Modern Research in Decision Making
Vol.5, No. 4, Winter 2021
pp. 145-164
Article type: Research paper

Soft modeling and explanation of causality between the risks affecting the return on investment in development of refinery units

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Received: 08/03/2020 *Accepted: 28/05/2020*

Abstract

Analysis and modelling the projects interdependency has become a vital and inevitable issue in project portfolio management. This study focused on modeling investment risks interdependency in a project portfolio**.** Risk in projects as an integral element, reduces the accuracy of the goals and the efficiency of the projects. Identifying, analyzing, prioritizing and planning to deal with these potential negative elements play a significant role in the success of the projects. In this paper, using Delphi Method and fuzzy cognitive mapping (FCM) as a powerful tool in the field of soft knowledge domains specially soft operation research, the direct and indirect causality between the risks affecting the return on investment in the development of refineries in Iran are identified and explained. Thus, using a hybrid qualitative and methodological approach, cognitive processes and all the outcomes investigated are based on the system of meaningfulness of the experts' and professionals' mental models in the field of refinery. Identified risks generally fall into four category of technology, marketing, finance and legal-political. Finally, using soft modeling, a network structure is presented as a potential negative factors affecting the return on investment, which leads to clarifying the dependencies and impact severity of forward and backward chaining. Furthermore, centrality criteria are used as a tool for static analyzing of created fuzzy cognitive map in order to interpret and give the meaning to the causal relationships between nodes.

Keywords: Development of refinery units, fuzzy cognitive map, Soft operation research, Soft modelling, Risk

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1. Introduction

Recent studies in project portfolio management focus on projects interdependency modelling and analysis. There are five types of interdependencies included benefit, risk, outcome, schedule and resources [1, p 737]. In this paper the interdependency of project portfolio's investment risk is modeled by using a hybrid qualitative method.

In recent years, investment risks are becoming greater and more concerning for investors for many reasons such as the increasing growth of the business environment changes, the emergence of several influential factors, the high level of capital needed for projects and limitation of financial resources and capital assets of organizations. In consequence**,** a scientific selection of appropriate investment projects in a portfolio ensures firms survival [2, p 204]. It is worth noting that petroleum industry, the main subjective of this paper, is characterized as an irreversible and uncertain investment among other industries because of rapid technological developments and increased demand for efficiency in this industry [3, p 891]. Thus for the countries like Iran, due to the reliance of the economy on the basis of the petroleum industry, investment risk management in this field should be at the forefront of the attention of experts and researchers.

In complicated investment problems the researchers are intent on adapting the problem-solving situation to the real world by exploring the effective factors and their severity in order to get more applicable consequences [4, p 244]. Hence, it is considered vitally important to identify risk factors and conduct a detailed risk assessment in order to make more factual investment decisions [5, pp 169-177]. A petroleum project during its life cycle, faces many risks, such as economic and political risks, financial and price volatility risks, geological and technical risks and environmental risks. Therefore, the investor faces a multi dimensional investment risk that should identify [3, p 891].

A large number of approaches exist for risk identification but there is no a "Best method" for it and an appropriate combination of techniques should be used [6, p 500]. To overcome these circumstances and identifying the risks of Iranian refinery units' development and analyzing how they affect the investment decision space, this paper presents a hybrid qualitative mechanism by combining Delphi technique and fuzzy cognitive mapping. The mentioned subjective methodology is applicable in the condition of knowledge inadequacies in which decision-makers are bound to decide based on their direct perceptions or the viewpoint of experts. Therefore, by implementing our methodology, a soft conceptual model of potentially negative impact factors which involve in the development of refinery units is constructed.

The remainder of the paper is organized as follow. In section 2, theoretical and empirical background are investigated. The basic concepts of project risks and methods of risk identification and assessment are explained. Then, related articles and their methodologies are introduced. In section 3, research methodology is presented. Then identified risk factors and their casual relations are described and analyzed in detail in section 4. section 5, draws conclusions and suggests some ideas for future investigations.

2. Literature review

Owing to the nature of the paper subject, the research background is investigated from two perspectives, theoretical background and empirical background. In the theoretical background, the concept of the project risk and risk identification and assessment have been explored and discussed, then in the empirical background, the focus is on the methodologies used for risk identification and risk analysis in previous researches.

2.1. Theoretical background

The concepts of risk and risk assessment date back more than 2,400 years, when ancient Greeks took risk assessments to make a decision. But these concepts are as a scientific background with a history of less than 40 years [7, pp 1-13]. Project risk is an uncertain event that has positive or negative effects on the achievement of the project's objectives. In this paper, the risk is considered to be negative. In other words, the project risk is the chance of adverse incidents and all related unpleasant consequences, which, if occurring, will delay, stop or break the project and affect the time, quality and cost [8]. Also because of the accuracy decrement in the estimation of the goals, project risk reduces the projects' efficiency [9]. Therefore, identification and prioritization of risks is considered as a necessary risk management challenge [10, p 157].

Risk identification is a precise, scrupulous, and exploratory process in which potential project risks are identified through interaction with knowledgeable project participants. This process is a qualitative process aimed at identifying and describing the risks that affect the project's objectives [11].

