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PRIORITIZATION OF THREAT FACTORS FOR PIPELINE OPERATOR'S REPUTATION SUSTAINABILITY FROM CUSTOMER'S PERSPECTIVES

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Abstract

A company reputation solely depends on how their stakeholders perceive them and their attributes, e.g., onshore oil and gas pipeline damage; sustaining the company reputation level amidst this deadly event is a great challenge to the owner. This article aimed to prioritise the contributing indicators of reputation loss as influenced by the customer perspective. These indicators were identified according to the 10 major onshore oil and gas pipeline explosion case studies; about 72 respondents had participated in the survey for data collection. Fuzzy analytic hierarchy process (FAHP) method was used to prioritise the factors and produced results as follows: factor A3 "Downgraded owner's ranking by ranking agencies", factor B2 "Bad word-of-mouth among customer", factor C3 "Accident facts hidden for personal interest" and factor D3 "Accident severity" were chosen to be the highest priority based on the customers' perception. This factor prioritisation process assists the owner to attend to these matter so that the impact of reputation loss, which influenced by the customer, may be avoided. Eventually the consequence assessment for pipeline damage can be successfully applied to evaluate the level of loss to be borne by the asset owner and eventually sustain the reputation of the company.

Keywords: Prioritization, Sustainability, Reputation, Pipelines, Consequence assessment.

1. Introduction

Existing pipeline failure consequence assessment computes the losses, in monetary terms, of damage events, i.e., human, production, asset and environmental

Nomenclatures

A	Comparison matrix
A_i	Matrix A with n elements for i = 1, 2, …, n
a_i	Constant expressing the weight given to i
d	Ordinate of the highest intersection point D between μ_{M_1} and μ_{M_2}
g_i	Goal for i = 1, 2, …, n
i, j, k	Elements of the matrix
l_1, l_2	First triangular fuzzy scale values representation
M_i	Convex fuzzy numbers for i = 1, 2, …, k
M^j_{gi}	Triangular fuzzy number for j = 1, 2, …, m
m	Extent analysis values
m_1, m_2	Second triangular fuzzy scale values representation
n	Dimension of the matrix
Si	Fuzzy synthetic extent with respect to the ith object
U	Goal set of $u_1, u_2, …, u_n$
u_1, u_2	Third triangular fuzzy scale values representation
V	Degree of possibility
W	Normalized weight vector of a non-fuzzy number
W'	Weight vector
w	Eigenvector
w_i	Weight of factor i
X	Object set of $x_1, x_2, …, x_n$

Greek Symbols

λ_{max}	Largest eigenvalue

Abbreviations

AHP	Analytic Hierarchy Process
CEO	Chief Executive Officer
CI	Consistency Index
CR	Consistency Ratio
FAHP	Fuzzy Analytic Hierarchy Process
LCY	LCY Chemical Corporation
QNG	Quebec Natural Gas Corporation
RI	Random Index
TFN	Triangular Fuzzy Numbers
US	United States

loss. These are quantitative losses which are countable and visible, as compared to reputation loss; it is usually neglected because of difficulties in quantification [1]. Excluding this loss in the assessment is not a choice; although it is an intangible asset, it is capable of making the owner suffer from unwanted tangible loss [2]. Moreover, pipelines are aging and the risk of failure is increasing, thus inclusion of reputation loss in pipeline consequence assessment is predicted to make it more conservative as compared to the current practice.

All companies have at least four major stakeholders, e.g., investors, customers, employees and the public. Reputation of a company depends on its stakeholders' beliefs. Warren Buffet, the chief executive officer (CEO) of a well-known multi-conglomerate company known as Berkshire Hathaway, reminded the business industry players in his famous quote: "It takes 20 years to build a reputation and five minutes to ruin it." [3-6]. In this quote, he has emphasized the importance of sustaining the company reputation by referring to the difference of duration to attain as compared to lose it. It is also applicable to the oil and gas onshore pipeline operators, where degradation of confidence level among stakeholders is a direct threat to the company's reputation [7]. Hence, a company's good reputation is the utmost priority so that their performance remains within the stakeholders' expectations [8].

