation
Feasibility study (before implementation)	Natural, local, regional	1	The impassibility of most ways of pipeline accessibility
		2	Adverse weather condition (warm and moisture summer/ cold winter with high rate of rainfall)
		3	Flowing of hot winds and dust storms in summers
		4	High rainfall and flooding the excavation canals and accessibility ways in winter
		5	Firelight
		6	wild reptiles and rodents and insects
		7	Uncertainty regarding the clearance of explosive remnants of war period
		8	The conflict between local and industrial cultures
		9	Far from city and city center
		10	Lack of primary hygiene facilities
	Laws, regulations and bylaws	11	Change of public laws and regulations
		12	Conflicts in laws and regulations
		13	Wrong interpretation of experts from laws and regulations
		14	The weakness of contractors and suppliers' evaluation regulations
		15	Conflicts in regulations of oil and gas utilization company and other organizations
		16	Delay in getting certificates and coordination
		17	Strict administrative bureaucracy in some parts of organization
	Economic	18	Failure to supply budget on time
		19	Rapid changes in rate of materials and equipment
		20	Inflation
		21	Rapid changes in exchange rate
		22	Various classification of the same exchanges
		23	Economic instability and oscillation of market prices
	Political	24	Sanctions
		25	Change of government and empowering of new cabinet (11th government)
		26	Political pressures out of organization on implementation of project
		27	Not considering national and international political issues
		28	Instability in government's policies
		29	Inaccessibility and interaction with foreign products' supply
	Planning	30	Lack of study in determining proper time of project implementation
		31	Weak managerial attitude in reducing design time and rapid transition to implementation phase
		32	Failure to use value engineering in design phase
		33	Weak in planning and initial timing of project
		34	Weakness in accurate planning and expense estimation in early design for budget
		35	Underestimation of initial bid due to use of price list of previous year
	Detailed design	36	Incomplete collection of initial data of the project
		37	Lack of map and complete information about pipeline path and its surrounding
		38	Lack of map and comprehensive information of underground facilities of other organizations
		39	Failure to use standard design method
		40	Failure to consider proper technology in detailed design
		41	use of traditional methods of designing
		42	weak design due to failure in precise identification and familiarization with pass, barriers and executive barriers of project
		43	Including insufficient specification, executive maps and explanation of technical situation in the contract manual
		44	Inattention of design experts to limitations imposed from other organizations in project execution site

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		45	Inattention to project issues including natural and environmental barriers
		46	Failure in knowledge of goods' items by designers for preparing the required values
Operationalized (at the time of implementation)	Contractual	47	The bidding not being two stages and impossibility to evaluate technical power of contractors
		48	Delay in solving legal issues of violators due to legal experts' lack of experience
		49	Weakness in retrieval of previous lands documents
		50	Resistance of owners of lands in pipeline path
		51	Legal weaknesses in contracts and necessity to revise it
		52	The lengthiness of bidding process and determination of contractor
		53	Failure to investigate and revise the work from legal and contractual approach
		54	Inattention to appropriateness or inappropriateness of contract time and beginning of project executive activities concerning the seasonal and local condition of the area
		55	Ambiguity in some articles of the contract
	Evaluation	56	Weakness in qualitative and technical evaluation of contractors
		57	Impossibility of precise evaluation of contractors due to lack of clear and measurable criteria
		58	The significance of project and the probability of winning of a weak contractor
		59	inattention to real executive capacities and contractors' power (regardless of previous qualitative evaluation)
		60	Inattention to contractors' capacity in terms of administrative and financial power in simultaneous execution of projects
		61	The unwillingness of expert contractors from working with city secondary companies
	Organizational	62	Unwillingness to introduce and attract skillful contractors due to being conservative and work policy
		63	Lack of required coordination and support between related sections with project and island performance of sectors
		64	Lack of team thinking between related sections to project
		65	Inattention to legal position of contractor
		66	Undefined official relations between contractor and employer
	Supervision on execution	67	Weakness of supervision organization in control and implementation of related standards in all project implementation
		68	Lack of plan and demand for preparation and supplying all products in proper time
		69	Lack of standard execution condition
		70	Lack of proper condition for keeping project materials and goods
		71	Not using proper and precise instrument at the time of water injection and leakage test of pipeline (hydrostatic test)
		72	Multiplicity, change and displacement of project supervisors due to nature of work
		73	Not using expert and experienced forces in all affairs at the time of project implementation
		74	Not receiving executive timing from contractor and his team
		75	Lack of unity in supervision
		76	Lack of managerial information system in project
		77	Unfamiliarity of supervisory factors on management and project control standards
		78	Lack of contractor's justification and unfamiliarity with project site
		79	The supervisors' working according their own taste and lack of authority to make decisions in sensitive situations
		80	Unfamiliarity and unskillfulness of the executors and supervisory team on contractual issues
		81	Weak training of supervisory organization before work implementation
		82	Inattention to safety regulations at the time of execution of project
		83	involving the tastes in all execution processes of project by contractor instead of emphasizing on standards
		84	Inattention to insurance and civil responsibility of project
		85	Lack of commitment to work execution based on timing plan
		86	Inefficient and unrealistic time plan of project implementation
		87	Lack of proper control on time and expenses by project control
		88	Not using all legal capacities due to unskillfulness of project executive
	Technical-executive	89	Presence of problems and fault and delay in identification and recognition of faults
		90	Flooding of excavation canals due to irrigation of agricultural lands
		91	Lack of liquidity and delay in paying bills of contractor based on contract and work done
		92	The pipeline being magnetic
		93	Equipment failure
		94	Accidents
		95	Lack of executive quality and the necessity to re-performing the task