As mentioned in the PMBOK standard, some of the techniques for collecting data for risk identification are the survey of historical records, brain storms, holding pre-occurrence analysis meetings, drawing affiliation charts, interviewing experts and specialists, nominal group technique, Delphi technique, hypothesis analysis, various graphing techniques [12]. It is worth noting that no method can be regarded as a superior method and should incorporate the appropriate combination of techniques in the form of group decision making [13, pp 154-162].

After identifying the risks, it is time to categorize and develop the structure and create a logical arrangement of them. Some studies considered this arrangement as a hierarchical breakdown structure (HBS), and some went a step further and viewed it as a network breakdown structure (NBS) with a deeper look [14, pp 1170-1181]

Risk assessment methods can be considered quantitatively and qualitatively. Quantitative approach assigns numbers to risks based on various risk reports and data generated. The decision making tree method is one of the most common methods in this approach. But in qualitative risk assessment all the analyzes are based on generalized idea of a risk and conceptual-descriptive approach. Therefore, this approach will make a better understanding of risks in order to choose better preventive plans [15, pp 107-116].

This article is based on a NBS and qualitative approach. One of the most recommended qualitative method in this regard is FCM[1]. This method was introduced by Kosko in 1986 and extend the idea of CM[2] by proposing the use of fuzzy causal functions taking number in [-1,1] in concept maps. These days, FCM as a soft computing tool has been extensively employed in various fields such as supply chain, fault detection, political decision making, process control, medical decision system and data mining [16, p 1445]. But so far, few studies have adopted FCM in investment risk analysis and this study is the first research focused on the investment risks in the development of Iranian refineries.

Now in the context of the review of empirical background, researches in the field of risk identification and classification will be addressed.

2.2. Imperical background

Various models have been introduced to increase the success of project risk management since 1990 [17]. Identifying and prioritizing project risks are main concepts of risk management. In this regard many researches in different fields, using several methods and models, various processes and structures [15, pp 107-116]. A summary of these studies is shown in Table 1.

Table 1. Researches to identify and prioritize project risk

Specialty field studied	Methodology used	Qualitative	NBS	Ref.
IT/IS investment evaluation process	FCM	√	√	[18]
Supplier selection problem	FCM and fuzzy soft set	√	√	[16]
Software project management	E-FCM	√	√	[19]
Project portfolio	FCM-computing with words	√	√	[1]
IT projects	FCM	√	√	[20]
Oil and gas construction projects	DEMATEL-ANP	√	√	[21]
Crude oil supply chain	DEMATEL-ANP	√	√	[22]
Project risks	Fuzzy DEMATEL	√		[23]
Russian refinery industry enterprises	Content analysis			[24]
Refineries' Process operations' fuzzy risk modeling	Delphi and fuzzy RBM	√		[25]
Quantitative risks of Refinery construction	Brain storming, AHP & decision tree analysis	Mixed		[26]
Civil projects	Best-Worst method	√		[10]
Energy management	Fuzzy AHP	√		[27]
Electricity industry Development Projects	Risk breakdown structure	Mixed		[15]
Tunneling	Linear allocation			[28]
Iran energy industry	TOPSIS	√		[29]
Electricity projects	Risk management process			[30]
Civil projects	Fuzzy decision making	√		[31]
IT Projects	Cluster analysis			[32]
Construction and transfer project	Prototype evaluation model			[33]
Dams industry	Multi objective decision making	√		[34]
Civil projects	Fuzzy AHP	√		[35]
Oil exploration	Brain storming & Fuzzy approach	√		[36]
Bridges construction projects	Group decision making	√		[37]
Electricity projects	Mathematical model			[38]
Civil projects	Fuzzy logic	√		[39]
Subway construction	Factor Analysis			[40]

As mentioned in table.1, various models and techniques are available for identification and assessment of risks but most of them overlook dependency and feedback effects between risk factors so the researches which focused on modelling the interdependency of risk factors are rare. Although the analytic network process method has been proposed to deal with the mentioned problem, but complicated problems with several factors make this method impractical. Two main problems are highlighted in this regard. The first is the problem of time consuming comparisons that sometimes lead to not sufficient results when experts try to compare the importance degree of an index to another. The second problem is the dependency of the results to the relationship structure among features which should be determined in advance. The different structure results different priorities. However, it is usually hard for experts to propose a correct and accurate relationship structure by considering many criteria [16, p1445].

Furthermore, ANP[3] method can only prioritize factors, while FCM is able to analyze the nodes in terms of direct-indirect and backward-forward impacts. This superiority has a significant role in managing the risk of portfolios in a more scientific way.

Considering the issues raised, the turning point of this study is to integrate the FCM and Delphi method for soft modelling the investment risks interdependency specially in the field of refinery units' development. This hybrid method not only takes to account the dependency and feedback effects among risk factors, but also considers the uncertainties on decision making process by using fuzzy logic.

In addition, present study attempts to develop a novel investment risk evaluation framework for development of Iranian refineries. Hence, the results lead to promote the domestic knowledge about the investment risk factors in Iranian refineries and the causal reasoning among them.

3. Research methodology

As presented in fiqure.1, this study aims to represent the risk factors as causal objects and the causality between the identified components in the development of refinery units. Therefore, from the perspective of the goal, an applied research is to be considered, and from the perspective of collecting data, it is a survey-analytic study.