Recent deadly onshore natural gas pipeline accident occurred in India and Taiwan in 2014 shows bad report of event consequence, e.g., multiple fatalities and injuries, great economic loss and devastative environmental damage [9]. Directly or indirectly, the cost to operator, owner and the company stakeholders is unquantifiable. Failure events have cost pipeline owners approximately one billion US Dollars over the last 15 years for gas transmission pipelines alone (2000 – 2015) [10]. Furthermore, stakeholders perceptions differ and are highly depend on company performance and incidence involving the company [11, 12], thus creating post-accident negative responses if preventive measures prior to the event are neglected. Identification of factors contributing to the loss of reputation is essential for the purpose of attracting and retaining customers [13]. The identification of reputation loss factors has been done but the prioritization of the factors has yet to be discovered [14]. In short, there is a need to determine which factor affects reputation of pipeline owner the most in regard to events involving damage to the society exclusively, and to rank its importance according to different perspectives of company stakeholders.

Thus, the objective of this article is to prioritize the reputation loss factors from the oil and gas company stakeholders' based on which reputation-threat factors affect the reputation of the owner the most, prior to the deadly event of an onshore pipeline explosion. There are 22 reputation-threat factors identified in 10 case studies of major onshore pipeline accidents that have occurred between 1965 and 2014, which were later grouped into four categories of stakeholder-influenced, e.g., investor-influenced, customer-influenced, employee-influenced and public-influenced category [15]. Among the four major constituents of a company aforementioned, this article concentrates on prioritizing the threat factor according to the perspectives of the customer only. To avoid biasness in the study, the survey was conducted among the customers of a Malaysian oil and gas company regardless of their background of knowledge related to pipeline integrity. Three types of customers were considered in this study, namely wholesaler, retailer and the end-user of the oil and gas company products. This article aimed to assist researcher and industry players to understand the stakeholder perceptions and expectations towards the company and to simultaneously reduce the impact of reputation loss, specifically influenced by the customer.

2. Literature Review

Onshore oil and gas pipeline accidents comprising explosion cause significant negative impact such as loss of life, destruction of private and public property and serious environmental damage, e.g., the BP Deepwater Horizon oil spill in

2010. Although it is known as the safest, most economical and fastest mode of transporting natural gas and hazardous liquids in large amount, pipelines are still susceptible to failure [16-20]. These failure events can harm the public, the environment, assets and production, eventually affecting the pipeline operator's reputation regardless of its operating procedures prior to the failure event. However, the impact of reputation loss imposed by stakeholder perceptions is neglected due to difficulties in quantifying factors [1, 21]. Moreover, the fluctuation of a company's reputation is time-dependent [11, 22]; multidimensional [23]; behaviour-dependent [22]; and highly prone to stakeholder experience with the company [8]. This qualitative nature of reputation characteristics and its subjectivity on the stakeholder's expectation are several of the reasons why pipeline operators choose not to include reputation loss aspect in the consequence assessment of pipeline failure. Nevertheless, it can endanger operator's profit margins [24]. Moreover, it is vital to most organizations [25].

Reputation is the belief that stakeholders have towards a company and its attributes [23]. There are four major stakeholder of a company, generally known as the investor, customer, employee and the public [23]. A person who allocates capital and expects financial return from a company is called an investor; a man or an organization who purchases goods or services from other organizations is known as a customer; an individual who works with a company and gain wages or salary from his employer is an employee; and other than aforementioned can be considered as the public. As they act as different personalities, their expectations towards a same company are dissimilar as well [23]: investor desires credibility; customer requests reliability; employee needs trustworthiness; and public demands responsibility. If a company is incapable to achieve these stakeholder's expectations, the impact may jeopardize the company reputation, hence significantly influencing company operations [26].

A good reputation is awarded to a company if they consistently successfully achieve their major stakeholders' expectations and necessities [27]. One can obtain good reputation if the company performance exceeds stakeholder's requirements [28]. Any negative perceptions towards the company can be considered as the company is losing reputation; obtaining stakeholders' trusts and beliefs are the main aim for sustainability of a company's reputation. Thus, it is crucial to determine the expectations of each stakeholder at the initial stage to reduce the impact of reputation loss, be it internal or external stakeholder, as both are equally important. For instance, sustainability of a company's reputation depends on the investor satisfaction indicators [29]: paid dividends amount [30]; share price performance; individual investor's information policy; and company's shares evaluation. On the other hand, early signs of a company's reputation degradation caused by the internal stakeholders, i.e., employees and executives are listed as follows [31]: low morale of employee; focus on internal politics is greater than executing job well; top executive leaves company; CEO credibility replaced by CEO popularity; and customers and clients are nuisances according to the employees.