		96	Lack of materials and equipment and their accessibility
		97	Falling of individuals or transportation in open excavation
		98	error of executive agents
		99	Firing
		100	Conflict with contractor due to his unskillfulness on contract and work policy of supervisory agents
		101	Limitation of production stop and restarting production
	Contractor	102	Lack of certain executive time plan
		103	Failure to preserve the sequence in project activities
		104	Contractor misuse of several supervisory entities
		105	Not spending the received money from employer for project execution
		106	Delegating the project to secondary weak contractors by the primary contractor and improper collaboration of primary and secondary contractors
		107	Unfamiliarity of contractor with the site and geographical condition of project site
		108	Lack of official coherence and organizational and formal hierarchy
		109	Weakness of contractor in supplying the proper equipment according to technical technologies for project execution
		110	Lack of contractor's management and lack of expert forces in contractor team
		111	Lack of standards and quality control systems in contractual organization
		112	Lack of managerial agents in contractual company in project
		113	Sabotage of local inhabitants of area due to nonlocal contractor
		114	Lack of skillful local and native workforce
		115	Lack of employees' training on safety principles
		116	Attempt to increase the contract volume

After identification of risks, the collection of data related to probability of occurrence of a risk on each criterion of time, cost, quality, safety and project environment has been done. To this end, a questionnaire has been constructed based on identified risks list and distributed between individuals who were interviewed before to specify the status of probability of occurrence, the effect on cost, the effect on time, the effect on quality, the effect on safety and the effect on environment through this questionnaire. In fact, two factors have been analyzed for each risk through this questionnaire:

- Probability of occurrence
- The effect on each of the projects' objective (cost, time, quality, safety and environment)

One of factors, which should be considered in this section of analysis, is the risks' probability occurrence, this part in questionnaire is classified in a five-scale spectrum (very low, low, average, high, very high). Table 2 shows the numerical value assigned to each point of five-rank scale.

Table 2: Quantification table of risks' probability of occurrence

Risk's probability of occurrence	Very high	High	Average	Low	Very low
The assigned numerical value	0.9	0.7	0.5	0.3	0.1

The other analyzed factor is the effect of each risk on the project's objective (cost, time, quality, safety and environment). To determine the effect of each risk on project's objectives and placing them in one of the determined categories, the range of these categories should be determined which were defined based on PMBOK standard as table 3:

Table 3: Determination of risks' effect on project objectives

Quantification of effect on objective					
Intended objective	Very low	Low	Average	High	Very high
Time	A bit increase	Less than 5% increase	5-10% increase	10-20% increase	More than 20% increase
Quality	A bit decrease	It affects just some of the	The acceptance of quality reduction is	Quality reduction is unacceptable	The project's objectives are

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		project functions	possible by getting stakeholder's certificate	for stakeholder	violated
Cost	A bit increase	Less than 10% in crease	10-20% increase	20-40% increase	More than 40% increase
Safety	a little risk	Somehow risky	Risky	Very risky	Catastrophic
Environment	a little risk	Somehow risky	Risky	Very risky	Catastrophic
The assigned numerical value	5%	10%	20%	40%	80%

In quantitative analysis, the simultaneous risk of effect and probability of occurrence of each risk on each one the project objectives will be calculated. In what follow, the ranking of five risk evaluation indices, i.e. time, cost, quality, safety and environmental effects has been brought through TOPSIS and fuzzy ANP.