On the other hand, because of using qualitative methods for initial identification of the phenomenon and interpretation data, this research has a qualitative approach and uses interpretive paradigm.

It is worth to note that in the qualitative methods unlike survey research methods, the validity of the research dose not depend on the number of participants in the survey, but depends on the scientific validity of the participating professionals and their awareness of the research subject. On the other hand, as Azar mentioned in soft operation research book, there are no limitations on the number of experts involved in cognitive mapping and even one person can do the conceptualization. But given the combination nature and the deductive and inductive procedures in this technique, groups of three upwards and even up to eight are suggested [41, p 202]. Therefore, in order to make the best use of the diversity of ideas and viewpoints of the participants, a group of five people through non-random purposeful sampling is used, all of which are experts and professionals in the field of petroleum industry specially refineries in the two section of university and industry.

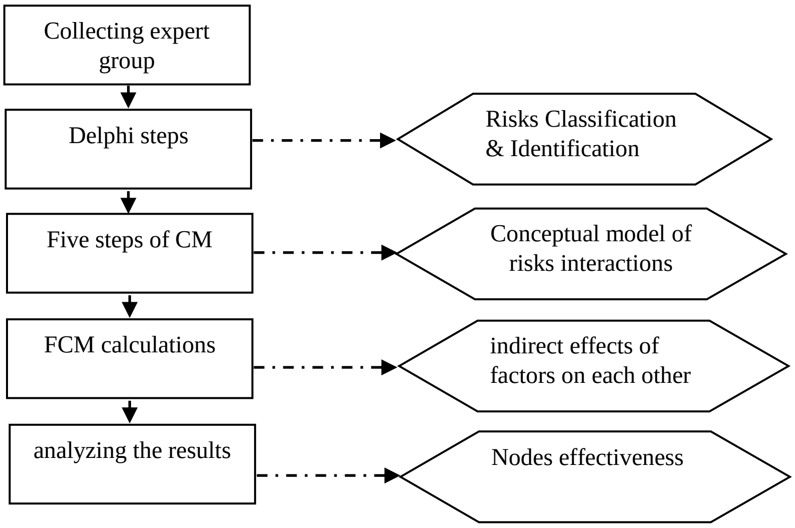


Figure 1. Research framework and research process flowchart

Delphi method which is used to identify risk factors, is a structural process for collecting and classifying the available knowledge in a group of experts and professionals. So in this step questionnaires were distributed through five experts individually and the feedbacks were listed in 3 rounds.

In the next step, by using fuzzy cognitive mapping as a powerful tool in the field of soft operation research, the existing causal reasoning between the identified risks were clarified.

Furthermore, in order to improve the internal validity of the research, the opinion of the experts was asked before and after cognitive mapping. Also in order to raise the level of reliability of the interviews, similar questions were asked from the interviewees. The following describes the cognitive mapping, implementation steps also cognitive fuzzy mapping that have been used in this research.

The roots and origins of cognitive maps is the knowledge of cognitive psychology that tries to understand the way humans think and comprehend their experiences [42]. This technique seeks to extract the expression of individuals from meaningful mental concepts and their relationship to a specific problem and expresses it as a cognitive map in the form of a visual expression and a schematic pattern [41, p 199]. The cognitive mapping in this study has been implemented in five steps in the following order [43, p 174].

- Define the scope, objectives and research questions
- Determine the sources of data collection and selection of participants
- discover causal relationships and draw maps
- Validate mappings
- Analyze and merge mappings

This research has gone a step further, and a more in-depth analysis of revealing and hidden relationships has been addressed. In real-world systems, the relationships are more complex than it can be expressed in Boolean or two-value terms, that's why Kosko in 1986 expand CM and introduced Fuzzy cognitive maps. Therefore, in this research by using a fuzzy approach, more realistic causal relationships between concepts are presented.

In these maps, instead of a positive or negative sign for the expression of the causality among concepts, a number in the interval [-1, +1] is assigned to each edge. That through which it can be quantitatively demonstrated that how the concept A impacts the concept B. The value of +1 is Maximum positive and -1 is minimum negative impact, and the zero indicates that there is no causal effect [44, pp 83-103].

Kosko expresses the fuzzy causal reasoning of concepts in cognitive mappings as follow. If there are m path from v_i to v_j as $(i, k_1', \ldots, k_n', j)$ and I_l (v_i, v_j) represents the indirect effect of the two variables v_i and v_j in the path l_m $(1 \leq l \leq m)$, to calculate the final effect of v_i on v_j, we must first determine the smallest value of $e(v_p, v_{p+1})$ on each individual path (Eq.1). $e(v_p, v_{p+1})$ is the weight of the causal relationships between the two successive variables p and (p + 1) between the two variables i and j in the path I [44, pp 83-103] [45, pp 65-75].

$$I_l(v_i , v_j)= \min \{ e(v_p , v_{p+1}) : (p , p+1) \in (i, k_1',\ldots,k_n', j) \} \quad (1)$$

Finally, to calculate the final effect of v_i on v_j, the largest value of I_l (v_i, v_j) from the possible path of m is considered based on the following equation (Eq.2).

$$T(v_i , v_j) = \max I_l(v_i , v_j) \quad , \quad 1\leq l\leq m \quad (2)$$

4. Research results

As indicated in the research methodology, by using the Delphi method and achieving five experts' viewpoints, the risk factors affecting the efficiency of a portfolio for development of Iranian refinery units are identified in the following four categories, technological, marketing, financial and legal-political.

