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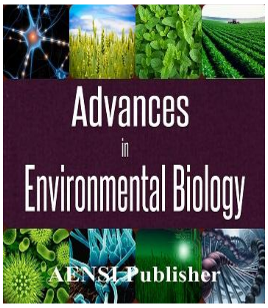

Identification and prioritization of critical success factors in Offshore Logistics Management of Gas Platforms, a F.MCDM approach (Case Study: Pars Oil & Gas Company)

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ABSTRACT
Iran's gas production takes place offshore. In order to ensure continuous production, the offshore installations need to be supplied regularly. This is done by using platform vessels. This Paper studied Pars Oil and Gas Company as one of the subsidiaries of National Iranian Oil Company. The aim of this study is the identification and prioritization of critical success factors (CSFs) in in Offshore Logistics Management of Gas Platforms. This research was conducted in three stages and in order to use the experiences and perceptions of experts to gauge the importance of the set of CSFs, three questionnaires were prepared. First, an initial screening questionnaire was used in order to remove items of lower priority extracted from literature study. At this stage, using a Fuzzy-decimal screening, factors of more importance were collected and used for the next phases. The second questionnaire was prepared to determine the relative importance of factors affecting logistics management of offshore gas platforms. In this stage using fuzzy AHP approach, factors were prioritized. Finally, the third questionnaire was used for identifying and investigating the relationship between the factors. In this step by the use of Dematel technique, the impact and influence of factors were examined. The results from fuzzy AHP method showed that factors related to the management of vessels, including safety and reliability, operational capability, sailing capability loading and unloading capability had the highest priority among the other factors. DEMATEL results showed that training the employees, determining clear objectives, and assessment and close monitoring the performance of the contractors have the most interaction with other factors.

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INTRODUCTION

Iran's gas production takes place offshore. In order to ensure continuous production, the offshore installations need to be supplied regularly. The only way to do this is using vessels such as Anchor Handling Vessels, Offshore Supply Vessels (OSVs), also called Platform Supply Vessels or just 'supply vessels', Crew Boats and Standby/Rescue vessels [1]

In the oil and gas industry 'downstream logistics' is defined as bringing oil and gas to onshore customers while 'upstream logistics' is defined as supplying the offshore drilling and production units with the necessary supplies [2] Important issues in upstream logistics are to support offshore activities so that these can be carried out as planned and in a cost-efficient way.

There are many types of offshore drilling and production units representing different logistical needs. It is common to distinguish between two types of units. First we have units that are mainly producing (but might also be drilling) and stay at the same position for a longer period, such as (production) platforms or production ships. Second, we have those moving around on commission, solely for exploration, called exploration (or wildcat) rigs/ships. The size of offshore drilling and production units can vary from small, unmanned units to large constructions, in which several hundred workers are needed onboard. Consequently, the need for supplies to support daily operations (like food, clothes and so on), and the amount and type of equipment needed, for instance to carry out drilling operations (for example, drill pipes and casing), will vary significantly [3]

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Installations do not only need to receive supplies. There is also a need for return transport and the directional balance is good. Most of the returned cargos are empty load carriers, waste, rented equipment and excess back-up equipment.

In general, offshore installations have a rather limited storage capacity, and thus it is important to have rather frequent visits to avoid a shortage of supplies or a buildup of return cargo. Much of the equipment, especially specialized equipment used in well and drilling operations, is rented with high daily rates; hence it is also financially important to return such equipment quickly [4]

The cost of chartering and operating a supply vessel is one of the largest logistics cost elements in the upstream chain. Consequently, getting the needed capacity at the lowest possible rate, and maximizing the utilization of the vessels are important objectives for the oil companies.

This Paper studied Pars Oil and Gas Company as one of the subsidiaries of National Iranian Oil Company which established in December 1998. The company is responsible for all phases of the South Pars gas field development. It is also responsible for the development of North Pars gas fields, Golshan and Ferdowsi and South Pars Oil Layer in the Persian Gulf.

Literature Review:

Halvorsen et al [5] studied Statoil Company in which, a set of offshore installations required supplies from an onshore supply depot on a regular basis, a service performed by a fleet of offshore supply vessels. The problem consisted of determining the optimal fleet composition of offshore supply vessels and their corresponding weekly voyages and schedules. a voyage-based solution method was presented for the supply vessel planning problem.