According to the taxonomy of company stakeholders and the related expectations, a customer or consumer requires product supply to be reliable, of high quality, satisfaction and delivered as promised [32]. Further expectations of other stakeholders are listed in Table 1 as shown. Service disturbance is of customer's least interest as they wish to obtain product with ease at their preferable time. That exploded pipeline disturbed current service, specifically service lines, is inevitable because it transports supply to customer directly, e.g., individual, retailer, etc. For example, on March 1, 1965, a whole block of 36-unit house apartment at LaSalle Height, Quebec, Canada was destroyed by an explosion caused by the service line beneath the building [33, 34]. This event caused 28 fatalities, 39 injuries and 200 homeless [35]. Quebec Natural Gas Corporation (QNG), who was responsible for the pipeline, had to stop gas supply to the other nearby blocks before it was confirmed safe. Likewise, service disturbance may have a greater impact on transmission pipeline, which transports natural gas from a gathering, processing or storage facility to a processing or storage facility, large volume customer or distribution system.

Table 1. Taxonomy of company's stakeholders and related expectations [32].

Stakeholders	Expectation
Shareholders and investors	Value and dividends
Fund managers	Deliver results
Business analysts	Competitive products/services
Rating agencies	Good business management
Financial media	
Potential employees	Ethical standards
Existing employees	Health and safety standards
Temporary/voluntary staff	Employment laws/regulations
Unions and trade bodies	Engagement with unions
Suppliers	Pay suppliers and contractors
Sales agents and distributors	Honour contracts
Subcontractors	Support business relationships
Trading partners	Cooperate with partners
Consumers	Supply reliable products
Wholesalers	Quality
Retailers	Customer satisfaction
Patients/passengers, etc.	Deliver against promise
Regulators	Meet standards
Local government	Act responsibly
NGOs	Respect stakeholders
Neighbours/communities/media	Good corporate citizenship

An example of transmission pipeline explosion occurred in Kaohsiung, Taiwan on July 31, 2014 to prove the statement earlier. A series of five explosions, which damaged at least four roads approximately six-kilometers from the explosion site, was later found owned by LCY Chemical Corporation (LCY) [36]. The Taiwan government halted pipeline service and reviewed the safety improvement plan, which eventually forced gas supply to 23,600 households to be cut off as well. Pipeline operator's reputation, which is affected by pipeline damage event, can be portrayed through owner's business service interruption, including the loss of product sales, legal action against pipeline operation, loss of contract, loss of funding for future pipeline project and loss of market share [37]. Hence, customer's post-accident responses may have significant effect on pipeline owner's reputation.

This paper studied 10 cases of major onshore pipeline explosion events that occurred between 1965 and 2014 [15]. From the literature search, 22 reputation-threat factors were identified, which later grouped into four categories of stakeholder-influenced, e.g., investor-influenced, customer-influenced, employee-influenced and public-influenced category [15]. However, prioritizing the threat factors based on the stakeholders' perspectives, specifically based on customer's point of views, has yet to be studied. The fuzzy analytic hierarchy process (FAHP) is an effective tool to solve the complex decision making by allowing respondents to prioritize the importance between predetermined factors by including the fuzziness in the decision makers responses [38, 39]. Integration of fuzzy theory and analytic hierarchy process (AHP) method eliminates the vagueness and uncertainty in decision makers' judgment [40-42].

3. Methods

The methods consist of three stages: identification of reputation loss factors, data collection and prioritization of reputation loss factors. The identification process was done by observing the reports related to exploded pipeline case studies [14]. Then, the extracted factors were arranged into questionnaire survey to collect rating of the level of influence of each factor towards stakeholders. Finally, factors were ranked from the highest to the lowest according to the respondents' preferences. This study only focused on the third stage by implementing the result obtained from stage one, which is the identification of the factors [14]. The overall framework of the methodology of this study is shown in Fig. 1 as follows.