Technological risks (TR)
TR.1.The technology monopoly and the high impact of political concerns in trade relations.
TR.2. Producing a product with the undesired specification because of the indirect connection with the foreign technical knowledge provider, or the lack of experience of the domestic technical knowledge provider.
TR.3. Non-availability of catalyst required during the process because of trade obstacle
TR.4. Failure of providing services during the operation from foreign licensors due to geopolitical problems
TR.5. Lack of expert human resources
Marketing risk (MR)
MR.1. The impossibility of selling the product caused by political instability.
MR.2. Increasing market competitors
MR.3. Arising alternative energies or the product quality standards changes transforms consumption patterns and reduces demand for the refinery's product in the target markets.
Financial Risk (FR)
FR.1. Increasing the costs during construction and production periods due to the fluctuations in exchange rates and international vicissitude.
FR.2. difficulties in attracting foreign investors caused by political and international concerns.
FR.3. failure to return on investment in due time.
Legal-Political Risk (LR)
LR.1. Termination of the Ministry of Oil's supportive policies (cancellation of crude oil supply or product purchase contracts).
LR.2. international policies deterioration such as sanctions.

After recognizing the risk factors, it is time to investigate the relationships between these factors through fuzzy cognitive mapping to provide a visual representation of how experts think about causal reasoning between entities. After recording experts' opinions during interviews, which in some cases led to two to three successive sessions, all five experts' Attitude in the cognitive process were implemented. First, the structure of concepts was derived through the adjacency matrix of zero and one in order to explain the relationship between concepts based on the views of each expert and the causal map of these individuals. The maps used are network-driven graphs, in which the nodes represent causal concepts and relationships represent the causal reasoning between concepts. Based on the recommendation of the CM researchers and in order to maximize the reliability of the collected data, the extracted maps were given to each expert for review and final confirmation. For example, Table 2 is an adjacency matrix based on an expert's view.

Table 2. Adjacency matrix based on expert opinion

	TR.1	TR.2	TR.3	TR.4	TR.5	MR.1	MR.2	MR.3	FR.1	FR.2	FR.3	LR.1	LR.2
TR.1	0	١	١	١	١	٠	٠	٠	٠	٠	٠	٠	٠
TR.2	٠	0	٠	٠	٠	٠	٠	٠	٠	٠	١	٠	٠
TR.3	٠	١	0	٠	٠	٠	٠	٠	٠	٠	١	٠	٠
TR.4	٠	١	٠	0	١	٠	٠	٠	٠	٠	١	٠	٠
TR.5	٠	٠	٠	٠	0	٠	٠	٠	٠	٠	٠	٠	٠
MR.1	٠	٠	٠	٠	٠	0	١	٠	٠	٠	١	٠	٠
MR.2	٠	٠	٠	٠	٠	٠	0	٠	٠	٠	٠	٠	٠
MR.3	٠	٠	٠	٠	٠	٠	٠	0	٠	٠	١	٠	٠
FR.1	٠	٠	٠	٠	٠	٠	٠	٠	0	١	١	٠	٠
FR.2	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	١	٠	٠
FR.3	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	0	٠	٠
LR.1	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	١	0	٠
LR.2	١	١	١	١	١	١	0	٠	1	١	١	١	0

In present study, after all participants presented their viewpoints, the majority method was used, which is one of the most prestigious methods in the cognitive map literature for extracting the integration map [46, pp 87-112]. For this purpose, the group adjacency matrix was created based on the sum of five experts' confirmed casual reasoning in Table 3. Then, according to an agreement of 60% of participants, a finalized and verified adjacency matrix, which included thirteen categories and twenty-seven causal relationships, was obtained. The final agreed mapping is presented in Fig. 2.

Table 3. Group adjacency matrix

	TR.1	TR.2	TR.3	TR.4	TR.5	MR.1	MR.2	MR.3	FR.1	FR.2	FR.3	LR.1	LR.2
TR.1	0	۵	۵	۴	۵	٠	٠	٠	٠	٠	٠	٠	٠
TR.2	٠	0	٠	٠	٠	٠	٠	١	٠	٠	۴	٠	٠
TR.3	٠	٣	0	٠	٠	٠	٠	٠	٠	٠	۵	٠	٠
TR.4	٠	۴	٠	0	۵	٠	٠	٠	٠	٠	۵	٠	٠
TR.5	٠	٠	٠	١	0	٠	٠	٠	٠	٠	٢	٠	٠
MR.1	٠	٠	٢	٠	٠	0	۵	٠	٠	١	۴	٠	٠
MR.2	٠	٠	٠	٠	٠	٠	0	٠	١	٠	٠	٠	٠
MR.3	٠	٠	٠	٠	٠	٠	٠	0	٠	٠	۵	٠	٠
FR.1	٠	٠	٠	٠	٠	١	٠	٠	0	۴	۴	٠	٠
FR.2	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	۴	٠	٠
FR.3	٠	٠	٠	٠	٠	٠	٠	٠	١	٠	0	٠	٠
LR.1	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	۵	0	٠
LR.2	۵	۴	۴	٣	۵	۴	0	٠	5	۵	۴	۴	0

To illustrate the severity of the causal relationships between the concepts and to determine the level of activation of each node, fuzzy direct effects have been used based on experts' point of views. One of the strengths of fuzzy theory for imperfect concepts is to make decisions according to verbal variables instead of numerical ones. These variables can proficiently analyze the ambiguity of human language in numerical -and quantitative terms [47, pp 17-46]. These variables are considered as an approach for quantifying the complex and not well-defined words and judgments and help us to perform mathematical operations on them [48, pp 1-17].