Maisiuk et al [6] presented a discrete-event simulation model for evaluation of alternative fleet size configurations taking into consideration uncertainty in weather conditions and future spot vessel rates.

Eugen et al [7]presented a mathematical formulation in a single vehicle routing problem with pickups and deliveries of multiple commodities where each customer required both pickup and delivery of several types of goods from a single depot.

Karahalios et al [8] applied Fuzzy Sets and Analytic Hierarchy Process (AHP) in contribution of risk management in ship management. for ship operators it is important to utilize management systems in reducing potential threats to shipboard crew and cargoes carried on board.

Woodcock et al [9] discussed the role of human factors issues in the management of emergency response at high hazard installations, in particular offshore installations.

Vestly et al [10] developed a performance indicator for psychosocial risk in the oil and gas industry by integrating psychosocial risk management into the larger HSE risk management process.

Parkes et al [11] presented a systematic review of the impact of shift schedules on oil and gas installations on performance, safety and health of personnel. His article focused on offshore working time arrangements, and presented a systematic review of studies which examined offshore day/night shift patterns in relation to operational safety and individual health risks.

Havold et al [12] reported result from a survey on 157 navigators (bridge officers) from eight offshore companies operating in the North Sea, studying stress on the bridge of offshore vessels. The questionnaire measured stress, work pressure and sleep/rest.

Research methodology:

The aim of this study is the identification and prioritization of critical success factors (CSFs) in Offshore Logistics Management of Gas Platforms. For theoretical study, internet searches and resources such as books, articles, journals and newspapers were used, Then to collect other information that was needed for the research, questionnaires were used. This research was conducted in three stages and in order to use the experiences and perceptions of experts to gauge the importance of the set of CSFs, three questionnaires were prepared.

First, an initial screening questionnaire was used in order to remove items of lower priority extracted from literature study. At this stage, using a Fuzzy-decimal screening, factors of more importance were collected and used for the next phases.

The second questionnaire was prepared to determine the relative importance of factors affecting logistics management of offshore gas platforms. In this stage using fuzzy AHP approach, factors were ranked.

Finally, the third questionnaire was used for identifying and investigating the relationship between the factors. In this step by the use of Dematel technique, the impact and influence of factors were examined.

Fuzzy AHP:

The general fuzzy-AHP process used in this paper is discussed as follows:

Step 1: Fuzzy synthetic extent calculation:

Let $X=\{x_1, x_2, \ldots, x_n\}$ be an object set, and $U=\{u_1, u_2, \ldots, u_m\}$ be a goal set. Using Chang's extent analysis approach [13] each object is taken and extent analysis for each goal is performed respectively. Therefore, *m* extent analysis values for each object can be calculated, and are denoted as:

$$A_{gi}^1, A_{gi}^2, \ldots, A_{gi}^m \qquad i = 1,2, \ldots, n$$

where all the A_{gi}^j $(j = 1,2, \ldots, m)$ are triangular fuzzy numbers. With respect to the ith object, the value of fuzzy synthetic extent is defined as:

$$S_i = \sum_{j=1}^{m} A_{gi}^j \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} A_{gi}^j\right]^{-1} \qquad (1-3)$$

Step 2: Comparison of fuzzy values [14]

The degree of possibility of $A_2 = (l_2, m_2, n_2) \geq A_1 = (l_1, m_1, n_1)$ is defined as:

$$V(A_2 \geq A_1) = \underbrace{SUP}_{x \geq y} [min(\mu_{A_1}(x), \mu_{A_2}(y))] \quad (2-3)$$

When a pair (x,y) exists such that $x \geq y$ and $\mu_{A_1}(x) = \mu_{A_2}(y) = 1$, then we have $V(A_2 \geq A_1) = 1$. Since they are convex fuzzy numbers so are expressed as follows:

$$V(A_2 \geq A_1) = hgt\,(A_1 \cap A_2) = \mu_{A_2}(d) \qquad (3-3)$$

where *d* is the ordinate of the highest intersection point between μ_{A_1} and μ_{A_2}.