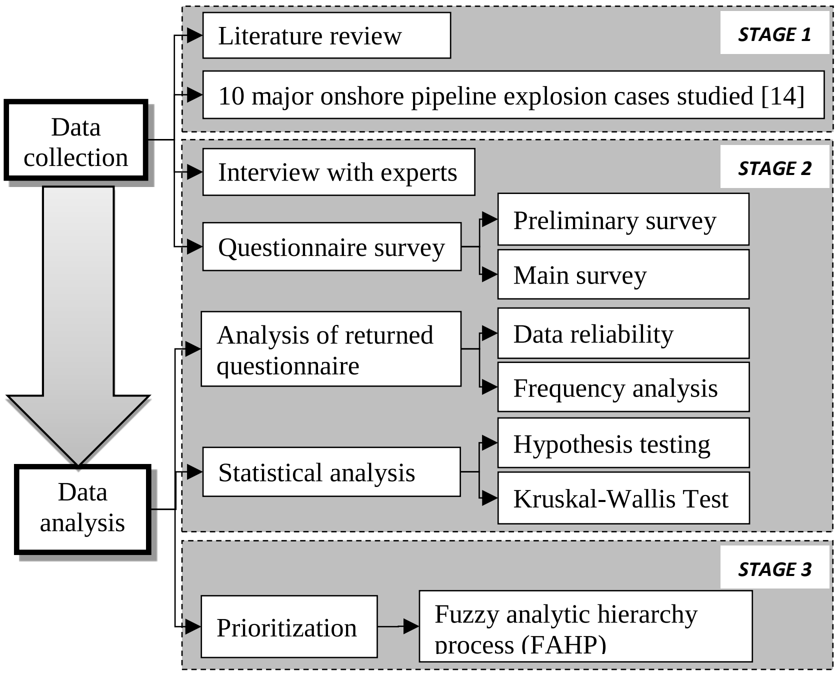

Fig. 1. Overall framework of the methodology.

3.1. Identification of reputation loss factors

The onshore pipeline explosion cases was selected based on the major oil and gas pipeline explosion events from the year 1965 to 2014, which consists of any one of these criteria [43]: multiple fatalities (10 or more); approximately 100 million US dollar property damage; and 1000 barrels of oil spilt. From each of the cases, negative responses from the stakeholders in the literature search, i.e., investor, customer, employee and the public, which are available online and public were recorded [14]. It was then rearranged into the categories of influence, e.g., investor-influenced, customer-influenced, employee-influenced and public-influenced of reputation loss factors and labelled as listed in Table 2 [15].

3.2. Data collection

The identified reputation loss factors were rearranged according to the analytic hierarchy process (AHP) method framework which corresponds to the stakeholders. A hierarchical structure was constructed with attention to creating hierarchical influence between the *Goal*, the *Criteria*, and the *Sub-criteria* as shown in Fig. 2 [15]. Based on this structure, the identified reputation loss factors were included in a newly developed questionnaire as a preliminary survey in order to gain responses related to the feasibility and understanding of the respondents on the questions and answering methods, including the questionnaire layout and design.

According to the responses received from the first 10 respondents, the questionnaire was improved and then distributed to the respondents randomly as a main survey. This improved questionnaire was designed into a respondents-friendly online survey with the help of Google website, which is known as Google Forms introduced by Google Drive. It is free, easy and the latest method to gain respondents interest to complete a survey. The survey was distributed online to the customers of oil and gas company, e.g., wholesaler, retailer, end-user. At least 30 surveys need to be collected as a rule of thumb for most research since the sample is randomly selected due to the large number of population [44]. Frequency analysis was used to obtain the percentage of nominal-type questions.

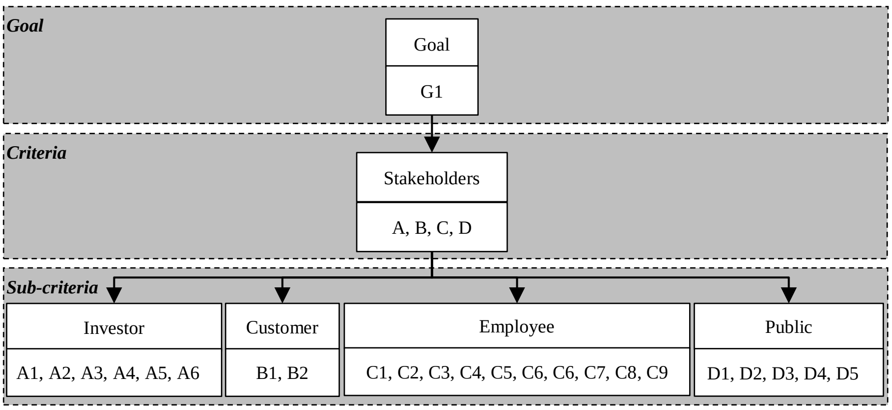

Fig. 2. AHP structure [15].