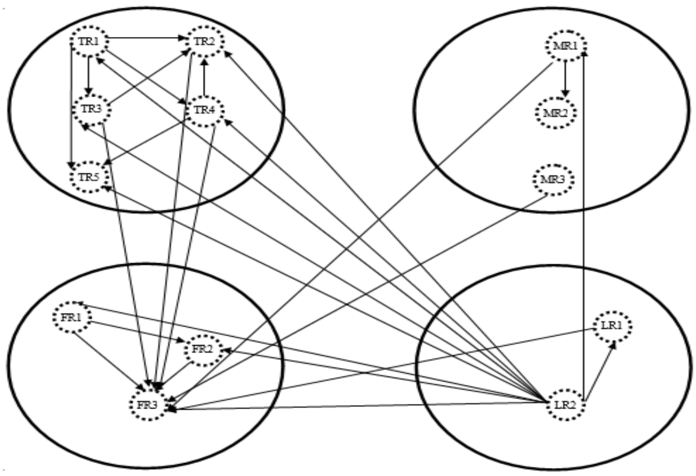


Figure 2. Cognitive mapping resulting from the final agreement

Table 4 shows fuzzy numbers equivalent to the verbal variables used in this study.

Table 4. Verbal variables and moderate fuzzy numbers [48]

Moderate fuzzy numbers	Verbal values of positive nature	Verbal values of negative nature
1	Very high	Very Low
0.75	High	Low
0.5	Moderate	Moderate
0.25	Low	High
٠	Very Low	Very high

It should be noted that at this stage, only the direct interactions of the factors are considered, and the numbers in each cell of Table.5 indicate the intensity of the direct effect of the nodes on each other, resulting from the geometric mean of the five experts' views after the defuzzification stage. Basically, geometric mean is appropriate for data which has proportional nature.

Table 5. Geometric mean of expert opinions on direct interaction between nodes

	TR.1	**TR.2**	**TR.3**	**TR.4**	**TR.5**	**MR.1**	**MR.2**	**MR.3**	**FR.1**	**FR.2**	**FR.3**	**LR.1**	**LR.2**
TR.1	0	١	0.78	0.68	0.84	٠	٠	٠	٠	٠	٠	٠	٠
TR.2	٠	0	٠	٠	٠	٠	٠	٠	٠	٠	0.89	٠	٠
TR.3	٠	0.76	0	٠	٠	٠	٠	٠	٠	٠	0.94	٠	٠
TR.4	٠	0.84	٠	0	0.73	٠	٠	٠	٠	٠	0.73	٠	٠
TR.5	٠	٠	٠	٠	0	٠	٠	٠	٠	٠	٠	٠	٠
MR.1	٠	٠	٠	٠	٠	0	0.60	٠	٠	٠	0.84	٠	٠
MR.2	٠	٠	٠	٠	٠	٠	0	٠	٠	٠	٠	٠	٠
MR.3	٠	٠	٠	٠	٠	٠	٠	0	٠	٠	0.89	٠	٠
FR.1	٠	٠	٠	٠	٠	٠	٠	٠	0	0.68	0.82	٠	٠
FR.2	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	0.57	٠	٠
FR.3	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	0	٠	٠
LR.1	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	0.87	0	٠
LR.2	١	0.73	0.89	0.89	0.72	0.75	٠	٠	0.78	0.84	0.94	0.84	0

In the final part of the paper, based on Kosko method and by using the direct fuzzy effects derived from the participants' viewpoints, the indirect effects of the factors on each other is presented. For instant, the indirect effects of TR.1 on other factors are calculated based on the identified routes as follows.

$I_1(TR.1,TR.2) = Max(1 , Min\{0.68,0.84\}, Min\{0.78,0.76\}) =1$

$I_2(TR.1,TR.3) = Max(0.78) = 0.78$

$I_3(TR.1,TR.4) = Max(0.68) = 0.68$

$I_4(TR.1,TR.5) = Max(0.84 , Min\{0.68,0.73\})= 0.84$

$I_{10}(TR.1,FR.3) = Max(Min\{0.78,0.94\}, Min\{1,0.89\})=0.78$

The final result of calculating the indirect effects for other nodes is presented in Table 6. As seen in this table, the severity of some relationships has no changes, such as the impact of TR.1 on TR.2. but for some relationships, like the impact of LR.2 on TR.2, the severity has been changed, and some indirect relationships such as the impact of TR.1 on FR.3 are created.