When $A_1 = (l_1, m_1, n_1)$ and $A_2 = (l_2, m_2, n_2)$ then $\mu_{A_2}(d)$ is computed by $(4-3)$

$$\mu_{A_2}(d) = \begin{cases} 1 & m_2 \geq m_1 \,, \\ 0 & l_1 \geq n_2 \,, \\ \dfrac{l_1 - n_2}{(m_2 - n_2) - (m_1 - l_1)} & otherwise. \end{cases}$$

For the comparison of A_1 and A_2 we need both the values of $V(A_2 \geq A_1)$ and $V(A_1 \geq A_2)$

Step 3: Priority weight calculation [15]

The degree possibility of convex fuzzy number to be greater than *K* convex fuzzy numbers can be defined by:

$$V(A \geq A_1, A_2, \ldots A_k)$$
$$= V[(A \geq A_1) \text{ and } (A \geq A_2) \text{ and } , \ldots, \text{and } (A \geq A_k)] \qquad (5-3)$$
$$V(A \geq A_1, A_2, \ldots A_k) = min\, V(A \geq A_i) \qquad i = 1,2, \ldots, k \qquad (6-3)$$

If

$$m(P_i) = min\, V(S_i \geq S_k) \qquad for\ k = 1,2, \ldots, n\,;\ k \neq i \qquad (7-3)$$

Then the weight vector is given by:

$$W_p = (m(P_1), m(P_2), \ldots, m(P_n))^T \qquad (8-3)$$

Here $P_i (i = 1,2, \ldots, n)$ are *n* elements.

Step 4: Calculation of normalized weight vector:

After normalization of W_p, we get the normalized weight vectors

$$W = (w(P_1), w(P_2), \ldots, w(P_n))^T \qquad (9-3)$$

where, *W* is a non fuzzy number and it gives the priority weights of one decision alternative over another.

Dematel technique:

The DEMATEL method is applied to solve the complex dependency issues among criteria. The four steps of method calculation are described as follows [16]

Step 1: Generate an original impact matrix (X)

The calculations of the original mean matrix are conducted by pairwise comparisons of dimensions (criteria) to evaluate the perceived level of impact of each respondent regarding the dimensions (criteria). The evaluation scale ranges from 0 to 4, where 0 represents no impact among the dimensions (criteria); 1 represents a low level of impact; 2 represents a medium level of impact; 3 represents a high level of impact; and 4 represents an extremely high level of impact The original mean impact matrix (X) can be obtained by the average of the summation of the expert answer matrices.

Step 2: Calculate the direct impact matrix (M)

First, obtain the maximum values of all rows or columns of the original mean matrix (X), then normalize the processes to obtain the direct impact matrix (M); then apply Eqs. (10-3), where *k* is the maximum amount of the summations of the rows and columns of the direct impact matrix (M)

$$M = k * X \qquad (10-3)$$

Step 3: Calculate the total impact matrix (***T***)

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By Eq. (11-3), the total impact matrix (***T***) can be obtained.

$$T = M(I - M)^{-1} \quad (11-3)$$

Next, obtain the row sum vector (D), and the column sum vector (R); then, obtain the row and column sum vector (D + R) and the row and column difference vector (D－R).

When the value of (D + R) is higher, it means that the mutual effects of the dimensions (criteria) are greater. The difference vector (D－R) represents the net impact of the total impact matrix. If (D－R>0), it means that the dimension (criterion) has greater impact on other dimensions (criteria) than the impact of other dimensions (criteria) on it. On the contrary, if (D－R<0), the dimension (criterion) has a smaller impact on other dimensions (criteria) than the impact of other dimensions (criteria) on it.

Case study example:

A three phase methodology has been applied to identify and prioritize the critical success factors in Offshore Logistics Management of Gas Platforms. The three phases of the research methodology are described in following subsections.

4.1. Application of Fuzzy-decimal screening

Through literature review to identify critical success factors, the number 64 factors was determined. Then using the fuzzy screening fraction, 24 of which were selected from a higher priority. These factors are shown in Table 1.