Table 4: The matrix of final weights of criteria in respect to objective in fuzzy ANP method

Component	Final fuzzy weight	Final certain weight of components
Cost	(0.291, 0.378, 0.472)	0.379
Safety	(0.207, 0.279, 0.359)	0.28
Quality	(0.135, 0.18, 0.237)	0.182
Time	(0.081, 0.106, 0.14)	0.107
Environment	(0.046, 0.58, 0.076)	0.59

Table 5: The matrix of final weights of criteria in respect to objective in fuzzy TOPSIS method

Row	Options	Distance to positive ideal	Distance to negative ideal	CC	rank
1	Quality	8.175	0.83	0.092	3
2	Cost	8.144	0.86	0.096	1
3	Safety	8.146	0.859	0.095	2
4	Environmental	8.352	0.662	0.073	5
5	Time	8.338	0.674	0.075	4

Calculaiton of Risk Effect Factor on Project:

Concerning the weights of determined significance and quantitative effects of each risk on each objective, the project risk effect is calculated through the following formula:

$$R_x = (R_X^S.W_S + R_X^T.W_T + R_X^Q.W_Q + R_X^C.W_C + R_X^e.W_e)$$

R_X^S : Risk effect factor X on Safety (S) objective

W_S: weighting value of safety (S) objective in project based on fuzzy ANP and fuzzy TOPSIS

R_X^T: Risk effect factor X on time (T) objective

W_T: Weighting value of time (T) objective in project based on fuzzy ANP and fuzzy TOPSIS

R_X^Q: Risk effect factor X on quality (Q) objective

W_Q: weighting value of quality (Q) objective in project based on fuzzy ANP and fuzzy TOPSIS

R_X^C: Risk effect factor X on cost (C) objective

W_C: weighting value of cost (C) objective in project based on fuzzy ANP and fuzzy TOPSIS

R_X^e: Risk effect factor X on environment (e) objective

W_e: weighting value of environment (e) objective in project based on fuzzy ANP and fuzzy TOPSIS

At the end, in table 6, the final ranking of risks based on TOPSIS and fuzzy ANP has been presented.

Table 6: Risks' final ranking based on fuzzy TOPSIS method

TOPSIS	Risk value	ANP	Risk value	Ranking
0.298	24	0.329	24	1
0.267	20	0.306	20	2
0.259	19	0.295	19	3
0.248	29	0.279	21	4
0.246	21	0.265	29	5
0.241	18	0.262	23	6
0.235	50	0.259	18	7
0.234	23	0.249	50	8
0.223	90	0.234	33	9
0.221	33	0.231	110	10
0.220	67	0.229	90	11
0.219	110	0.229	58	12
0.218	58	0.227	68	13
0.212	86	0.227	67	14
0.211	68	0.223	86	15

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0.211	91	0.222	91	16
0.204	96	0.216	96	17
0.202	31	0.215	31	18
0.200	111	0.208	109	19
0.198	85	0.207	111	20
0.198	109	0.204	113	21
0.193	113	0.203	85	22
0.184	101	0.195	35	23
0.184	79	0.195	36	24
0.183	73	0.191	2	25
0.180	100	0.191	101	26
0.180	36	0.190	79	27
0.179	35	0.190	59	28
0.179	59	0.190	100	29
0.179	2	0.189	73	30
0.179	4	0.189	34	31
0.178	60	0.189	4	32
0.176	64	0.187	64	33
0.175	63	0.187	83	34
0.175	82	0.184	63	35
0.173	76	0.184	60	36
0.173	83	0.182	76	37
0.173	38	0.182	57	38
0.173	34	0.181	38	39
0.171	57	0.181	87	40
0.171	87	0.180	82	41
0.168	114	0.179	114	42
0.167	7	0.178	7	43
0.167	89	0.177	107	44
0.167	81	0.177	42	45
0.166	42	0.176	89	46
0.166	107	0.175	41	47
0.164	115	0.173	116	48
0.164	41	0.172	81	49
0.162	30	0.172	30	50
0.162	103	0.171	115	51
0.162	56	0.170	102	52
0.161	104	0.170	56	53
0.161	102	0.168	103	54
0.161	77	0.168	104	55
0.159	72	0.167	77	56
0.159	98	0.165	98	57
0.158	17	0.165	43	58
0.157	116	0.164	93	59
0.157	88	0.164	1	60
0.156	1	0.164	88	61
0.156	93	0.164	17	62
0.155	37	0.163	72	63
0.155	14	0.163	45	64
0.154	45	0.162	37	65
0.154	43	0.161	14	66
0.153	69	0.156	105	67
0.152	105	0.156	74	68
0.149	74	0.156	9	69
0.148	95	0.155	69	70
0.146	75	0.154	95	71
0.145	78	0.154	75	72
0.145	61	0.153	61	73
0.145	80	0.150	78	74
0.143	44	0.150	44	75
0.143	48	0.150	80	76
0.142	106	0.147	48	77
0.140	70	0.147	106	78
0.139	99	0.145	8	79
0.138	9	0.145	62	80
0.138	54	0.145	28	81
0.137	62	0.145	32	82
0.136	8	0.145	70	83
0.135	16	0.141	99	84
0.134	32	0.140	54	85
0.131	112	0.140	16	86