Table 6. The indirect effects of factors on each other

	TR.1	TR.2	TR.3	TR.4	TR.5	MR.1	MR.2	MR.3	FR.1	FR.2	FR.3	LR.1	LR.2
TR.1	0	۱,۰۰	۰,۷۸	۰,۶۸	۰,۸۴	۰	۰	۰	۰	۰	0.78	۰	۰
TR.2	۰	0	۰	۰	۰	۰	۰	۰	۰	۰	۰.۸۹	۰	۰
TR.3	۰	0.76	0	0.84	۰	۰	۰	۰	۰	۰	۰.۹۴	۰	۰
TR.4	۰	0.84	۰	0	0.73	۰	۰	۰	۰	۰	0.73	۰	۰
TR.5	۰	۰	۰	۰	0	۰	۰	۰	۰	۰	۰	۰	۰
MR.1	۰	۰	۰	۰	۰	0	0.60	۰	۰	۰	0.84	۰	۰
MR.2	۰	۰	۰	۰	۰	۰	0	۰	۰	۰	۰	۰	۰
MR.3	۰	۰	۰	۰	۰	۰	۰	0	۰	۰	0.89	۰	۰
FR.1	۰	۰	۰	۰	۰	۰	۰	۰	0	0.68	0.82	۰	۰
FR.2	۰	۰	۰	۰	۰	۰	۰	۰	۰	۰	0.57	۰	۰
FR.3	۰	۰	۰	۰	۰	۰	۰	۰	۰	۰	0	۰	۰
LR.1	۰	۰	۰	۰	۰	۰	۰	۰	۰	۰	0.87	0	۰
LR.2	۱	1	0.89	0.89	0.84	0.75	0.60	۰	0.78	0.84	0.94	0.84	0

In the next step, based on the distribution degree of nodes approach in graph theory and by considering the adjacency matrix derived from the experts' average opinion (table.6), the direct and indirect connections of the factors in a network has been analyzed and statically evaluated. The procedure is to calculate the absolute values of each node’s input and output. The output weight of each node indicates how it make an impression on other nodes and the input weight indicates how it is influenced by others [49, pp 30-37]. Table 7 shows normalized weights of direct and indirect effects of causal concepts.

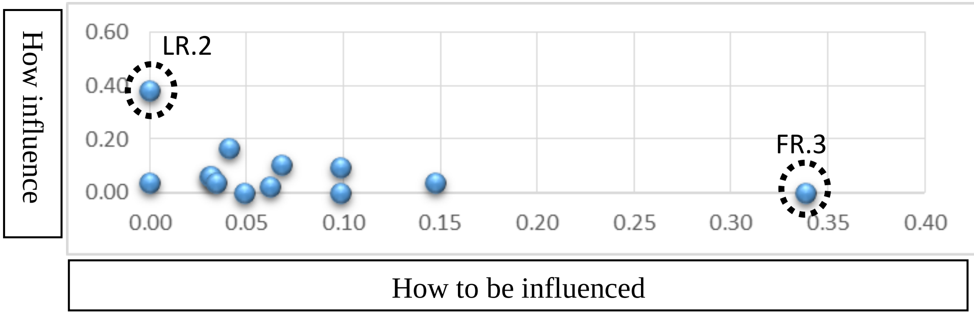
Table 7.how Influence and being influenced

	TR.1	TR.2	TR.3	TR.4	TR.5	MR.1	MR.2	MR.3	FR.1	FR.2	FR.3	LR.1	LR.2
Normal.In	0.04	0.15	0.07	0.10	0.10	0.03	0.05	۰	0.03	0.06	0.34	0.03	۰
Normal.Out	0.17	0.04	0.1	0.09	۰	0.06	۰	0.04	0.06	0.02	۰	0.04	0.38

Also Figure 3, schematically analyzes how causal nodes affect others also how they are influenced. The horizontal axis indicates the influence level and the vertical axis indicates the being influenced level of each node.

It is worth noting that managing the higher impacted nodes is more difficult because they are influenced by many factors. On the other hand, the more effective the node is, the risk factor should be considered more and more, since managing it can reduce the likelihood of occurrence of other related factors [49, pp 30-37]. As shown in the figure, the most effective risk factor is LR.2 and FR.3 is influenced more than others.

Figure 3. Factors' Effectiveness



5. Conclusion and suggestions

In order to make a reasonable and methodical investment and selecting the optimal portfolio of the projects, it is important to investigate the potential negative factors affecting the investment. This paper differs from the pervious studies in that we focused on development of Iranian refineries and presented hybrid risk identification and assessment mechanism. What is more, we paid particular attention to the dependence and feedback effects via modelling causal interdependencies.

The first achievement of this research is recognizing the risk factors that affect the return on investment in the development of Iranian refineries at four categories of technology, marketing, economic and legal-political. In the next step, by using the fuzzy cognitive mapping and through the essential subjective models of the experts, thirteen categories and twenty-seven causal relationships were identified and, finally, the direct and indirect relations between the factors were explored. In the area of technological risks, the most influential factor is the monopoly of technology, in the marketing field, the risk of impossibility to sell impacts the most, in the financial sphere, increasing cost of construction and operation and in the legal area international policies deterioration are the most impressive factors. Also according to experts' point of views, the most influential factor among all is the international policies deterioration such as sanctions and the most influenced factor is the inability to return capital in due time. The results of these qualitative analyzes can be applicable in investment risk management and choosing practical solutions for the stated potential factors.