Table 1: The criteria and sub-criteria of critical success factors in Offshore Logistics Management of Gas Platforms

criteria	sub-criteria
management of supply vessels S_1	safety and reliability C_1 sailing capability C_2 operational capability C_3 loading and unloading capability C_4
maritime disaster management S_2	explaining to employees about their duties in case of disaster C_5 correct and precise forecast of weather condition C_6 appropriate allocation of hours of work and hours of rest C_7 vessel design and equipment C_8
psychological risk management S_3	explaining the working conditions at the time of recruitment and selecting employees more compatible with the existing terms C_9 designing of flexible working hours C_{10} stress management and reduction C_{11}
empowerment of employees S_4	supporting employees C_{12} motivating employees C_{13} employee performance evaluation C_{14} determining clear objectives C_{15} training the employees C_{16}
outsourcing S_5	selection of appropriate contract between the employer and the contractor C_{17} accurate selection of suppliers and contractors C_{18} assessment and close monitoring the performance of the contractors C_{19} analysis of the costs associated with outsourcing C_{20} the effects of outsourcing on productivity and moral obligations of employees C_{21}
communications infrastructure S_6	proper coordination and communication between the client and the contractors and subcontractors C_{22} appropriate communication among onshore facilities, platforms and vessels C_{23} communicational infrastructure between operational management and logistics management C_{24}

Application of fuzzy AHP in determining weights of criteria

After determining criteria and sub-criteria, the discussion has been further prolonged to decide the different priority weights of each criteria, sub-criteria and alternatives using linguistic comparison terms and their equivalent triangular fuzzy numbers (TFN) defined by Gumus in Table 2. [15]

Table 2: Triangular fuzzy numbers of linguistic comparison measures

Linguistic terms	TFN
Perfect	(8,9,10)
Absolute	(7,8,9)
Very good	(6,7,8)
Fairly good	(5,6,7)
Good	(4,5,6)
Preferable	(3,4,5)
Not bad	(2,3,4)
Weak advantage	(1,2,3)
Equal	(1,1,1)

The fuzzy comparison matrices are prepared with the help of questionnaire. The fuzzy comparison matrices of criteria with calculated weights are shown in Tables 3.

The fuzzy comparison matrices of sub-criteria along and weights can be calculated in the same fashion.

Table 3: The fuzzy comparison matrices of criteria with calculated weights.

weight	S_6	S_5	S_4	S_3	S_2	S_1	
0.283	1,2.7,4	1,1.8,3	2,3.8,0.5	1,2.2,3	3,4,5	1,1,1	S_1
0.238	2,3.6,4	1,2,3	2,3,4,	2,3,4,	1,1,1	0.20,0.25,0.33	S_2
0.087	1,2.1,3	0.33,0.5,1	0.2,0.26,0.5	1,1,1	0.25,0.33,0.5	0.33,0.45,1	S_3
0.196	1,2.8,4	1,1,1	1,1,1	2,3.9,0.5	0.33,0.43,1	0.2,0.26,0.5	S_4
0.151	1,2,3	1,1,1	1,1,1	1,2,3	0.33,0.5,1	0.33,0.56,1	S_5
0.045	1,1,1	0.33,0.5,1	0.25,0.36,1	0.33,0.48,1	0.25,0.28,1	o.25,0.37,1	S_6

The weight calculations using Chang's extent analysis approach for Table 3 are given below.

The values of fuzzy synthetic extent of six criteria with respect to the goal are calculated as below by using Eq. (1-3).

$S_1 = (9.00\ ,15.50,21.00) \otimes (31.93,51.73,71.33)^{-1}$
$= (0.1261,0.2996,0.5676)$
$S_2 = (7.20,12.15,15.33) \otimes (31.93,51.73,71.33)^{-1}$
$= (0.1009,0.2348,0.4801)$
$S_3 = (3.12,4.64,7.00) \otimes (31.93,51.73,71.33)^{-1}$
$= (0.0436,0.0897,0.2192)$
$S_4 = (5.53,9.40,12.50) \otimes (31.93,51.73,71.33)^{-1}$
$= (0.0775,0.1816,0.3914)$
$S_5 = (4.67,7.06,10.00) \otimes (31.93,51.73,71.33)^{-1}$
$= (0.0654,0.1363,0.3131)$
$S_6 = (2.42,2.98,5.50) \otimes (31.93,51.73,71.33)^{-1}$
$= (0.0338,0.0576,0.1722)$

The V values calculations using Eqns. (3-3) and (4-3) are as follows.