This online survey was divided into three sections, i.e., demographics, stakeholder's perceptions and operator's reputation. A case study of a worst onshore pipeline explosion case scenario designed based on the 10 case studies was included in the survey and verified by the experts in order to assist the respondents in providing relevant responses. Referring to the provided worst case scenario of pipeline failure, the respondents will rate the factors based on the level of influence on the loss of pipeline operator's reputation. The 5-point rating scale ranged from 1 (very low) to 5 (very high) was selected, indicating that the level of operator's reputation degrades as the scale is increasing. The 5-point or 7-point Likert scales contribute slightly higher mean scores than 10-point scale according to Dawes [45]. The reliability of the data has to be tested based on the Cronbach's alpha value; this survey should obtain at least 0.70 for a new construct to show the internal consistency of the questionnaire is above an acceptable level [44]. Then, the collected questionnaire can be further analysed. Prior to prioritization of the reputation factor, statistical analysis was executed and the result shows that there is no significant difference between the respondents of different types of customer.

Table 2. Reputation loss factors due to pipeline explosion events [15].

Stakeholders	Factors contributing to pipeline operator reputation loss
A: Investors	A1: Sudden drop of share price and market capitalization
	A2: Services or sales progress disturbed
	A3: Ranking downgraded
	A4: Reduction of credit rating
	A5: Loss of new pipeline contracts
	A6: Loss of sponsorship opportunity
B: Customers	B1: Loss of customer confidence
	B2: Bad word-of-mouth among customers
C: Employees	C1: CEO responds with unreasonable actions towards victims
	C2: CEO neglects victims' welfare
	C3: CEO hides facts about the accident
	C4: CEO refuses to take responsibility
	C5: CEO mismanages allocations to lobby politicians
	C6: Employees demotivated
	C7: Job applications for position reduced
	C8: Skilled worker resignations
	C9: Employee(s) caused accident
D: Public	D1: Recurrence of similar accident
	D2: Loss of public trust
	D3: Severity of accident
	D4: Mishandling public reports
	D5: Negative media report

3.3. Prioritization of reputation loss factor

Previously, responses from the customers of oil and gas company in Malaysia who participated the survey was automatically stored in an Excel sheet. These data cannot be processed before converting the selecting 5-point Likert scale to the 9-point AHP fundamental scale as shown in Table 3. The responses then underwent the pairwise comparison method in order to obtain the relative weight of each criterion. Each level of criterion was scored with respect to its parent criterion by comparing one choice to another. Relative scores for each choice are computed within each leaf of the hierarchy and eventually result in a matrix of scores, say $a(i, j)$. The pairwise judgment data transformation process was implemented to overcome the complexity in the analysis as the number of variables increases and to reduce number of questions in a survey [46]. The principle of data transformation scheme is summarized into a table of 1 to 9 scale survey questions as shown in Table 4.

Table 3. Qualitative scale conversion into AHP scale.

Qualitative Scale	Quantitative Scale	AHP Method Fundamental Scale	
		Intensity	Definition
Very Low	1	1	Equal importance
Low	2	3	Moderate importance
Moderate	3	5	Strong importance
High	4	7	Very strong importance
Very High	5	9	Extreme importance

Table 4. Data transformation scheme to pairwise judgment [46].

Scale	Linguistic scale term	Paired comparison of criteria
1	Equal	1:1
2	Equally to moderately dominant	2:1, 3:2, 4:3, 5:4, 6:5, 7:6, 8:7, 9:8
3	Moderately dominant	3:1, 4:2, 5:3, 6:4, 7:5, 8:6, 9:7
4	Moderately to strongly dominant	4:1, 5:2, 6:3, 7:4, 8:5, 9:6
5	Strongly dominant	5:1, 6:2, 7:3, 8:4, 9:5
6	Strongly to very strongly dominant	6:1, 7:2, 8:3, 9:4
7	Very strongly dominant	7:1, 8:2, 9:3
8	Very strongly to extremely dominant	8:1, 9:2
9	Extremely dominant	9:1