For future research, it is suggested to investigate the risk factors dynamically and over the time. Furthermore, applying another hybrid approaches can be considered as a subject for future research. Completing the risk management process also would be worth for further exploration.

6. Postscript

1. fuzzy cognitive map
2. Cognitive map
3. Analytic Network Process

7. References

[1] Pena Gonzalez, M., Barrionuevo, C. & Cedeno Moran, F. (2016). Fuzzy cognitive maps and computing with words for modelling project portfolio risks interdependency. *International journal of innovation and applied studies*, 15(4): 737-742.

[2] Liu, M. , Jin, F., Xie, Q. & Skitmore, M., (2016). Improving risk assessment in financial feasibility of international engineering projects: A risk driver perspective. International *Journal of project management*, 35: 204-211.

[3] Xie, G., Yue, W., Wang, Sh. & Keung Lai, K., (2010). Dynamic risk management in petroleum project investment based on a variable precision rough set model. *Technological forecasting & social change*, 77: 891-901.

[4] Salehi, M. & Hosseinpour, Z., (2016). Providing a new model for investment management in selecting investment projects using error analysis and fuzzy network analysis process. *Journal of risk modelling and financial engineering*, 1(2): 244-263.(in Persian)

[5] Virclics, A., (2013).Investment decision making and risk. *Procedia Econ. Finance*, 6: 169-177.

[6] Mojtahedi, M., Mousavi, M. & Makui, A. (2010). Project risk identification and assessment simultaneously using multi-attribute group decision making technique. *Safety science*, 48: 499-507.

[7] Aven, T. (2016). Risk assessment and risk management: Review of recent advances on their foundation. *European Journal of Operational Research*, 253(1): 1-13.

[8] Carter, B., Hancock, T., Morin, J., & Robins , N. (1996). *Introducing RISKMAN: The European Project Risk Management Methodology*. Stationery Office.

[9] Wideman, R., & Max, E. (1992). *Project and program risk management: A guide to managing project risks and opportunities.* Project Management Institute.

[10] Mohaghar, A., Hosseini dehshiri, S. & Arab, A. (2017). Investigating and evaluating project risks based on the best-worst-practice method. Human Resources Management Research, 7(2): 157-173. (in Persian)

[11] Ward, S., & Chapman, C. (1996). *Project risk management processes, techniques and insights*. New York: John Wiley & sons.

[12] A Guide to the Project Management Body of Knowledge: (PMBOK Guide) 4th Edition. (2008). Maryland: Project Management Institute.

[13] Najafi, A. A., & Pourahmadi, Z. (2016). An efficient heuristic method for dynamic portfolio selection problem under transaction costs and uncertain conditions. *Physica A*, 448: 154-162.

[14] Suliman Bu-Qammaz, A., Dikmen, I., & Birgonul, M. (2009). Risk assessment of international construction projects using the analytic network process. *Canadian journal of civil engineering*, 36(7):1170-1181.

[15] Kalahan, F., rezaie-Nik, A., Hassani, M., ramezanpour& H., Tajaddod, A.(2015). Identifying and prioritizing the risks of development projects of the country's power industry (Case study: Transmission and Distribution Zone of Khorasan Regional Electricity Company). Industrial Engineering Journal, 49 (1): 107-116. (in Persian)

[16] Xiao, Z., Chen, W. & Li, L. (2012). An integrated FCM and fuzzy soft set for supplier selection problem based on risk evaluation. *Applied mathematical modelling*, 36: 1444-1454.

[17] Grey, S., Cooper, D., Walker, P., & Geoffrey , R. (2005). *Project risk management guidelines: managing risk in large projects and complex procurements*. New York: John Wiley & sons.

[18] Irani, Z., Sharif, A., Love, P. & Kahraman, C. (2002). Applying concepts of fuzzy cognitive mapping to model: The IT/IS investment evaluation process. International journal of production economics, 75(1-2): 199-211.

[19] Lazzerini, B. & Mkrtchyan, L. (2010). Risk analysis using extended fuzzy cognitive maps. *Intelligent computing and cognitive informatisc international conference*.

[20] Salmeron, J. (2010). *Fuzzy cognitive maps advanced in theory, methodologies, tools and applications*. Berlin: Springer.

[21] Dejdash, G., Zin, R. & Ferwati, M. (2017). DEMATEL-ANP risk assessment in oil and gas construction projects. *sustainability*, 9: 1-24.

[22] Fazli, S., Kiani Mavi, R. & vosooghidizaji, M. (2015). Crude oil supply

chain risk management with DEMATEL-ANP. *Operational Research*, 15(3): 453-480.

[23] Khatami Firouzabadi, A., Vafadar Nikjoo, H. & Shahabi, A. (2013). Determining most significant project risk's categories with considering causal relations between them in the fuzzy environment. *Management research in Iran*, 17(3): 49-69. (in Persian)

[24] Khayrullina, A., Mingazova, A. (2016). Content analysis of the risks specific to the refining industry enterprises in the Russian Federation. *Academy of strategic management Journal*, 15(2): 121-130.