$$V(A_2 \geq A_1) = \mathrm{hgt}\ (A_1 \cap A_2) = \mu_{A_2}(d)$$

$$\mu_{A_2}(d) = \begin{cases} 1 & m_2 \geq m_1\ , \\ 0 & l_1 \geq n_2\ \ , \\ \dfrac{l_1 - n_2}{(m_2 - n_2) - (m_1 - l_1)} & \text{otherwise.} \end{cases}$$

$V(S_1 \geq S_2) = 1\ , V(S_1 \geq S_3) = 1\ ,$
$V(S_1 \geq S_4) = 1\ ,$
$V(S_1 \geq S_5) = 1\ \ , V(S_1 \geq S_6) = 1$
$V(S_2 \geq S_1) = 0.8453\ , V(S_2 \geq S_3) = 1,$
$V(S_2 \geq S_4) = 1,$
$V(S_2 \geq S_5) = 1, V(S_2 \geq S_6) = 1$
$V(S_3 \geq S_1) = 0.3071,$
$V(S_3 \geq S_2) = 0.4490, V(S_3 \geq S_4) = 0.6065,$
$V(S_3 \geq S_5) = 0.7674, V(S_3 \geq S_6) = 1$
$V(S_4 \geq S_1) = 0.6921,$
$V(S_4 \geq S_2) = 0.8452, V(S_4 \geq S_3) = 1,$
$V(S_4 \geq S_5) = 1, V(S_4 \geq S_6) = 1$
$V(S_5 \geq S_1) = 0.5338,$
$V(S_5 \geq S_2) = 0.6830, V(S_5 \geq S_3) = 1,$
$V(S_5 \geq S_4) = 0.8387, V(S_5 \geq S_6) = 1$
$V(S_6 \geq S_1) = 0.1599,$
$V(S_6 \geq S_2) = 0.2868, V(S_6 \geq S_3) = 0.7999,$
$V(S_6 \geq S_4) = 0.4328, V(S_6 \geq S_6) = 0.5755$

We obtain the minimum degree of possibility with the help of Eq. (5-3) as
$V(S_1 \geq S_2, S_3, , \dots S_6) = 1$
$V(S_2 \geq S_1, S_3, , \dots S_6) = 0.8453$

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$V(S_3 \geq S_1, S_2, , \ldots S_6) = 0.3071$
$V(S_4 \geq S_1, S_2, , \ldots S_6) = 0.6921$
$V(S_5 \geq S_1, S_2, , \ldots S_6) = 0.5338$
$V(S_6 \geq S_1, S_2, , \ldots S_5) = 0.1599$

Then using Eqns. (8-3) we calculate the weight vector as:

$W_p = (1, 0.8453, 0.3071, 0.6921, 0.5338, 0.1599)^T$

After normalization of W_p using Eqns. (9-3), we get the normalized weight vectors as

$W = (0.283, 0.238, 0.087, 0.196, 0.151, 0.045)^T$

The other weight calculations are not given here because they follow the same procedure as discussed above.

Finally, the importance weights of each criterion and sub-criterion in order of preference are shown in table 4.

Table 4: Importance weights of each criterion and sub-criterion in order of preference.

criteria	weight	sub-criteria	weight
S_1	0.283	C_1 C_3 C_4 C_2	0.377 0.369 0.226 0.029
S_2	0.238	C_6 C_7 C_5 C_8	0.379 0.276 0.184 0.161
S_4	0.196	C_{15} C_{16} C_{13} C_{12} C_{14}	0.280 0.253 0.250 0.145 0.072
S_5	0.151	C_{17} C_{21} C_{20} C_{18} C_{19}	0.274 0.247 0.214 0.185 0.080
S_3	0.087	C_9 C_{11} C_{10}	0.513 0.391 0.096
S_6	0.045	C_{22} C_{24} C_{23}	0.369 0.330 0.301

Application of DEMATEL method

In this stage we apply the DEMATEL method to investigate the dependency issues among factors. The four steps of method calculation, as described in section 3.2 are as follows:

Step 1: Generating an original impact matrix (X)

The original mean impact matrix (X) is obtained by the average of the summation of the expert answer matrices

Step 2: Calculating the direct impact matrix (M)

In this step we apply Eqs. (10-3) to calculate the direct impact matrix (M)

Step 3: Calculating the total impact matrix (***T***)

By Eq. (11-3), the total impact matrix (***T***) can be obtained

Next, we obtain the row sum vector (D), and the column sum vector (R), the row and column sum vector (D+R) and the row and column difference vector (D－R).