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0.131	28	0.139	112	87
0.131	3	0.133	39	88
0.128	40	0.132	3	89
0.128	39	0.131	40	90
0.124	49	0.130	49	91
0.120	46	0.129	46	92
0.114	66	0.125	66	93
0.111	52	0.123	52	94
0.111	25	0.118	84	95
0.109	10	0.117	25	96
0.107	84	0.113	10	97
0.106	71	0.112	22	98
0.104	22	0.109	108	99
0.103	26	0.107	26	100
0.103	108	0.105	13	101
0.099	65	0.104	94	102
0.098	94	0.103	71	103
0.098	55	0.103	65	104
0.097	13	0.102	55	105
0.097	47	0.101	47	106
0.092	53	0.099	53	107
0.091	51	0.097	51	108
0.089	27	0.096	27	109
0.087	92	0.091	11	110
0.085	11	0.091	92	111
0.077	12	0.082	97	112
0.075	97	0.081	12	113
0.060	5	0.062	5	114
0.059	6	0.061	6	115
0.057	15	0.060	15	116

Conclusion and Recommendation:

The results of this ranking for 20 first risks, which in fact can be critical risks, have been presented based on fuzzy ANP and fuzzy TOPSIS techniques in table 7 and 8.

Table 7: Final ranking of risks based on fuzzy TOPSIS method

Ranking	Risk explanation	Risk No
1	Sanctions	24
2	Inflation	20
3	Rapid changes in rate of materials and equipment	19
4	Inaccessibility and interaction with foreign products' supply	29
5	Rapid changes in exchange rate	21
6	Failure to supply the budget timely	18
7	Resistance of owners of lands in pipeline path	50
8	Economic instability and market price oscillation	23
9	High rainfall and flooding the excavation canals and accessibility ways in winter	90
10	Weak in planning and initial timing of project	33
11	Weakness of supervision policy in control and execution of related standards in all project processes	67
12	Contractor's weakness in management and lack of expert forces in contractor team and its executive factors	110
13	The significance of project and the possibility of winning for weak contractors	58
14	Inefficient and unrealistic timing plan of project execution	86
15	Lack of plan and comprehensive demand for preparation and supply of all products in proper time	68
16	Lack of liquidity and delay in paying the bills of contractor based on contract and work done	91
17	Lack of materials and equipment and their availability	96
18	Weak managerial attitude in reducing design time and rapid transfer to implementation phase	31
19	Lack of standards and quality control systems in contractual organization	111
20	Lack of commitment to work implementation based on timing plan	85

Table 8: Ranking of 20 first risks based on fuzzy ANP

Ranking	Risk explanation	Risk No
1	Sanctions	24
2	Inflation	20
3	Rapid changes in rate of materials and equipment	19
4	Rapid changes in exchange rate	21
5	Inaccessibility and interaction with foreign products' supply	29
6	Economic instability and market price oscillation	23
7	Failure to supply the budget timely	18
8	Resistance of owners of lands in pipeline path	50

9	Weak in planning and initial timing of project	33
10	Contractor's weakness in management and lack of expert forces in contractor team and its executive factors	110
11	Flooding of excavation canals due irrigation of agricultural lands	90
12	The significance of project and the possibility of winning for weak contractors	58
13	Lack of plan and comprehensive demand for preparation and supply of all products in proper time	68
14	Weakness of supervision policy in control and execution of related standards in all project processes	67
15	Inefficient and unrealistic timing plan of project execution	86
16	Lack of liquidity and delay in paying the bills of contractor based on contract and work done	91
17	Lack of materials and equipment and their availability	96
18	Weak managerial attitude in reducing design time and rapid transfer to implementation phase	31
19	Weakness of contractor in supplying proper equipment according to technical standards of project	109
20	Lack of standards and quality control systems in contractual organization	111

The results of table 7 and 8 are clear and important. From 20 first risks of project, 19 cases are shared in both methods; just risk number 85 (Lack of commitment to work implementation based on timing plan) in fuzzy TOPSIS method, i.e. final risk list, and risk number 109 (Weakness of contractor in supplying proper equipment according to technical standards of project) in rank 19 in fuzzy ANP method are different. The results are indicative of another important issues, sanction and inflation are as the first and second identified main risks in both methods. Furthermore, the comparative results of two tables show that the identified risks almost have the same rank in both methods.