The matrix holds the expert judgment of the pairwise comparisons. However, the judgment should be consistent. A matrix $a(i, j)$ is consistent if all its elements achieve the rules of transitivity and reciprocity shown in Eqs. (1) and (2) [47]

$$a_{i,j} = a_{i,k} \cdot a_{k,j} \quad (1)$$

$$a_{i,j} = \frac{1}{a_{i,j}} \quad (2)$$

where *i*, *j* and *k* are any elements of the matrix. For instance, if the factor “A1” is two times more important than factor “A2”, then factor “A2” should be ½ times more important than factor “A1” and so on. In the pairwise comparison matrices, a consistent matrix and the matrix formation are presented as the following Eqs. (3), (4) and (5)

$$A=\begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \vdots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix}=\begin{bmatrix} w_1/w_1 & \cdots & w_1/w_n \\ \vdots & \vdots & \vdots \\ w_n/w_1 & \cdots & w_n/w_n \end{bmatrix} \tag{3}$$

$$\begin{bmatrix} w_1/w_1 & \cdots & w_1/w_n \\ \vdots & \vdots & \vdots \\ w_n/w_1 & \cdots & w_n/w_n \end{bmatrix}\times\begin{bmatrix} w_1 \\ \vdots \\ w_n \end{bmatrix}=n\begin{bmatrix} w_1 \\ \vdots \\ w_n \end{bmatrix} \tag{4}$$

$$\mathbf{A}\cdot\mathbf{w}=n\mathbf{w} \tag{5}$$

where **A** is the comparison matrix , **w** is the eigenvector and *n* is the dimension of the matrix. The λ_{max} is equal to the number of comparison for a consistent reciprocal matrix, $\lambda_{max} = n$. A weights vector is defined as the normalized eigenvector corresponding to the largest eigenvalue, λ_{max}. The procedure of obtaining the weight of each factor using the λ_{max} method begins with the summation of each column element of a pairwise comparison matrix, followed by dividing each element of a column with the summation of the respective column as calculated earlier. The arithmetic average of each row of the normalized matrix gives the weight of the corresponding criterion. The total weight of the criterion should equal to 1.

The accuracy of this judgment is increased when the pairwise comparison matrix has a low consistency ratio (CR). It is necessary as it able to identify possible errors in judgments data entry as well as actual inconsistencies in the judgments themselves. Inconsistency measures the logical inconsistency of the expert judgments. The value of CR of less or equal to 0.1 obtained using Eqs. (6) and (7) indicates that the inconsistency of judgment is acceptable or judgments need to be revised, otherwise

$$CR=\frac{CI}{RI} \tag{6}$$

$$CI=\frac{\lambda_{max}-n}{n-1} \tag{7}$$

where *CI* is the measure of consistency known as Consistency Index and RI is the Random Index of a sample size of 500 matrices proposed by Saaty [48]. Next, Chang’s extent analysis of FAHP method [49] was implemented as it is considered as the simplest method of FAHP. Each object is taken and an extensive analysis is executed for each goal, g_i (i = 1, 2, …, n). Let $U = \{u_1, u_2, \ldots, u_n\}$ be as a goal set and an object set of $X = \{x_1, x_2, \ldots, x_n\}$. Extent analysis values, *m* for each object can be attained with the signs of $M_{g_1}^1, M_{g_2}^2, \cdots, M_{gi}^m$ where M_{gi}^j (j = 1, 2, …, m) and all are triangular fuzzy numbers (TFN). Table 5 shows the linguistic scale for importance which converted qualitative terms of factors into fuzzy quantitative values.

Table 5. Linguistic scale for importance.

Linguistic scale	AHP fundamental scale	Triangular fuzzy scale	Triangular fuzzy reciprocal scale
Absolute equal (AB)	1	(1.00, 1.00, 1.00)	(1.00, 1.00, 1.00)
Equally importance (EI)	1	(0.50, 1.00, 1.50)	(0.67, 1.00, 2.00)
Intermediate1 (EM)	2	(0.75, 1.25, 1.75)	(0.57, 0.80, 1.33)
Moderate importance (MI)	3	(1.00, 1.50, 2.00)	(0.50, 0.67, 1.00)
Intermediate2 (MS)	4	(1.25, 1.75, 2.25)	(0.44, 0.57, 0.80)
Strong importance (SI)	5	(1.50, 2.00, 2.50)	(0.40, 0.50, 0.67)
Intermediate3 (SV)	6	(1.75, 2.25, 2.75)	(0.36, 0.44, 0.57)
Very strong importance (VI)	7	(2.00, 2.50, 3.00)	(0.33, 0.40, 0.50)
Intermediate4 (VE)	8	(2.25, 2.75, 3.25)	(0.31, 0.36, 0.44)
Extreme importance (XI)	9	(2.50, 3.00, 3.50)	(0.29, 0.33, 0.40)