Ranking factors based on (D+R) and (D－R) are shown in Table 5

Table 5: Ranking factors based on (D+R) and (D－R).

rank	factor	(D+R)	factor	(D-R)
1	C_{16}	3.8802	C_6	0.8164
2	C_{15}	3.3691	C_{15}	0.6876
3	C_{19}	3.2395	C_{16}	0.6793
4	C_{13}	3.2053	C_{14}	0.6127
5	C_{20}	3.1917	C_8	0.4972
6	C_{12}	3.1869	C_{19}	0.4832
7	C_{14}	3.1626	C_{12}	0.3945
8	C_{23}	2.7330	C_{20}	0.3598
9	C_{24}	2.7285	C_{13}	0.1465
10	C_{11}	2.6175	C_{17}	-0.0630
11	C_{18}	2.6172	C_{24}	-0.0642
12	C_{10}	2.5404	C_9	-0.0859
13	C_{21}	2.5293	C_7	-0.1023
14	C_{22}	2.4762	C_{11}	-0.1188
15	C_{17}	2.4399	C_{22}	-0.1415
16	C_7	2.2409	C_{18}	-0.1684
15	C_3	2.2230	C_{10}	-0.2197
18	C_9	2.2200	C_{23}	-0.2673
19	C_5	2.2154	C_{21}	-0.3642
20	C_4	2.1315	C_2	-0.5099
21	C_1	2.1039	C_4	-0.5496
22	C_2	2.0800	C_3	-0.6013
23	C_8	1.7507	C_5	-0.6365
24	C_6	0.9974	C_1	-0.7846

Conclusion And Recommendation:

In this study the findings reveals that management of supply vessels is ranked the highest, so it is recommended that in selecting the vessels and making shipping contracts, items like safety and reliability, sailing capability, operational capability and loading/unloading capability to be considered greatly especially in long-term contracts, because lack of attention to these factors in the beginning could lead to future problems or having to breach the contract that will have costly consequences.

The second most important criteria obtained from fuzzy AHP is maritime disaster management and the sub-criterion of correct and precise forecast of weather condition is ranked first, in addition, results from dematel technique has also showed that this item has the greatest impact on the other factors mentioned in this study, with respect to the nature of work at sea it is essential to have close forecast of sea weather condition, So it is recommended that in signing contracts to receive weather forecast, organizations with valid and successful background to be selected.

Regarding the second sub-criterion from maritime disaster management criterion, that is appropriate allocation of hours of work and hours of rest, proper division of tasks and personnel workload is recommended and if the workload requires more personnel, more people need to be employed onboard.

In case of explaining to employees about their duties in case of disaster, that is the third sub-criterion of maritime disaster management, quick response training and emergency evacuation maneuvers are recommended.

According to results from this survey, after factors related to the vessels, the employee empowerment is of prime importance, in this case supporting, training and motivating employees are recommended.

Outsourcing is the next factor in this study and sub-factors of selection of appropriate structure of contract between the employer and the contractor, analysis of the effects of outsourcing on productivity and moral obligations of employees, analysis of the costs associated with outsourcing, accurate selection of suppliers and contractors, assessment and close monitoring the performance of the contractors are in order of priority.

Considering the next priority which is the item of explaining the working conditions at the time of recruitment and selecting employees more compatible with the existing terms, more emphasis on face to face interviews and assessment of psychological characteristics in addition to their technical skills are recommended.

Stress management and reduction and designing flexible working hours, are the next important item in psychological risk management factor and adoption of more flexible management styles is recommended in this case.

Finally communications infrastructure is the factor that respondents perceived lowest ranking for it. Proper coordination and communication between the client and the contractors and subcontractors, communicational infrastructure between operational management

and logistics management, appropriate communication among onshore facilities, platforms and vessels are its sub-factors in order of priority.

Recommendations for Future Researches:

In this study, fuzzy AHP approach is used to rank the factors, in future studies other fuzzy MCDM methods can be applied.

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