[25] Sa'idi, E., Anvaripour, B., Jaderi, F., Nabhani, N. (2014). Fuzzy risk modeling of process operations in the oil and gas refineries. *Journal of loss prevention in the process industries*, 30: 63-73.

[26] Dey, P.K. (2002). Quantitative risk management aids refinery construction. *Hydrocarbon processing*, March: 85-95.

[27] Jingmin, W., & Sun, Y. (2012). The intuitionistic fuzzy sets on evaluation ofrisks in projects of energy management contract. *Systems Engineering Procedia*, 3, 30-35

[28] Sayadi, A., Hayati, M., & Azar, A. (2011). Assessment and ranking of risks intunneling projects using linear assignment technique. *international Journal of Industrial Engineeering and production management*, 22(1): 27-38.

[29] Jabal-Ameli, M., Rezaeifar, A., & Bakhsh Langroudi, A. (2008). Ranking project risks using MADM methodologies. *Journal of faculty of engineering (university of Tehran)*, 41(7): 863-871.(in Persian)

[30] Wyk, V., Riaan, Bowen, P., & Akintoy, A. (2008). Project risk management practice: The case of a South African utility company. *International Journal of Project Management*, 26(2):149-163.

[31] Jiahao, Z., An, M., & Jon Smith, N. (2007). Application of a fuzzy based decision making methodology to construction project risk assessment. *International journal of project management*, 25(6): 589-600.

[32] Linda, W., Keil, M., & Rai, A. (2004). Understanding software project risk: a cluster analysis. *Information & Management*, 42(1): 115-125.

[33] Tarek M., Z., & Chang, L.-M. (2002). Prototype model for build-operate transfer risk assessment. *Journal of Management in Engineering*, 18(1): 7-16.

[34] Yousefi, O., Naseri, P. & Nilipour Tabatabaei, A. (2014). Project risk assessment model using multi-objective decision-making approach (Case Study: The earth dam project Asalooye). *Journal of Industrial*

Engineering, 48(1): 125-135. (in Persian)

[35] Ana, N. M & Ruz-Vila, F. (2011). A fuzzy approach to construction project risk assessment. *International Journal of Project management*, 29(2): 220-231.

[36] Jafarnejad, A., & Usefi, Z. (2008). Presenting fuzzy risk ranking model in petropars company drilling projects. *Industrial management journal*, 21-38. (in Persian)

[37] Wang, Ying-Ming, & MS Elhag, T. (2007). A fuzzy group decision making approach for bridge risk assessment. *Computers & Industrial Engineering*, 53(1): 137-148.

[38] Min, L., & F. Wu. , F. (2007). Risk management in a competitive electricity market. *International Journal of Electrical Power & Energy Systems*, 29: 690-697.

[39] An, M., Baker, C., & Zeng, J. (2005). A fuzzy-logic-based approach to qualitative risk modeling in the construction process. *World Journal of Engineering*, 2: 1-12.

[40] Sid, G., & Jintanapakanont, J. (2004). Identifying and assessing the critical risk factors in an underground rail project in Thailand: a factor analysis approach. *International Journal of Project Managemen*, 22(8): 633-643.

[41] Azar, A., Khosravani, F. & Jalali, R. (2016). Soft operational research; problem structuring methods. Tehran: Industrial Management organization poblication. (in Persian)

[42] Pidd, M. (2009). *Tools for Thinking; Modelling in Management Science*. (3rd ed.) Chichester: John Wiley and Sons Ltd.

[43] Naghibi, H., Fareskhani, H., Kasaie, M. & Zandieh, M. (2016). Explaining the Influential Components in the World-Class Production Structure in the Automotive Industry. *Modern researches in decision making*, 1(4): 167-186. (in Persian)

[44] Azar, A. & Mostafaie, K. (2012). Fuzzy Cognitive Mapping A New Approach to Soft Modeling: Modeling at the Center of Statistics of Iran. *Management research in Iran*, 16(3): 83-103. (in Persian)

[45] Kosko, B. (1986). Fuzzy cognitive maps. *Int. J. Man-Machine studies*, 24: 65-75.

[46] Sadeghi-Moghaddam, M. (2012). Provide a model for coordinating the automotive supply network by applying a causal mapping (Case Study: Automotive Network Provision. *Industrial management journal of Tehran university*, 4(2): 87-112. (in Persian)

[47] Barzdeh, S. & Taghavi-fard, M. (2013). Design and development of a law-based fuzzy expert system for assessing the credit of business customers. *Commercial Management Journal of Tehran University*, 5 (2): 17-46. (in Persian)

[48] Nasrabadi, A., Hosseinpour, M., & Ebrahimnejad, H. (2013). Strategy-alligned fuzzy approach for market segment evaluation selection: a modular decision support system by dynamic network process (DNP). *Journal of Industrial Engineeering international*, 9: 1-17.

[49] Jafari-Eskandari, M. & Farhang, M. (2015). Designing a Fuzzy Cognitive Map Model of Factors Affecting Cost-Time-Quality in South Pars Gas Complex Projects. *Monthly Oil and Gas Exploration and Production*, (125): 30-37. (in Persian)