The first step of the procedure is to obtain the value of fuzzy synthetic extent with respect to the ith object, S_i using following Eq. (8)

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} \tag{8}$$

where the fuzzy additional operations for particular matrix, $\sum_{j=1}^{m} M^j{}_{g_i}$, $\sum_{i=1}^{n}\sum_{j=1}^{m} M^j{}_{g_i}$, and $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M^j{}_{g_i}\right]^{-1}$ of M^j_{gi} (j = 1, 2, …, m) are shown in Eqs. (9), (10) and (11).

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{i=1}^{m} l_j, \sum_{i=1}^{m} m_j, \sum_{i=1}^{m} u_j \right) \tag{9}$$

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{i=1}^{m} l_j, \sum_{i=1}^{m} m_j, \sum_{i=1}^{m} u_j \right) \tag{10}$$

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} l_j}, \frac{1}{\sum_{i=1}^{n} m_j}, \frac{1}{\sum_{i=1}^{n} u_j} \right) \tag{11}$$

The next step is to express the degree of possibility $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$, which is defined into equivalent definition as shown in Eqs. (12) and (13)

$$V(M_2 \geq M_1) = sup_{y \geq x}\left[min\left(\mu_{M_1}(x), \mu_{M_2}(y)\right)\right]\ y \tag{12}$$

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1 & if \quad m_2 \geq m_1 \\ 0 & if \quad l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & otherwise \end{cases} \tag{13}$$

where d is the ordinate of the highest intersection point D between μ_{M_1} and μ_{M_2}. Both $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$ values are required to compare value of M_1 and M_2. Then, the degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers, M_i (i = 1, 2, …, k) can be determined using Eq. (14)

$$V = M \geq (M_1, M_2, \cdots, M_k) = V\left[(M \geq M_1), (M \geq M_2), \cdots, (M \geq M_k)\right]$$

$$V = \min V(M \geq M_i) \tag{14}$$

Assuming $d'(A_i) = \min V(S_i \geq S_k)$. For k =1, 2,…, n; $k \neq i$. Then the weight vector is given by Eq. (15)

$$W' = \left[d'(A_1), d'(A_2), \cdots, d'(A_n)\right]^T \tag{15}$$

where A_i are n elements. Finally, the normalized weight vectors are attained using Eq. (17)

$$d(A_i) = \frac{d'(A_i)}{\sum_{i=1}^{n} d'(A_i)} \tag{16}$$

$$W = \left[d(A_1), d(A_2), \cdots, d(A_n)\right]^T \tag{17}$$

where W is a non-fuzzy number.

In conclusion, the normalized weight vectors can be considered as the value of the importance of each factor. Thus the ranking of the reputation loss factors is obtained by rearrangement of the values of importance of the factors as aforementioned. Hence, prioritisation of reputation loss factor can be accomplished.

4. Result and Discussion

The designed main questionnaire achieves the minimum level of internal consistency 0.70 with the Cronbach’s alpha value of 0.891. A total of 72 sets of questionnaires were answered completely and collected successfully. From the analysis of the customer’s demographic, more than half of the respondents, or 51.4%, were aged between 30 to 39 years old; 44.4% were aged below 30 and between 40 to 49 years old are the others. Most of the respondents are the end-users (person who purchase products for own use) with 94.4% and the rest are the retailers (person who purchase products from oil and gas company and sells in small quantities). 86.1% of the respondents were aware of onshore oil and gas pipeline accident by readings and the rest are not.