Practical Recommendations:

Table 9: practical recommendations for critical risks management

Row	Risk explanation	Practical recommendations for risk confrontation
1	Sanction	- Establishment of R&D unit - Supporting local manufacturers - Making effective communication of industry and university, knowledge-based institutions and science and technology parks - Continuous monitoring of pipelines and preventive measures appropriate with results - Use of anti-corrosion chemical materials for prevention of local corrosion of pipelines
2	Inflation	- Supporting local manufacturers - Removing intermediaries - Collaboration of private sector in investment
3	Rapid changes in rate of materials and equipment	- Removing intermediaries and purchasing from the local known and credible supplier - Insuring the sellers of the certainty in purchase and on time payment
4	Rapid changes in exchange rate	- International agreement in major area by the government - Participation of private sector in investment - Attraction of various local capitals by selling bonds
5	inaccessibility and transaction with supplying foreign products	- international agreement in major area by the government - supporting local manufacturers - establishment of R&D unit - Making effective communication of industry and university, knowledge-based institutions and science and technology parks
6	Economic instability and severe market price oscillations	- Economic re-planning in major level by government - Making international agreement in major area by government and removing of intermediaries
7	Failure to supply budget on time	- Proper definition of project and position evaluation in project justification - Effective communication with mother companies for attracting executive budget of project
8	Resistance of owners of lands in pipeline path	- Identification of authorised and unauthorized opponents before project implementation and effective agreement with them - In investigation of legal documents of lands ownership in pipeline paths before implementation and removing of unauthorized opponents by providing legal documentation and follow up - Use of effective communication with local authorities for developing the project objective and removing barriers
9	Weakness in planning and initial timing	- Preparing work report based on reality by consideration of barriers and problems - Timing with approximate estimation proportionate with defined works in working condition
10	Contractor's weakness in management and lack of expert forces in contractor team and its executive factors	- Revising the selection criteria of contractor - Defining the specialized teams for implementation
11	Flooding of excavation canals due	- Building diversion channels for changing the agricultural waters' path

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	to irrigation of agricultural lands	- Preserving the project implementation - Agreement with farmers for changing the time or type of product
12	The significance of project and the possibility of winning for weak contractors	- Revision contractors' selection criteria - Identification and inviting of strong contractors - Making the bidding in two stages selection of proper technical criteria in the second stage
13	Lack of comprehensive program and demand for preparation and supplying of products in proper time	- Preparation of good and proper timing for project implementation - Preserving the sequence in implementation according to timing plan - Supplying on time budget
14	Weakness of supervision policy in control and execution of related standards in all project processes	- Training of supervising engineers in familiarization with standards - Use of expert and experienced supervising engineers
15	Inefficient and unrealistic timing plan for project implementation	- Revision of timing plan at the time of project implementation - Use of the results of present study for managing risks of the project
16	Lack of liquidity and delay in paying the contractor's bill based on contract and work done	- Proper prediction proportionate with project implementation - Effective communication with mother companies for on time budget supply
17	Lack of materials and equipment and their availability	- Associate employer for supplying materials to contractor - Cooperation of employer on supplying part of materials in the warehouse in emergency situation and reclaiming the products in unnecessary conditions
18	Weak managerial attitude in reducing design time and rapid transfer to implementation phase	- Training mid and high managers on the necessity of knowledge management - Use of the results of present study by mid and high managers
19	Weakness of contractor in supplying equipment according to technical standards for project execution	- The revision of contractor selection criteria - Identification and invitation of strong contractors - Making the bidding in two stages selection of proper technical criteria in the second stage - Cooperation of employer in guidance of contactor in using proper equipment
20	Lack of standards and quality control systems in contractual organization	- Revision the contractor selection criteria - Involving quantitative and qualitative scores in proposed price of contractors - Giving special scores to contractors having certificate for quality management systems
21	Lack of commitment to work implementation based on timing plan	- Use of skilful and experienced supervising engineers - Fining for delay in execution of project - Making financial and credit promotion in early implementation or according to project timing

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