Figure 3 shows the results of the priority vector and the ranking of reputation loss factor by the category of influence, e.g., investor-influenced, customer-influenced, employee-influenced and public-influenced factors. The highest ranking shows that the factors may affect the reputation of the pipeline operator prior to onshore pipeline explosion damage according to the customer's perspectives; they are A3 "Downgraded owner's ranking by ranking agencies", B2 "Bad word-of-mouth among customer", factor C3 "Accident facts hidden for personal interest" and D3 "Accident severity". According to the customer of oil and gas company, factor A3 "Downgraded owner's ranking by ranking agencies" scored the highest in the category of investor-influenced reputation loss factor. It is considered reliable as the company's performance assessed by the ranking agencies affects the customer's preferences and loyalty [50]. However, the company's performance affects its ranking over time, and changes of perception are an indicator of how the company is perceived by the public [23]. Reputation of a company is more than just a financial issue; it includes non-financial aspects like "commitment to social and charitable issues" [29]. It is one of the reasons why the customer agreed that factor B2 "Bad word-of-mouth among customers" ranked the highest scored factor of reputation loss in the customer-influenced category. It was found that customers are more likely to engage in positive word-of mouth intention if they favour the company [51].

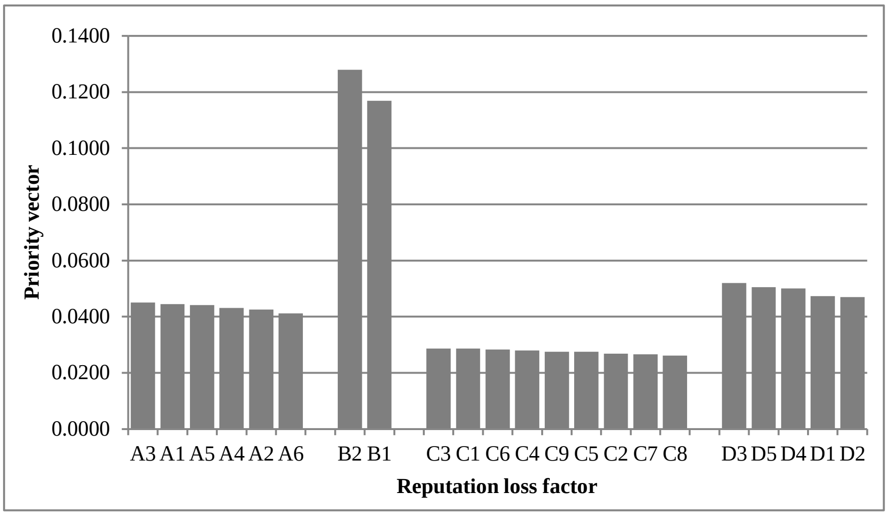

Fig. 3. Ranking of reputation loss factor according to customer perceptions.

Furthermore, the customers agreed that the factor C3 "Accident facts hidden for personal interest" is the main factor that causes reputation loss of a company, which is influenced by the employee. A study shows that stakeholders follow the behaviour of the company's executives in order to investigate the sincere intentions of the company [52]. Thus, integrity is vital for sustaining the reputation and to gain the trust of the stakeholders according to the customer's perspectives [53]. Finally, the factor D3 "Accident severity" has a great impact on pipeline owner reputation as it was ranked first in the public-influenced category by the customer of oil and gas company in Malaysia. The severity of the accident, especially for deadly event of onshore pipeline explosion, is the least favourable for all stakeholder as it affects both internal and external stakeholders physically and mentally [15].

5. Conclusions

This article has successfully prioritized the reputation loss factors identified from an in-depth review on 10 case studies of major oil and gas onshore pipeline explosion based on the perspective of the customer. The broader understanding on customer expectation on the company, the company reputation can be better sustained. Results shows that the customer has ranked the reputation loss factors according to each category of influence in ascending manner; they selected factor A3 “Downgraded owner’s ranking by ranking agencies”, factor B2 “Bad word-of-mouth among customers”, factor C3 “Accident facts hidden for personal interest”, and the factor D3 “Accident severity” as the highest influence on reputation loss. The prioritization of factors may assist pipeline operator to entertain the most influential factors from the perspective of the customer as precaution measures. Hence, prioritization of the factors according to other stakeholders is highly recommended in the future research i.e. employee, investor and public. In addition, the oil and gas industry players are now looking forward into considering these reputation loss factors if they can be transformed into money; thus the loss impact on economic aspects are visible and quantifiable. If all factors influences the loss of company reputation can be identified and overcome earlier, the impact of reputation loss can be reduced. The evaluation of reputation loss to be borne by the pipeline owner can be done to achieve a comprehensive consequence assessment for pipeline damage in order to secure and sustain company reputation.

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